ISCTE Business School
Instituto Universitário de Lisboa

The Manufacturing Value Chain of Power Generation Equipment: A Case Study

ZHANG Wenfeng

Thesis submitted as partial requirement for the conferral of

Doctor of Management

Supervisor:

Professor Nelson António, Full Professor, ISCTE-IUL, Departamento de Marketing, Operações e Gestão Geral

Co-supervisor:

Professor LI Shiming, Full Professor, University of Electronic Science and Technology of China, School of Management and Economics

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Abstract

On the basis of literature study and data collection, this thesis analyzes the value chain in Chinese power industry, power generation equipment industry, and steam turbine manufacturing industry systematically, in combination with Chinese power generation equipment industry background. It obtains a conclusion that the manufacturing takes the core status in the whole value chain. Around the manufacturing value chain, this thesis analyzes the key links and the key components of manufacturing value chain by case study of Dongfang Turbine Co., Ltd. It also makes a concrete description of manufacturing value chain's management and upgrading in the aspects of technology innovation, manufacturing technology layout optimization, production and quality management, and the management of value network.

Key words: power generation equipment industry; manufacturing value chain; value network; Dongfang Turbine Co., Ltd.

JEL: M1; M11

Resumo

Com base na revisão de literatura e na recolha e tratamento de dados, esta tese analisa a cadeia de valor na indústria energética Chinesa no que respeita à produção de equipamento para a geração de energia e turbinas a vapor. A tese conclui que a produção assume um lugar central em toda a cadeia de valor.

Tendo como pano de fundo a cadeia de valor da produção esta tese analisa as principais ligações e as principais componentes da produção da empresa Dongfang Turbine. Ltd. A tese descreve também a gestão da cadeia de valor da produção, dando especial ênfase à inovação tecnológica, à optimização do layout, à gestão da qualidade e à gestão do valor produzido em rede.

Palavras Chave: indústria de equipamento gerador de energia; cadeia de valor da produção, Valor da rede, China, Dongfang Turbine Co. Ltd

JEL: M1; M11

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This thesis is a demonstration of the results in my three years' DBA study. Due to my lasting efforts, the thesis is finally completed, which marks the finish of my DBA study. Looking back the past three years' hard working, I would like to express my gratitude to all those who have helped me.

First of all, I would like to extend my sincere gratitude to ISCTE Lisbon University Institute and University of Electronic Science and Technology of China, which provide me such precious learning opportunity. As one member of the top management of a big enterprise, time is limited and many business matters may bother you. However, lifelong learning is what I exactly expect. During my study, many teachers taught me profound knowledge, which would be of great help for my future work.

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Chapter 1: Introduction

1.1 Background

The report of an economic research and consulting company, IHS GLOBAL INSIGHT demonstrates that China took the place of America to become the biggest manufacturing country in the world. If the output is considered, the output of the manufacture industry in China in 2010 was up to 1,955 billion US Dollars and its percentage in the total output of the manufacture industry of the world was 19.8%, while in America these two figures were 1,952 billion US Dollars and 19.4% respectively. Based on UN statistics, the manufacture industry in China has more obvious advantage in its scale.

The total value of the output of the manufacture industry in China has already reached the highest of the world, but its production efficiency is still much lower than that in America. The per capita output of China is only one eighth of that in America. It is obvious that the manufacture industry in China is concentrated on the lower added value sectors while on the higher added value sectors in America.

If viewed in the global value chain system, Chinese manufacture enterprises do not get significant profit. The economist, Dr. Lang Xianping (2008) said that the Chinese manufacture industry has been on the lowest side of the industry chain for a long time, profiting little added value while facing huge competition. The research of the classical industry value chain demonstrates that the curve of the profit of the industry chain is U-shaped: R&D and design are on one side; sale and service are on the other side. On these two ends, the profit is about 20%—25%; while in the middle, the profit of the manufacture is only about 5%. This is the famous Smiling Curve Theory. We can see the example of this theory in many industry sectors such as electrical appliances, automobile, clothing, IT industry in China.

However, if we turn our focus on the power generation equipment manufacture industry, we can find that the traditional Smiling Curve is not applicable. The main manufacturers in the world are GE and Westinghouse in America, Alstom in France, Siemens in Germany, Hitachi and Mitsubishi in Japan; while in China the major manufacturers are the three enterprise groups of Dongfang Electric, Shanghai Electric and Ha'erbin Electric.

Internationally, the countries or regions such as America, Europe and Japan where the manufacture industry is highly developed are maintaining their dominant position in the high and new technology; meanwhile, they have begun the worldwide optimized allocation of the resources, with the target of constantly decreasing the production cost and enhancing the competiveness; significant change is happening in their industry structure. In the traditional developed countries, the ratio of the secondary industry, especially the ratio of the manufacture industry, has decreased from more than 60% to the current 20~30%. It is the same case for their power generation equipment manufacture sector.

In the meantime, the manufacture industry in some developing countries is rising rapidly. In the recent years, the traditional manufacture industry has gained great development in such countries as China and India. The manufacture industry is the advantageous industry in these countries, their industry foundation is getting more and more sound, their comparative advantages are becoming stronger and stronger in the process of industrialization and they have absorbed large amount of manufacture industry transfer. The total yield of the power generation equipment manufactured by China's three major enterprise groups in 2010 reached so high as 84.6GW, exceeding the world's annual average increment. China is getting so increasingly outstanding in the large complete set of equipment manufacture that it has become worthy of the name of "World Factory".

Although China owns strong manufacture capability and great progress has been made, there is an undisputable fact that China is still at a lower end position in the global value chain, Chinese products' added value is obviously low, industry innovation ability is insufficient and the international competiveness is still weak. The reality in the power generation equipment manufacture motivates us to have a further thinking on the industry characteristics and value creation.

Firstly, the large complete power equipment manufacture industry is pivoted in the high-end of the manufacture industry, representing the highest level of the machinery industry and equipment industry in a country. As a result, large complete power equipment manufacture industry has a great capacity of value creation in this era when innovation has become the deciding factor in the development and the technology has become the deciding factor in the value. In China's twelfth 'Five-year Plan' ,the government takes the high-end equipment manufacture industry as an important development orientation, which embodies the determination and strength in manufacture industry of the nation.

Secondly, in the industry sectors such as general consumer commodities, electric appliances and electronics products, in which the competition among many makers is very severe and an enterprise is aiming at the selection of resource capacity and competitive advantage buildup, enterprises are mainly positioned in one or some sections of the industry value chain, known as the 'point' positioning in the industry value chain. Different from these industry sectors, the competition among the manufacturers of large complete power equipment is a kind of competition among oligarchic companies and gigantic manufacturers. We can take the large coal-fired power and nuclear power generation equipment as the example: there are only 10-plus manufacturers in this industry sector in the whole world, these enterprises are not positioned in the "point" of the cross section of the industry value chain, but positioned in the longitudinal "line" of the industry value chain, ranging from R & D, design, manufacture, process, sale to after-service and covering the longitudinal line of the whole chain. It is hardly found that there is the large complete power equipment manufacturer positioned in one link of the industry value chain. This is why we pointed out that the value chain of the heavy equipment manufacture industry including large complete power equipment manufacture industry is different from the value chain of the general consumer commodities, electric appliances and electronics products and the distribution of the industry value does not present the typical 'U' type distribution, but possibly an equilibrium distribution and even an inverted "U" type distribution.

Finally, as mentioned above, large complete power equipment manufacturers are positioned in the longitudinal "line" of the industry value chain, and the R&D, design, manufacture, process, sale and after-service of these enterprises make up a large and complex industry value chain, covering hundreds of thousands of the components and millions of processing steps, which results in that even the giant multi-national enterprises cannot produce all the components and perform all the processing steps. The actual industry scenario is that many small enterprises are supporting the manufacturing for core leading large complete power equipment manufacturers, forming industry clusters. Those core leading enterprises subcontract some production of the non-core components or non-core processes to the small enterprises. In this way, core leading enterprises need not only to manage its own production processes, but also manage the power equipment industry value chain. The study of the power equipment manufacture industry value chain we are doing in this thesis is exactly the basis and precondition of the optimization of these enterprises' own value chain and implementation of the governance of power generation equipment manufacture industry value chain.

Furthermore, western enterprises have comparative advantage in the development, design, marketing and after-service of the products, while Chinese enterprises including power equipment manufacturers have comparative advantages in manufacturing stage which is considered as the main way to create the value and cash flow. Nowadays, the international industrial division becomes more meticulous and in the aspects of the ability of independent innovation, marketing channel construction and brand value, Chinese power equipment manufactures cannot surpass multinational enterprises in a short time, therefore, orientating to the stage of the manufacturing is still the main choice of Chinese power equipment manufactures in recent time. Under the background that China has become the world factory, Chinese power equipment manufacturers shall break the traditional thinking of following 'barrel principle' to make a wasted effort to make up for the short plates of the enterprises, re-think the development of the enterprises from the angle of modern industry value chain; study every phase of the manufacturing value chain carefully; strength the manufacture business of the power equipment manufacturers through the scientific positioning of manufacturing value chain, based on their own actual circumstances and advantage, enhance their own core competitive advantage, quicken the process of upgrading of product design, sale and service to get more value creation and sharing of the industry value chain and improve the integration the resources of the industry chain and the overall competitiveness. Thus, studying the value chain of the power equipment manufacture industry has important theoretical and practical significance.

In a word, being driven by the theoretical and realistic background, it is necessary to take a further study of the value chain, especially the manufacturing value chain. Paying attention to the structure, evolution and governance of the manufacturing value chain of the power equipment industry will contribute to the better development of the industry and the better operation of Chinese manufacture enterprises.

1.2 Research Issues

On one hand, China is in the leading position of the manufacturing industry, but its competitiveness is relatively weak; on the other hand, Chinese power generation equipment manufacture enterprises stand out in the global value chain by virtue of their manufacturing capacity. Although Chinese power generation equipment manufacturing industry cannot exceed the multinational companies in a short period of time in the aspects of technical innovation and brand building, it has a clear comparative advantage in manufacturing aspect. This thesis selects the power generation equipment (represented by steam turbines) manufacturing enterprises' manufacturing value chain as the research subject. It focuses on the manufacturing sector, and analyzes the issues such as the structure of manufacturing value, value creation, value distribution, value management theoretically and empirically, from the perspectives of industrial chain, value chain, industrial cluster, production services and national energy strategy.

The following issues are mainly discussed in this thesis:

First, what are the main factors of value chain among different industries and enterprises? The basic form of value chain has been well known, but the structure of value chain often varies in specific macro environment and under the particular industry background. Especially, every enterprise' resources and capacity characteristics also determine the differences in the value creation sector. This thesis analyzes the influencing factors of value chain from the angle of economic background, industry background, and enterprise background.

Second, the basic structure and evolution tendency of power generation equipment manufacturing value chain. The research subject of this thesis is power generation equipment manufacturing industry. This thesis analyzes the manufacturing value chain structures of power industry, power generation equipment industry and steam turbine manufacturing industry. It also analyzes the main value activities, specific value distributions and evolution processes of last twenty years, which will provide the basis for further analysis.

Third, the ways to govern the manufacturing value chain, so as to enhance the manufacturing enterprise's competitiveness. The manufacturing value chain's governance has been researched a lot in the academic world. Based on China's development practice and industry situation, this thesis thoroughly does researches on the issues of the various means to enhance efficiency in the internal manufacturing value chain, and the issues on the value chain orientation and integration in the external reliance production network.

1.3 Research Basis

Based on the theoretical framework of value chain, industrial value chain and industrial cluster, this thesis analyzes the derivation and evolution of the manufacturing enterprise's value chain systematically from the enterprise itself and its external environment by using case study method. This thesis also tries to find a new perspective and new methods to study the manufacturing value chain. Not only from an economic perspective, but also from a management point of view, especially from the perspective of strategy, this thesis discusses how the participation subjects will accurately analyze their industrial value chain, sum up the rules, seek the value creation opportunities and appropriately obtain their created value.

This thesis is widely involved with economics (enterprise theory, industrial organization theory, and general equilibrium theory), management science (strategic management theory, value chain theory, and supply chain governance theory), game theory, operational research and many other discipline theories. On the basis of qualitative analysis, this thesis will introduce the quantitative data analysis model, combines the methods of theoretical analysis and case study, fully learn and absorb the latest research results from China and other countries.

Taking the typical representative of the power equipment manufacturing enterprise-Dongfang Turbine Co., Ltd. as the example, this thesis adheres to the refocusing strategy, uses the methods of value analysis and technical grading, conducts systematical evaluation by quantitative analysis, and explores value-added research model of the power equipment manufacturing enterprises' manufacturing value chain from the perspectives of internal and external value chains.

1.4 Research Significance and Value

As the manufacturing industry's high-end field, power generation equipment manufacturing industry concentrates on dense points of high technology and advanced management models in manufacturing industry, and represents the highest level of machinery industry. Having comparative advantage of added value sector in power generation equipment manufacturing industry, manufacture is the main source of value creation and cash flow. Therefore, based on the actual situation in China, studying the value chain of the enterprises, industry chains and their management modes is of great significance in theory and in practice.

First, in the aspect of theoretical model, this thesis points out the phenomenon of "Reverse Smiling Curve", integrates and amends the existing value chain theory, and comes up with manufacturing value chain's theoretical framework of structure-evolution-governance. The theoretical research model of this thesis itself is an innovation and enriches the theoretical framework of value chain study.

Second, in the aspect of study perspective, this thesis does the studies from an integrated perspective of industrial chain, industrial cluster and production service, which was less used in the previous studies. The previous studies mainly concentrated on these factors separately. And this is an important contribution of the research.

Third, different from many other value chain's studies focusing on marketing, service, design and development, this research subject focuses on the manufacturing sector, studies its value chain from the industrial perspective, refines and extends the study of the value chain.

The results of this study have greater reference value for Chinese manufacturing enterprises in their work of analyzing value chain, improving potentiality of the manufacturing value chain, and gaining competitive advantages.

This thesis is divided into six chapters:

Chapter one is an introduction. It introduces the research background, research issues, main research significance and inspiration. Chapter two reviews and summarizes the literatures on manufacturing value chain and industrial cluster, and also shows the significance of this thesis's contents. Chapter three introduces the design of this study, which mainly includes the study's theoretical basis, research framework and research methods. Chapter four describes the power generation equipment industry's manufacturing value chain, analyzes the economic rules of power industry and power generation equipment industry, and sorts out its basic structure and evolution. In combination with the manufacturing value chain business practice of Dongfang Turbine Co., Ltd., Chapter five does some case studies from the internal and external parts to obtain theoretical results of this thesis. Chapter six is a conclusion, which describes this thesis's main contribution and potential problems.

In addition to the analysis of the industrial general situation, this thesis mainly combines the business practice of Dongfang Turbine Co., Ltd. to summarize scientific matters and to do the targeted analysis.

Chapter 2: Literature Review

The key words of this thesis include “value chain”, “manufacturing value chain”, “industry value chain” and “industry cluster”. In order to maintain the logical consistency, this chapter summarily performs the description on the above, and provides theoretical basis for the contents though literature review and inspiration.

2.1 Study of Value Chain

2.1.1 Value Chain Theory

In this thesis, “Value” refers to the economic value, and is obviously reflected by price. Lancaster K (1975) treats the value of a product or service as a tribute associated with it. Brandenburger and Stuart (1996) regards the added value as “the prerequisite condition (non-sufficient condition) of the participants getting the value”, in their analysis of business strategies based on value. Value-Based Management Theory (VBM) says, value creation means that the capital return is bigger than investment costs, and emphasizes the important role of the resource to gain the future value. But it does not extend the specific processes of value creation.

The concept of “value-chain” was first proposed by Michael E. Porter in *Competitive Advantage (1985)*. He describes that value chain is “an assembly of a company used for design, production, marketing, product delivery, and various activities which play the supporting role for the products, meanwhile, all the activities in enterprises can be reflected by value chain”. Mainstream literature of value chain study treats Porter as a pioneer. Porter builds the value chain at the perspective of company’s competitive advantages, takes the company as a whole. However, he cannot recognize and discover the source of the competitive advantages. In order to find and nurture the competitive advantages, companies must analyze the business activities and business processes from their internal parts.

In Porter’s theory, the resources are allocated in the value chain, and his value chain model shows that if an enterprise wants to be more competitive than the competitors, it must perform the value activities in the value chain at a lower cost, or lead to product differentiation by different value structures. Other scholars, such as Shapiro JF *et al*., (1993), Hojk B, *et al*., (1999), Haavengen B, *et al*., (1996), have analyzed the value creation processes through value chain structures from different perspectives. Value chain which is defined by Porter only regards profits as the main target, and is re-defined as “the transport line of integrated material value” by Hines. The direction of Hines’s value chain is opposite to the traditional one. Hines puts the needs of customers on products as the end of the production processes, and takes the profit as a by-product to meet this goal. Hines’s value chain stresses cross function of the basic value chain activities, and regards information technology as an auxiliary activity.

With the development of value chain theory, Rayport and Sviokla (1995) put forward the viewpoint of “developing the virtual value chain”. They believe that the physical value chain of enterprises is constituted by the material world while the virtual value chain is made by information, and in any stage of virtual value chain, the following five events are included: information collection, sorting, filtering, integration and transmission. Virtual value chain weakens the boundary of the value chain, and reduces the value chain links. In December, 1995, the theorists of the two camps *Harvard Business Review* and *Sloan Management Review* pointed out that paralleling with physical value chain, virtual value chain can be used in all stages of physical value chain and adds value relatively. However, virtual value chain needs to operate on the Internet, which means the suppliers create new value by the Internet. The new value chain is not a chain created by increasing the members of value, but by a network of virtual enterprises. It constantly changes its shape: it expands, shrinks, increases, decreases, transforms and deforms. And it is known as value network. Value network is a network composed of virtual enterprises. Relying on the electronic information technology, it links the independent enterprises to share information resources, mutually complements advantages, responds to the market changes rapidly and creates more value for customers. As a value creation system focusing on customers, value network changes the linear relationship in traditional supply chain, puts more emphasis on interactive network relationship to provide customers with reliable and fast service.

Based on the above content, Porter (1997) notes that enterprises’ value chain may contain a larger “Value System” outside the enterprises, and it includes suppliers’ value chain, sales channels' value chain and customers' value chain. Supply chain and value chain own some "natural" properties, and they have similarities in many aspects such as value distribution, which were deeply analyzed by many scholars.

In the study of value chain, some scholars thoroughly study the theory in value chain by different methods. For example, Du Yifei (2005) thinks that value creation needs more cooperative game and value distribution has more feature of non-cooperative game, according to the game theory. Hou Mei (2005) uses case study method to analyze Wal-Mart's value chain management and point out that value chain analysis can guide the organizational structure's optimization. Hou Jinhong and Leng Junfa (2007) build the value chain's integration model suiting the manufacturing enterprises' development on the basis of analyzing the manufacturing enterprises' value chain. Zhao Juan (2007) studies the peculiarities of manufacturing enterprises from the value addition perspective in value chain, discusses the value addition features and further establishes the manufacturing enterprises' value chain structure models.

2.1.2 Studies of Manufacturing Value Chain

One of the main objects in the value chain study is the manufacturing industry, so there are many books and analysis of value chain study focusing on manufacturing industry. Based on the research and investigation, we will conduct the discussion of manufacturing industry value chain in the following aspects.

The manufacturing in the manufacturing value chain is not just the activity of manufacturing itself, but a series of activities of the value creation as well. There are several viewpoints on the understanding of manufacturing capability, including cost control capability, quality management capability, servicing supply capability and innovation capability.

The structure and level of the manufacturing capability of an enterprise will influence the performance and achievement of this enterprise to a great extent. Henderson and Cockburn (1994) verified that the different influence of the manufacturing capability on the performance and achievement of the enterprise through the study of the capability evolution of a single enterprise. Schroeder, Bates and Junrrila (2002) carried out the research of the important influence of manufacturing capability on the performance through case studies. Guan

Jiancheng, on the basis of putting forward the manufacturing capability, did the empirical research on the relationship between the manufacturing capability of Chinese enterprises and innovation performance, based on the manufacturing ability.

The study on the global value chain mainly focuses also on the governance issue recently. Kaplinsky and Morris (2000), in accordance with the theory of separation of powers in western countries, raised an analysis frame of the value chain governance: the legislative governance, execution governance and supervision governance in the value chain. Some parts of the theory have been reflected in the empirical research, but theoretically they are still not so perfect and systematic.

Gereffi and Korzeniewicz (1994), based on the study of retail industry value chain in America, raised the global commodity chain analysis method and distinguished two types of the global commodity chains: buyers-driven and producers-driven. The producers-driven chain is a vertical division system which plays a core role mainly in the construction and adjustment of the large multinational manufacturers in the global producing networks (GPN). In producers-driven chain, the manufacturers producing advanced products like aircrafts, not only get much higher profit, but also control the material and component suppliers upstream and the distributors and retailers downstream.

Sturgeon and Lee (2001) classified three categories of suppliers in accordance with the standardization level of the production and manufacturing process through his study of contract manufacturing in electronic industry: the ordinary commodity suppliers which provide standardized products through the regular market relationship, the captive type suppliers which are highly controlled by the buyers and adopt special equipment to produce and provide non-standardized products, and the turnkey suppliers which adopts non-specific equipment to produce and provides turnkey service to the buyers. Later on, Sturgeon (2002) performed further study to raise the concept of three kinds of GPNs. On the basis of the GPNs theory raised by Sturgeon and Puhwel, Gereffi (2005) and other scholars inducted five kinds of typical global value chain governance ways for the first time. From low level to high level of the asymmetry of the coordination and force between the main bodies in the chain, they are listed as market type, module type, relationship type, leadership type and hierarchical type.

Humphrey and Schmitz (2000, 2002, 2003) studied the relationship between the global value chain governance and local industry upgrading and put forward four basic modes of the governance of market, network, hierarchical and quasi-hierarchical and the four ways of industry upgrading under the value chain governance of process upgrading, product upgrading, functional upgrading and cross-industry upgrading. On the basis of the above-mentioned study, Bazan and Nava-Alembn (2003) analyzed the Sinos Valley footwear industry cluster in Brazil empirically by using the systemic and comparative methods.

Various global value chain governance modes are based on the structure modalities of the whole value chain viewed from the angle of the leading enterprises (core role, called by Gereffi) in it. And this is also the depiction of the specific industry environment for a specific enterprise.

The study of the value chain upgrading is another branch of the research of manufacturing industry value chain, which is raised in the theory of the global value chain. The scholars in the IDS Research Center of Sussex University published theses regarding the global value chain governance and local industry upgrading (Humphrey and Schmitz, 2000,2002; Kaplinsky and Morris, 2001; Lizbeth, 2011). Among these scholars, Schmitz (2000) conducted a deep research on the rise and fall of Sinos Valley shoes industry cluster in Brazil which demonstrated that the global competition impels that not only the local cooperation but also the external relationship for the industry cluster shall be enhanced. Many studies are also done on manufacturing industry value chain upgrading in China academic circle. Wen Hu and Zeng Gang (2004) studied the issue of the local construction ceramic industry cluster and its upgrading in the global value chain. They analyzed the position of China's construction ceramic industry cluster in the global value chain and its possible upgrading ways, concluding that the cluster needs not only the intensive internal relationship but also embedding into the global value chain positively for the value's creation, maintenance and capture. Mei Lixia (2005) demonstrated two ways of the Chinese manufacturing industry cluster upgrading by taking the example of Chinese manufacturing industry cluster in the global value chain. During her investigation on the 'Taipei to Hsinchu' Corridor, she pointed out that hi-tech industry system in Taiwan presents the characteristics as vertical separation, network learning and excessive grounding in the process of globalization, with the advantage of collective learning.

Besides the upgrading and governance of the value chain, studies were also done on industry innovation aspect in the manufacturing industry value chain. These studies focus mainly on the meaning of the concept and characteristics of the industry innovation (Zhang Zhihe, 2003), the industry innovation system models (Zhang Zhihe.et al., 2006), the industry recession and industry innovation (Lu Guoqing, 2002), the relationship between the value-chain-based industry innovation, technology innovation and system innovation and industry innovation (Wang Aiqing, 2005) and some empirical studies on the industry innovation.

The main content of study on the industry innovation of the manufacturing industry value chain is in the following aspects. Chinese scholars analyze the issues of the industry innovation in China from the industry perspective. Du Yifei (2004) et al studied the details of the industry innovation of the power equipment manufacturing industry in China from the view of value creation and distribution. Zhang Zhihe and Xie Zhongquan (2006) analyzed the issues encountered in the innovation and development of the China's steel industry and put forward the corresponding management improvement measures from the industry perspective. Zhu Xufeng analyzed various issues faced by the IT industry innovation policy after China's accession to the WTO and expected to give inspiration to industry innovation.

Now the new direction of the manufacturing industry value chain study is to combine the manufacturing with the service. The development tendency of the 'Manufacturing plus Service' is rising up in foreign manufacturers. The well-known manufacturing enterprises like IBM, GE, GM and Ford are all laying more and more emphasis on the important role of the service in their operation processes. Some enterprises even are transitioning their core strategic orientations onto service business. The scholars who study the manufacturers and service management are paying closer attention to the process of the manufacturers' service innovation, seeking for the influence of the service innovation on the development of the manufacturers (Drucker, 1990, 1998; Quinn, 1992). The scholars, such as Berger&Lester(1997), Sheehan(2000), Gu Jianxin and Qi Guoning(2000) all pointed out that the boundary between the manufacturing and the service has become dimmer and the service is playing more role in the manufacturing. Now enhancing the enterprise's competitiveness through service business and taking it as the important creation source of the value has become an important tendency of the development of an enterprise (Lin Lei and Wu Guisheng, 2006).

The scholars' studies on the transition from manufacturing business to service business laid the foundation for the theory research and guidance of the continuous study by Chinese scholars. The representative scholars in China are: Guo Chongqing(2006) an Academician, who pointed out that Chinese equipment manufacturing industry shall develop to manufacturing service industry and that service business can improve the competitiveness of the whole Chinese equipment manufacturing industry ; Lin Lei and Wu Guisheng(2009) who studied the practical significance of the 'service enhancement' on Chinese equipment manufacturers in global competition; Zheng Jichang(2005) who put forward that the resource raising ability based on the costumers' value innovation is the real inner motivation to promote the development of the manufacturing service and the manufacturing base, thought that gathering the integral power is a very important supportive factor for the development of the cluster of the advanced manufacturing base, according to the objective requirements for the resource in the different stages of the development of the advanced manufacturing base cluster. Lin Guangping (2008) studied the construction of the manufacturing enterprise service value chain, in combination with the specific enterprise cases.

2.1.3 Summary

Academic studies have been done in different aspects on manufacturing industry value chain. They demonstrated the factors of the value structure, value creation, value distribution of the manufacturing industry value chain from different perspectives and different angles. Such studies provided different solutions to the ways of improving the manufacturing industry strength and competitiveness. We think that the analysis on the manufacturing industry value chain shall be always conducted around 'value'. No matter from the angle of industry innovation, the promotion of the service value chain or the upgrading and governance of the manufacturing value chain, the improvement of the manufacturing industry's competiveness is considered from the viewpoint of value. Later in this thesis, we will try to understand more about the influence and role of the 'value' factor of the manufacturing industry value chain in different study points and perspectives from the aspect of industry value chain and industry cluster.

2.2 The Study of Industry Value Chain

2.2.1 The Study of Industry Value Chain Theory

Inspired by the Porter's Value Chain Theory (1985), many scholars apply the methods of the value chain to the industry and expand it to the industry chain so as to study the organizational form of the value. Industry chain applies the ideas and methods of the value chain to the industry circle, considering the organizational form of value creation in more micro perspective is a natural extension of the analysis method of the value chain, value system and value network.

Kapanliksy (2000) expands the Michael Porter Value Chain Theory to consider the relationship between companies. The value chain between industries, the value chain in the industry and different industry value chains are different, so is the process of the value creation. Industry value chain extends the concept of value chain to the scope of overall the industry. Reasonable exchanging and allocating resources, optimizing and coordinating value activities can make the overall industry gain more value. The definition of the industry value chain is based on the appropriate combination form of the resources and value activity, then to define the scope of the industry value chain. There is no strict inclusive relationship between industry value chain and the enterprises; one industry value chain can be in the inner of one enterprise. Bryan E F (1990) analyzes the value relationship between IBM and its upstream and downstream in the industry. Porter M E (2001), Ghosh S (1998), Bodily S and Venkataraman S (2004) demonstrate that the analysis of the enterprise strategy shall be carried out by placing it in the industry value chain, under the environment of Internet. Gadiesh O and Gilbert J L (1998) demonstrate the way of creating the profit space for the company through the point of industry. Stalk G, *et al*., (1996), Day G S (1997) discuss how to survive and develop in industry value chain in different environment. Wu F and Loy C B (2004) analyze the developing process of Chinese semiconductor industry chain and its inspiration for development. Yu Weiping and Cui

Miao (2003) demonstrate how to optimize the industry and gain competitive advantage in the global industry value chain in the process of economic globalization. The core analysis method is still based on the Michael Porter Value Chain Theory to analyze from the industry for the integration of resources and activities in industry value chain from higher and more macro perspective.

Industry value chain is an aggregation of interrelated enterprises, which take on a certain core technology or process and provide the utility system to meet the customers' needs. This definition emphasizes the core role of a certain technology or process concludes that industry value chain is in the aggregation of inter-connected enterprises; but ignores the organizational structure of value creation and value activity (Pan Chengyun, 2001). Lu Minghua and Li Guoping (2004) point out that, when the subject of the value chain theory turn from a certain specific enterprise to the whole industry, the industry value chain is formed. Industry value chain is a series of value added activities of the purchasing of raw material, production, sales and service inside an enterprise or between the connected enterprises for meeting the customers' specific needs or specific production (service); it comprehensively analyzes the value creation activities in each phases of the industry chain and the core factors influencing the value creation on the basis of the industry chain. The relationship of the industry value chain, industry chain and value chain lies in the industry chain research from the point of value chain or the analysis method of value chain. Fang Xin and Yu Jiang(2002) point out that industry value chain embodies the thought and method of the management of the modern enterprises, information technology, network technology and integrated technology to realize the effective planning and control of the information flow, logistics flow, cash flow, trade flow, value flow and work flow in the whole supply chain in order to connect the related core enterprises with end-customers, distributors, suppliers and servicers into a complete net chain structure, forming an extremely competitive enterprise alliance. Du Yifei and Li Shiming(2004) point out that industry chain is an aggregation of sequentially interconnected, horizontally extended and orderly economic activities for a series of related specific products and services to meet the needs from the raw material providing to the market sales. Meanwhile, the industry chain is also an aggregation of enterprises or a business; it is an interactive system in which subjects are longitudinally connected.

The setup of the industry value chain is, on the basis of industry structure, to follow the process of the value discovery and re-creation, to fully integrate each enterprise's value chain in the industry chain and to conduct unceasing design and re-design of the value system of the industry chain. In the industry value chain, the thought and method of the value chain are applied in the realm of the industry, and the organizational form of the value creation in more macro perspective is considered. In the new competition environment, especially in the internationally competition environment, the competition in the market is not merely characterized as the competition between single enterprises; it is more characterized as the competition between industry chains, between enterprise clusters and even the enterprise clusters in different multinational industry chains. To analyze the competition between these larger competitive collectives, it is necessary to bring in more macro value creation organizational structure. Industry value chain and global value chain are just such analysis methods.

Porter also thinks that any of the enterprise value chains exists in the wider value system. Extension value chains, which include supplier value chain, enterprise value chain and customer value chain, have the basic thought that the creation and distribution of an enterprise value have to follow the consideration of the upstream value and downstream value. Furthermore, the enterprises are essentially subordinate to a certain ecological system linked by value, which is discussed in the classic literature of Moore J. (1993)

2.2.2 The Study of Manufacturing Industry Value Chain

A current enterprise can fully orientate its industry value chain to certain critical and core parts of the industry value chain and outsource the uncritical parts to get competitive advantage. The industry structure concept of the enterprise competitive advantage has also evolved to a new concept of the competitive advantage based on the industry value chain structure. However, fundamentally, the competitive advantage concept based on the industry value structure comes from the competitive advantage concept based on the value chain. One manufacturing industry value chain reflects the value creation attribute of one specific industry chain. In a manufacturing industry chain structure, the manufacturing enterprise's value chain is contained in the greater value activity group which organizes the value activities of the enterprises to realize the value creation of the whole system. Manufacturing industry value chain represents the greater value system in the industry realm in which the enterprises' value is blended. The value activities of the manufacturing industry value chain contain the all value activities of the manufacturers and their partners, which are not a simple mix, but the value discovery and value creation under the value organized form in the industry realm.

The structure of the manufacturing industry value chain is made up of the enterprises' value chains which are linked by the connection point. Before the setup of the value chain, each enterprise value chain is independent respectively with loose connection, even no connection. Through industry integration, enterprises are tied to the industry value chain system to form the industry value chain. And the new value is created through the application of the innovation connection of the value chains between different enterprises. Typically, in the manufacturing industry value chain, the manufacturing enterprises are in the intermediate and are the main link for generating the value chain. However, when change happens in the market environment and customer demand, it is very important to adjust production in time while guaranteeing the high efficiency of the enterprises.

From the view of the modern industry value chain, a complete industry value chain contains the steps of raw material processing, intermediate production, manufactured parts assembly, sales and service. Different participating roles work in different steps, function differently and gain their respective benefits. The activities of each step in the industry value chain affect the whole industry value activities directly and in each step, many similar enterprises with similar value creation activities are contained. The industry value chain is the integration of all the enterprise value chains, which is linked by the jointing point. Before the setup of the industry chain, each enterprise value chain is independent respectively with loose connection, even no connection. Through industry integration, enterprises are linked to the industry value chain system to form the industry value chain.

The added value of Chinese manufacturing industry is low and is in the lower-end of the distribution of the international industry value. The production business and the technology patents are under strong control of multinational companies and overseas capital, which is a huge pressure on the industry upgrading of Chinese economy and smooth transition of growth mode. Yang Chunli (2008) points out that with the deepening of the market competition, the reliance of the manufacturing industry on the processing and manufacturing steps is gradually decreasing while the demand for the production service throughout the upstream, midstream and downstream phases is in constant increase, which makes the value increase in the manufacturing industry move onto production and service. Porter also confirms that the production and service are penetrating into the value chain of each manufacturing industry enterprise in his value chain analysis process. Therefore, production service is also becoming the indispensable value increase step in the manufacturing enterprise’s value chain. With the rapid development of IT industry and telecommunication technology and the speedup of globalization a deep revolution is under way in the international manufacturing industry. In recent years, the management of the manufacturing industry value chain is attracting more and more attention of the scholars. Du Yifei (2005), in his PhD dissertation “An Study on Value-Creation-and-Distribution-based Industry Value Chain”, uses the Game Theory Method to study the value creation and value distribution process in the industry value chain.

In the present, the manufacturing and service of many products are scattered in countries all over the world. The globalization becomes the more and more important background of the enterprise operation. Kogut’s article (1985) about value-added chain based on global strategy view is regarded as the starting point of the research on Global Commodity Chain and Global Value Chain. Gereffi (1999) raises the concept of Global Commodity Chain: It links family workshops, enterprises and governments related to a certain product, closely to the World economy system through a series of international networks. Generally, these network relationships have the characters of special adaptability and local cluster aggregation in the theory of the Global Value Chain(Gereffi,1999).

In some literature, it is also pointed out that developing countries will improve their technology capability through participating in the global value chain. The value chain research also turns its focus to the nature of various value activities relationship and the participators (Morrison et al., 2008; Giuliani, E et al., 2005; Kaplinsky, R. and Readman, J.2005; Pietrobelli,

C. and Rabellotti, R, 2007)

The Global Value Chain Theory deepens the division theory further. In the global value chain division system, each separated value segment generally has the character of extremely geographic concentration. And the highest form of this division is Global Producing Network. Sturgeon (2002), through the American electronic industry global value chain; Gereffi, Humphrey and Sturgeon (2005), through the bicycle industry, clothing industry and electronic industry global value chain governance mode, investigate the change of the multinational companies' Global Producing Network.

2.3 Industry Cluster Study

2.3.1 Industry Cluster Theory Study

The earliest research regarding industry cluster can be seen in the Industrial District Theory established by A. Marshall at the end of 19th century. In his research of Sheffield and Lancashire, he found small handicraft companies would gather together with many frequent contacts, and in the districts, production activities presented themselves the special feature. He defined such districts as industrial districts. Porter introduced concept of cluster after studying international competitive industrials in ten countries including Great Britain. This concept of 'Industrial Cluster' provided a brand-new strategic thinking, i.e., the so-called 'District Industrial Cluster' strategy.

Industrial clusters are widely studied in many countries and Porter's theory is a typical one. He figures out that the industrial clusters, which can promote the development of local industry via creating new environment, are more competitive and of more creative power than their competitors abroad. In Porter's industrial cluster theory, the thinking of cluster economy, economic externality and new social economics are absorbed, and the new industry region theories such as the Regional Innovation Networks and specialized division are also related or referred to. Industry cluster theory ties the network theory, social capital, agglomeration economy and enterprise competition theory, even the approach of economic prosperity together and further extends them to a wider range. Since 1996, Dicken (2001) and Scott (2002) found the economic phenomenon that multi-national corporations outsource the parts which are of no core competiveness and the steps of the production process go beyond borders and spread into various industrial clusters. Then, they studied the relationship between regional economy and global economy with the theoretically analyzing framework of global producing network (GPN), global commodity chain (GCC), Global Value Chain (GVC), and they also put the value analysis method into the analytical framework of Regional Economy Development. They all emphasize that an industrial cluster cannot develop in a closed area and it is supposed to be blended into the global industry network to realize upgrading.

Industrial cluster theory has attracted the attention of the governments of the developed countries and has become the theoretical basis of new industrial policy framework with various contents. Since 1999, many American and European countries conduct the industry cluster strategy, organize the enterprises, government units and research institutions in a region to become cooperation partners, which commonly promote the development of the industry clusters the competitive power is enhanced. In the time to come, the study of industrial cluster is supposed to not only concentrate on endogenetic force inside the clusters, i.e., the promotion of competitive power, innovation activities and building innovative environment inside the district, but also further study the global bonding of the innovation network inside the industry clusters in the open global economy, i.e., cooperation and interaction among the industry clusters in different countries and different forms. The development patterns of resource sharing in the cross-regional industry clusters, especially the interaction and sharing in the cross-regional high and new technology industry clusters are being studied outside China.

Wang Jici (2001), in Beijing University, did the deeper study on China industry clusters at early time. She thinks that the system innovation is the key to realize China’s industrial cluster strategy. As a huge manufacturing country, the main stream of developing industry clusters in China is to build industry clusters on the basis of low cost (including high and new technology). In the process of the industry cluster development, many difficulties such as increasing cost, industrial transfer, trade barriers and green barriers are encountered, so the innovation and upgrading become imminent. In the areas where social capital is insufficient, public policy intervention is especially needed to carry on the industrial cluster strategy. Industrial cluster is an industry localization phenomenon appearing after the mid-1980s under the circumstances of global industrial division and information technology Innovation, which combines the New Regionalist theories such as industry area theory, regional innovation systems theory together. These important opinions have the guiding role for the development and study of China's industry clusters.

Zhang Yuanzhi (2004) holds the opinion that industrial clusters represent a new pattern of future region competition and clear the way for industrialization and advanced technology application, and is strongly capable of accumulating capital. The industrial cluster environment decreases the technological threshold and business risk and helps to cultivate regional "social capital", so the cost of transactions can be significantly decreased. In the New Era, industrial cluster policy is the key tool of national macro policy, which can integrate regional policy, technology policy and industrial policy together organically and inspire the enthusiasm of central government and local government and local business.

Cui Haichao (2005) thinks that the industrial cluster is one economic organizational pattern between companies and the market. Due to high relevancy inside a cluster, the industrial cluster economy possesses the advantages of both cooperation & coordination and scale economy. The industry cluster economy has a close combination with the regional resource advantage. Such prominent characteristics make it be in the possession of competition advantages. It shall be the preference economy pattern in regional economy development.

Zhang Zhancang(2006) noted, in the development of a region, only a part of industry are suitable to become stronger and bigger, such as coal mining, oil chemical raw materials production, iron-making and steelmaking and automobile manufacturing. In other wider industries, consumer diversification is to be taken into account and they are suitable to be developed in the pattern through in industry cluster pattern. In the middle and the west of China where economy is underdeveloped, more people pay attention to make their backbone enterprise strong and big, but they have little recognition of the effective promotion function for the local economy through industry clusters. Thus Industrial clusters should be taken into government policy as regional development strategy, especially in those areas at low administrative levels. For instance, the industry cluster development is a very suitable route for the economy development in counties and in townships for the completion of industrialization.

Chen Liuqin (2006) takes the industrial cluster as a worldwide economic phenomenon. The theory of industrial cluster competition force has gradually evolved systematic theory with the constant development of industry clusters. Industry clusters are influencing the competiveness of the industries, which is embodied in the progress of the integral competiveness of the industries, the strengthening of the effective cooperation among the enterprises inside a cluster, the promotion of the innovation ability of the enterprises, the growth of the enterprises, the exertion of resource sharing effect and the formation of regional product brands. Therefore, industrial clusters have become the key to improve industrial competitiveness. Chinese industrial clusters are still at the beginning stage. In the aspect of improving industrial competitiveness through industrial clusters, the government is supposed to "have something to do and have something not to do". The clustering, interfusion and ecologization of industries are the new trends in the 21^{st} century.

While some other scholars hold the view that there is not just one industry in an industrial cluster and there should be some supporting industries. They define such structure as enterprises cluster. When most of the enterprises clusters are composed of medium or small sized enterprises, such clusters are called Small and Medium Enterprises Cluster.

The study of industry clusters done by the Chinese scholars is mainly concentrated on the features, operating mechanisms and competitive advantage of industrial cluster, but we barely see the combination of study of the value chain and industrial clusters. This thesis will do the analysis in different perspectives and from different angles such as value chain and industrial chain to build a frame of 'value chain –industrial value chain- industrial cluster'.

2.3.2 Studies on Manufacturing Industry Cluster

A modern manufacturing industry cluster is a complex network, on which each organization or enterprise acts as a knot in network. Only in this network can a knot play a unique role. In the complex network some are key knots, around which many organizations an enterprises offer their professional service. Each of them only acts as one phase in the whole process. Therefore, a modern manufacturing industry cluster is a complex network.

In the industry clusters which take the industry value chain as the leading chain, the inner interaction among the internal enterprises is characterized as “supplier-consumer” relationship, and a clear professional production division is needed among the enterprises. Enterprises in an industry chain take their respective market segmentation and specialized division on the basis of their respective advantages and interests, and finally form a regional economic factor coupling pattern, in which the cooperation between upstream and downstream companies is well performed and their external resources are well allocated in one industry chain. Industrial cluster development is the new trend in the equipment manufacturing industry both at home and abroad. A good way is: taking the endogenous enterprises as the core, supported by the scientific planning of the government from the top to the bottom and relied on autonomous development of the enterprises from the bottom to the top, develop the industry clustering in accordance with the different priorities, steps, districts and professions to improve the competitiveness of the equipment manufacturing industry. While, in the progress of specific application of the industrial cluster theory, Bazan and Navas-Alenan (2003) analyzed the Sinos Valley shoes industry cluster in Brazil by systematization and comparison method and found out that the prospect of industrial cluster upgrading varies with the difference of the governance modes of global value chain.

2.3.3 Summary

A “value chain cluster”, is to form an industry cluster through the expanded “input and output” or supply chain. In the chain, there are the final market producer, and first and second direct or indirect suppliers in trading, which contains complex and diversified industrial departments. An industry cluster is cluster connected and composed of multiple sub-clusters of material flow and service flow, and the interconnection among them is stronger than that of other sectors of the national economy. Therefore, the industry cluster is regarded as the inevitable phenomenon formation to realize the increase of an enterprise’s value chain and industry value chain.

2.3 The Deficiency and Space of the Existing Study Results

The existing study results of the value chain, industry value chain and industry clusters lay an extensive and solid theoretical foundation for the research done in this thesis. In retrospect to the history of the study on the transition of the manufacturing enterprises into service, it is not hard to see that the scholars in the management circle and enterprises have carried out the theoretical and practical exploration, have built different patterns for competition strategy and development routes of the manufacturing enterprises service transition process and analyzed the successful cases of service transition processes of the manufacturing enterprises such as GE, IBM and NIKE. However, due to the short history of the study, it is still in the scattered study stage; the thinking way of the study is not clear enough and no complete or systemic theoretical frame has been put forward. The existing study is limited to the general expression of the phenomenon, shallow analysis of the mechanism and simple summary of the modes; it is in lack of deep theoretical exploration. Such status provides a research space for this thesis. Meanwhile, as mentioned above, there are relatively few theoretical and practical studies related to the manufacturing value chain, manufacturing industry chain, manufacturing industry clusters and manufacturing phase value chain, so the deep research to the manufacturing value chain of the manufacturing enterprises in this thesis becomes of more significance.

In this thesis, at the beginning, we will conduct a general study to build the enterprises' empirical research framework which is based on value chain and industry value chain; then we will study the ways of realizing the manufacturing value chain appreciation in the power equipment manufacturing enterprises in China; finally we will apply the established framework to analyze and discuss the manufacturing value chain of one of the representatives of the power equipment manufacturing enterprises- Dongfang Turbine Co., Ltd in detail. On the basis of this study, we will conduct deep research on the power equipment manufacturing enterprises in China from the perspective of industry value chain—enterprise value chain—value chain management with the aim to find out the development dynamic of the power equipment manufacturing enterprises and establish an theoretical foundation for the sustainable development of the Chinese manufacturing enterprises.

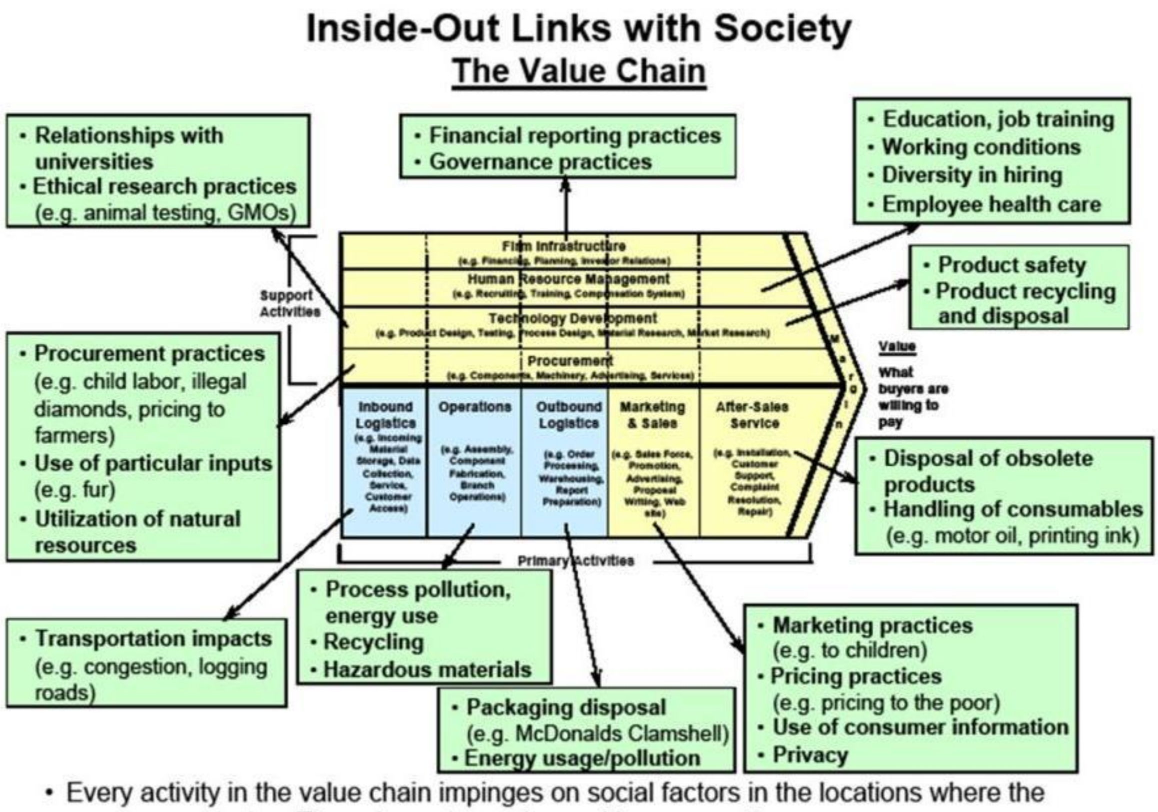
Chapter 3: Research Design

3.1 Theoretical Basis

The literature review of this thesis has introduced the related theories of manufacture value chain in detail. In this section, the illustration of the relevant theories will be done to bring out the research subject of this thesis.

Firstly, it is the Value Chain Theory. In Porter's Value Chain model, the value activity of an enterprise is divided into main activity and supportive activity. The main activity includes production, sale, delivery and service, while supportive activity mainly supports the main activity (Fig. 3-1).

Figure 3-1 Enterprise Value Chain Model



From Porter (1985)

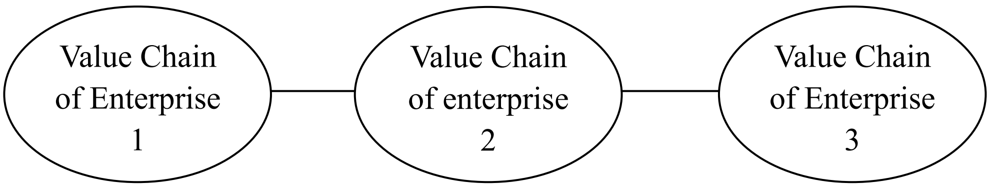
In accordance with Michael Porter's Value Chain Analysis Theory, each manufacture enterprise business activity can be divided into several business operations related to value creation, and the enterprise creates the value for its customers finally through finishing a series of the business operations and forms its profits. The connection of the business system forms a chain aggregation, called Value Chain or Business Chain. The enterprise value chain is not a closed system. Between the suppliers and the enterprise and between the customers and the enterprise, there are external connection points of the value chain. The supplier, enterprise and customer are regarded as an entirety and the enterprise is a just link in the whole value chain.

In the viewpoint of the Value Chain Theory, the enterprise activity can be divided into a series of value activities. Because of enterprise heterogeneity, each enterprise is different in special value activity performance and the performance differences between enterprises are embodied in the realization way of the specific value activity. To operate the value activity more efficiently or to provide differential product and service through special abilities is where the enterprise competitive advantage lies. As a result, Value Chain Theory provides the basis for enterprises to conduct value chain analysis and get advantages through taking over advantaged value activities.

Based on Value Chain Theory, there are more and more different forms of enterprise value activities. The value chain structure, industry form and enterprise organization form are expanding. The new issues related to value chain operation and management keep arising, such as expansion of the enterprise internal manufacture value chain to industry value chain. The industry chain is the value chain relationship (Yang Gongpu and Xia Dawei, 2005) of all the continuous value addition activities of the same industry. If we understand it from point of the network, the industry chain is the chain value addition process (figure 3-2) which is of mutual reliance, of labor division cooperation between manufacturers during their operation and is formed from the raw material to the product in customer's hand.

The nature of the industry chain is to describe an enterprise cluster structure which has certain internal relationship (Yang Gongpu and Xia Dawei, 2005). It is a relatively macro conception with two dimensional attributes: structure and value. There are many relations between upstream and downstream and mutual value exchanges. Upstream link conveys the products or service to downstream link and downstream link feeds the information back to upstream link. Corresponding to Porter's definition for the value chain, the enterprise in industry chain performs a series of value activities in the competition. It is called industry value chain based on the activity definition only from the value point. One industry value chain reflects the value creation attribute in a specific industry chain. Industry value chain is the structure form of value organizing and value creation behind the industry chain, representing industry chain value attribute. Industry value chain reflects the deeper value meaning of the industry chain, deciding the business strategy and competitive advantage of the industry chain. In one industry chain, each enterprise value chain is included in the greater value activity cluster. Industry chain organizes the value activities of enterprises on the basis of the industry value chain to realize the value creation and realization of the whole industry chain.

Figure 3-2 Expanded Industry Value Chain



As a result, the manufacture value chain is also embedded in a certain industry value chain; a clear recognition of the industry chain is a necessity for analyzing manufacture value chain. As the value-added activity is becoming the manufacture industry core, compared to traditional value chain, manufacture value chain has some main changes, including (1) the constituting factors of the value chain being expanded from an enterprise inside to its outside; (2) the value chain being transforming into value network or value system; (3) the value chain point being transforming to value chain module; (4) value increment mainly being more relying on information technology.

Such expansion of the value chain and industry chain enables the network, the cluster and the system to be a general business form. Generally, the complex relationship in the modern manufacture industry cluster system can be divided into three levels. Firstly, the system, in whole, is composed of the interested parties. The complex relationship between the related parties is the foundation of the interactive evolution between system and environment. Secondly, the system keeps expanding, from a single organization or enterprise (point) to supply logistics system (chain) which is corresponding to the product value chain and then develop into a modern manufacture industry cluster ecological system (network). This is the evolution result from simplicity to complexity during the process of the interactive effect between modern manufacture industry cluster system and environment. Finally, the traditional manufacture industry cluster further evolves into the modern manufacture industry cluster and this is the natural reflection in the management consciousness and concept during the evolution process (from immaturity to maturity) of the modern manufacture industry cluster system.

The industry chain makes us analyze the value chain under the background of industry evolution, participate in the value creation and search for the enterprise orientation. Additionally, the value chain has developed into the network state and enterprises are located in the established ecological system. The structure of the enterprise's manufacture value chain has turned from the traditional chain form to an open cross-network form.

No matter how the form of the value chain changes, its inspiration to this thesis is determined.

（1） What activity links does the industry value chain have?

（2） What is the structure of an enterprise value chain?

（3） What is the composition of the enterprise manufacture value chain?

（4） How to manage the manufacture value chain to improve the enterprise competitive ability?

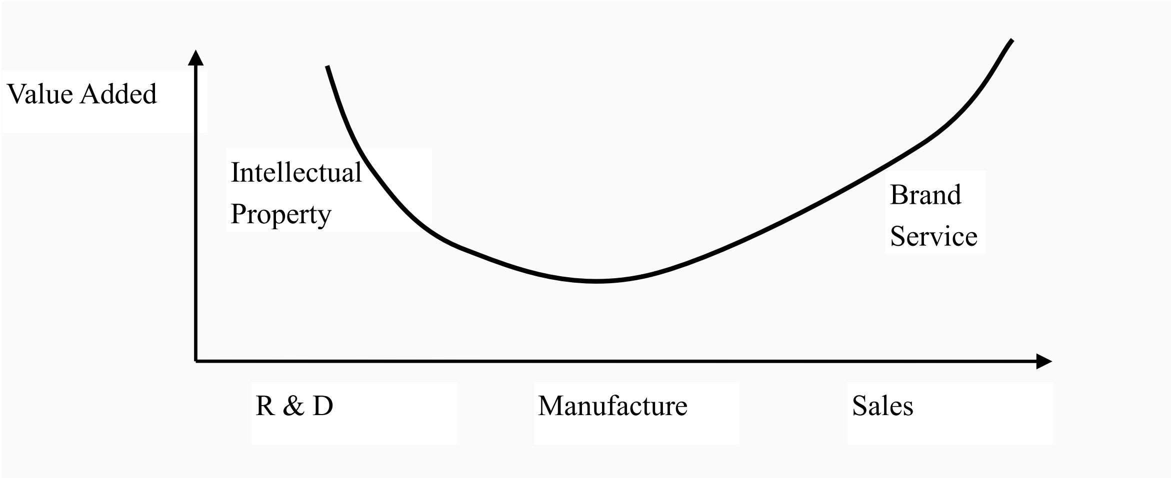
The study of power generation equipment manufacture industry and enterprises by this thesis will try to answer the questions above.

Secondly, it is the Smiling Curve Theory. Stan Shih illustrates the famous Smiling Curve Theory in his book 'Reengineering Acer', its original definition being from PC industry. Through the value analysis on the PC industry, it is known that the design, chip production and basis software are at the higher end of the profits and the application, sales and system integration are at another higher end of the profits, while there is lowest value addition in the intermediate machine assembling. This forms an upward bending curve, 'Smiling Curve'. (Figure 3-3)

In Stan Shih's view (2005), in an industry chain composed of R&D, raw material purchasing, transportation, manufacturing, orders, sales, wholesale & retail and brand, the highest value is at two ends like R&D and brand while lowest value is in the intermediate link like manufacturing. Strictly speaking, Smiling Curve is not a theory. It is a phenomenon summarized from IT industry practice. The forming of Smiling Curve originated from the transformation of international labor division from the product division mode to the key factor division mode. That is, the enterprises in different countries participating in the international labor division now just complete their certain activities in the product manufacture process based on their respective key factor endowments, instead of manufacturing the final products.

After Smiling Curve being raised, its application range has extended. The global industry value chain is generally led by powerful multinational companies. If the manufacture link activity is taken as the boundary, the global industry chain can be divided into three major link activities of product design, manufacturing and circulation. From manufacture process to final product and then to final product sale, the value created in each link activity in the industry chain varies with the concentration of various key factors. In the industry chain, value addition is more at the both ends of the design and sales, while the manufacture link activity has the lowest value addition in the intermediate part of the chain. The value-added can be thought as the potentiality of an enterprise to get profits. Those technologically-proven, low-threshold and generalized technologies may easily lead to the appearing of so-called "low-profit" enterprises, and they belong to the low value-added industry. Ordinary manufacture and assembling enterprises are just belonging to the low value-added industry. In order to survive, they have to keep on expanding their production capacity to get sustainable profits. However, once market demand decreases, the product price goes down, and the product sale cannot grow any longer, the enterprise will face business crisis. Manufacture enterprises engaged in the low value-added activities have a higher dependence on external environment and poorer ability to resist the business risks. The operation of any low value-added labor-intensive manufacturers in China was deteriorating under the impact of the financial crisis and many enterprises went bankrupt. Such case could be well explained by the Smiling Curve.

Figure 3 3 Smiling Curve



There are two key points about Smiling Curve: the first one is that the locations of the value-added can be found. By analyzing industry chain, we can describe the detailed value distribution to get the value-added situation in each link activity. Of course, it needs the deep analysis on product structure and all the manufacture links. The second one is regarding the competition pattern. According to the industry value chain, different enterprises lie in different places of the value curve with different resources, different relative value contents and different competition advantages. This is a reflection of the industry competition structure.

The discussion on Smiling Curve generally applies to the follow circumstances.

Firstly, the industry is the one which is adequately labor-divisible. Different division forms will decide the difference of the manufacture organization forms and the value creation ways. With the labor division becoming more and more professionally specific, modular division is proved to be a tendency. Modular division includes vertical chain division, horizontal parallel division and even network division. Based on this division mode, different enterprises possess different resources, different technologies and different internal industry divisions and occupy their own respective value modules (Baldwin et al., 2000). With this division mode, the shape of Value Smiling Curve forms.

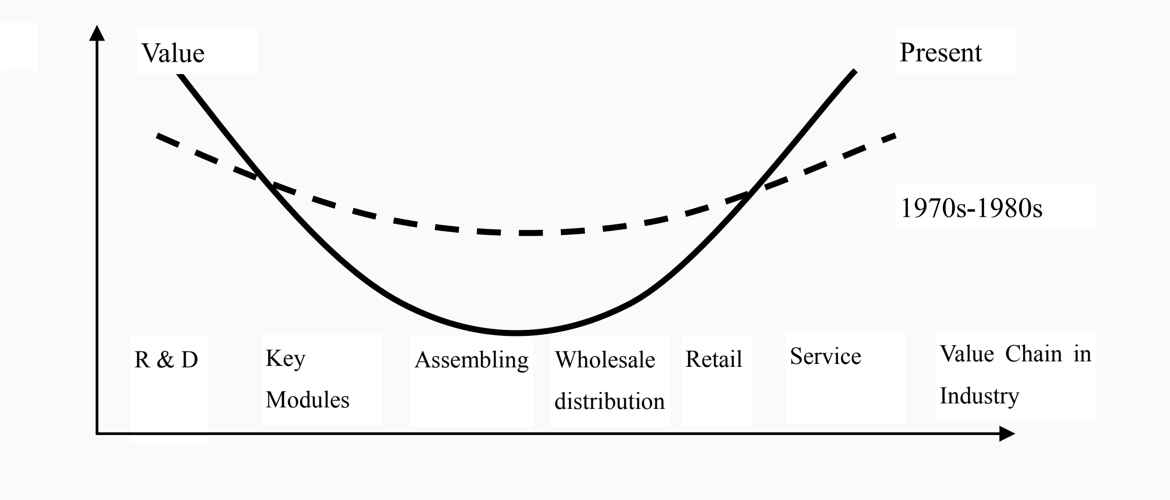
Secondly, Smiling Curve is generally recognized most from the point of global value chain. Not only does it include the industry division, but also the regional division. Because the globalization has become the irreversible wave, the influence of multinational companies becomes greater and greater. And the tendency of manufacture industry globalization is more obvious. Such facts demonstrated at the beginning of this thesis are all based on the international division background. The difference of added value of the curve part is embodied in the difference in the industry advantage and industry division among countries.

Thirdly, the Smiling Curve industries are usually in the business sectors of mass consumer goods. In the mass consumer goods sectors, there are more sufficient competition and more meticulous industry chain. This field presents a decentralized competition situation.

Additionally, it can also be analyzed from the points of the International Industry Transfer (Feenstra, 1998), Product Life Cycle (Klepper, 1996), the value chain analysis, multinational enterprises' behavior feature (transnational conglomerate). For the action in these more fields in theory, detail discussions will not be conducted.

The inspiration of the Smiling Curve to people is that the industry shall transfer to higher value-added links and to improve the competition capacity through industry upgrading or industry integration, i.e., to enhance the value-added through technology innovation and industry integration. The implied foundation is knowledge and technology which are the significant source to acquire value.

Figure 3-4 Distribution Change of Value Chain



Under the Smiling Curve frame, manufacture industry seems to be losing its position, but some people refute that. Because the industry chain links' profitability is affected by the competition structures, in certain links there are low threshold and fierce competition with low profitability while in other activities, there are high threshold and not so fierce competition with probable high profitability. The profitability has no necessary connection with which link activity, whether it is R&D or the manufacture or the brand and sales. In every link activity of the industry value chain, necessary and considerable value exists. And the key point is how to operate it.

For the manufacture enterprises of which the profitability is going down, as demonstrated in Figure 3-4, transferring to the ends of the Smiling Curve is not the only way. There are many ideas for manufacture enterprises to improve the operation efficiency and investment return: (1) to transfer the manufacturing to the low-cost areas; (2) to improve the R&D and manufacturing method level and efficiency to become advanced manufacture enterprises so as to resist key factor cost rise. An enterprise can cooperate with foreign technical-advanced companies actively through its own industry position and domestic large market scale; (3) to transfer the core-manufacture capacity to the products in the relevant industry field to expand the product lines and market areas; (4) to re-orient, refine and to segment the market deeply instead of simply expanding the production scale; (5) to add service function, including technology, supply chain and finance service; (6) to optimize and even reconstruct the business way. In certain links of the industry chain, different investment return rates can be obtained in different business mode decides; (7) merger and integration; (8) to quit.

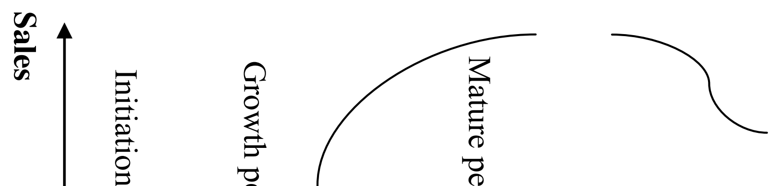
The power equipment manufacture enterprises to be studied in this thesis are obviously different from the Smiling Curve in the industry modality. The phenomenon described in Smiling Curve is often seen in the industries with adequate industry division, which generally include the link activities of procurement, design, manufacture, sales and service. The power equipment manufacture industry is highly intensive. Though different enterprises have different resources and advantages, it is hard to establish a professional and meticulous labor division. An enterprise generally has all the links such as design, procurement, manufacture and sales. So such enterprises do not have adaptability to the Smiling Curve. However, through the analysis on the power equipment industry, we may give some new interpretation of the Smiling Curve.

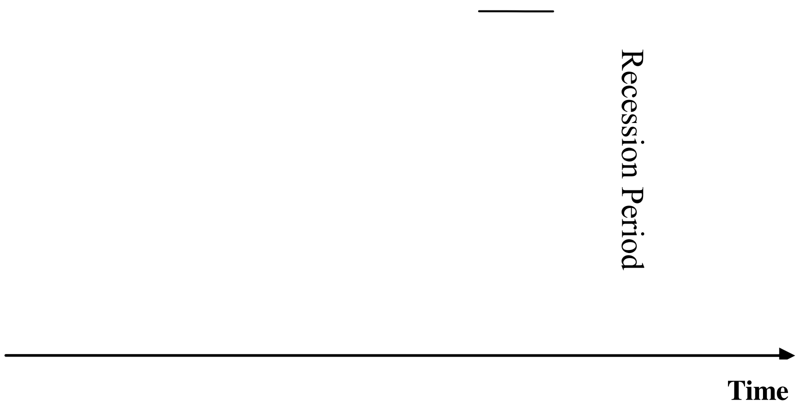
As shown in the law of changes in the natural world, the development of industry has its cyclic characteristic. Product Life Cycle Theory conducts a detailed discussion on this (Figure 3-5). The evolution of industry is driven by the factors of demand, division, technology and supply.

Industry forming period is also called industry budding period or industry initiation period, which is the process of constant nurturing and gathering of certain productions or certain social economic activities and then a certain industry is formed after the gradual evolution and constitution of its key factors. The critical factor in the forming of the industry is the appearance and extensive application of new technologies, which is the value realization process of scientific inventions. Another key to the forming of the industry is the industry innovation and enterprise innovation (Nelson, R and Sidney G, 1982).

Industry growth period or industry expansion period means the process of expanding itself by its absorbing a variety of economy resources after its formation. The industry expansion contains both expansion in amounts and the qualitative change in contents. The former means the growth of amounts of enterprises in the industry and their production capacity, the latter means the growth in technique, the development of Management Quality, the upgrading and the rationalization of Industrial Organization (P.K.Turner, 1988).

Figure 3-5 Industry Life Cycle Curve





After significantly expanding to the limits of the industry, the expansion of the production capacity and spaces goes to stagnation. Afterwards, the industry goes into a phase with steady scale, steady technique and stable supplies and demands, steady productions prominent position, which is the mature period of the industry. The main characters of mature period are: (1) being strong and prosperous. The appearance is unprecedented industrial scale, prominent position, popularity and flourishing, highly popularity of production, staff taking pride in it and money speaking. (2) the production capacity being nearly saturate, market demand being saturate, balance between supplies and demands and the buyers' market appearing. (3) becoming the mainstay industry. The production key factors, production value and profit and tax take a great proportion in the national economy.

Recession of the industry is the process from prosperity to decline. It mainly presents itself the states of relative or absolute production scale shrinking, product aging, and degeneration and function decline.

As for power equipment manufacturing industry, we can take coal-fired electric power for instance; it has already stepped into mature time. The technology of steam turbines has a long history of more than a century, and the current technology progress is mainly embodied in the performance improvement under the existing present patterns. In the world, the market of coal-fired power reaches into saturation with slow increase. Nowadays, a few dominant manufacturers take charge of the development of industry .The production scale is the key of their success.

The last to be taken account is outsourcing theory. Hamel and Prahalad (1990) for the first time mentioned the word “outsourcing”. Outsourcing means that an enterprise allocates its own functions and the services and those of other enterprises dynamically, and utilizes the external resources to work for its internal production and operation. As a management strategy, outsourcing takes stress in the integration of the enterprise’s resource and the flexibility of organization structure to realize the increase of enterprise’s core competiveness.

The deepening of division in labor is one of the reasons for the occurrence of outsourcing. Division among industries has been taken place by the division within a certain industry or even a certain product.. The intensification of specialization causes the growth of longitudinal link activities during production, the division and the cooperation in a certain organization have been replaced by social division and outsourcing is the way to realize such replacement. Transaction Cost Theory can also interpret the outsourcing, that is, when high asset specificity, high trading frequency and high uncertainty exist, an enterprise usually takes the governance mode of internal integration way, on the contrary, an enterprise inclines to borrow outer resource to optimize the production cost and transaction cost (Williamson, 1985). Furthermore, competence theory of the firms (Prahalad and Hamel, 1990), RBV (Wernerfelt, 1984; Barney, 1996), Supply Chain Theory (Lambert et al, 1996) , also provide the theoretical support for outsourcing.

Outsourcing mainly contains four elements: outsourcing subject, outsourcing object, outsourcing partners and outsourcing design. For outsourcing, it is necessary to choose appropriate business. Usually in an enterprise, business activities can be divided into the core business (closely related to the survival of the enterprise), the business that is closely related to the core business, supportive business and general business. In the outsourcing work, it is necessary to take the value chain analysis as the premise to make sure which value links the enterprise have, which are the unique and advanced in the enterprise, which are those that the enterprise does not have, then to choose the appropriate outsourcing link activities and specific outsourcing management.

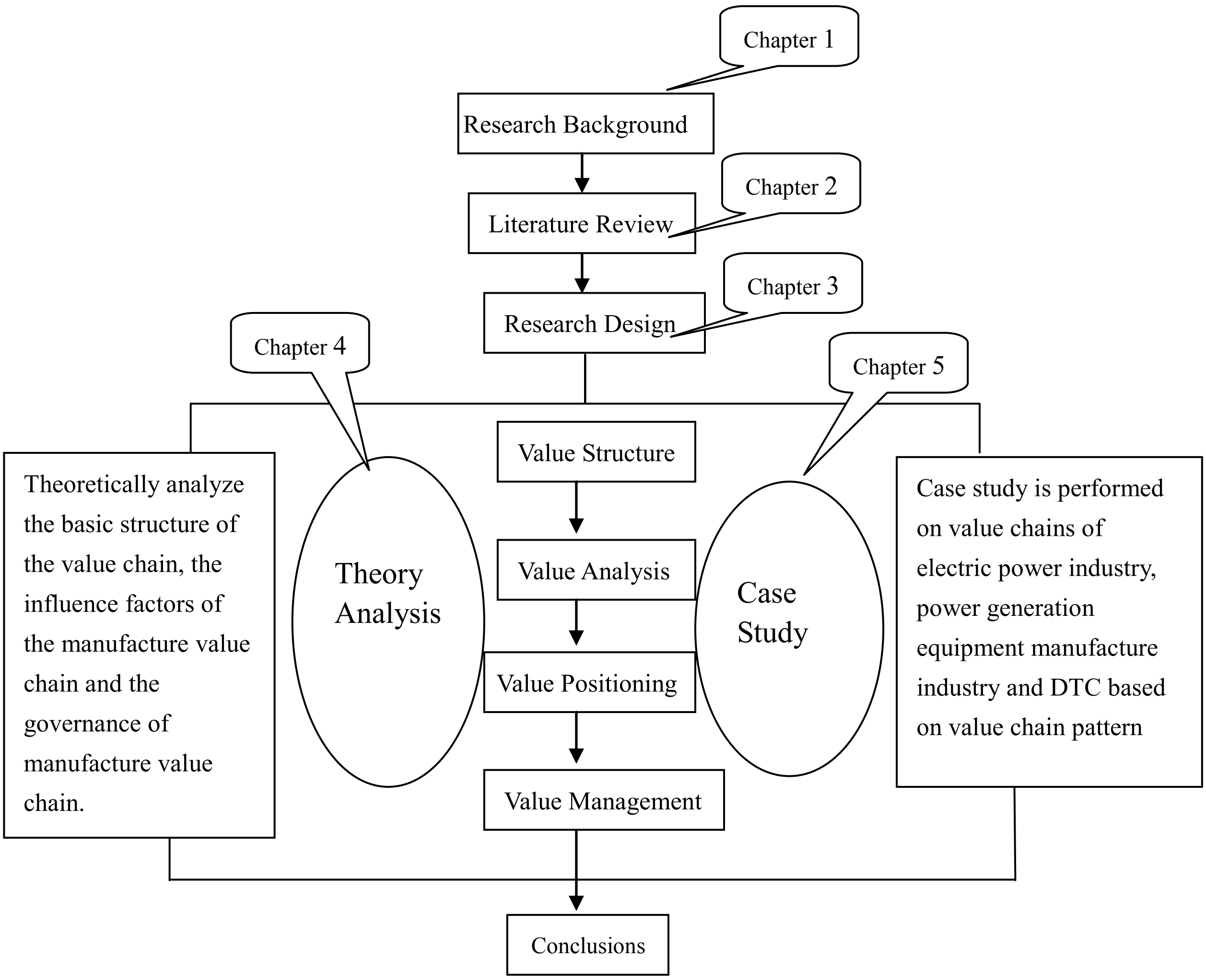
In fact, outsourcing can reduce enterprise operation cost and improve the professional level to make the enterprise concentrate on its expertise core-capacity. The risk is also one of the potential to-be-considered factors. Now the outsourcing has more and more forms, like R&D outsourcing, manufacture outsourcing, logistics outsourcing and service outsourcing. Many large manufacture enterprises use the outsourcing to improve their production efficiency. In a word, outsourcing is a manufacture organization way to make the enterprise integrate the network-like resources and conduct its production more efficiently based on the basis of industry division.

The theoretical introduction give above is not only the basis and the background of the research of this thesis, but also to provide an extensive space for this thesis' theoretical content. Smiling Curve Theory has us consider its adaptability and generality. The value chain theory is the basic analysis perspective and tool of this thesis; the Industry Life Cycle Theory provides the basis for the industry chain analysis; and the theory such as outsourcing is the inevitable choice for the management and upgrading of the manufacture value chain. So the core questions of this thesis are: Is the Smiling Curve has the universality? Can the new value space be found around the manufacture value chain? How can the manufacture value be managed more scientifically?

3.2 Research Frame

The research frame of this thesis is given in Figure 3-6. In this thesis, the power equipment (steam turbine) enterprises are taken as the research objects; the value chain analysis is taken as the research perspective; and case study is applied as the core method. Through the concrete sequential study on the power industry, the power generation equipment manufacture industry and Dongfang Turbine Co., Ltd, in the perspective of value chain analysis and the basic logic of value structure—value distribution—value orientation—value management, this thesis will try to reveal the structure and evolution principle of the manufacture value chain and try to provide a reference for the enterprises to develop their manufacture capacity. In the first three chapters, the stress is mainly on the background, literature review and research-design. In the fourth and fifth chapters, the key parts of this thesis are illustrated. Through the combination of theoretical research and case study, in the two chapters, we try to demonstrate the value structure and special management practice of the power equipment manufacture value chain and answer the raised theoretical questions. The last part of this thesis will give out the summary and inspirations.

Figure 3-6 Research Frame of This Thesis



3.3 Research Methods

According to the characteristics of the research issues and the actual conditions, this thesis adopts the following research methods.

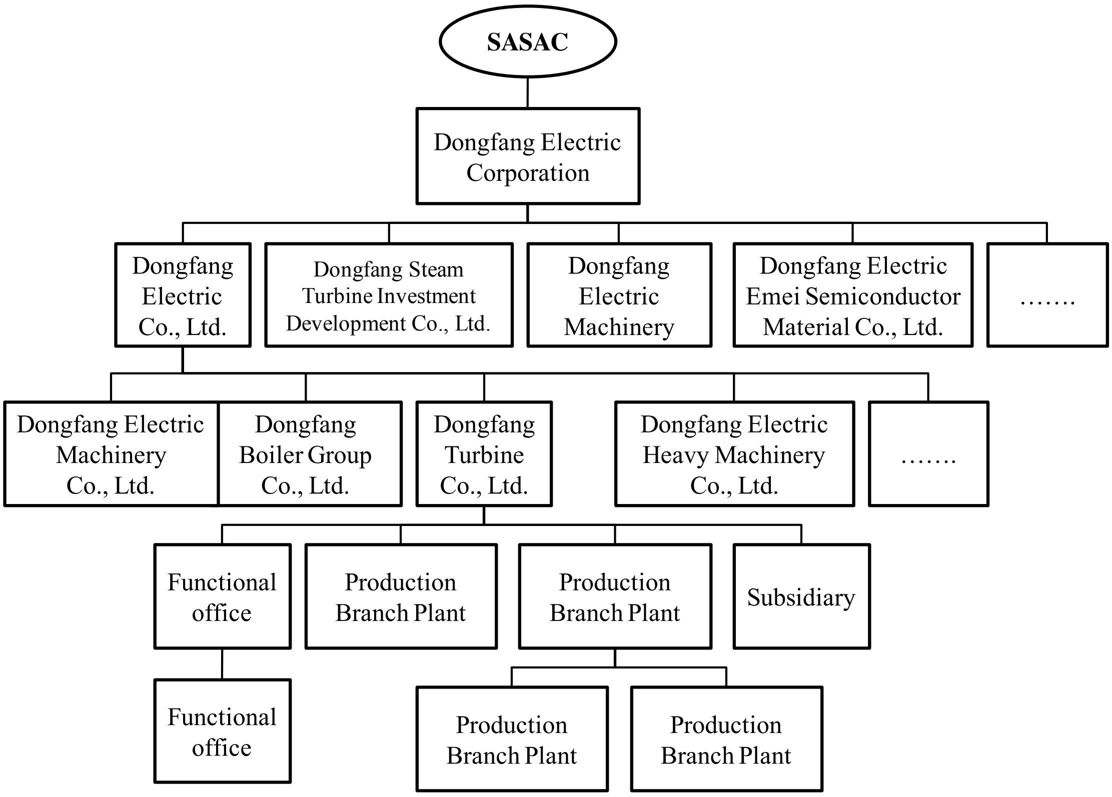
3.3.1 Case Study

After understanding the literature about case study method, this thesis takes case study as the main research method. Case study is not a method of data collection, but deals with the matters of "what is it like?", "how does it happen?" and "what's the result?" though researching the design. Unlike statistical inductive logic of large sample study, case study does inductive analysis and also has the corresponding research process (Eisenhardt, 1989; Yin, 1994).

This thesis mainly adopts the single-case multi-level analysis approach. Taking power generation equipment industry as background and Dongfang Turbine Co., Ltd. as the basic analysis unit, this thesis also studies the operation of the company's internal organizations on manufacturing value chain.

Dongfang Turbine Co., Ltd. (hereinafter referred to as "DTC") is restructured from Dongfang Steam Turbine Works, and affiliated to China Dongfang Electric Co., Ltd. DTC's organization structure chart is given in Figure 3-7. DTC was established in 1965, started construction in 1966 and put into operation in 1974. It is a large state-owned high-tech enterprise specialized in research, design and manufacturing of power generation plant equipment in China. DTC is one of the top 100 enterprises of machinery industry and one of the three turbine manufacturing bases in China. After 40 years' hard work and entrepreneurship development, DTC's manufacturing capability of core components reaches 28 million KW. At the same time, its annual output value and its sales income are more than 20 billion Yuan, creating the miracle of production without loss. DTC has produced more than 1,000 sets of various types of power plant equipment, and its installed capacity is more than 200 million KW while its products' market share in China is more than 30%. The products are sold throughout 27 provinces and autonomous regions all over the country and many countries in the world.

Figure 3-7 Organizational Structure and Subordinating Relation Diagram of Dongfang Turbine Co., Ltd.



Note: In the above Figure 3-7, SASAC is the State-owned Assets Supervision and Administration Commission of the State Council of Chinese Central Government

DTC focuses on various industries such as coal-fired power, nuclear power, gas turbine power, wind power and solar energy. This thesis mainly analyzes the coal-fired power products (steam turbines) which have been sold for many years, and takes other industries into account at the same time.

Various methods have been adopted to enhance the scientific research.

(1) Validity. First, the cases refer to multiple sources of evidence, which include official statistics, reports and the company's internal documents, files. The surveys and interviews have been used to analyze the main issues, and this study penetrates into the company's all levels and departments to understand the operation of manufacturing value chain. The coherent and logical evidence chain is been formed according to the data in the case writing process to enhance the construct validity. In the meanwhile, when sorting and selecting the case database, we seek the views of staff within the company.

For theoretical explanation and causality analysis, this thesis strives to seek support from the existing theories and enhance the study's internal validity in the aspects of events order and logical reasoning.

This thesis takes the power generation equipment manufacturing industry as the object, and even it is just one of the manufacturing sector, but this research's findings still have external validity. As an enterprise engaged in power generation equipment business for many years in China, DTC has a certain representation. The situation analyzed in the thesis can be copied and promoted. The research findings give inspiration to the industries owning the similar attributes with power generation equipment manufacturing industry (such as machinery manufacturing industry, mass customization industry) under the economic background of the continuous development in China.

(2) Reliability. Reliability of case study refers to the dependability and repeatability of the research processes. Case resource collection is highly required. This study complies with scientific procedures in the research process, and prepares the corresponding case study proposal and case study database.

Case study can be simply divided into three stages of preparation, implementation and dialogue, and many works in it are cross repeated. The whole case study specifically includes following tasks:

(1) Stage One: Preparation.

In case study, firstly the research topic should be identified. Though the above theoretical summaries, the topic of this thesis is "a study of power generation equipment manufacturing enterprise's manufacturing value chain". It discovers the characteristics of manufacturing value chain by reflecting the smile curve. Furthermore, the subject can be split into manufacturing value chain structure (i.e., what links does manufacturing value chain include, and how about their functions and value contributions), manufacturing value chain evolution (i.e., how does manufacturing value chain structure and value distribution change with the industrial development), and manufacturing value chain management issues (i.e., how to enhance the capacity of manufacturing value chain and manage it). This thesis does the research around the above issues, and they are specifically discussed in the follow-up.

This thesis adopts the single case study method. Although the conclusions of multiple cases studies are more convincing, this thesis chooses the method of single case study after considering the specific research issues and research investment. In fact, single case study suits to challenge and develop the existing theories, or owns the complementary function to complement and deepen the previous theories.

This thesis takes the enterprise (DTC) as the basic analysis unit, but it includes the embedded analysis units of the industry and DTC's internal organizations. As a result, the analysis of this thesis is single-case multi-level analysis.

This thesis chooses a diverse approach to gather information, including in-depth interviews (structured interviews and unstructured interviews), direct observation, documents reviews

(2) Stage Two: Implementation

This stage mainly includes data collection and data analysis.

In the data collection phase, the data are collected focusing on the core issues of this thesis. This thesis firstly collects and sorts the texts, files, images and written reports to study the power generation equipment manufacturing industry's basic status and DTC's own development conditions. And those data are from the official institutions, industry associations, securities companies and the company's internal reports. This thesis adopts the way of open interviews, and respondents are allowed to speak freely around the core issues for getting the valuable ideas and problems. DTC is a large enterprise with many levels, so the numbers of interviews between the senior and the middle staff are distributed. Because the research issues are related to the company's organization, the proportion of the interviews for first-line people is not high. In short, the sources of the case data are multiple, objective and rich, especially there are many first-hand information, which can support the follow-up study. Details are shown in table 3-1 and table 3-2.

After two months' data collection, in Phase 2, DTC's organizational structure, process layout, the whole production processes of steam turbines are comprehensively surveyed. After that, in-depth interviews are carried out in many of DTC's internal departments to have a better understanding of the distribution of manufacturing value and value chain management.

Table 3-1 Main Data Sources (A Part)

Names of the data	Main Contents	Sources
DTC's Memorabilia	Main events since DTC's establishment	General Managers' Office
Company's Annual Report (2008-2010)	Company's annual sales summary and next year's plan	General Managers' Office
The 12th Five-Year Plan (2011-2015)	Plans for the company's next five years' strategies and industrial programs	Planning and Project Management Department
Notes of Operation Meetings	Arrangement of the company's production and operation	Production Department
Details of Planned Cost	Planned cost for steam turbines of 300MW, 600MW and 1000MW	Finance Department
Outsourcing Management Report	Management of the company's outsourcing and their related production data	Outsourcing Department
Steam Turbines' Production Flow	Composition and main manufacturing processes of the products	Manufacturing Technology Department
This Industry's Development Report	The situation of electric power industry, steam turbines' domestic and foreign markets, and the company itself	Planning and Project Management Department
This Industry's Business Index Statistics	Business data of main turbine manufacturers	Planning and Project Management Department
DTC's Business Development Data	The data of the company's yields, production value, incomes and profits in recent 20 years	Enterprise Management Office
DTC's Other Industrial Layout	Introduction of the company's business in the field of wind power and solar energy	Planning and Project Management Department

Table 3-2 Company's Internal Interviews

Interviewee	Main Contents	Department Post
Mr. Hu	The company's basic situation and development strategies	Deputy general manager
Mr. Zhang	The company's production layout and production capacity	Production Department
Mr. Yin	Main outsourcing manufactures and their management	Outsourcing Department
Mr. Fu	Turbines' key technology	Chief Engineer's Office
Mr. Wang	Company's market competition situation and major customers' distribution	Marketing Department
Mr. Li	Turbines' assembly processes	First Branch Plant of Main Engine Production
Mr. Li	Cost construction of typical units	Finance Department
Mr. An	The relevant industrial policies of the country and the company's core capacity	Office of Party and Government Affairs
Mr. Leng	The evaluation of turbines' key manufacturing technology and key parts	Manufacturing Technology Department
Mr. Yang	Products' components, parts classification and the evaluation of key parts	Welding Branch Factory

After data collection, the next is collation and analysis. The thesis mainly filters, codes, classifies and selects the data related to the research subject for further analysis. This process combines with the case writing, and also improves the evidence, modifies the design to obtain the relevant theory.

(3) Stage Three: Dialogue.

After basic case preparation and implementation, according to the facts and the relevant theory, literature dialogue has been conducted to get the main theoretical contribution and inspiration of this thesis.

In fact, the author and its team have the ability to carry out the above research. The author of this thesis has been working in DTC nearly thirty years and mainly engaged in strategic management in recent years. The author is familiar with the relevant industries, the company's business and production operation. In the meanwhile, many relevant workers in DTC have been absorbed in this research, so the case's fundamental work is very solid.

3.3.2 Secondary Data Analysis

Differing from the original data, secondary data are the literature materials collected and collated by others for different purposes. They generally include the data obtained by other researchers and research institutions though the survey, or collected by the governmental institutions. In management research, secondary data method is widely applied. Although this thesis does the studies for the specific industry and the enterprise, but, embedded in the industry environment, this thesis uses lots of secondary data besides the establishment and analysis of the original data. Those secondary data mainly come from the notices of statistics departments, industry associations, listed companies and network resources. And they are mainly the macro-economic data, industry development data, and enterprises' competition data. Secondary data often owns a large amount of sample and information, and suits for long time data analysis. In addition, secondary data is relatively objective and strongly convincing based on its source (Chen Xiaoping *et al*, 2008).

3.3.3 Quantitative Statistical Analysis

This thesis collects a large amount of data during writing, and some basic conclusions are obtained based on the data. EXCEL is used for the input and collation of the basic data, while SPSS statistical software is used for systematically analyzing the data. Descriptive statistics and simple quantitative relation are also used, but relatively sophisticated econometric tools are not adopted. In fact, statistical method has become a very fundamental tool of economic management research, and it's very practical too.

Actually, this thesis combines all the above methods in its writing.

3.4 Data Acquisition

Based on the above research issues and methods, this thesis collects and collates lots of data from various aspects. The data are collected from many different channels, such as, Yearbooks, Statistics Reports of Industries, Annual Reports of Listed Companies, and relevant associations of industries. They form a rigorous data evidence chain to support the research.

Firstly, these data are the basic data about electric power industry development. The development of electric power industry depends on the macro-economic environment (mainly determines the demand and supply of the electric power). This thesis systematically analyzes the growth of the power industry in recent years, so as to support the value chain research of power generation equipment industry. Secondly, these data are the data about the power generation equipment industry and the enterprises, mainly describing the data of the power generation equipment manufacturers at home and abroad, including their main business, scales and development strategies. These data are used for identifying the rules of this industry's development and the characteristics and advantages of different enterprises. In the meanwhile, as for the core enterprise of this thesis-DTC, this thesis collects its development data in recent 20 years, which include its fundamental operation status, key events of development and value chain evolution, to provide the necessary materials for the case study research. The detailed data are shown in the analysis parts of Chapter 4 and Chapter 5.

The sources of all the data are marked. And because some data are related to the business secrets, they are somewhat modified and covered up in this thesis accordingly.

Chapter 4: The Study of Power Generation Equipment Manufacturing Industry's Value Chain

According to the research framework of this thesis, it mainly studies the following issues: general analysis of the basic situation and value chain in electric power industry, power generation equipment industry and steam turbine manufacturing industry, from macroscopic view to microscopic view and from the whole to the local. This chapter studies on the steam turbine manufacturing value chain, and takes DTC as a typical object for case study.

4.1 The General Form of Electric Power Industry'S Value Chain

The electric power industry is a pillar industry of national economy development, and is beneficial to the people's livelihood. It is a public utility business in many countries and a monopoly industry which has been controlled by the state. All countries in the world take this industry as an important area which shall be intervened by the government. The electric power development is closely related to the economy. The electric power is an important material base for guaranteeing the economic development, while the economic development is the inner motive force of the electric power development. Based on the actual situation in China, this thesis simply introduces the demand and supply of the electric power and the basic composition of the value chain.

4.1.1 The Basic Situation of Chinese Power Industry

Though 30 years' reform and opening up, Chinese economy keeps the rapid development, and China has been the second largest economy in the world (in 2011). Driven by the economic growth, the electric power industry also has obtained a good development. Table 4-1 shows, Chinese GDP is generally maintained the average annual growth rate of 10%, and the installed capacity is higher than the GDP growth rate in the recent years. At the same time, the power generation capacity keeps synchronous growth, with slight fluctuations. In the elastic coefficient of electricity consumption, it is more than one before the year of 2008, which shows the Chinese extensive economic features, and it appears an inflection point after 2008, which reflects the economic structure's adjusting trend. These data suggest that the electric power industry has significant correlation with the economic development.

Table 4-1 China's GDP and Growth Rate of the Electric Power Industry

Item	2003	2004	2005	2006	2007	2008	2009	2010
GDP	10.0%	10.1%	10.4%	11.1%	11.4%	9.0%	8.7%	10.3%
Installed Capacity	9.78%	12.60%	15.36%	22.34%	14.68%	11.10%	10.29%	10.08%
Power Generation	15.17%	14.79%	13.16%	14.54%	12.08%	5.77%	7.15%	13.24%
Power Elastic Coefficient	1.5170	1.4644	1.2654	1.3099	1.2632	0.57	0.71	---

The data of GDP are processed according to *National Economic Statistical Bulletin* (2003-2010) The other data are obtained by analyzing *The Electric Power Development Yearbook and Industry Reports*.

According to the relationship between Chinese economic development and the electric power demand growth, and the analysis of the electric usage level in comprehensive construction well-off society, the Chinese electric power demand needs to maintain rapid development speed in the future twenty years. The average annual growth rate is expected around 7.0%, and about 5% in the last ten years. The total electric consumption of Chinese society will reach about 6.3 trillion Kilowatt hours in 2020. Taking the present Chinese power structure into consideration, it needs power generation units' capacity of about 1.2 billion KW. It is expected that Chinese per capita power consumption will reach 4200 kilowatt hour, and that used in normal life will reach 840 kilowatt hour.

In addition to the frequent extreme climate, the increasing social demand and the improvement of life quality also make power demand increase. Taking the first half of 2011 as an example, the national power consumption increased by 12% compared with that in the same period of 2010. In short, from the medium and long-term view, Chinese electric power consumption will maintain a constant growth under all sorts of economic and social influence.

The relevant data analysis indicates that, in electric power consumption structure, Chinese secondary sector still takes absolutely leading position. In 2010, the industry power consumption is 3.6905 trillion kilowatt hour, and the proportion consumed by the second industry reaches 85% (heavy industry accounts 70%), which is consistent with the feature of the manufacturing power country’s status. The economic policy of stimulating domestic demand drives the manufacturing industry and the other related industries, such as energy, raw materials and transportation. The rapid growth of machinery industry, steel industry and chemical industry further stimulates the electric power demand. But China is now in the stage of transforming from the industrialization to “post-industrial” age, and the goal of industrial structure adjustment is to increase the proportion of the tertiary sector represented by high technology industry and service industry in the national economy. A clear signal is that the electric power consumption elasticity coefficient appeared an inflection point after 2008. It is less than 1 for the first time and appears the trend of decline in the recent two years.

In addition to power demand and consumption, power supply is also an important economic factor in electric power industry. From worldwide aspect, all countries’ power structures are closely related to the characteristics of their resources. For example, the United States and Germany own rich coal resources and their proportions of coal are around 50%; Canada is rich in hydropower resources and its hydropower proportion reaches 56%; France mainly develops nuclear power and its generation capacity is more than 70%.The other countries such as Japan and England, their various power supplies are more evenly.

China owns rich coal reserves, followed by water resources. As a result, the thermal power and hydropower are currently absolute superiority in the power structure. Although nuclear power and wind power maintain rapid growth in recent years, the proportion of new energy is still very low.

By the end of 2010, Chinese power generation industry’s total installed capacity got to 960 million kilowatt, including thermal power industry accounted for 73%, hydropower accounted for 22%, and both accounted for 95% (table 4-2). It is worth noting that, nuclear power and wind power have rapid growth in recent years, and wind power’s average annual growth rate is as high as 40%. It is expected that Chinese installed capacity's average annual growth rate increases by8%during "Twelfth Five-Year Plan"(2011~2015), and till 2015, the total capacity will reach 1.436 billion kilowatt. The whole country's installed capacity of electricity will change in the structure. The coal ratio will be reduced from 70% to 60%, and the clean energy ratio such as wind power, hydropower and nuclear power will be greatly improved. From the whole trend, China develops from the original single coal-fired electric power to hydropower, nuclear power, gas, wind power and solar power. It forms a diversified development business structure, and synchronously increases development opportunities and challenges.

Table 4-2 Chinese Power Installed Capacity and Structures

Year	Total installed capacity		Thermal power		Nuclear power		Water power		Wind power	
	Capacity	Growth rate	Capacity	Pro.	Cap.	Pro.	Cap.	Pro.	Cap.	Pro.
1999	29877	7.75	22343	74.79	226.8	0.709	7297	24.4	27	0.091
2000	31932	6.88	23754	74.39	226.8	0.663	7935	24.9	34	0.107
2001	33849	6.6	25301	74.75	226.8	0.62	8301	24.5	40	0.118
2002	35657	5.34	26555	74.47	458.6	1.048	8455	24.14	47	0.133
2003	39141	9.77	28977	74.03	636.4	1.62	8871	24.24	57	0.149
2005	44247	22.43	32944	74.45	741	1.552	10826	24.48	76	0.172
2005	50841	14.9	38413	75.56	776	1.347	11652	23.02	125	0.246
2006	62200	15	48405	77.82	776	1.101	12857	20.67	250	0.402
2007	71329	14.36	55442	77.73	858	1.241	14526	20.36	596	0.836
2008	79250	11.11	62017	78.25	910	1.148	16536	20.87	839	1.059
2009	87407	10.23	65205	74.6	910	1.039	19679	22.51	1613	1.845
2010	96219	10.08	70663	73.4	1082	1.125	21340	22.18	3107	3.229

The data are from China Electric Power Yearbooks（2000-2011）

The current reality of Chinese national conditions determines that the thermal power generation is still the main form. Integrating all forecast data, Chinese main power supply is thermal power in future ten years, and fluctuates around 70%. Under the realistic background that coal-based energy is the main source of one-time energy, the power structure is bound to let thermal power be the top, and thermal power generation equipment industry still has a huge room for development.

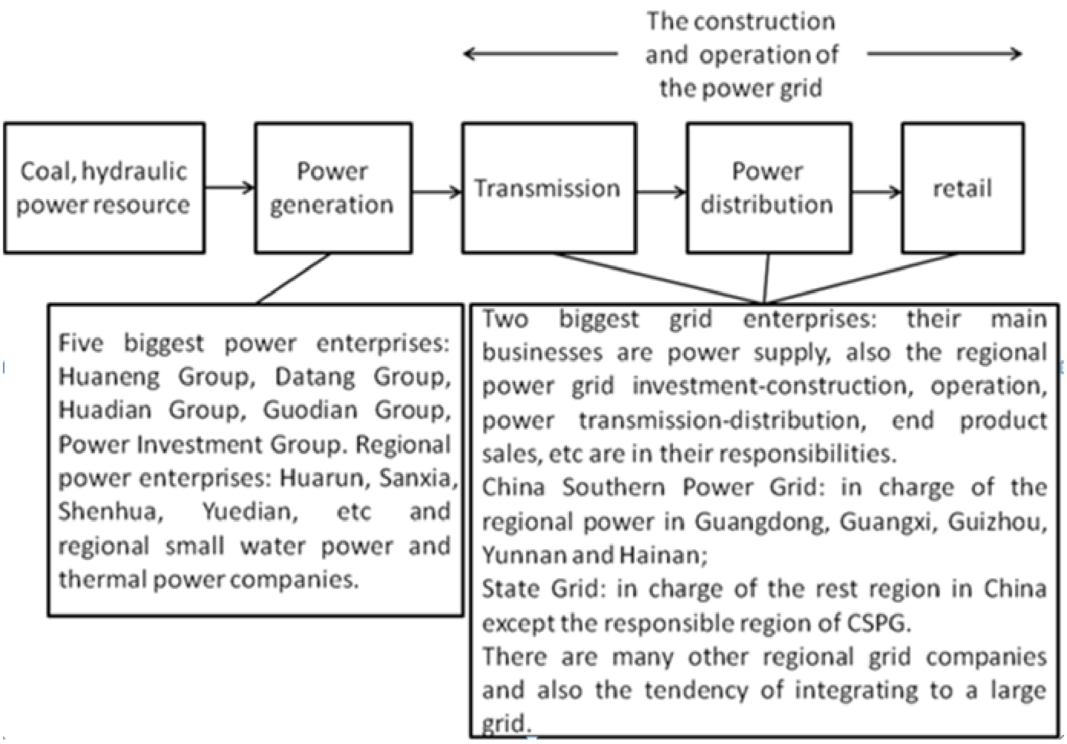
4.1.2 The Composition of Power Industry Value Chain

Power industry is a specific industry having its own characteristics. From the supply chain aspect, the industry's main product is energy, which refers to the electricity power. It is the pubic product relating to the entire society's food, clothing, housing, transportation and people life need. Power generation, substation, transmission, distribution and consumption composite a system of electricity production, transmission, distribution and consumption. According to the product sales supply chain, the power industry value chain can be divided roughly into power generation, transmission, distribution and electric energy sales. The energy products' production is the main task of power generation, and power plant is mainly for this sector. Power transmission can be understood relating to the ordinary industry products' transportation, and transmission grid is the "highway" of power products transportation. The Electric Power Dispatching Center and power company's Network Facilities Maintenance Department are concerning to this sector. Distribution refers to the distribution of energy products, and the relevant department mainly is the department of the Power Supply Bureaus (companies) responsible for the distribution network's operation and security. Electric energy sales, including electric energy's wholesale and retail, and the relevant department is the power company's Marketing Department (or Power Utilization Department).

For a long time, Chinese power industry's monopoly characteristics put power generation, transmission, distribution, and electricity sales into a same company, which made the management of industry supply chain become a kind of company's internal supply chain management. After that, Chinese electric power system reform has gone through three major stages: First, opening the power generation market after 1987, and encouraging many companies (refer to diversified investment and business entities) generate power; Second, represented by the establishment of the State Power Corporation and the elimination of the original Ministry of Power Industry in 1997, a system reform having the goal of separating the government from enterprises and trading the market as the main body; Third, the State Council issued "Power System Reform Plan" in February 2002, deciding to split the State Power Corporation. In general, the basic thoughts and main lines of power reform are highly consistent, that is, the market orientation is gradually deepening.

After some debates, Chinese power system reform eventually took traverse-longitudinal bidirectional spilt reform mode, which separated the power plants and the grids, and reorganizing enterprises of power generation and the grids. The specific measures include: (1) splitting the State Power Corporation into two parts, power generation and power grid; (2) dividing the State Power Corporation's assets into five regional restructuring power generation groups, equally competing with various power generation enterprises; (3) reforming the power grid part into two major companies, State Grid and China Southern Power Grid; (4) reforming the pricing mechanism, implementing two tariffs and bidding strategies for power generation companies; (5) establishing a professional regulation institution, State Electricity Regulatory Commission.

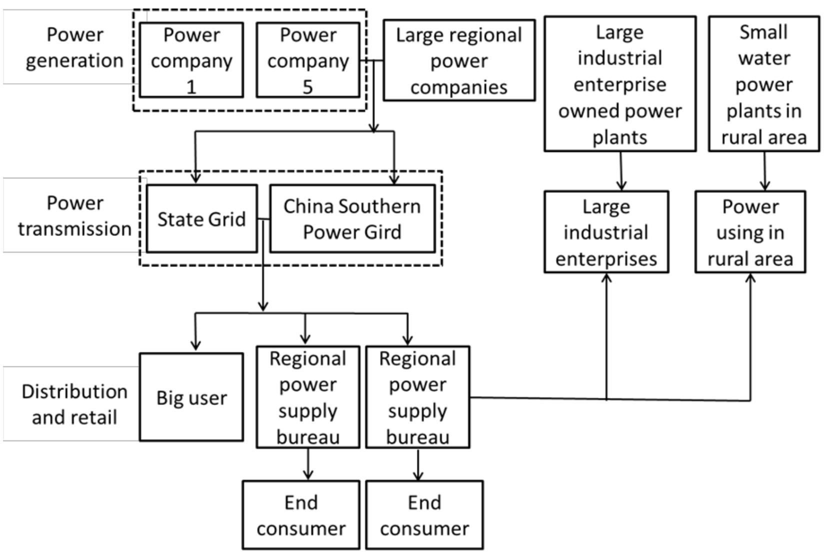
Figure 4-1 Value Chain of Power Industry



Power industry value chain is shown in Figure 4-1. The upper part is the coal, hydropower, and other energy industries. These one-time energies are the main source of electricity production. In power generation sector, power stations convert various energy resources into electricity through the power generation equipment, and they bid for paralleling into the grids at the same time of power generation. There are five major power generation groups recently in this sector, and their installed capacity accounts for 49%, their proportion of power generation accounts for about 50% of the country, but there are also many local power generation companies. Because of the rising coal prices and government tariff restrictions, power generation enterprises reflect weakness in overall business. All the other power sectors except power generation are managed by grid enterprises. Due to scale economy, density economy and fixed cost depositing, transmission fields has a strong monopoly characteristic. At the national aspect, it divides into State Grid and China Southern Power Grid. The revenue of State Grid is up to US$ 1.5427 trillion in 2010 and ranks the eighth in the world top 500. State Grid is also the largest utilities enterprise in the world.

Power industry's market structure after the reform is shown in Figure 4-2, which is objectively describing the Chinese current electricity power market conditions in detail.

Figure 4-2 Basic Structure of Chinese Power Market



This diagram is obtained from the web resources such as Sichuan Electric Power Report.

The above is just the basic form of Chinese power industry value chain. With the deepening of power system reform and introduction of more competitors on the agenda, especially in the electricity sales end, a high degree of monopoly situation will change sooner or later. From this perspective, power industry value chain needs to be optimized.

4.2 General form of Power Generation Equipment Industry Value Chain

In the value chain of power system, power generation equipment belongs to the generation sector, which is the core component of power station undertaking the functions of converting a variety of energy into electricity and providing power supply.

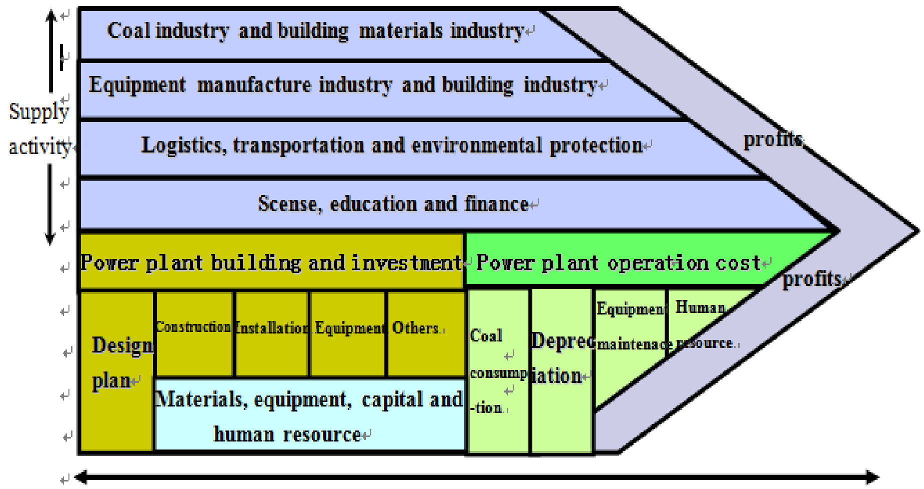
4.2.1 The Composition of Power Generation Equipment Value Chain

Power plant construction and operation belong to power generation sector in power industry value chain. Taking a power plant for example, its own value chain composition is shown in Figure 4-3.

Figure 4-3 shows that the power plant value chain mainly includes the construction and operation. According to the relevant data which had been operating in the power plants, the highest value in construction sector (construction cost) is the equipment, while the highest value in operation sector (operation cost) is energy consumption. The power generation equipment industry which this thesis concerns is precisely relating to these two highest value sectors.

Power generation equipment industry is the core part of power equipment industry. Power equipment industry is in the intermediate position of power industry chain, while the upstream industry is the iron, steel and nonferrous metals industry, and the downstream industry is power industry including power generation industry and power transmission industry. Power industry relates to power equipment industry. The growth of power demand promotes the development of power industry, thereby provides market for power equipment industry; while the technical progress of power equipment industry also directly stimulates the development of power industry.

Figure 4-3 Power Plant Construction and Operation Value Chain

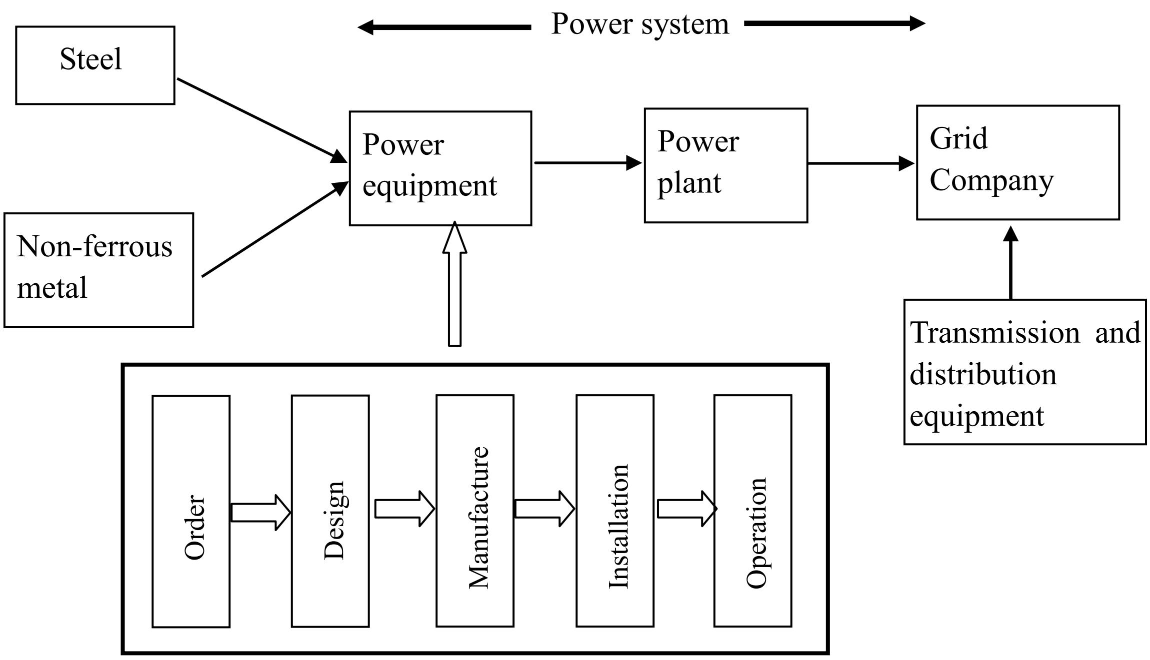


Power equipment industry mainly includes power plant equipment industry, power transmission and distribution one-time equipment industry, power transmission and distribution two-time equipment industry, and power plant environment protection equipment industry. Power plant equipment (also known as power generation equipment) industry mainly produces boilers, steam turbines, hydraulic turbines, generators and air-cooling units. Power transmission and distribution one-time equipment industry is responsible for power transmission, producing transformers, reactors, inductors, capacitors, switchgear, wire and cable; power transmission and distribution two-time equipment industry mainly produces the equipment monitoring and protecting the “one-time device”, including power plant automation, substation automation, dispatching automation, power distribution automation, circuit protection, the main equipment protection and power metering and billing automation products. Power plant environment protection equipment industry produces the equipment solving dust, waste water, sulfur dioxide, and nitrogen oxides, including dust catcher, flue gas desulfurization and gentrification equipment.

As the power generation equipment products are numerous, it should be based on the specific power generation equipment products to analyze the value chain. Power plant equipment, taking thermal power for example, mainly includes boilers, steam turbines and generators, which is a large customized discrete manufacturing industry, and only a few companies have the capital, technology and capacity to do the business. As for the general power transmission and distribution equipment, it is in a state of fierce competition. There are many relevant companies and low barriers for others to entry. This thesis mainly focuses on the large-scale power generation equipment manufacturing value chain, and also analyzes the composition of thermal power generation equipment value chain.

From the aspect of value activities, power generation equipment industry's value chain is shown in Figure 4-4. The upstream is mainly raw materials, while the downstream is power generation enterprises. From the aspect of industrial categories, it belongs to the power equipment industry. Power generation equipment is a large discrete manufacturing industry, whose production organization mode is different from the general customer goods industry. Usually the first is to obtain power generation enterprises' equipment orders, and then produces, assembles and operates the equipment according to the specific requirements in the orders and the products' personalized design. Typically, this period can be taken as long as more than two years.

Figure 4-4 Power Generation Equipment Industry Value Chain



4.2.2 Main Manufacturers of Power Generation Equipment at Home and Abroad

There are seven main manufacturers of power generation equipment in the world. They are: America's General Electric, Westinghouse Electric, Japan's Hitachi, Toshiba, Mitsubishi, Germany's Siemens and France's Alcatel Alston. The power generation equipment part of Westinghouse was purchased by Siemens in 1998.As a result, the world's main power generation equipment manufacturers currently are America's General Electric, Siemens in Germany, Alcatel Alstom in France and Hitachi, Toshiba, Mitsubishi in Japan. All of them are among the world's top 500 enterprises.

General Electric (the sales income in 2010 is $156.7 billion) is no longer a traditional electric company. At present, the finance industry (investment management, insurance, and credit cards) has reached 40% of the whole group's revenue. The company's each business spans greatly, including media, finance, electric power, engine and customer products. Its industry diversification and the enterprise management mode make it to be a management model of multinational enterprises. In its relevant industries, such as power equipment, it emphasizes on production innovation and technology development, and still keeps higher investment in the R & D. The current R&D expenditures accounts for 2% of the total turnover, but because of the company's large sales, R&D absolute amount is still very big. In manufacturing, General Electric only retains the most important sectors of manufacturing gas turbines' core components and assembling the generator sets. The products' complete sets mainly finish by global outsourcing and global procurement.

Siemens (the sales income in 2010 is 76 billion euro) has expanded its business in more than 190 countries of the world, and its staff are over 430000. Having a clear long-term enterprise strategy, it aims to become a leading global high profitability, electrical engineering and electronic products diversification manufacturing enterprise. The industrial combination strategy is combining the long cycle products with short cycle ones to cover the effect of reducing macro economy risk. The company's products are mainly in electrical engineering and electronic products, so it especially pays more attention to products' technology research and development.

Siemens' R&D expenditures accounted for 6.7% of the whole year turnover in 2004, and this investment put other international peers behind. In global competitiveness training, it uses and optimizes global value chain, and recognizes the expansion opportunities in high growth areas and tries to implement. The joint venture was established with Shanghai Electric to share the Chinese power generation equipment market, and Siemens purchases Alston's medium and small industrial turbine business to strengthen its product categories and capacity and purchases Bonus Energy's wind power generation group.

Alstom (the sales income in 2010 is $19.6 billion) has its business in more than 70 countries and owning staff over 75000. Its product structure is relatively single and high risk compared with other three companies, and its main source of income is concentrated in the long period industrial products whose sales are highly influenced by macro economy. The electric power is the largest group in the company, and accounts for 50% of the total income, including three industries of electric power turbine system, equipment and services. In manufacturing, it provides supports for the worldwide regional business, owning main bases in Europe, North America and Asia Pacific regions. It is searching for low cost manufacturing base of emerging market to reduce cost, and the joint venture companies separately with Beijing Heavy Electric Machinery and Wuhan Boiler in China are the cases. In the 1950s, Alstom supplied the first lot electric locomotive and electric drive internal combustion engines for China. In 1979, the first representative office was established in Beijing, and it is one of the earliest multinational companies doing business in China after Chinese reform and opening up.

Hitachi (the sales income is $96.4 billion) has become the world's biggest multinational group owning many industries, consumers and high-tech products, including electric power, computer and network system, environmental traffic facilities, medical/ scientific equipment, household goods. Its products industries spans large and its future industrial target will focus on the technical products. Its long-term goal is, taking innovation as the motive, and independently develops and invests high added value and high-tech products. In order to realize the group's technology innovation demand, the R&D investment remains at the level of 4.3% of the sales income even though the company's profit rate is only 0.6%. However, Hitachi is too dependent on the Japanese market, resulting that the company's profits are largely negatively influenced by the prolonged recession of Japanese economy. Hitachi will get rid of the dependence on Japanese market, and further increase internationalization, especially for the Chinese market. In order to reduce costs, Hitachi will put more production bases into low cost areas.

Mitsubishi Heavy Industries (the sales income is $31.6 billion) is the core enterprise of Mitsubishi Group, the largest manufacturer of heavy industry in Japan, and the leader of the world nuclear industry. The business is divided into five parts: shipbuilding and marine development, electric power system, mechanical and steel components, aerospace industry, and small and medium sized machinery. MHI's Electric Power System plate covers all types of resources, mainly including gas turbine, steam turbine, boiler, nuclear power system, small gasoline engine, diesel generator, gas generator, wind power generation system and solar power generation system.

Japan's Hitachi, Toshiba, Mitsubishi and other power generation equipment manufacturers are influenced by the prolonged recession of Japanese domestic economy as well as the restrictions of entry the other countries' markets, so the three power generation equipment manufacturing plants' production capacities are seriously superfluous. According to the statistics, Japanese three big companies own an annual output of 30 million KW, and their actual outputs are 14 million KW. In around 2000, when American electric power market developed rapidly, Japanese three big companies all did the outsourcing business with GE and SIMENS, and they became the important suppliers of GE's power department in Asia. Between 2004 and 2007, Chinese power generation equipment market grew fast, and the three companies also undertook a large number of orders from Chinese three big power generation groups and took outsourcing tasks from them.

Through the above mentioned international power generation equipment manufacturers, the following conclusions can be reached:

(1) These enterprises are large scale and all the world's top 500 enterprises. They mostly engage in diversified business, while power generation equipment is generally one of their main businesses. Alstom's power relevant business is more

than others, up to 50%. And other companies' proportion is lower.

(2) These companies own high degree of internationalization, covering long industrial chain in power generation equipment area including R&D, design and manufacturing. At the same time, their product lines are broad.

(3) From the trend, these companies' manufacturing sectors are relatively weak, and their core abilities reflect in the technology. Because of the global economic slowdown and the exhausting situation of power industry, their performances in the overall market appear inferior.

Entering the knowledge economy era, on the one hand, the high-tech industries such as life science, aerospace, marine technology, and service industries such as information, finance and consulting, grow fast. The strategic technologies such as information and biology have become the commanding heights of the global competition. On the other hand, some labor-intensive industries (such as textile, clothing and food), and industries of high energy consumption, high material consumption and high pollution in Europe, America, and Japan are declining. They are constantly looking for new areas to undertake the low capacity of manufacturing industry chain. These backgrounds promote western old enterprises to re-examine their own development direction, look for new business space and transfer manufacturing capacity. The above enterprises have been doing some adjustment here.

Power generation equipment industry's characteristics make the technical barriers, capital barriers and policy barriers higher, and their businesses in China are mainly concentrated in a few large enterprises.

China has three large power generation equipment manufacturing enterprises, Shanghai Electric, Dongfang Electric Corporation and Harbin Electric Corporation. Shanghai Electric Group is one of Chinese leading industrial diversification group, designing, manufacturing and selling products and relevant services of various electric power equipment, electromechanical integration equipment, transportation equipment and environmental system. In 2010, its sales income is nearly 90 billion Yuan. Dongfang Electric's and Harbin Electric's production structures are relatively single. They can produce, sell three main equipment of thermal power and the equipment of hydropower and undertake the main contractor and service projects of power plant project. In 2010, their sales incomes were not more than 50 billion Yuan. The above three big domestic power equipment manufacturing groups' total power generation equipment production achieves 84.6 million KW, and exceeds the world average power increment. With the steady and rapid growth in domestic GDP, power market will continue its fast growth, resulting in the development of power generation equipment manufacturing industry.

Before the founding of new China, Chinese power equipment manufacturing industry was completely blank. In 1952, China introduced the manufacturing technology of 6MW and 12MW thermal power units from the former Czechoslovakia. In 1953, China introduced the manufacturing technology of 6MW and 50MW thermal power units from the former Soviet Union. So far, Chinese thermal power equipment manufacturing industry started development. Before reform and opening up, China had been able to completely independently research the high pressure, super-high pressure, sub-critical power plant boilers, impulse turbines, double water cooling and other 6-300MW thermal power generation units. The thermal power units of 100MW, 125MW, 200MW and 300MW were the main units throughout the grids. In the meanwhile, the three large power generation equipment production bases (Harbin Electric Corporation, Shanghai Electric and Dongfang Electric Corporation) were initially formed.

After reform and opening up of china, China introduced the design and manufacturing technology of 300MW, 600MW sub-critical thermal power units.

By 2000, Chinese power generation equipment had been developed to the level of sub-critical units, which highly improved the power generation unit's efficiency. In the early 1990s, China introduced the super-critical units, and the performance of Chinese 600MW super-critical thermal power units reached the international advanced level.

After 1990s, because of the worldwide energy shortage and environmental pressure, ultra-super-critical technology entered into a new stage of development, and a group of tested new design methods and new structures which highly improve the units' economical efficiency, reliability and operation flexibility is formed. They have been considered as the most practical and effective ways to solve the problems of power shortages, low energy efficiency and serious environmental pollution. Harbin Electric Corporation, Shanghai Electric and Dongfang Electric Corporation respectively introduced 1000MW ultra-super-critical technology from Mitsubishi (boiler), Toshiba (steam turbine), Siemens (steam turbine), Alstom (boiler) and Hitachi (steam turbine and boiler), and finally produced 1000MW ultra-super-critical thermal power units.

Chinese future thermal power generation units'developmentis to improve and enhance large sub-critical units' performance and quality, reduce energy consumption, improve average efficiency, accomplish ultra-super-critical units' domestic localized production, and large gas-steam combined cycle units' technology introduction and localization.

4.3 The Form of Steam Turbine Value Chain

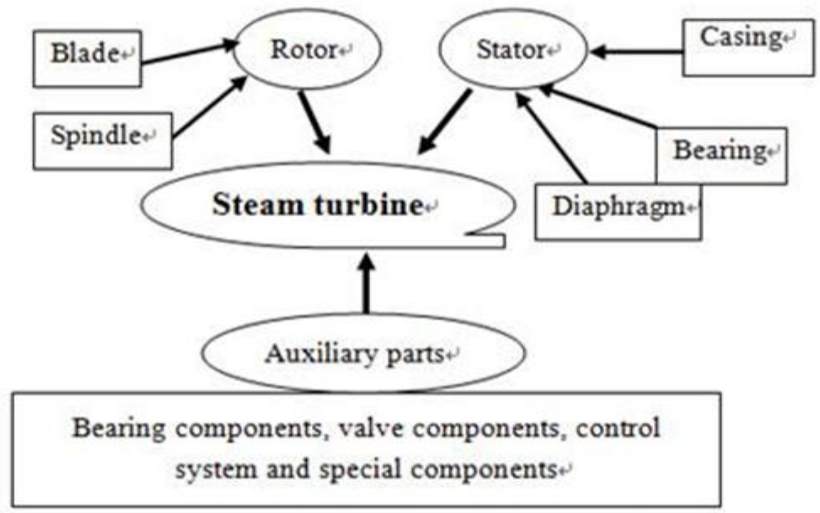
4.3.1 Products and Technology Principle

Steam turbine is one of the main equipment in thermal power generation units, and one of the three core components of thermal power generation units. The power generation form of adopting steam turbines accounts 80% of the total power generation generated by various worldwide power generation forms. Steam turbine is external combustion rotary machinery converting the heat energy into the mechanical work. Coming from the boiler to the steam turbine, steam flows through a series of annular configuration of the nozzles and blades, and the heat energy of the steam converts into the mechanical energy by steam turbine rotors' rotating. Because of different forms of steam's energy conversion, there are different types of steam turbines by different work principles.

Steam turbines often work in the condition of high temperature, high pressure and high speed. A steam turbine is a sophisticated heavy machinery, and often needs to work with the complete set of equipment which is constituted by a boiler (or other steam generator), a generator (or other driven machinery) , condensers, heaters, pumps.

Figure 4-5 shows the connection among steam turbine's several modules. Steam turbine usually consists of the two parts of rotating part (rotor) and static part (stator).The rotor includes shaft, impeller, blade and shaft coupling. And the stator includes inlet section, steam turbine cylinders, diaphragms and vanes, steam seal and bearings. Besides these, there are many auxiliary parts supporting their work. A standard 600MW power plant steam turbine is 40 meters long, 5 meters high and weights over 1000 tons, owning tens of thousands of components.

Figure 4-5 Steam Turbine Structure Sketches



This diagram is from Liu Xinggui (2009)

The cylinder is the shell of a steam turbine, and its role is to separate the steam turbine's flow path from the atmospheric air, form a closed steam chamber to guarantee the completion of the energy conversion process. Inside the cylinder, there are nozzle box, diaphragms, diaphragm sleeves and other components. And outside the cylinder, there are pipes for steam inletting, exhausting and extracting. Diaphragms are used for fixing the stator blades, and dividing the cylinder into several steam chambers. Moving blade are assembled in the rotor impeller or drum, accepting the high speed airflow coming from the nozzle cascade, and transferring the kinetic energy into mechanical energy to make the rotor rotate. The role of the main bearing is to undertake the whole weight of rotor and the centrifugal force caused by rotor's unbalance mass, and determines the correct radial position of rotor in the cylinder.

The rotating component of steam turbine is called a rotor, and its role is to convert the kinetic energy into mechanical energy. The blade is the basic component of the turbine, and can be divided into moving blade and static blade. Installed in the rotor impeller, moving blade accepts the high speed steam flow from the nozzle, and using the steam's kinetic energy to make the rotor rotating. Static blade mainly ensures the necessary changes of steam flow direction, and guides the steam into the next moving blade.

There are many classification means of steam turbines, such as according to the work principle, thermodynamic characteristics, use, and the steam's initial pressure.

In the large thermal power generation power plant which takes coal as the fuel, the current mainstream and large coal-fired generators can be divided into 300MW, 600MW, 1000MW units according to the equipment capacity, and can be divided into sub-critical, super-critical, ultra-super-critical units according to the steam parameters (shown in Table 4-3).The higher capacity and higher steam conditions the equipment owns, the higher technology the power generation equipment has. And the difficulties of the manufacturing and higher requirements of technological equipment ask for more technology innovation.

Table 4-3 Power Generation Unit Classified By Steam Parameters

	Tem.	Pressure	Output		Tem.	Pressure	Output
	℃	kg/cm2	MW		℃	kg/cm2	MW
Sub-critical	535	180	≥200	Ultra super-critical	600	240	≥700
Super-critical	566	240	≥300	Ultra super-critical	600	300	≥1000
Ultra Super-critical	566	300	≥600	Ultra super-critical 4	1000	300	≥1000

The data are from DTC's technological departments.

As the core component of power generation system, the performance parameters and safety coefficient of steam turbines are particularly important. According to steam turbines' principle and function, the most key performance requirement is the heat rate which is the consumption heat of producing 1 kilowatt electricity per hour, and it reflects the steam turbines' energy utilization and conversion efficiency. In order to improve the heat rate, besides the continuous improvement the efficiency of the turbine itself including improving the blade design (for reducing flow loss) and reducing the loss of valves and the intake and exhaust pipes, measures can also be taken from the thermodynamic aspect.

In addition, in the steam turbine device, a reasonable thermodynamic cycle must be selected. The flow path should have good thermal and aerodynamic characteristics, and the body, auxiliary equipment and the main components of steam turbine should have higher strength and vibration characteristics. They should have good automatic regulating performance and reasonable manufacturing technology availability.

Steam turbines' key manufacturing technology is reflected in the following aspects:

1) The optimization of flow path
2) The optimization of thermodynamic system
3) The study of rotor dynamic performance
4) The development of last-stage long blade.

The research of large steam turbines is an important direction of turbines' future development. And manufacturing the longer last-stage blade is the key point of steam turbine's further development. Research on improving thermal efficiency is another direction of turbine's development, and the above performance indexes and key technologies determine that the production of steam turbine is a complicated process. It has the characteristic of capital intensiveness and technology intensiveness, especially for the large steam turbine, and only a few enterprises have the whole link activities' design and manufacturing ability.

4.3.2 The Competition Situation of Chinese Industries

In 1980, in order to improve the power industry and thermal power equipment manufacturing industry, China decided to introduce 300MW, 600MW sub-critical thermal power units' design and manufacturing technology from outside. In 2000, Chinese power generation equipment had been developed to sub-critical level and greatly improved the generator's efficiency. From the late 1980s, China began to pay attention to the development of super-critical thermal power unit, and did large-scale localization based on introducing many units. From the measured data of the units' thermal performance which have been put into operation, Chinese600MW super-critical thermal power unit's performance has reached the international advanced level. After 1990s, because of the worldwide energy shortage and environmental pressure, ultra-super-critical technology entered a new development period, forming a group of tested new design methods and new structures which have greatly improved the units 'economic efficiency, reliability and operation flexibility, and it is recognized as the most practical and effective way of solving power shortage, energy low efficiency and serious environmental pollution.

At present, owning super high pressure, sub-critical parameter between 135MW and 600MW, Chinese steam turbines' manufacturing quality, performance, reliability and other comprehensive indexes have reached the international level of similar units. China has the ability to design and manufacture the sub-critical and super-critical large steam turbines, and the localization rate of introduced technology type of new generation of 300MW-600MW steam turbine is above 95%. 300MW-600MW steam turbines' guaranteed heat rate has achieved the international advanced level.

The shortcoming of Chinese enterprises is that their R&D capacity is relatively weak, and their independent innovation needs to be strengthened. Enterprises autonomy mainly faces three core problems: first, some introduced technology products' design and technology have not been really absorbed; second, some key alloy steel profile and large castings rely on imports; third, some core components and accessories also rely on imports. These three problems have become a bottleneck restricting the industry's development, and they reflect that there are some weak sectors in the common industry and basic experimental research. The domestic public core technology R&D platform has not yet completely formed, and the industry has a long difficult journey to endure in the process of introducing, absorbing and re-innovating technology.

Besides, the development trend of Chinese power generation industry shows that the thermal power still have room for growth, but the fast growth period is over. The demand for steam turbines will be stable, and the proportion will decline in the future. Therefore, for the enterprises, the technical breakthrough is the key point to increase the manufacture value. The first is to improve the thermal efficiency, the second is to reduce pollution emission, and the third is to reduce the dependence on the import of core components.

There are 32 Chinese steam turbine enterprises, and the top four enterprises' market share accounts 59% nearly occupying all the domestic market of over 600MW units. And the top seven enterprises' market share accounts87.3%. These main domestic enterprises are introduced as follows:

(1) Shanghai Turbine Co., Ltd. (STC)

Shanghai Turbine Co., Ltd. (STC) is the subordinate enterprise of Shanghai Electric Group, located in Shanghai, and is the joint venture organized by Shanghai Steam Turbine Works and Siemens-Westinghouse Electric Corporation (America WH). Its Chinese equity is 68%, while the foreign one is 32%. STC is the former Shanghai Steam Turbine Works which was founded in 1953 and the earliest power plant steam turbine manufacturing enterprise. The domestic first 6000 kilowatt turbine was manufactured in Shanghai Steam Turbine Works in 1955. In 1980s, it introduced the 300MW design and manufacturing technology from America's Westinghouse, and later introduced the 600MW design and manufacturing technology, realizing that China had the mass manufacturing capacity of 300MW and 600MW units. In 1996, it established a joint venture with Westinghouse and owned the design and manufacturing technology transfer of Westinghouse's complete large power steam turbines. After that, Germany's Siemens annexed America's Westinghouse. Therefore, STC has the world's advanced turbine technology, domestic first-class equipment and management.

(2) Harbin Turbine Co., Ltd.

Harbin Turbine Co., Ltd is a wholly owned subsidiary of Harbin Power Equipment Co., Ltd. which is a listed company in Hong Kong. Harbin Turbine Co. Ltd. is the former Harbin Steam Turbine Works, locating in Harbin, and the two (power plant steam turbine and marine main power equipment) of the 156 fundamental construction projects in China "First Five Year Plan" period. And it is the large enterprise in the design and manufacturing of the large thermal power (including nuclear power) steam turbines, gas turbines and marine main power equipment. In 1994, though shareholding system reform, it changed into a limited liability company. The products' technology is based on the steam turbine design and manufacturing technology of the former Soviet Union, the 600MW sub-critical steam turbine technology of Westinghouse, the 600MW super-critical steam turbine design and manufacturing technology of Mitsubishi, and gas turbine technology of GE.

(3) Dongfang Turbine Co., Ltd.

Dongfang Turbine Co., Ltd. is a wholly owned subsidiary of Dongfang Electric Co., Ltd. which is a listed company, and is the former Dongfang Steam Turbine Works, located in Hanwang Town of Mianzhu city, Deyang, Sichuan Province. Dongfang Steam Turbine Works was one of the national third-line enterprises jointly supported and established by Harbin Steam Turbine Works, Shanghai Steam Turbine Works and Shanghai Boiler Research Institute in 1965. Started in 1966, its first 75MW steam turbine was produced in 1971, and it got the national basic construction acceptance in 1974. At the beginning of 1980s, it developed the domestic 300MWsteam turbine by itself, and it jointly developed the 600MWsub-critical steam turbine with Hitachi in 1990s. In 2000, it completed the Ling'ao nuclear power steam turbine's subcontracted manufacturing and turbine assembly of France' Alstom. And later, it introduced Hitachi's 600MW super-critical steam turbine technology. In 2003, it started to develop 1000MW ultra-super-critical units. At the beginning of 2003, the gas turbine consortium between Dongfang Steam Turbine Works and Mitsubishi won a bid, and it started to introduce Mitsubishi F heavy-duty gas turbine technology and established a gas turbine joint venture company. In the Chinese power equipment market's gloomy period from 1998 to 2002, DTC undertook the steam turbines' subcontracted parts manufacturing from GE, Hitachi, Toshiba and other large multinational companies.

The economic operation data of the three major steam turbine manufacturers in the recent nine years are given in Table 4-4.

Table 4-4 Three Large Steam Turbine Manufacture Enterprises in China
(Unit: ten thousand Yuan)

	Enterprise	Year 2002	Year 2003	Year 2004	Year 2005	Year 2006	Year 2007	Year 2008	Year 2009	Year 2010
Total industry output value	Shanghai Turbine Co., Ltd.	90527	162888	236995	544789	823589	753913	620299	591348	610047
	Dongfang Turbine Co., Ltd.	99769	152696	302256	601270	1007520	1122000	1084525	1674709	1922155
	Harbin Turbine Co., Ltd.	69015	116392	378822	693648	614036	704774	794575	633465	640427
Industry value added	Shanghai Turbine Co., Ltd.	17629	43426	59790	137027	123044	152669	187624	131280	106006
	Dongfang Turbine Co., Ltd.	34452	53454	91458	204767	321761	346200	175266	260013	285838
	Harbin Turbine Co., Ltd.	11689	34261	89848	213956	138158	129588	130740	106443	119195
Main business revenue	Shanghai Turbine Co., Ltd.	94711	133099	221858	427373	591126	822346	740054	637043	646102
	Dongfang Turbine Co., Ltd.	98317	164198	248493	508505	659323	1126400	885926	1231779	1570252
	Harbin Turbine Co., Ltd.	66591	97461	268403	416793	794066	717399	768797	635481	618967
Total profits	Shanghai Turbine Co., Ltd.	-10458	10496	41226.5	93741	72258	75155	81257	31076	17197
	Dongfang Turbine Co., Ltd.	662	5000	26205	105000	107759	139600	-99320	70451	76533
	Harbin Turbine Co., Ltd.	266	394	5090	25158	31405	40684	41493	24012	4078

The data are from DTC's Planning and Project Department.

4.3.3 The Composition of Steam Turbine Value Chain

In combination with the above analysis, steam turbine value chain and the relationship of the above industry value chain are shown in Figure 4-6. This relationship also reflects the relationship among the industries and the influence factors of industry development.

The analysis of steam turbine value chain can be divided into several levels. The first level is the value division in the scope of industry. In the global steam turbine industry, some enterprises' business (such as GE, Siemens, Hitachi, Alston) focus in technology R&D and technology transfer, occupy the high-end industry, and sublet manufacturing business to other countries' manufacturers. This thesis calls these enterprises as technology-centering enterprises. Some other enterprises mainly concentrate in manufacturing, gain competitive advantages by manufacturing capacity based on introducing and absorbing the advanced technologies. And this thesis calls these enterprises as manufacturing-centering enterprises. However, even focusing on manufacturing, these enterprises pay more attention to the technology now, such as Chinese three large turbine manufacturers. Otherwise, there are a number of small enterprises mainly doing the business of some products' subcontracting, providing the raw materials or intermediate products for key enterprises, and barely R&D. This thesis calls them the auxiliary enterprises. These three kinds of enterprises' characteristics are summarized in Table 4-5.

Figure 4-6 The Relationship of several Value Chains

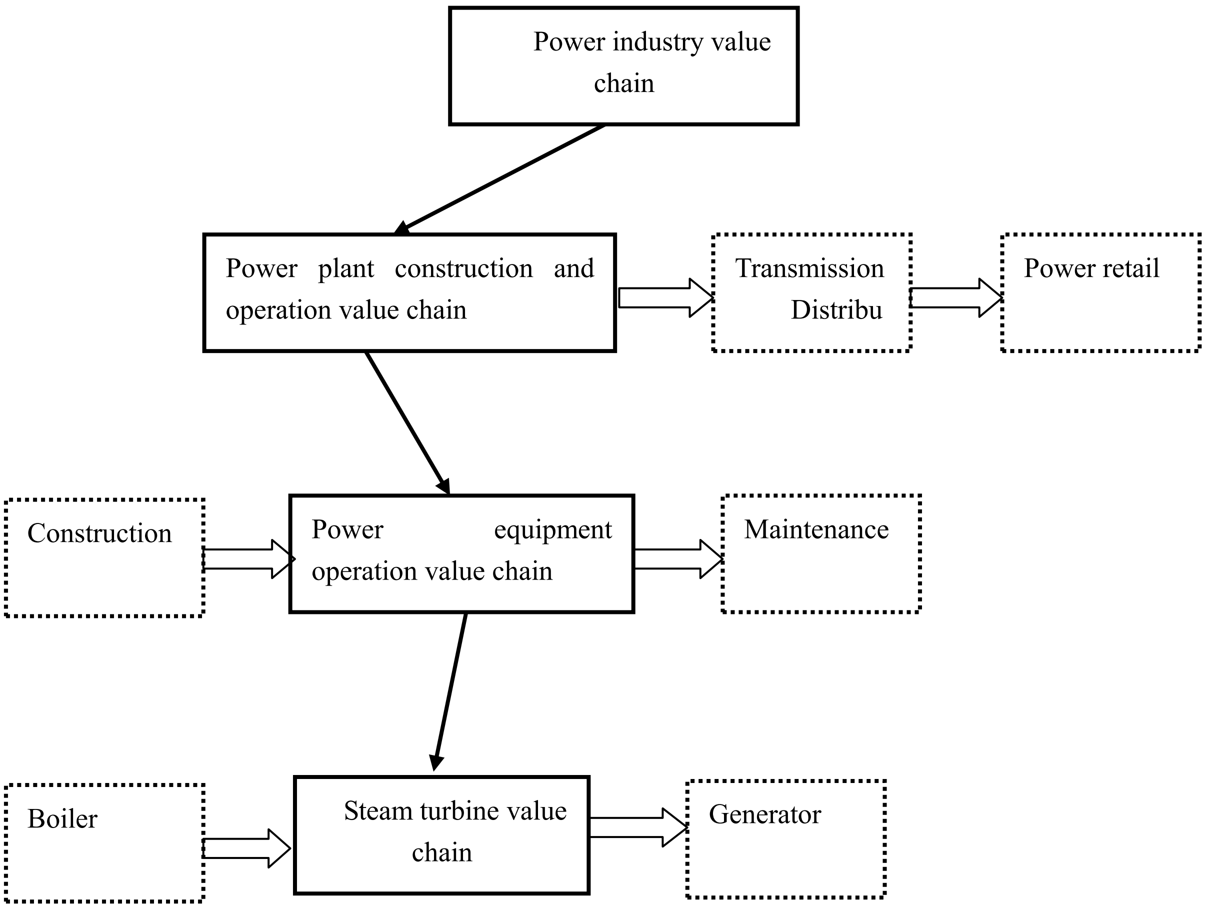


Table 4-5 The Comparison of Different Kinds of Steam Turbine Manufacturers

Type	Character				Typical Ones	Competitiveness
	R&D	Manufacture	Service	Market		
Technology centering	Advanced technology, having industrial core-technology	Global sourcing, core-component processing and unit assembly	Technical consultation and the service value from spare parts monopoly is equal to or even over the manufacture value	Facing to global market and transferring to the developing countries' markets because of the saturated developed countries' markets	Siemens, GE, Hitachi, Mitsubishi, Alston and Toshiba	Very strong
Manufacture Centering	Technology developing to grasp the whole set advanced technology	Powerful manufacture capacity, completing most components inside its factory	Open service market, but having the relatively low industrialization	Concentrating on the domestic market, exploring the oversea markets for its low cost from the manufacture and having a large potential market space	Dongfang Turbine Co., Ltd, Shanghai Turbine Co., Ltd and Harbin Turbine Co., Ltd	Strong
Auxiliary	Only available to manufacture based on drawings	As the supplier for the whole unit manufacture workshop, doing the out sourcing	Mostly having none service	Small market space and restricted by the whole unit manufacture workshops	China Heavy I, China HeavyII, Wuxi Blade Factory	Weak

What are the above three kinds of enterprises performance in the industry? Undoubtedly, an enterprise relying on advanced technology can obtain more added values and guide the direction of industry development. But in fact, considering the actual situation and trend of thermal power market, manufacturing-centering enterprises obtain the better performance. It should be specifically analyzed from the Chinese background and industry characteristics. Steam turbine industry is relatively mature. Under the existing paradigm, the products and technology develop slowly, and have entered in a mature industry period. As a result, the key competitive elements are not only technology, but manufacturing, price and other sectors. For example, the Chinese enterprises have no difference with foreign enterprises on key technology absorption and manufacturing promotion. Furthermore, driven by Chinese economy, these Chinese enterprises have more extensive markets as well as materials and human resources. So they can provide products and services with low-price and high-performance. On the opposite, the technology and manufacturing capacity of auxiliary enterprises are relatively weak, so their added value is lower than that of the other two types.

Therefore, from the steam turbine industry value chain division, the technology-centering enterprises have the highest added value, while the manufacturing-centering enterprises have the best performance. It brings a new consideration to the Smiling Curve: Is the manufacturing sector is really weak? Obviously, it cannot be concluded from industry practice of steam turbine that manufacturing value chain has huge potential to discover.

The analysis on the second level of the steam turbine value chain is mainly about the consideration of manufacturing value. Based on the steam turbine manufacturing process, the relevant value activities can be divided into order acquisition, contract analysis (mainly for the special requirements of the customers), product design and processing technique, manufacturing preparation, manufacture, assembly and testing, transportation and acceptance. In the manufacturing sector, it can also be divided into casting, forging, welding, finishing and assembly. (Figure 4-7). Among these activities, the manufacturing activity with advanced equipment and high technology has more value. Such as in finish machining sector, the manufacturing cost and relative value is higher than others.

The analysis on the third level of the steam turbine value chain is mainly about the value of the key components based on the products in order to confirm the key points of manufacturing work. This analysis will be done in Chapter 5 in combination with Dongfang Turbine’s operation data. Generally, the relative value sequence of each component is as follows:

1) Rotor manufacturing, blade processing (geometry precision, streamline shape, intelligent control, reflecting the key manufacture technology)

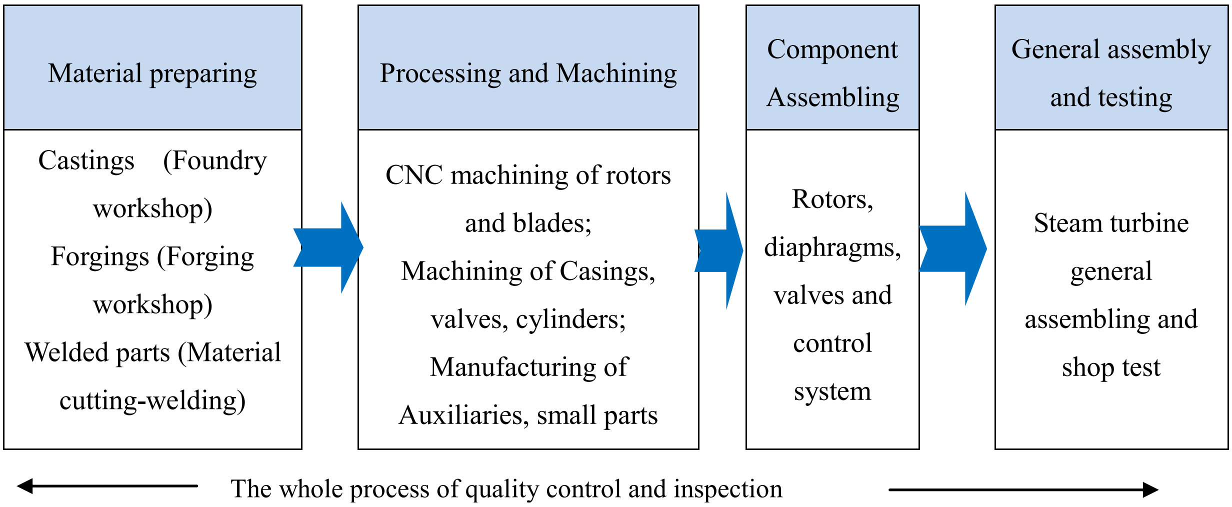
2) Large stationery parts: casing, diaphragm, tank and nozzles.

3) Bearings: journal bearings, thrust bearings.

4) Valves

5) Auxiliary equipment manufacture: supporting pipeline system, LP heaters, condensers and water boxes.

Figure 4-7 Main Manufacturing Sectors of Steam Turbine



The following can be concluded from the discussions above in this thesis.

(1) The good behavior of Chinese economy has brought the prosperous development of power market; and electric power market development further stimulates the increase of the demand of power generation equipment. In long-term perspective, coal-fired thermal power industry still has some developing space.

(2) The relationship of power industry, power generation equipment industry and steam turbine industry demonstrates the relevant development and influence factors among them. Based on the practical situation of Chinese market, these industries have their own specific characteristics, needing specific analysis under the Chinese background.

(3) Steam turbine is the core-equipment of the power generation unit in a power plant, and its value chain analysis should base on various aspects. Especially,

through the introduction of relevant manufacturers, we believe that manufacturing enterprises play a very important role in the power generation equipment industry and the overall performance of Chinese enterprises is outstanding. As a result, it is necessary to specifically analyze the power generation equipment (steam turbine) manufacturing value chain.

Chapter 5: The research of DTC's Manufacturing Value Chain

The above chapters analyzed the value chain of power generation equipment industry, especially that of steam turbine industry. Such analysis described the fundamental characteristics and the competitive situation of the industry. On the other hand, the analysis also constructed the basic form of the value chain, especially in the key value activities. The above analysis demonstrates that manufacturing industry is not a "sunset" industry, and it is worthy to pay much attention to the practice and theoretical study. In combination with DTC's business development, this chapter analyzes the management practice experience of DTC's manufacturing value chain under the background that the industry is in constant change. In the studying, we review many of DTC's historical data files, documents and conduct many times of investigations and interviews.

5.1 DTC's Development

DTC, as the research object of this thesis, has not yet been comprehensively introduced. Based on the unique national conditions of transitional economy and market-oriented reform, this thesis makes a brief description of DTC's development. First we will carry out the introduction of the company's basic status, and then we will retrospect the critical events in the company's development history.

5.1.1 DTC's Basic Situation

Dongfang Turbine Co., Ltd. (referred to as "DTC" in this thesis) is the succeeding company of the former Dongfang Steam Turbine Works, and is affiliated to Dongfang Electric Corporation. DTC construction was planned in 1965; its formal construction was begun in 1966 and was put into production in 1974. It is a large state-owned high-tech enterprise specialized in research, design and manufacturing of power generation equipment in China. DTC is one of the Top 100 Enterprises in Chinese machinery industry and one of the three bases which manufacturer turbines in China.

The company's original site was in a remote town of Hanwang, Mianzhu County, Sichuan Province. Generations of the staffs worked hard there for more than 40 years. Because of the limited and special geographical location, a corporate culture that the staffs take the company as their homes was formed. As a result, they created an enterprise operation miracle of having no deficit in consecutive 43 years before the 2008 Wenchuan Earthquake and achieved the enterprise's sustainable development.

For many years, adhering to the enterprise tenet of "Green Power, Benefit Human Beings" and the product development strategy of "One Generation in Production, One Generation in Reserve, One Generation in R & D and One Generation in Conception", DTC has been actively carrying out independent innovation of the technology. It constantly releases new products to meet the market demand, and vigorously implements the strategy of developing diversified power products simultaneously such as coal-fired power, nuclear power, wind power, gas power and solar energy. Its products' quality has reached the contemporary international advanced level, and the products extend to the industry sectors of marine turbines, chemical industry, automatic control, environmental protection, surface engineering, transportation, sea water desalination. After 40 years' diligent work and entrepreneurship development, DTC's core manufacturing capacity reaches 28GW, and its annual turnover and sales income are more than 20 billion RMB. Over 1000 units of various power plant equipment has been produced, with an installed capacity of over 200GW. Its steam turbine products take over the share ratio of 30% in Chinese market, and spread all over the country in 27 provinces in China and are in operation in many countries in the world as well.

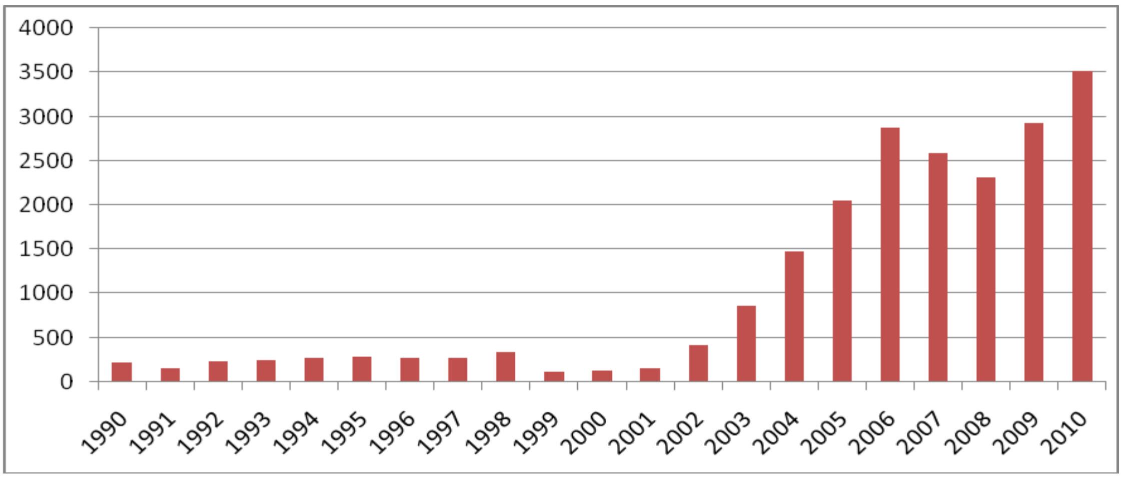
Wenchuan Earthquake in 2008 brought an unprecedented loss to DTC. In line with the sustainable development and the scientific reconstruction principle, the company's new base located in Bajiao, Deyang was put into operation in 2010, and the company's development entered into a new chapter.

Figure 5-1, 5-2, and 5-3 present DTC's 20 years' business performance. In the production output value, the company produced various power generation equipment of 35GW in 2010, which is 15 times of that in 1990. The company's overall production sizes in the recent five years have been maintained more than 25GW. In the sales revenue, the company's income in 2010 was 15.5 billion RMB, which was 82 times of that in 1990 and 20 times of that in 2000. In profits, the company's profits in 2010 were 2500 times of that in 1990. These data indicate that the company has been paying more attention to the production efficiency when the production capacity is increasing. The added value of unit product shows the trend of increase.

It is worth noting that the company's profits in 2008 appeared a deficit of 1 billion RMB. But this deficit was not due to the enterprise operation. Wenchuan Earthquake in 2008 caused an unprecedented disaster to the company, and led to a loss in finance. In addition, from the relevant data, the company's all economic indexes have maintained rapid growth since 2003. Such rapid growth is the result of the excellent industrial development prospect and high market demand, and it is also benefited from the company's unceasingly enhancing ability in business expansion.

With many years' hard working, DTC achieves a good performance in nuclear power equipment, ultra super-critical col-fired power units. With forty years' continuous efforts, DTC has made great contribution to the development of Chinese power industry, and has been providing an important support to the rapid development of Chinese national economy.

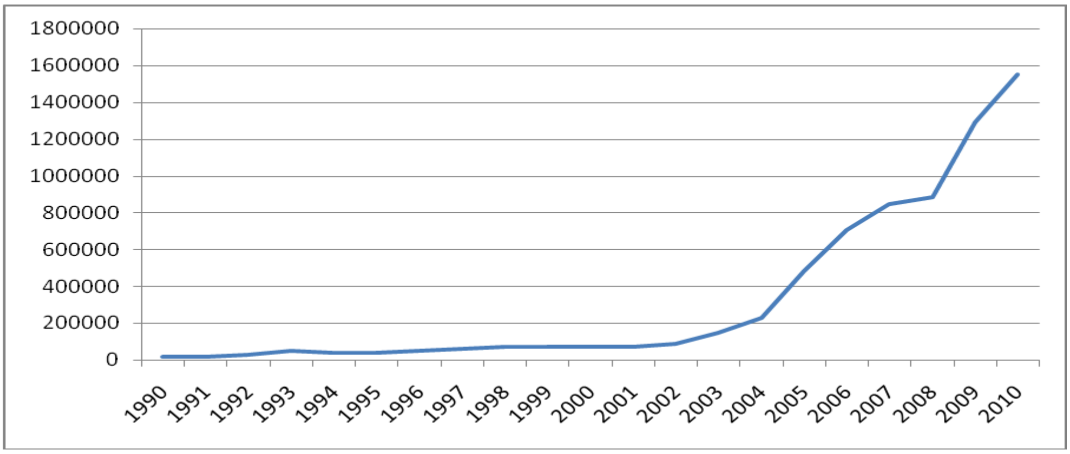
Figure 5-1 Output Value of DTC's Main Products



Come from DTC's internal statistics.

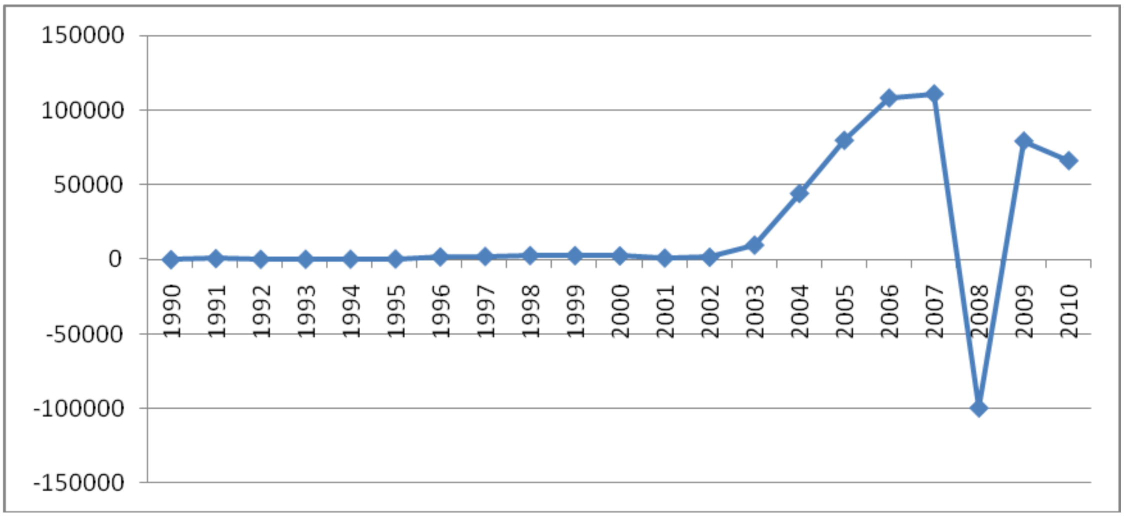
Figure 5-2 Sales Revenue of DTC

(Ten Thousand RMB)



Come *from DTC's internal statistics*

Figure 5-3 Profit Index of DTC
(Ten Thousand RMB)



Come from DTC's internal statistics.

5.1.2 Critical Events of the Company's Operation

DTC was established 45 years ago. According to its business fields, competition positions and development characteristic, this thesis is trying to divide its development into three stages from the establishment to the present, and important strategic choice was made in every stage by the company based on the industrial background and environment at that time.

The first stage is a stage when DTC mainly focusing on coal-fired steam turbines.

DTC is the last established one among the Chinese three major steam turbine companies. DTC produced its first steam turbine of 75 MW in 1971, and the steam turbine of 200 MW in 1975. The design & manufacturing of 300 MW class steam turbines is the landmark event in DTC development history. No matter whether in technology, in performance or in manufacturing capacity, 300MW-class steam turbine has higher requirements, and it needs more investment in the capital, manpower, and technology. At that time, China was still in the era of planned economy, and the enterprise’s autonomous right was limited. The country arranged the task of producing 300 MW-class steam turbine to Shanghai Steam Turbine Works and Harbin Steam Turbine Works, and both of them introduced the technology from outside China.

If DTC’s large-output power generation steam turbine technology was backward, it would mean that DTC would been driven from the frontline companies in China’s power generation equipment manufacturing industry. Therefore, it was extremely essential to master 300MW steam turbine technology, so DTC staffs decided to design and manufacture 300MW class steam turbines independently. Breaking through many difficulties, DTC’s 300MW class steam turbine was successfully put into operation in 1983, which is an important event in the company development history and also a turning point of DTC’s destiny. 300MW class steam turbine units which are continuous optimized, gradually become DTC’s main representative products from 1980s to 1990s, and they provide a series of subsequent products and services for the company. 300MW class steam turbine series products also have great significance to improve the company’s technical strength, promote the company’s manufacturing capacity and expand the company’s market.

In the 1990s, 600MW steam turbines gradually became the mainstream units in China. In order to meet the market demand faster, DTC introduced 600MW steam turbine technology from Hitachi, and co-designed and co-manufactured 600MW turbines with Hitachi. In 1996, the company’s first 600MW steam turbine unit was successfully put into commercial operation. The success of first 600MW steam turbine brought advanced technology, management, standards to DTC and also enhanced the company’s technology digestion and absorption ability.

Since then, DTC, by cooperating with Hitachi, continued its technology progress and manufacturing of large-output steam turbines. In 2006, the manufacturing of two units of 1000 MW ultra super-critical coal-fired steam turbines was completed. 1000MW class ultra super-critical thermal power generating units will become DTC's leading steam turbine products, and also the mainstream products of recent world thermal power plants. In coal-fired power field, DTC has caught up with the world's highest level of the technology development.

The second stage is from only manufacturing coal-fired steam turbines to manufacturing diversified power generation equipment.

In addition to the traditional coal-fired steam turbines, DTC has been continuously breaking through its own industrial layout to accommodate the change of power market. It not only consolidates the DTC's advantages in coal-fired steam turbines, but also does well in the other power generation equipment areas.

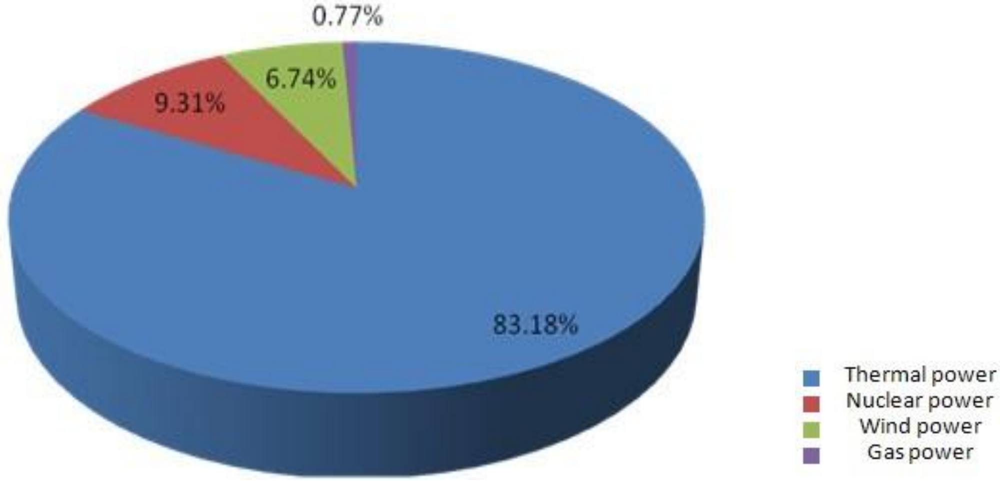
Gas turbines belong to efficient clean green energy, and gas turbines are new generation of widely-recognized efficient power generation equipment. The overall level of gas turbine R&D and manufacturing has become an important symbol of a country's industry technology level. Gas turbine is known as the "crown jewel of machinery manufacturing industry". In 2003, DTC introduced gas turbine technology from Mitsubishi, and in 2005, the shop test of Chinese first heavy-duty gas turbine with high localization rate was successfully done. At present, DTC's gas turbines are stably at the first in Chinese gas turbine market, and the localization rate reaches 67%. DTC owns the whole set of manufacturing capacity except the machining and testing ability of combustors and turbine blades, and the layout plan of China domestic manufacturing of hot path components has been completed.

In nuclear power field, two units of 1000 MW full-speed nuclear power units of Lingao Phase One Project whose contract was awarded to ALSTOM of France in 1997, and DTC did subcontracting for ALSTOM in component assembling and steam turbine unit general assembling. This marked that DTC began to enter into the nuclear power field. Through absorbing technology, the company set up a special project office responsible for nuclear business in 2005 which has been effectively promoting the nuclear power business development. In the supply of two units of 1000 MW full-speed nuclear power steam turbines of Lingao Phase Two Project, DTC became the main contractor for nuclear steam turbines, while ALSTOM was the subcontractor and only provided technical supports. These two units were put into operation successfully and achieved full-load commercial operation in 2010.As Chinese nuclear power policy changing from “proper development” to “active development”, Chinese nuclear power industry developed rapidly. Till June 2008, DTC had been awarded 16 units of 1000MW class nuclear steam turbine orders, taking more than 50% market share in China, and became the nuclear power steam turbine manufacturer which has the most China domestic orders.

Wind power is the DTC’s fastest growing business in recent years. When the coal-fired power generation equipment market was still in high demand in 2004, DTC began the wind power equipment technology introduction, absorption and innovation. In only one year, DTC’s wind power products officially entered the Chinese market. In 2007, among all DTC’s new orders, orders of wind power were more than those of coal-fired steam turbines. In 2008, the output of wind power equipment had exceeded that of power plant steam turbines, and wind power business became DTC’s major business. In 2010, the company produced 2370MW wind power generation equipment, being the top three in the Chinese market. Through the technology introduction of Germany’s Repower, DTC developed the 1.5 MW-class series units, and jointly designed and independently developed the units of 1 MW, 2 MW and 2.5 MW. It is now actively to carry out R & D of the wind power turbines over 3.5 MW.

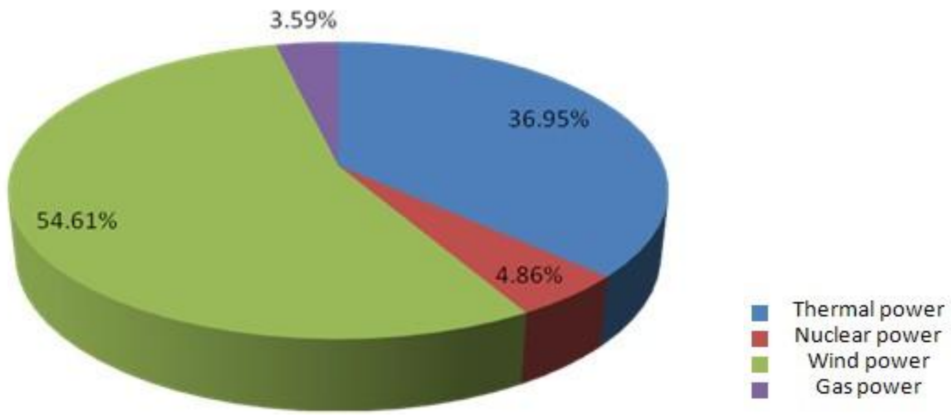
Figure 5-4 shows, from the production output, the company has transferred from single coal-fired power steam turbine to diversified products. Coal-fired steam turbines are still the main business, accounting for 83% of the whole output, and followed by nuclear power and wind power. From the specific output value Figure 5-5), wind power business revenue has exceeded 50%, followed by coal-fired steam turbine business, nuclear power business and gas turbine business. At present, the company’s product structure is still in the further optimization.

Figure 5-4 The Output Structure of DTC's Main Products



The data comes from DTC's internal statistics.

Figure 5-5 The Output Value Structure of DTC's Main Products



The data comes from DTC's internal statistics.

The third stage is the experience of the reconstruction and renascence after Wenchuan Earthquake.

On May 12, 2008, a massive earthquake destroyed DTC's Hanwang Production Base. The casualties, collapsed buildings, damaged equipment and the staffs' housing made DTC lose most of its production capacity and living conditions. The earthquake brought unprecedented economic loss to DTC, and the indirect loss was greater. On August 1, 2008, through scientific discussions, DTC's new production base's construction was begun in Bajiao, Deyang Economic Development Zone, occupying more than 430 acres of land area.

Chinese central government demanded the reconstruction should be completed in three years. On May 10, 2010, a DTC's new production base owning "First-class Technology, First-class Equipment, First-Class Management, and First-class Quality" located in Bajiao was put into production, and a new DTC was born whose layout optimized, test system complete, equipment level raised, industrial chain competitiveness strengthened. Less than two years, DTC successfully fulfilled the commitment of "Building a new DTC in two years", and converted itself into an internationally first-class steam turbine manufacturing enterprise. The unconventional "Dongfang Turbine Speed" and astonishing efficiency surprised the world peer enterprises such as GE, Mitsubishi, and achieved the amazing Oriental miracle.

Since the occurrence of the earthquake three years ago, thanks to the leadership of Chinese central government and the support of the community, DTC impressed the world with its cohesive power and influence, just less than one month after the earthquake, the recovery production began. Despite the disaster, DTC completed a record high of the 10.8 billion RMB production value in 2008. In 2009, it finished the production output value of 16.747 billion RMB, and greatly increased to 20 billion RMB in 2010. DTC was not struck down by the disaster, but developed itself in earthquake relief and recovery, and realized its new ascension.

5.2 The Manufacturing Value Chain Analysis of DTC's Coal-Fired Steam Turbines

The manufacturing value chain is the core link of the whole power generation equipment manufacturing value chain. Analyzing manufacturing value chain has great significance to optimize value chain, scientifically manage value activities and upgrade the enterprise's competitiveness. Therefore, this thesis will, in combination with the practice of DTC , further study the steam turbines' manufacturing value chain. This analysis includes two aspects. The first is that in steam turbine product structure, which is the largest amount of value or manufacturing value? And this decides the core link of the enterprise' production and management. The second is how to manage and optimize the current manufacturing value chain in order to improve efficiency as far as possible, which is related to the operation effect of manufacturing value chain and enterprise's competitive advantage.

The basic process of value chain analysis contains the following aspects:

(1) The recognition of value activities. One is to identify all activities related to the value in enterprise's business operation, and these activities chain concerning to value creation will form the enterprise's basic work chain; and the other is classification and integration of the work chain which is concerning to value creation by the function and importance, in order to establish the enterprise's overall value chain.

(2) The determination of value chain. The determination of value chain is made by the classification and integration of the enterprise's various activities related to value creation, according to the internal and external functions, manufacturing process flow and the importance.

(3) The analysis of value chain internal activities and mutual relations among the activity links. In this system, there are internal relations among various value activities and these relations generally can influence the change of one activity and cost volume by the change of another activity and cost volume.

(4) The value chain's "value-cost" analysis. The value chain's "value-cost" analysis is the key point of value chain analysis.

(5) The optimization of value chain. The optimization of value chain means that changing the arrangement of the enterprise's some activities by utilizing the connection inside the value chain's links and the connections among the various links, so as to reduce the cost of products and service, and to achieve the maximization of an enterprise's added value and meet the customer's requirements.

The above is the flow process of a complete value chain analysis. But due to the difficulties of basic data acquisition, for such complex products as steam turbines, it is hard to elaborate its value activities in detail and their "discrete machining-the whole machine manufacturing" pattern makes it difficult to measure the actual cost. Based on the data provided and collected in DTC, this thesis simply classifies the steam turbine's manufacturing value chain. And this classification is mainly based on the products' components, instead of value activities links.

According to the steam turbine units' cost breakdown data provided by DTC, taking a certain 300MW steam turbine for example, DTC divides the steam turbine product into 10 levels with 27826 parts in its internal accounting. The first level is the steam turbine, and the second level includes seven large modules. After the third level, the number is numerous and the basic relations are shown in Table 5-1 and Table 5-2. The upper level components contain the next lower level components, and for some components, they are not necessarily traced back to the last level.

Table 5-1 The List of Steam Turbine's Level One and Level Two Components (A 300MW Steam Turbine)

Code	Component	Level
D300N-77T	D300N-77T D300NM73, the second phase of the Fujian Longyan Pit Power Plant Project 2×300M	1
D300N-77TA1	D300N-77TA1 HIP module	2
D300N-77TC1	D300N-77TC1 LP module	2
D300N-77TD1	D300N-77TD1 Module Not Used in Shop General Assembling	2
D300N-77TE1	D300N-77TE1 HP Main Stop/Control Valve Module	2
D300N-77TF1	D300N-77TF1 IP combined valve module	2
D300N-77TD147	D300N-77TD147 auxiliaries module	2
D300N-77TDL	D300N-77TDL independent sub-component	2

The data come from DTC's internal statistics.

Table 5-2 Orders of Magnitude in Steam Turbine Components

(A 300MW Steam Turbine)

Level	1	2	3	4	5	6	7	8	9	10	total
Quantity of Components	1	7	125	2127	4063	6031	5499	3650	6305	18	27826

The data come from DTC's internal statistics.

In the concrete analysis, this thesis, taking the steam turbine products' complexity, research's feasibility and analysis difficulty into consideration, mainly focuses on the third level components. The third level has 125 components, and this thesis lists those whose costs are higher. In the steam turbine unit cost data, there mainly are costs, material fee, and labor cost. The cost is the total of the material cost and labor cost. The material cost refers to the price of raw materials or semi-products before entering into the company, while the labor cost includes the manufacturing cost, management cost, and staff cost. The amount of total cost can relatively reflect the content of the components' value, and the amount of labor cost can reflect the amount of manufacturing value. Table 5-3 and Table 5-4 respectively sort the third level component's' cost and labor cost of a 300MW steam turbine unit, and this thesis chooses those whose proportions are more than 1%.

After each unit's delivery, DTC will carry out output value interpretation. Its essence is to apportion the total value into each component based on the contract price interpretation, and then to apportion the total output value into each production shop based on the manufacturing flow so as to determine the workshop's workload and to check the completion conditions of their tasks. In the production output interpretation value table, nearly 300 components' specific values are listed, which is essential for our understanding of steam turbines' value structure. At the same time, because of steam turbines' production characteristics, the accurate values of many parts cannot be obtained. For the components which can be purchased in the market, they can be estimated by their market price, but for most components produced in the workshops, and their values can only be roughly calculate. The formulating basis and basic classification of production output value interpretation table is different from those of cost interpretation table, and the production output value interpretation table has more significance to this research.

Taking a 600 MW steam turbine for example, the first level output value interpretation is shown in Table 5-5.

It is clear that the proportion of the steam turbine proper's value is as much as 68%, and in further subdivision, the components whose proportion are more than 1% are shown in Table 5-6.

Table 5-3 The Sequence of the Third Level Components Based on Total Costs (A 300MW steam turbine)

Component	Cost ratio	Rank
D300N-77TC101-M1 LP rotor assembly	24.00%	1
M053-021000B HIP outer casing	9.15%	2
D300N-77TA101-M1 HIP rotor assembly	5.84%	3
M036-031000A LP outer casing	5.50%	4
D300N-77TC102-M1 LP diaphragm assembly	5.45%	5
D300N-77TD147-L2 pressure vessel (R catalogue)	4.80%	6
D300N-77TD147-L3 steam and water system (A catalogue)	3.90%	7
M036-032000A LP inner casing (left side layout	3.60%	8
D300N-77TA102-M1 HIP diaphragm assembly	3.55%	9
D300N-77TD147-L1 condenser (N catalogue)	3.51%	10
M206-261000B HP main stop/control valve	3.22%	11
D300N-77TD147-L4 oil system (F catalogue)	2.30%	12
M237-265000A IP combined valve (left and right)	2.26%	13
D300N-77TD109 auto-control system parts not used in general assembly	2.13%	14
M053-020000A HP inner casing	1.99%	15
D300N-690300AU Steam Turbine Proper spare parts	1.81%	16
D300N-291000A HP main steam piping	1.41%	17
D300N-198000C LP module base plate	1.09%	18

The data come from DTC's internal statistics.

Table 5-4 The Sequence of the Third Level Components Based on Labor Cost (A 300MW steam turbine)

Sets	Labor cost ratio	Rank
D300N-77TC101-M1 LP rotor assembly	23.57%	1
D300N-77TA101-M1 HIP rotor assembly	11.21%	2
D300N-77TC102-M1 LP diaphragm assembly	8.33%	3
D300N-77TA102-M1 HIP diaphragm assembly	7.05%	4
M036-031000A LP outer casing	6.52%	5
M206-261000B HP main stop/control valve	5.42%	6
M237-265000A IP combined valve (left and right)	4.64%	7
M036-032000A LP inner casing (left hand layout)	4.48%	8
D300N-77TD147-L2 pressure vessel (R catalogue)	3.92%	9
M053-021000B HIP outer casing	3.76%	10
D300N-198000C LP module base plate	3.70%	11
D300N-690300AU steam turbine proper spare parts	2.15%	12
M009-041000A nozzle chamber and nozzle partitions	1.79%	13
D300N-77TD141 HIP module parts not used in shop general assembly	1.35%	14

The data come from DTC's internal statistics.

Table 5-5 A 600MW Steam Turbine's Output Value Interpretation

Component	Value	Ratio
Turbine Proper	129403	67.97%
Auxiliaries	34060	17.89%
Control	7099	3.73%
Electrical Protection	3532	1.86%
Pressure vessels	5755	3.02%
Automation	2045	1.07%
Supplementary Order	1055	0.55%
General Assembling, Test and Painting	4480	2.35%
Others	2940	1.54%

The data come from DTC's internal statistics.

Table 5-6 The Production Output Value Construction of a 600MW Steam Turbine Proper

Sets	Ratio	Rank
HIP rotor (purchased from Hitachi)	5.25%	1
A LP rotor	3.68%	2
B LP rotor	3.68%	2
HIP outer casing	3.31%	4
A LP outer casing	2.27%	5
B LP outer casing	2.27%	5
The assembly of the 7th stage bucket in LP (steam turbine side)	2.20%	7
The assembly the 7th stage bucket in LP (generator side)	2.20%	7
IP combined valve(purchased from Hitachi)	1.92%	9
HP main stop/control valves	1.63%	10
A LP inner casing	1.40%	11
B LP inner casing	1.40%	11
The assembly of the 6th stage bucket in LP (steam turbine side)	1.37%	13
The assembly of the 6th stage bucket in LP (generator side)	1.37%	13
Cross-over pipe	1.33%	15
IP inner casing	1.31%	16
HP inner casing	1.17%	17

The data come from DTC's internal statistics.

According to the above logic, based on the investigation, a 1000 MW unit's value is analyzed and shown in Table 5-7 and Table 5-8.

For some core components such as blades in a 1000 MW steam turbine, their value takes 14.6% in the whole value chain of the steam turbine proper. But after specifically analyzing the blades, it can be found that there still are big differences among the values of different blades. There are 21 stages of blades, including low-pressure stages (totally 6 stages), intermediate-pressure stages (totally 6 stages), and high-pressure stages (totally 9 stages). Table 5-9 lists these blades and their value sequence. From the table, we can find that the low-pressure stages of blades are longer and they are difficult to produce. So they have greater value. For a single part, the value of lower pressure sixth stage blades is much higher than that of other parts, and it is the core part of the blades.

Table 5-7 The Output Value Decomposition of a 1000MW Steam Turbine

Component	Value	Ratio
Steam Turbine Proper	179888	62.20%
Condenser	38215	13.21%
Auxiliaries	21845	8.80%
Control	14930	5.16%
Pressure vessels	12080	4.18%
Assembling, test and painting	7100	2.45%
Others	6692	2.31%
Electrical protection	3220	1.11%
Automation	2860	0.99%
Supplementary Order	2400	0.83%

The data come from DTC's internal statistics.

Table 5-8 The Output Value Interpretation of a 1000MW Steam Turbine Proper

Component	Ratio	Rank
LP inner casing	5.25%	1
A LP rotor	3.68%	2
B LP rotor	3.68%	2
2# IP inner casing	3.31%	4
HP outer casing	2.27%	5
A LP outer casing	2.27%	5
B LP outer casing	2.20%	7
IP outer casing	2.20%	7
HP rotor	1.92%	9
IP rotor	1.63%	10
HP inner	1.40%	11
IP combined valve	1.40%	11
The assembly of the 6^{th} stage bucket in LP (generator side)	1.37%	13
The assembly drawing of the 6^{th} stage bucket in LP (steam turbine side	1.37%	13
1# IP inner casing	1.33%	15
HP main stop valve	1.31%	16
LP inlet steam chamber	1.17%	17
HP control valve	1.50%	18
Steam Guide	1.33%	19
Cross-over Pipe	1.31%	20

The data comes from DTC's internal statistics.

Table 5-9 The Value Construction of a 1000MW-class Steam Turbine's Blade

Component's Name	Value	Ratio
LP part (6 stages with 12 blades in all)	15360	58.5%
IP part (6 stages with 12 blades in all)	7200	14.1%
HP part (9 stages with 9 blades in all)	3700	27.4%
LP the 6th stage blade (quantity:2)	7520	28.6%
LP the 5th stage blade (quantity:2)	2440	9.3%

The data come from DTC's internal statistics.

By summarizing above analysis, the followings can be concluded:

(1)From the analysis of steam turbine product systematic structure, the steam turbine proper has the greatest value. Therefore, DTC should lay its stress on the steam turbine proper's production and management. For different MW class units, the components' value sequences are also different; For example, a condenser relative value is much higher in the higher MW class turbine units.

(2)From the specific components, their sequence in value chain is "rotors, cylinders, diaphragms, blades, condensers, main stop valves". The results of data analysis are basically consistent with our internal investigation into the company.

(3)For different units, the differences among the total value are large. But from the aspect of value distribution, except the condensers, the components' value sequence is basically same.

(4)Since there are many steam turbines classes and their structures are complex, the further analysis of specific components demonstrates that the components with different structures have big differences in their values too. The value of the sixth stage of low-pressure blades is much higher than others. Therefore, they need more refined analysis and management.

In addition to acquiring the value amounts in all departments, the analysis of manufacturing value chain also helps us focus the company's core competence and resources on the components which have the greatest values, and organize the production based on such focusing.

5.3 The Management of Manufacturing Value Chain

Manufacturing is the core activity link of power generation equipment industry chain. For power generation equipment enterprises, they should establish and improve their own manufacturing value chain, cultivate core competence, and participate in the international competition. Manufacturing capacity is a kind of system resultant force. This features of this capacity include the ability to extend and to integrate, and the resultant force is reflected in cost control ability, quality management ability, flexible production capacity, delivery ability, service ability and innovation ability (Cheng Qiaolian, 2009).These abilities should be embedded in the company's business activities, and be reflected in the company's daily management of manufacturing value chain. Therefore, this thesis analyzes the manufacturing processes and technical management, production and quality management, and value network management in DTC's manufacturing value chain one by one.

5.3.1 Manufacturing Process Layout and Technology Management

Manufacturing process layout determines the production line and the final production efficiency. In Hanwang Factory, before Wenchuan Earthquake, because the workshops were built around the mountains, the logistics was obstructed. The technological process was unscientific from the very beginning, and the equipment layout was unreasonable. For the manufacturing of one same part, sometimes it was transported into and out of many processes in several workshops, which increased the times of its lifting and transporting, reduced the whole production efficiency, and influences the progress of the production capacity. With the intensification of the contradiction between the production capacity and market demand, the problem of DTC's process flows being unscientific and unreasonable became more and more apparent. In addition, the yearly production output goal had been set to be 600 MW when the company was established, but the yearly production output had already achieved 4000 MW by the early years of this century. Along with the power market fast growth, DTC's core capacity has reached 28000 MW now. During this process, DTC has been continuously adjusting the manufacturing process flows, increasing the machining equipment, building new workshops and expanding the old ones to meet the need of the manufacturing output. But all these measures were modifications from the original basis, which led to the messy layout, the unsuitable process flow, large range of management and increased cost.

DTC new base's construction has completely eliminated the disadvantages of the original layout. Taking the turbo-machinery as the typical products, the production centralization principle of products and components was applied to work out the workshop and process layout. The production units of the general assembling center, large components machining center, diaphragm manufacturing center, blade manufacturing center, wind power division, turbine division were set up. The reasonable and centralized process flow layout is realized, the components have their clear internal flow processes and the management difficulty is reduced. In the overall process inside the factory, the general assembling workshop is taken as the center; on the basis of the factory's topographic features, the flow process requirements, and logistics characteristics, the southwest area of the factory is set to be raw material entrance and for the use of hot processing and raw material preparation, while the northeast is set to be general assembling and delivery area. In this way, a smooth logistics process from south to north and from west to east is formed. Such manufacturing process layout's adjustment and optimization also improves the company's value chain and makes the value activity more efficient.

Although there are no technical activities in the main chain of value chain, the technology is used as auxiliary activity which does not create value directly. But the technology innovation itself makes more and more contribution. In the power generation equipment industry, the manufacturing is still taken as the key at present, but the manufacturing industry's upgrading and technology performance enhancement have become the inevitable requirement. The application of the advanced technology and manufacturing mode in production and superior products' constantly entering the market have become an inevitable choice of the enterprise's management. Some top-class enterprises also constantly seek technology breakthroughs to lead the industrial direction. With the expansion of the company's capacity, the change of the products' structure, and the accumulation of the ability, DTC gradually strengthens the R&D activities in order to support its sustainable business. The company has formed a professional R&D center for steam turbines, wind power and industrial turbines, and it has separated the research and development team from production and technical preparation team to make the technological professionals focus their attention on R&D and to improve research & development efficiency. Taking R&D investment for example, the company's total R&D investment amount in the "Eleventh Five-year Plan" (2006~2010) was five times of that in the "Tenth Five-year Plan" (2001~2005), which is demonstrated in Table 5-10.

Table 5-10 The Patents and R&D investment of DTC in recent years

	2006	2007	2008	2009	2010
Patent application	20	29	30	36	43
Invention and patent application	12	17	26	31	37
Patent authorization	15	18	19	15	21
R&D investment (ten thousand Yuan)	14262	24509	35382	30791	47698

Source： DTC´s internal Statistics

In the coal-fired field, through the implementation of Innovation Project, DTC has the development and manufacturing ability from the small steam turbine units to 1000MW ultra supercritical steam turbines. In the wind power field, DTC has the development and manufacturing ability of series of wind power generating units. In the heavy-duty gas turbine field, the ratio of China locally-manufactured parts has reached 67%, and in the nuclear power field, DTC has the complete development and manufacturing ability of the second generation plus nuclear power units. In the future, DTC will formulate the R&D layout, taking the key projects and key products as the basis, cultivate and promote the independent innovation and R&D ability.

The integration of manufacturing and service is a new trend of manufacturing industry. The global economy is transforming from product economy to service economy, and manufacturing industry is also undergoing profound change. The manufacturing industry's operation mode is gradually shifting from the traditional mode of focusing on product manufacturing to the new one of providing customers with comprehensive service.

In fact, the boundary between manufacturing and service has gradually become fuzzy. Based on the value flow, products and services mutually connect and support each other. In the design and manufacturing links of the products, the added consumer service and extension products shall be taken into consideration and a series of related service programs should be provided. Manufacturing is leading, while service is complementary. The combination of the two further improves the products' value chain. The rebuilding of manufacturing enterprises' service value flow is a service management mode focusing on the customers, and by the connection between the internal factors and external products, its service value chain is constructed (Lin Guangping and Du Yifei, 2008). The value-added service given by the manufacturing industry shall take the value chain as the foundation, and the service is reflected in the entire production process.

Power plant service has two key points or two phases. The first key point task is to serve the users, which is also known as "priceless service". This task takes serving customers as the sole purpose. Even though there may be a certain profit in some projects, it does not take making profit as the purpose, but for having a good service to the customers. The second key point task is to create profits, which is also known as "paid service". Power plant service industry is an industry which uses less company's resources, has less risk, but creates huge profits. There are five basic businesses to create profits in the power plant service industry: unit/power plant technology retrofitting, spare parts, unit/power plant inspection and maintenance, routine maintenance/emergency repair, and power plant operation.

At present, the output value of DTC's power plant service accounts for only 4% of total output value, and it has a huge gap to the technological enterprises which have fully integrated manufacturing and service. This gap demonstrates that DTC is still in the manufacturing value-oriented stage. The company's service value is mainly reflected in the "priceless services" such as solving the quality problems, ensuring units' safe operation and meeting the performance standards, but they earn little.

The company has recognized the importance of integrating manufacturing and service, and has actively begun entering into the power plant service field. DTC not only provides follow-up services for its own units, but also for other manufacturers' units. DTC's service concept is to make customers feel satisfactory and assist the customers to succeed. The "24-hour service" originated by DTC has become Dongfang Electric Corporation's service brand, and the service content has been extended to "Life service, services in all aspects and whole process, and beforehand and extra-value service". Through providing services with site installation technical discussions, site installation surveillance, customers' training and manufacturer surveillance from customers in all-round way, and establishing a remote monitoring center for large steam turbines in order to monitor, collect and diagnose operation data, DTC tries its best to create the greatest value for the customers. With the increase of units which have been put into operation, DTC aims to further improve service system, promote service industry, and realize the integration of manufacturing and service to bring great profit value for the enterprise.

5.3.2 Production and Quality Management

The particularity of power generation equipment industry requires the products' safety and efficiency to be the basic premise, and the quality management is always the core work of the big major companies. DTC introduced the concept of "total quality control" in the last century, and set up the ISO9001 quality management system, nuclear power quality assurance system, measuring system, and GJB9001A defense products quality management system. The establishment, operation, and the successful certificate acquisition and recertification of these systems have been guaranteeing DTC product quality improvement, new products' development, Dongfang Turbine's brand building, and market exploration, and have been ensuring that DTC's products have excellent quality. The company always adheres to the manufacturing concept of "Continuous Improvement, for Creating High-quality Products", strengthens the quality improvement, and makes full use of DTC's first-class equipment and strong manufacturing capacity after reconstruction to supply first-class products and service to the customers.

In specific quality management, DTC strengthens the construction of quality management system, promotes quality management and control mode represented by nuclear power products. The strict manufacturing process discipline, strict product process control, strict incoming quality control of raw material, purchased parts and subcontracted parts, and strict delivery quality control of products' visual appearance and painting are carried out. Through continuous improving the quality, high-quality products are manufactured. The company strengthens the construction of export products quality control, strictly controls the products' quality during their production, and especially enhances the manufacturing and service quality control of export products to improve the products' reputation in China domestic and oversea markets.

Today's most advanced production mode is the lean production mode, which is originated in Japan in 1950s, known as Toyota Production System (TPS), and is adopted by European and American enterprises in the middle 1980s. It is the second generation of production mode based on the reformation of the first generation of American Ford vehicle assembling line manufacturing mode. Lean production thoughts lead the fundamental change of manufacturing enterprises' management concept, organization, people and the relationships, which is known as the second management revolution. Its five basic principles are determining the value from the end users' view, identifying each product family's value flow, making the products move, pulling the enterprise's business by customers, and making the whole enterprise's operation perfect. It has achieved the purpose of shortening the production cycle, reducing inventory and rejection rate, and ensuring the safety at production sites.

Through the introduction of lean thoughts, DTC promotes the change of production management mode. It further optimizes the production management organization, strengthens the communication and coordination between the production system and various industries, increases the production efficiency, guarantees the production schedule and the product quality, and reduces consumption and production costs. Relying on information platform, the company continuously further promotes ERP/PLM system, achieves its evaluation and control based on MRP plan. It continuously improves production and refines manufacturing through the sits' 5S management, equipment management, continuous process optimization and reorganization, and work standardization to ensure realizing the production plan and satisfying delivery demands. Through optimization of management mode, the unit output is rising in successive years. In 2011, it is over 40000 MW, and the workers' number which is needed in getting the unit output is from 1.97 at the end of 2005 to 1.17 at the end of 2010, reducing 25%. The typical product's production cycle shortens more than 50%. Introducing and applying ERP, MRP, PLM, and CAPP information system, making process clear, speeding up the physical distribution efficiency, reducing inventory and process loss laid a solid foundation for realizing just-in-time production management objectives.

5.3.3 The Management of Manufacturing Value Network

In Chapter 2, the relevant literatures described the extension direction of value chain. An enterprise's value activities are not a single enterprise's activities, but the participation of many enterprises into the product development, design and manufacturing. Therefore, the enterprise's activities are in a certain value network. Different enterprise has the different status in the network, and such status shapes the enterprise's influence and competitiveness.

Steam turbines are of complex structure, difficult manufacturing, and long manufacturing cycle. In DTC, a manufacturing value network with the company itself as the core has formed during the long-term operation. The network contains its suppliers, some key components' providers, and some subcontracted manufacturers. Around the network, there are some supports from all parties in other value activities. Through the manufacturing network, DTC can carry out production quickly and achieve the faster reaction ability than that of its competitors.

Outsourcing is a mode widely used in manufacturing value network. It means the action that by using its professional labor-division advantages, the enterprise entrusts some part of its daily business to the outside professional service institutions or economic institutions for completing the business. The purposes include but do not limit to improving production capability, supplementing business, saving cost and reducing risk. In recent years, with the rapid increase of DTC's output year after year and its continuous technology level improvement, in the principle of keeping its core business activities, DTC continues to extend the outsourcing business. Besides the traditional business of property management, customer service and equipment inspection & maintenance, DTC further increases the technical cooperation and outsourcing. Especially the some manufacturing processes' outsourcing has become an important part of DTC's production network. With the expansion of the company's business scale and the upgrading of the enterprise's competitive status, more and more enterprises have begun providing their external service for DTC.

DTC has established the standardized management for outsourcing. First of all, outsourcing parts are classified in levels for determining which parts are to be outsourced. The importance the parts and components is judged by the above analysis of manufacturing value. Table 5-11 shows that outsourced parts are categorized into strategic level, key level and ordinary outsourcing level, and the specific guidelines are formulated. Secondly, the outsourcing procedures are designed. Because DTC's outsourcing manufacturers are numerous and every branch factory has certain autonomy, DTC intensifies the outsourcing procedures by the company's regulations. Finally, the management of outsourcing suppliers is strengthened so as to assist them adapt to DTC's production network and provide better supporting services. By outsourcing, the company can focus the advanced resources on the key activity links, which is helpful to enhance the core competitiveness of the company itself.

Table 5-11 DTC's Manufacturing Business Classification and Outsourcing Strategy

Outsourcing level	Outsourcing reason	Relationship with supplier	Outsourcing feature	Acquisition Way	Specific Component Example
Strategy outsourcing	Outstand the core competitiveness, Reduce non-core business maintenance cost and disperse operation risk to meet the design modular requirement and increase market influence.	Strategic cooperation for win-win, share profits and risk, coordinate and penetrate	The future is foreseeable, the strategic cooperation partners, the optimized development programming, commitment to stand out their competitive advantages	Partner relationship, long-term cooperation	Rotor machining, bucket and gas turbine components
Key outsourcing	Non-strategic components, improve producing progress, meet the market demand change and reduce cost	Competition and cooperation, relative stable, negotiation and coordination	Cooperation consciousness strengthening, short-term feature and limited quality improvement, less investment, relative quantity stability, lack of effective development plan	Ensuring supply	Outer casing machining, condensers and valves
Ordinary outsourcing	Temporary needs	No coordination, traditional and temporary	Little possibility to cooperate again, unstable outsourcing quantity, less investment, high outsourcing cost, less quality improvement	Bidding	Ordinary components, bearing boxes, base plates, auxiliaries

Source： DTC´s internal Statistics

DTC's manufacturing value network is mainly reflected in the manufacturing process subcontracting. The company's Production and Cooperation Department takes the charge of subcontracting management. The main components whose manufacturing processes can be subcontracted are the commonly low value-added components, excluding gas turbine, nuclear power, over 600MW and over ultra supercritical coal-fired steam turbines' rotor machining, long blades, high and intermediate casings. The supplier accessing mechanism and dynamic evaluation system is set up to enlist the qualified supplier according to its merits by the means of bidding in the principle of being fair, open and just. The technical factors such as the supplier's equipment, technology, quality and the commercial factors such as delivery time and price should be taken into consideration. In the subcontracting implementation process, it is a compulsory practice to formulate the inspection & test plan, to strengthen quality control and incoming inspection, and ensure the subcontracted products' quality. Through the implementation of manufacturing process' subcontracting management, DTC makes full use of social resources, reduces the manufacturing cost, focuses the core business and meets the products' delivery requirements.

The company itself has the strict rules for outsourcing. For nuclear power turbines, gas turbines, defense products and export coal-fired units, they should be basically internally manufactured; the key components relating to the units' performance should be internally manufactured. The responsible department can apply for additional and temporary subcontracting due to resource shortage, equipment trouble or other uncertain factors.

In the entire manufacturing value network, DTC occupies the core position. It is reflected in the company's control of the whole value network's points, chains and network. The "points" refers to the company's advantages in the key value activities and manufacturing sectors, such as rotor machining and general assembling, which are also the company's core manufacturing capacity. The "chains" mainly refers to the company's process flow control of steam turbines from the getting the orders to the production and final delivery, and only a few manufacturers have such ability now. The network control is reflected in the company's control over the entire value network by employing its internal and external resources to serve the manufacturing of steam turbines. For example, after the Wenchuan Earthquake, most of DTC's production capability guarantee was provided by its manufacturing value network. The control of manufacturing value's points, chains, and network are finally shown the company's core status in the industry chain, its driving force to the related enterprises, its promotion in the industry development and industry cluster, and its providing the supports for regional economic development. Deyang, where DTC is located has become an important equipment industrial base of China.

DTC's manufacturing value's ascension is based on the comprehensive management and promotion of value network. Therefore, DTC takes some targeted management measures, which are shown in Table 5-12.

Table 5-12 The Relevant Management Measures of DTC's Manufacturing Value Chain

Variable Category	Variable Names	Description
Technology R&D	Products' strategy	Setting up the products' strategy based on market demand, taking the manufacturing technology, and leading the market.
	Research system	Improving the scientific research system covering project management, staff training, salary stipulation mechanism and technology utilizations
	R&D platform	R&D platform which is of high efficiency, collaborative and open, parallel development, coordinated evaluation, verification testing
	Method and Means	Using the advanced simulation software tools, teat equipment to promote achieving R&D goals
The management of supply chain	Suppliers' management	suppliers' accessing mechanism and dynamic management according to the results of assessment
	Strategic supplier	Mutual trust and mutual benefit with suppliers, and cultivating the sustainable partners
	Electronic business	Promoting plan and purchase, storage and logistics, the management of information and cash flow to realize seamless interfacing
The enterprise's management	Strategic management	Focusing on the enterprise development strategy's planning, interpretation, implementation, evaluation, adjustment to guide the enterprise's sustainable development
	Human resource	Enrolling the suitable talents, completing their professional career planning and human resource development, establishing perfect and effective stipulation mechanism, establishing reasonable talent structure to enhance the enterprise's core competitiveness
	Business flow process	Optimizing business management process, making duty division clear, strengthening the system construction to improve business efficiency and operation efficiency
	Organization structure	Establishing the reasonable organization structure according to the company's developing requirements, realizing the necessary centralization and decentralization to make the organization become flexible and scientific
	Excellent Working Achievement	Establishing the fine and overall working achievement management mode to stimulating the vitality of the enterprise and the staff's working enthusiasm
Variable Category	Variable Names	Description

Lean production	Plan management	Implementing the clear and strict management pattern, to improve the products' timely delivery
	Standardized operation	Establishing the standardized work instructions to ensure the stability of the operation time and products' quality in manufacturing process
	JIT production	Promoting the optimization of production time, cost, the timeliness of the supportive work, and using the continuous manufacturing mode to improve the resource turnover rate and utilization efficiency
	Information construction	Relying on ERP information platform to plan the production resources, improve production efficiency and shorten the delivery time.
	Advanced manufacturing technology	Making the high efficient and low cost machining technology to improving the products' completion efficiency
Lean production	Job Sites' 5S management	Ensuring the safety of the job sites and guaranteeing the efficient manufacturing process
	Visible production	Strengthening the whiteboard management at job sites to making the obligation, goal, plan and instruction clearly visible, eliminating waste and reducing harm
Quality control	Total quality control	Make IS09000 quality system's operation effective, adequate and appropriate to improve the customers' satisfaction
	Quality improving activities	Using QC or 6singma to solving multiple and stubborn quality problems
	Quality honesty system	Establishing the quality honesty system to enhance the staff's quality awareness and promote active quality management
Production capacity upgrading and maintenance	Equipment Upgrading	Investing the more advanced equipment or modifying the existing equipment to meet the quality and delivery requirements
	Equipment maintenance	Implementing the TPM (total capacity maintenance) and equipment categorized maintenance to establish the planned equipment maintenance system focusing on precautions

5.4 The Manufacturing Value Discussion of the Other Power Generation Fields

The enterprises' core competitiveness can be extended, and the enterprises can arrange various businesses around it. DTC's business extension from the steam turbines to the other power generation areas is just based on the manufacturing value chain's diversification development strategy.

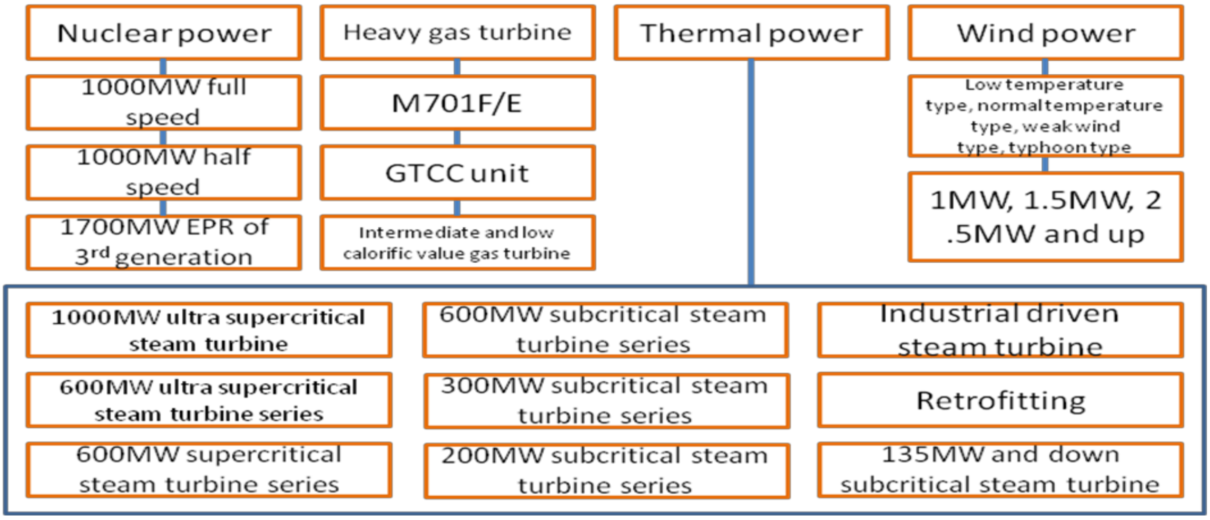
After decades' of development, DTC keeps the leading competitive position in the traditional business, and its resources such as the talents, technology, manufacturing capacity, market channels and brands which have been accumulated in the power plant steam turbine field, and the competence basis, can further develop its production scale effect and wide-scope economies. So, DTC selected the fields of gas turbines, nuclear power, wind power and solar energy and it has changed from a single power plant steam turbine manufacturing enterprise to a large diversified manufacture enterprise of for the equipment used in thermal power (coal), gas turbine (gas power), nuclear power, wind power and solar energy simultaneously, and it also engaged itself in other new industries such as seawater desalination.

On the basis of its success in the thermal power industry, though absorbing the advanced technology, increasing the manufacturing capacity, promoting the product's and industrial structure adjustment, DTC has formed the industrial layout of developing various power products simultaneously such as coal-fired power, nuclear power, gas power, wind power and new energy in the past few years.

In the nuclear power field, DTC has mastered the key components' manufacturing technologies such as that of nuclear power turbine blades, nuclear power turbine rotors and nuclear power steam turbine low-pressure weld rotor. Through carious efforts, it owns the mass manufacturing capacity of nuclear power steam turbines. DTC is the only Chinese domestic enterprise having 1000MW class nuclear power turbine manufacturing and operation experience, and its products include the second generation plus and the third generation nuclear power turbines, taking the top position in Chinese market share.

By the end of 2010, DTC had formed a relatively complete gas turbine manufacturing layout. The China localized manufacturing rate of the company's gas turbines is at the top in China, and 14 units of gas turbines have been put into operation by now.

Figure 5-6 The Main Products of DTC



Since entering the wind power field in 2004, DTC's wind power business has exceeded 10 billion RMB and takes half of the company's revenues. The market share in China has lent to the top three in china from the null. Till 2010, DTC had produced 4449 wind power turbines with 6689.5MW output.

In DTC's extension process to diversified products', the original manufacturing capacity and manufacturing value chain played a crucial role. The company has the advanced production equipment, experienced R&D staff, good customer relationships, and perfect manufacturing value network. All of these have been creating good conditions for the follow-up products, and also they are also the deep development based on the original manufacturing value chain.

Chapter 6: Conclusion and Prospects

This thesis analyzed the Chinese power generation equipment manufacturing value chain in detail, and the research gives inspirations to Chinese manufacturing enterprises' value chain analysis and their manufacturing value chain management. Major research conclusions are reached and it also provides some further studying space.

6.1 Conclusions

In combination with the actual background and the enterprises' business operation practice in Chinese industries, through large amount of data analysis, induction and deduction, and using the case study method, the followings have been conducted in this thesis.

First of all, the description and analysis of the basic competitive situation and the basic value chain structure of Chinese power industry, power generation equipment industry and steam turbine industry have formed a value chain which is in line with Chinese industry situation.

Secondly, we selected the typical products of a typical enterprise and analyzed the key links, key value activities and key components of steam turbine's manufacturing value chain and had the knowledge of the key points to which great attention should be paid in manufacturing value chain.

Finally, in accordance with the above value chain analysis, we made a general description and analysis to the manufacturing value chain's upgrading in the aspects of technical innovation, manufacturing technology layout optimization, production and quality management, and the management of manufacturing value network.

The analysis in this thesis is based on the logic of "value structure--value analysis--value positioning--value management" which has wide representativeness and universalism.

Through the research, we can draw the following conclusions:

Firstly, this thesis shows the limitations of the Smiling Curve by studying power generation equipment industry. Smiling Curve believes that the ends of value chain (R&D and sales) have the higher value, but it has its applicable boundary. This thesis argues that this theory apply in the industries which own the obvious integration characteristics. In particular, through analysis, this thesis believes that manufacturing value chain is the core of power generation equipment industry.

Secondly, this thesis established the analytical structure of manufacturing value chain, and based on this structure, we analyzed the manufacturing value chain of power generation equipment (mainly, steam turbines) systematically. This thesis listed several key components which have highest value.

Finally, because the importance of the manufacturing value chain, it is necessary to intensify the management of business sectors which are highly related to the value chain (R&D, production and quality) to improve the overall efficiency of manufacturing value.

6.2 Issues Needing Further Study

Limited by the boundary of the research issues, this thesis cannot make all the issues clear. Although some creative work is reflected in the thesis, many issues still need further research.

First is the propagation of this thesis's conclusion. This thesis only took power generation equipment industry as the example, and pointed out the limitation of the Smiling Curve's and the importance of manufacturing value chain through case study. We are sure that all equipment manufacturing industries which have the similar characteristics with power generation equipment industry shall also support this thesis' conclusions. But to which industries can this conclusion apply? This is a question needing further research.

Second is that the research of manufacturing value chain's management needs more comprehensive and in-depth study. This thesis only briefly mentions some practice on the technological R&D, production and operation, quality management and network management. In fact, not just in the above aspects, the research of the specific manufacturing value network management should have broader space. For example, how to combine manufacturing and service? How to reflect technology's contribution in manufacturing value chain? How do the core enterprises control the manufacturing value network, drive the relevant enterprises' development, and enhance the regional clusters' competitiveness? Further study is needed to these issues.

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Appendix 1: The Structure of Chinese Energy and Power Industry

Year	Total energy production	The ratio of electric power production in the total energy production (%)	Total energy consumption	The ratio of electric power consumption in the total energy consumption (%)
	(ten thousand tons of standard coal)	(%)	(ten thousand tons of standard coal)	(%)
1990	103922	4.8	98703	3.4
1991	104844	4.7	103783	4.8
1992	107256	4.8	109170	4.9
1993	111059	5.3	115993	5.2
1994	118729	5.9	122737	5.7
1995	129034	6.2	131176	6.1
1996	133032	6.2	135192	6
1997	133460	6.5	135909	6.4
1998	129834	6.8	136184	6.5
1999	131935	6.3	140569	5.9
2000	135048	6.9	145531	6.4
2001	143875	7.9	150406	7.5
2002	150656	7.8	159431	7.3
2003	171906	7	183792	6.5
2004	196648	7.3	213456	6.7
2005	216219	7.4	235997	6.8
2006	232167	7.5	258676	6.7
2007	247279	7.8	280508	6.8
2008	247279	8.6	291448	7.7
2009	274618	8.7	306647	7.8

The above data are from Chinese Statistics Yearbooks (1989~2010).

Appendix 2: The Industrial Growth of China National Economic Development and Electric Power Growth

Year	Industry growth	Growth rate	Electric Power Generation (hundred million KWh)	Growth rate	New increased installed units quantity	Growth rate
1992	10116	----	7470	----	1527	----
1993	14140	39.78%	8200	9.77%	1527	0.00%
1994	18359	29.84%	9200	12.20%	1527	0.00%
1995	24718	34.64%	10000	8.70%	1451	-4.98%
1996	28580	15.62%	10750	7.50%	1525	5.10%
1997	31752	11.10%	11350	5.58%	1376	-9.77%
1998	33541	5.63%	12290	8.28%	1839	33.65%
1999	35357	5.41%	13180	7.24%	1891	2.83%
2000	39570	11.92%	13890	5.39%	1884	-0.37%
2001	42607	7.68%	14780	6.41%	1516	-19.53%
2002	45935	7.81%	16540	11.91%	1165	-23.15%
2003	53612	16.71%	19107	15.52%	3000	157.51%
2004	62815	17.17%	21870	14.46%	5055	68.50%
2005	76190	21.29%	24747	13.16%	6326	25.14%
2006	90351	18.59%	28344	14.54%	10117	59.93%
2007	107367	18.83%	32777	15.64%	10009	-1.07%
2008	129112	20.25%	34668	5.77%	9051	-9.57%
2009	134625	4.27%	37146	7.15%	8970	-0.89%
2010	160030	18.87%	42065	13.24%	9118	1.65%

The data above are from China National Statistical Bulletin

Appendix 3: Chinese Electric Power Production Output and Consumption

Year	Total electric power production	Water power	Coal-fired power	Nuclear power	Total power consumption	Industry consumption	Personal consumption
	(hundred million KWh)				(hundred million KWh)		
1993	8382.6	1543.8	6838.8				
1994	9280.8	1821.6	7459.2		9260.37	6982.95	866.97
1995	10077.3	1905.8	8043.2	128.3	10023.4	7659.81	1005.58
1996	10800.2	1879.7	8777.1	143.4	10764.29	8044.67	1133.04
1997	11344.7	1959.8	9240.7	144.2	11284.4	8395.66	1253.15
1998	11662	2080	9441	141	11598.43	8405.95	1324.5
1999	12393	2038.1	10205.4	149.5	12305.23	8832.74	1480.78
2000	13556	2224.1	11141.9	167.4	13471.38	9653.62	1671.95
2001	14716.6	2774.3	11767.5	174.7	14633.46	10444.66	1839.23
2002	16404.7	2879.7	13273.8	251.2	16331.45	11793.16	2001.42
2003	19105.8	2836.8	15803.6	433.4	19031.6	13899.68	2238.04
2004	22033.1	3535.4	17955.9	504.7	21971.37	16254.29	2464.49
2005	25002.6	3970.2	20473.4	530.9	24940.39	18481.69	2824.81
2006	28657.3	4357.9	23696	548.4	28587.97	21247.74	3251.58
2007	32815.5	4852.6	27229.3	621.3	32711.8	24630.8	3622.71
2008	34668.8	5851.9	27900.8	683.9	34541.35	25388.63	4396.1
2009	36811.86	5716.82	30116.87	700.5	36595	26755	4575.00

The data above are from China Electric Power Statistics Yearbooks (1994~2010)

Appendix 4: The Comparison Economic Data in 2010 of Chinese Main Manufacturers of Steam Turbines and Generators

Index	Measuring unit	BTC	DEMC	Nanjing Turbine	Hangzhou Turbine	WTC	QTC	HTC	Shanghai Turbine	DTC	DTC rank
Industrial output value (present price)	Thousand RMB	1299878	6620961	3732232	5248677	1075830	2411646	6404274	6100474	19221552	1
Industry increase value (present price)	Thousand RMB	380684	1820764	924196	2161538	301230	462318	1191950	1215868	2858379	1
Export value (present price)	Thousand RMB		1220667	397555	878264	28757	306751	1042894	915395	2543267	1
Steam turbine quantity in power plant	unit	11		141	198	60	360	50	61	78	1
Steam turbine KW in power plant	Ten thousand KW	297		475.21	212.91	208.8	437.62	2082.73	2902.76	3284.44	1
Industrial Drive turbine	unit				288		55	28	16	87	1
Technical development expenditure	Thousand Yuan	57810	297030	120912	149619	33000	55177	303150	542290	532677	2
Consumption of standard coal per ten thousand RMB increase	ton	0.1	0.09	0.04	0.04	0.09	0.08	0.15	0.15	0.17	3
Average number of employees	person	2548	7381	2735	4651	2731	2749	5691	3056	7127	1
Average wage of employees	RMB	46370	77906	56926	79370	47968	33339	63150	93275	79937	2
Final total asset	Thousand RMB	2255827	14271780	6352267	8470671	2027389	4030606	11440683	9214909	46267507	1
Operation revenue	Thousand RMB	1147748	6359380	3948057	5269624	1200876	2941645	6190304	6461023	15588091	1
Total profits	Thousand RMB	30741	562790	549259	811547	124927	205258	43903	171969	790256	1
The cost profit margins	%	2.74	9.85	15.91	17.46	11.86	7.48	0.73	2.87	5.49	1
Return rate of total asset	%	5.2	9.65	12.01	13.53	12.95	6.85	2.94	3.27	6.21	1
Asset-liability ratio	%	66.49	76.14	61.68	48.94	56.58	65.33	78.53	98.41	93.18	2
Capital maintenance and increment ratio	%	103.37	109.51	116.87	121.96	106.56	125.5	101.22	45.97	118.73	1

The data are summarized from the statistic data in industry.

Appendix 5: DTC's Business Operation and Development Situations

Year	Main production	The composition of production (ten thousand KW)				Industrial drive turbine	Output value	Value increase	Revenue	Profits
	Ten thousand KW	Coal-fired power	Nuclear power	Wind power	Gas Turbine	unit	Ten thousand RMB	Ten thousand RMB	Ten thousand RMB	Ten thousand RMB
1990	226.35	226.35	0.00	0.00	0	3	20864	5931	18811	26
1991	160.80	160.80	0.00	0.00	0	2	24446	8958	19253	725
1992	234.28	234.28	0.00	0.00	0	3	29977	9751	30102	259
1993	247.90	247.90	0.00	0.00	0	5	38090	6383	53166	302
1994	280.90	280.90	0.00	0.00	0	1	48799	21134	40518	357
1995	283.85	283.85	0.00	0.00	0	0	52696	25397	42962	459
1996	280.50	280.50	0.00	0.00	0	3	57239	12804	51165	1879
1997	275.60	275.60	0.00	0.00	0	6	69468	22730	60948	2192
1998	345.00	345.00	0.00	0.00	0	10	87057	27713	70764	2775
1999	120.30	120.30	0.00	0.00	0	2	77529	37350	71311	2771
2000	131.80	131.80	0.00	0.00	0	2	73433	31545	74205	2561
2001	151.70	151.70	0.00	0.00	0	5	59561	25341	73027	1123
2002	424.80	424.80	0.00	0.00	0	6	99769	34452	87478	1655
2003	862.00	862.00	0.00	0.00	0	7	152696	53454	150960	9755
2004	1477.00	1477.00	0.00	0.00	0	12	302256	91458	232560	44349
2005	2056.40	1948.40	0.00	0.00	108	29	601270	204767	484830	79975
2006	2872.15	2731.15	0.00	6.00	135	49	1007520	32177	707589	108348
2007	2581.70	2496.50	0.00	31.20	54	34	954955	257798	845493	111009
2008	2320.00	2092.00	108.00	120.00	0	20	1084525	175266	885926	-99320
2009	2928.05	2674.45	0.00	199.60	54	34	1674709	260014	1292925	79489
2010	3521.79	2929.44	328.00	237.35	27	34	1922155	285838	1551193	66379

The data are above are from DTC's Planning and Project Department.

Appendix 6: The Status of DTC's Subsidiaries and Branch Companies

	Company name	Operation range	DTC Holding
1	Dongfang Electric (Tianjin) Wind Power Technology Co., Ltd.	Wind power generation equipment, normal and special equipment design, construction, installation, commissioning, maintenance, marketing, mechanical and electrical equipment parts sales	100%
2	Dongfang Electric (Tongliao) Wind Power Technology Co., Ltd.	Wind power generation equipment, normal and special equipment design, construction, installation, commissioning, maintenance, service after sales, components, material purchasing, processing, marketing, technology retrofitting, consultation, service	100%
3	Dongfang Electric (Jiuquan) New Energy Co., Ltd.	New energy development like wind power and solar power, new energy technology introduction and related equipment design, construction, installation, commissioning, maintenance, service after sales, components, material purchasing, processing, marketing, technology retrofitting, consultation, service	100%
4	Tianjin Dongqi Wind Turbine Blade Engineering Co., Ltd.	MW class wind power unit blade and machine warehouse cover producing, marketing and related service	55.63%
5	Mitsubishi Heavy Industries Dongfang Gas Turbine (Guangzhou) Co., Ltd.	Heavy gas turbine components (high temperature channel parts) producing, its own product sales, service after sales and consultation providing, maintenance service and technical support service for gas combined cycle unit	49%
6	Beijing Huaqing Gas Turbine and Coal Gasification Combined Cycle Engineering Co., Ltd.	Technical development, technical promoting, technical transferring, technical consultation, technical service	15.50%
7	Dan An Wind Power Branch of Dongfang Electric Corporation Dongfang Turbine Co., Ltd.	Wind power unit and the component installation and marketing, wind power and its equipment research, design, installation and commissioning, retrofitting, maintenance service	Branch
8	HulunBuir Wind Power Branch of Dongfang Electric Corporation Dongfang Turbine Co., Ltd.	Wind power unit and the component installation and marketing	Branch
9	Shandong New Energy Branch of Dongfang Electric Corporation Dongfang Turbine Co., Ltd.	Wind power unit and the component installation and marketing, wind power and its equipment research, design, installation and commissioning, retrofitting, maintenance service	Branch

Source： DTC´s internal Statistics

Appendix 7: A 660MW steam turbine body component break-down

Drawing number	Name	Drawing number	Name
D660B-020000A	HP inner casing	D600B-121000A	7th diaphragm of A LP generator side
D660B-021000A	HIP outer casing	D600C-122000A	1st diaphragm of A LP turbine side
D660B-025000A	IP inner casing	D600C-123000A	2nd diaphragm of A LP turbine side
D660B-028000A	High temperature bolt and nut	D600C-124000A	3rd diaphragm of A LP turbine side
D660B-029000A	HIP casing component	D600C-125000A	4th diaphragm of A LP turbine side
D660B-014000A	A LP casing drawing	D600B-126000A	5th diaphragm of A LP turbine side
D600B-015000A	B LP casing drawing	D600B-127000A	6th diaphragm of A LP turbine side
D600B-030000A	A LP inner casing	D600B-128000A	7th diaphragm of A LP turbine side
D600C-031000A	A LP outer casing	D660C-129000A	1st diaphragm of B LP generator side
D600B-032000A	B LP inner casing	D660C-130000A	2nd diaphragm of B LP generator side
D600C-033000A	B LP outer casing	D660C-131000A	3rd diaphragm of B LP generator side
D600B-034000A	A LP inner casing inlet chamber	D660C-132000A	4th diaphragm of B LP generator side
D600B-035000A	B LP inner casing inlet chamber	D600B-133000A	5th diaphragm of B LP generator side
D600B-036000A	LP turbine water spray piping and gland piping	D600B-134000A	6th diaphragm of B LP generator side
D660B-037000A	Atmospheric valve	D660C-136000A	1st diaphragm of B LP turbine side
D660B-038000A	Main body supporting piping	D660C-137000A	2nd diaphragm of B LP turbine side
D600B-039000A	LP casing exhaust port accessory	D660C-138000A	3rd diaphragm of B LP turbine side
D660B-041000A	Nozzle room and nozzle group	D660C-139000A	4th diaphragm of B LP turbine side
D660B-083000A	Steam Guide	D660B-140000A	5th diaphragm of B LP turbine side
D600B-098000A	Diaphragm sealing	D600C-141000A	6th diaphragm of B LP turbine side
D600B-099000A	Diaphragm accessories	D600C-142000A	7th diaphragm of B LP turbine side
D600B-102000A	HP 2nd diaphragm	D600C-170000A	Drawing of sealing ring in the end side
D600B-103000A	HP 3rd diaphragm	D660C-160000A	Sealing part assembly drawing
D600B-104000A	HP 4th diaphragm	D660C-161000A	1# sealing
D600C-105000A	HP 5th diaphragm	D660C-162000A	2# sealing
D600C-106000A	HP 6th diaphragm	D600C-163000A	3# sealing
D600C-107000A	HP 7th diaphragm	D600B-164000A	4# sealing
D600C-108000A	HP 8th diaphragm	D600B-165000A	5# sealing
D600C-109000A	IP 1st diaphragm	D600B-166000A	6# sealing
D600C-110000A	IP 2nd diaphragm	D600B-167000A	7# sealing
D600C-111000A	IP 3rd diaphragm	D600B-189000A	Bearing box accessory
D600C-112000A	IP 4th diaphragm	D600C-181000A	Front stand
D600C-113000A	IP 5th diaphragm	D600C-182000A	Intermediate stand
D600C-114000A	IP 6th diaphragm	D600B-183000A	Turning gear box
D600C-115000A	1st diaphragm of A LP generator side	D660B-190000A	Embedded part
D600C-116000A	2nd diaphragm of A LP generator side	D600C-201001A	The assembly drawing of HP 1st stage bucket

Continue

Drawing number	Name	Drawing number	Name
D600C-117000A	3rd diaphragm of ALP generator side	D600C-201002A	The assembly drawing of HP 2nd stage bucket
D600C-118000A	4th diaphragm of ALP generator side	D600C-201003A	The assembly drawing of HP 3rd stage bucket
D600B-119000A	5th diaphragm of ALP generator side	D600C-201004A	The assembly drawing of HP 4th stage bucket
D600B-120000A	6th diaphragm of ALP generator side	D600C-201005A	The assembly drawing of HP 5th stage bucket
D600C-201006A	The assembly drawing of HP 6th stage bucket	D600C-244000A	Support bearing (3#, 5#)
D600C-201007A	The assembly drawing of HP 7th stage bucket	D600C-245000A	Support bearing (4#)
D600C-201008A	The assembly drawing of HP 8th stage bucket	D660C-246000A	Support bearing (6#)
D600C-202001A	The assembly drawing of IP 1st stage bucket	D600B-260000A	HP main steam control valve group
D600C-202002A	The assembly drawing of IP 2nd stage bucket	D660B-261200A	Filter screen
D600C-202003A	The assembly drawing of IP 3rd stage bucket	D600C-263000A	HP main steam control valve cradle
D600C-202004A	The assembly drawing of IP 4th stage bucket	D660C-265000A	IP combined valve (HTC)
D600C-202005A	The assembly drawing of IP 5th stage bucket	D660C-267000A	IP combined valve support (whole structure)
D600C-202006A	The assembly drawing of IP 6th stage bucket	D660B-268000A	Main steam pipe blower device
D600C-203001A	The assembly drawing of 1st stage bucket in LP turbine side	D660C-269000A	Reheat pipe blower device
D600C-203002A	The assembly drawing of 2nd stage bucket in LP turbine side	D600A.275Z	BDV
D600C-203003A	The assembly drawing of 3rd stage bucket in LP turbine side	D600A.276Z	VV
D600C-203004A	The assembly drawing of 4th stage bucket in LP turbine side	D600A.277Z	The assembly drawing of BDV pneumatic system and solenoid valve
D600B-203005A	The assembly drawing of 5th stage bucket in LP turbine side	D660C-278000A	HP control valve accessory
D600B-203006A	The assembly drawing of 6th stage bucket in LP turbine side	D660B-291000B	HP main steam pipeline
D600B-203007A	The assembly drawing of 7th stage bucket in LP turbine side	D660B-292000B	HP main steam pipeline cradle
D600C-203008A	The assembly drawing of 1st stage bucket in LP generator side	D660C-293000A	IP main steam pipeline
D600C-203009A	The assembly drawing of 2nd stage bucket in LP generator side	D660C-295000A	IP steam admission pipeline
D600C-203010A	The assembly drawing of 3rd stage bucket in LP generator side	D660C-296000A	Connected pipeline
D600C-203011A	The assembly drawing of 4th stage bucket in LP generator side	D20.612Z	Steam filter
D600B-203012A	The assembly drawing of 5th stage bucket in LP generator side	D600E-197000A	Anchor bolt
D600B-203013A	The assembly drawing of 6th stage bucket in LP generator side	D600C-198000A	Base frame
D600B-203014A	The assembly drawing of 7th stage bucket in LP generator side	D660E-651000A	Steam turbine cover shell drawing
D660B-217000A	HIP rotor drawing (HTC)	D660B-652000A	Front stand cover shell
D660B-218000A	A LP rotor drawing	D660B-653000A	HIP casing cover shell
D660B-219000A	B LP rotor drawing	D660E-654000A	Intermediate stand cover shell
D660B-210000A	General rotor component	D600C-655000A	A LP bearing box cover shell

Continue

Drawing number	**Name**	**Drawing number**	**Name**
D600B-221000A	HIP-A LP coupling	D600C-656000A	B LP bearing box cover shell
D1000A-222000A	A LP-B LP coupling	D600C-657000A	A LP cover
D600B-223000A	B LP-generator coupling	D600C-658000A	B LP cover
D600B-231000A	Turning gear	D600C-659000A	Connected pipeline cover shell
D600C-241000A	Support bearing (1#)	D600C-660000A	General component of random tool
D600C-242000A	Support bearing (2#)	D600C-661000A	Equipment for casing lifting
D600C-243000A	Thrust bearing	D600C-665000	Equipment for rotor lifting
Drawing number	Name	Drawing number	Name
D600B-668000A	Equipment for diaphragm lifting	D600C-798300A	HIP casing and HP main control valve temperature measuring instrument
D600A.670Z	Rotor bracket	D600B-798400A	LP casing instrument
D600B-671000A	Equipment for rotor holding up	D600C-798900A	Valve and instrument
D600A.672Z	Tool for nut lifting	D600A.673Z	Tool for casing moving
D600A.673Z	Tool for casing moving	D600E-650300A	Main body nameplate
D600C-685000A	Large bolt electric heater	D600E-697300A	Steam turbine body heat insulating material and component
D600A.687Z	Bolt elongation measuring tool	D600C-699300A	Main body package
D600C-689300A	Tools delivered with the machine	D600C-799300A	Valve and pipeline delivered with machine
D600B-693000A	Tool for coupling reaming	D600C-798000A	Instrument and accessory

The Data are from DTC financial department.

Appendix 8: A certain 660MW class steam turbine auxiliary part component break down

Drawing number	Name	Drawing number	Name
M700-265000A	N-36250 condenser	M732-023000A	Spray type attemperator
M701-233000A	Condenser Neck	D600E-799100B	Random supplied valve and pipeline
M702-223000A	Condenser Shell	D600C-715000A	Shaft seal and fan installation
D660E-703000B	Condenser hole and accessory drawing	M715-015000A	Shaft seal and fan
M786-096000A	Fluviograph	D600E-615000B	Seal pipeline layout drawing
M730-086000A	PRDSⅠ	D600B-511000A	Main oil pump
M740-143000A	Drain flash tank Ⅰ in HP side	D600A.506Z	Oil turbine
M740-144000A	Drain flash tank Ⅱ in LP side	D600B-513000A	Emergency oil pump
D600E-650130B	Condenser nameplate	D600B-514000A	Start-up oil pump
D600E-683100B	Condenser tube expand tool	D600B-515000A	Auxiliary oil pump
D600E-689100B	Condenser random tool	D600E-765000A	Switching valve
D600E-690130B	Condenser spare part	D600E-720000A	Oil cooler
D600E-699130B	Condenser package	D600C-601000A	Jacking device
M778-279000A	1st stage extraction check valve	M522.X01Z	UH-125-25 single disc check valve
M778-280000A	2nd stage extraction check valve	M522.X02Z	UH-150-25 single disc check valve
M778-281000A	3rd stage extraction check valve	M519.X02Z	Lampblack separator
M778-282000A	4th stage extraction check valve	D600B-518000A	Main oil pump installation base
M778-283000A	5th stage extraction check valve	D600E-650100B	Steam-water system nameplate
M778-284000A	6th stage extraction check valve	D600E-699100B	Auxiliary package
M779-049000A	Exhaust check valve	D600E-501000A	Central oil tank
D600C-705000A	JQ-150 seal heater	D600E-605000A	Jacket oil pipeline
M727-005000A	LS-25-3 water filter	D600E-650200A	Oil system device nameplate
M612.X09Z	LZ-150-1.6Y-1 steam filter	D600E-689200A	Oil system random tool
M612.X12Z	LZ-200-1.6Y-1 steam filter	D600E-699200A	Oil system package
M612-015000A	LZ-150-6.4Y steam filter	D600E-799200A	Oil system random pipeline

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