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23001
(1 of 2)

UNIDO Contract No. : 03/120

UNIDO Project No. : EG/CPR/99/G31

Activity Code: 450D32

P. O. No. : 16000473

The Final Report

to

the United Nations Industrial Development Organization (UNIDO)

for the Contract

Provision of Services for the Execution of a Coking Sub-sector Survey

related to the Project

Energy Conservation and Greenhouse Gas Emissions Reduction in Chinese Township and Village Enterprises – Phase II

Prepared by

Academy of Mathematics and Systems Science, the Chinese Academy of Sciences (CAS)

Shanxi Township and Village Enterprise Bureau (Shanxi TVE Bureau)

Karen R. Polenske

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1.00 Introduction & acknowledgement

Introduction

This is the final report submitted to the United Nations Industrial Development Organization (UNIDO) by the Academy of Mathematics and Systems Science, the Chinese Academy of Sciences (CAS) as the contractor according to the contract entitled "Provision of Services for the Execution of a Coking Sub-sector Survey" between UNIDO and CAS, related to the Project entitled "Energy Conservation and Greenhouse Gas Emissions Reduction in Chinese Township and Village Enterprises - Phase II."

According to the requirements of the contract, we should undertake eight tasks. This report is a summary of work and achievements from the end of August 2003 to the middle of March 2004, including the following parts:

a. Summary of progress based on the TOR

b. Attachments: Report of Each Task

Acknowledgement

The results reported here are a joint effort of CAS, Shanxi TVE Bureau, Karen R. Polenske, and Zhou Zongli. We would like to thank all the participants of our joint team for their hard work on writing analysis reports, and collecting data. We are very grateful to the Production Management Office (PMO), Ms. Wang Guiling, the UNIDO Cheif Technical Advisor (CTA), Dr. Zhang Zhihong, and Hongyuan Energy and Environmental Protection Co. Ltd (Hongyuan), Mr. Song Dongfeng and his colleagues, and the Contracts Officer, Ms. Mounira Latrech, Dr. Enver Khan, and other UNIDO staff, for their support and guidance in the challenging work.

2.00 Summary of Progress

According to the contract, we should undertake the following eight tasks:

Task 1: To provide an updated profile of the cokemaking industry in Shanxi Province, including, but not limited to, the number of establishments, volume of production, output value, employment, characterization of technologies (by coke-oven type), energy consumption, and environmental pollution;

Task 2: To review recent national and provincial/local government policies and regulations related to the cokemaking industry, illuminate the policymaking process, and assess the impact of the policies and regulations on the structure of the cokemaking industry and its future development;

Task 3: To compile an inventory and summarize the main results of major surveys/studies and initiatives related to the cokemaking sector (focusing on Shanxi Province) that have been conducted in the past five years;

Task 4: To analyze domestic and international trends of market supply and demand of coke and their impact on the Shanxi cokemaking industry;

Task 5: To investigate the marketing and distribution system of the TVE cokemaking industry in Shanxi, including but not limited to the export market;

Task 6: To compile an inventory of major Chinese and international cokemaking equipment manufacturers, as well as design institutes, industrial associations, and other support institutions;

Task 7: To assess the technical, economic, and environmental characteristics of prevailing coke-oven technologies (including the "clean" coke oven) in Shanxi Province and propose strategies for the GEF project intervention (including selection of a pilot TVE for demonstration) in the cokemaking subsector;

Task 8: To determine the needs of the cokemaking TVEs for (national and international) technical assistance and propose activities to be undertaken.

On August 26, 2003, in a meeting with the contract officers from UNIDO, PMO, Hongyuan and CTA in Beijing, we reported briefly the preparations for the project, including the assembling of the institutions to

conduct the contract, and the methods to fulfill the eight tasks.

We assembled the following institutions or experts, with Professor Chen Xikang as the general coordinator:

The Chinese Academy of Sciences (CAS): Chen Xikang, Yang Cuihong, He Jing, Wang Eryuan, and Li Jinghua

Shanxi Township and Village Enterprise (TVE) Bureau: Zhou Mingding, Zhao Zhijie, Meng Yulin, Xugang, and Li Dongyan

Karen R. Polenske, and her graduate students at the Massachusetts Institute of Technology Li Yu and Shi Xiaoyu

Zhou Zongli

CAS staff has been to Shanxi Province twice respectively in the middle of, and at the end of September 2003, to discuss with Shanxi TVE Bureau and Mr. Zhou Zongli the progress of their tasks. From November 10 to 14, 2003, CAS staff went with staff from PMO, Hongyuan and the CTA, to Shanxi Province, they met with officials from Shanxi TVE Bureau, Shanxi Provincial Environmental Protection Agency, and also visited several operating cokemaking ovens. From January 9 to 11 2004, CAS staff and Prof. Karen R. Polenske's team went to Shanxi Province where they met Shanxi TVEs official to discuss the progress of the contract and current situation of Shanxi cokemaking TVEs, visited coke-marketing companies and some coke-technology design institutes including Shanxi Provincial Chemical Design Institute. Through the seminar and field visit to the plants, we found that the officials believe that the "Clean" coke oven has great potential to spread in Shanxi cokemaking TVEs because of its fine environmental protection, energy efficiency, low investment, and fairly good coke quality. We concur with them for a short-term solution because of the importance of reducing pollution, but for the long term, we propose obtaining additional information on possibilities of pollution reduction for other types of coke ovens, especially large machinery coke ovens in order to conserve potentially valuable chemicals and other by-products.

By mid March 2004, we have the following results of the eight tasks.

2.01 Task One: Current Profile of Shanxi Cokemaking Industry

Our team has done the following work:

(1) Conducted a general survey of Shanxi TVE cokemaking industry.

In order to know the current situation of Shanxi cokemaking industry in TVE, the Shanxi TVE Bureau conducted a detailed survey on the basic situation of cokemaking TVEs. The survey mainly included the number of establishments, volume of production, output value and technologies (by coke oven type) in the survey form, and expected to get the entire profile of the cokemaking industry.

Although we hope to get the entire information of Shanxi TVEs cokemaking industry especially the total coke output, total number of the plants and total employment, the data we got from the survey are smaller than practical situation. The coke output of all surveyed TVEs in 2003 may reach to 33,402 thousand tonnes. Some plants did not report their information for several reasons, the main results are listed briefly as follows.

a. Concerning the structure of coke ovens, although modified coke ovens still dominate in number, accounting for 69% of the total TVE cokemaking plants, their output is fairly small, representing only 26.0% of the total coke output of cokemaking TVEs. In contrast, 22,182 thousand tonnes of coke is produced by traditional machinery coke ovens, accounting for 66.4%. Compared to the above two types of coke ovens, the output of "clean" coke ovens is relatively low. Local officials and cokemaking experts, however, think that the "clean" coke oven is relatively good in many aspects, especially in its environmental-protection properties. Thus, although only a few cokemaking plants built this kind of oven, they feel that it may have a great potential for spreading in main cokemaking areas in Shanxi Province.

b. As to the structure of specific coke ovens, in traditional machinery coke ovens, the 58 type is the dominant one, accounting for almost 27% of total coke output. Large plants have adopted the JNK43-98 and JNK43-98D types, producing 9.1% and 8.9%, respectively, of surveyed coke output. Although modified coke ovens were ordered to shut down, some "advanced" modified coke oven, such as TJ-75, SJ-96, are still in production. Other machinery coke ovens such as TJL4350A and TJL4350D especially TJL4350D developed in recent years have been built because of the coal-tamping technique. "Clean" coke ovens are at an initial stage of adoption.

(2) Conducted a sample survey of TVE cokemaking plants of Shanxi Province

In order to well understand the TVE cokemaking industry in Shanxi Province more specifically in plants level and trace the changes of this industry in Shanxi Province in the past several transitional years, we did a sample survey from October to the end of December 2003.

Conducting a sample survey is actually a relatively complicated work if we expect to get excellent results.

First, in the middle of September 2003, CAS staff designed a questionnaire and exchanged the copies with Shanxi TVE Bureau, PMO and Hongyuan staff and the CTA. The questionnaires covered the following: coke oven type, coke output of each oven type; coke market and distribution system, and coke export destination; technological characteristics of coke ovens; by-products; policies and regulations; employment and pollution.

Second, the CAS staff trained local Shanxi Province officials in conducting the survey. On September 27, 2003, Professor Chen Xikang and Dr. Yang Cuihong attended a meeting organized by Shanxi TVE Bureau at Lishi City, Shanxi Province. At that meeting, they trained 29 local officials who would be directly in charge of the survey, including: explaining each question on the questionnaire, considering the situations they may encounter when actually conducting the survey, and determining how to deal with the situation if the interviewees gave ambiguous or even wrong information.

Then, with the help of the Shanxi TVE Bureau official , they distributed 150 plant manager's questionnaires and 30 local official survey forms to the officials who are responsible for cokemaking industry.

Of those distributed, 131 plants and 27 officials returned questionnaires, of which we determined that 110 plants and 24 officials were qualified for tabulation. We disqualified plants that returned questionnaires with seriously inconsistent information, some plants obviously fill in the questionnaires randomly because several plants have very similar information..

From the sample survey, we have the following major findings.

a. As shown in the results of the official survey done by Shanxi TVE Bureau at the end of last year, modified coke oven, such as TJ-75 type, and small machinery coke oven like Red Flag type, small 58 and WJ 663, are still widely adopted by Shanxi TVE plants managers. As to large and medium-size coke ovens, like JNK43-98D, and other newly designed machinery coke ovens such as TJL4350A and TJL4350D,

more and more plants are building these ovens. As to "clean" coke oven, QRD-2000 is the main one, 5 plants adopt this type.

Concerning the future selection of coke ovens that are suitable for local situation, most plants said that good environmental protection characteristics, and industrial policies are the main factors for future coke oven selection, chemical-products recovery is also an important reason. JNK43-98D, TJL4350D, Joint Environment-friendly oven and QRD-2000 are the top four types, the plants that adopt them accounting for 10.9%, 10.0%, 9.1% and 8.2% of qualified surveyed plants, respectively.

b. The coke output went up sharply in 2002 and 2003, to about 13627.8 and 16593.5 thousand tones in qualified surveyed plants. If we consider the plants that did not fill in the estimated coke output of 2003, while we got their coke output through field survey and other sources, the surveyed coke output of 2003 may exceed 18000 thousand tonnes.

Because of the increasing coke demand and price both in domestic and international market, and the coke output value went up drastically in the past two years. The average coke output value per ton of coke remained about 325 RMB during 1998 and 2000, there was a slight turnaround in 2001 and 2002, to about 340 and 380 RMB yuan respectively. In 2003, however, it soared to 610 RMB yuan, increasing by 60% than 2002.

In international coke market, due to strict environmental policies and aged coke ovens, the coke output of several developed countries such as the United States, Japan, Germany decreased sharply in the past several years while the coke demand increased. Besides, CIA countries are also reducing coke output. So, other countries are more and more dependent on Chinese coke export. The overseas coke destination of most plants is mainly the United States, Japan, Germany, Brazil, Korea and India.

c. By-products recovery increased sharply. Since the wide adoption of large and medium-scale machinery coke oven, more and more by-products could be recovered. In 2003, total coal tar volume rushed to 376.89 million cubic meters, almost threefold as that in 2002. Some plant has the capacity of coal tar deep-processing, the output of coal tar rose rapidly too.

d. Structure of employees changed. Because it is not easy to operate, machinery coke oven demand more skillful technicians in production process. With the construction of many large and medium-scale machinery coke ovens, the percentage of technical staff increased, especially since 2002, from 8.61% in 2002 to 9.96% in 2003, showing that the quality of employees improve with the upgrading cokemaking

technology.

From both the official survey and sample survey, we could see that cokemaking industry in Shanxi Province came through a deep technical change in the past several years, especially after 1999. The restructuring of this industry greatly affects the production, market of coke, and other related aspects including environmental pollution, employment of local farmers. In summary, technical structural adjustment are regulating this industry, the energy efficiency is increasing, the environmental situation which the governments concern is becoming better in Shanxi Province especially in cokemaking areas, and the coke market is now flourishing.

2.02 Task Two: Recent Government Policies, Regulations and their Impacts

We gathered the text of several national and provincial government policies and regulations. The main ones include:

(1) The Catalogue of Elimination of Heavy-polluting Technologies and Equipments (the First Series) (Guo Jing Mao Zi, No. [1997] 367). The Catalogue was jointly enacted by State Economic and Trade Committee, National Environmental Protection Agency and former Ministry of Machinery on June 5, 1997;

(2) The Catalogue of Preventing Redundant Projects in Industrial and Commercial Investment Field (the First Series). Generally called the 14th Order, the Catalogue was enacted by State Economic and Trade Committee on August 9, 1999;

(3) The Catalogue of Elimination of Less-Backward Production Capacity, Technology and Products (the Second Series), called the 16th Order, was issued by State Economic and Trade Committee on December 31, 1999;

(4) Implementation Measures of Cokemaking Restructuring in Shanxi Province, is an important part in 'Implementation Measures of Industrial Restructuring in Shanxi Province' which was issued by the Shanxi Provincial Party Committee and Shanxi Provincial Government at the end of 2003 (Jin Zheng Fa No. [2003]28);

(5) Instructions for Upgrading and Renovation of Cokemaking Sector, drafted by Shanxi TVE Bureau in about 2000.

(6) Management Rules and Regulations of Coke in Shanxi Province, will be enacted in 2004.

As regards to the policy-making process, several aspects push the government to take measures. First, energy inefficiency happens from the use of less advanced techniques in Shanxi Province. On average, although it is a little lower in advanced modified indigenous coke ovens, the coal-input coefficient in indigenous (including modified indigenous) coke ovens is often higher than 1.4, while that in machinery coke ovens is generally between 1.2-1.3. Second, low-level repeated construction and out-of-order competition among plants are serious. Because of low amount of investment required to build indigenous or modified indigenous coke ovens, plant managers can build or not operate them easily, so that the entry and exit rates are high, which creates a drastic fluctuation in coke output. During 1995 and 1999, although coke was in oversupply on the market, many small plants were still built. The coke price decreased sharply to less than US$ 50 per tonne coke, which was much lower than the coke price from other countries. Third, the wastage of resources, especially chemical products, and the environmental pollution are extremely serious. For most indigenous or modified indigenous coke ovens, managers seldom recover any chemical products but burn them in the coke oven or discharge them into the air, causing both wastage of resources and heavy environmental pollution in those years in Shanxi Province.

The Chinese Government and related agencies, Shanxi Provincial Government and relevant departments attached much importance to the problems caused by cokemaking and other relative industries. In order to protect resource and environment, and, to keep a sustainable development, it is necessary and urgent to eliminate less advanced techniques, upgrade the technology level and to optimize the industrial structure. On the other hand, it is very critical to realize total volume control in order to regulate domestic and international market and, to stabilize Chinese coke price. Therefore, State Economic and Trade Committee and related agencies enacted a series of industrial policies.

The industrial policies and regulations widely affected the Shanxi Province cokemaking industry. First, the technological structure experienced a great change. Since 1999, most of the indigenous or modified indigenous coke ovens were closed. Up to January 2004, 709 Indigenous coke ovens, 628 modified indigenous coke ovens plants and 354 improved modified indigenous coke ovens were closed. Many machinery coke ovens with good chemical-products recovery installation, such as JN6-6, JNK43-98D, as well as "clean" coke ovens, such as QRD-2000 have been built or are being built in Shanxi cokemaking plants. Second, to reduce the coke output to a relatively suitable level. The national and provincial

governments officials have tried to regulate the output of coke. One result has been an increase in the Chinese coke price in these years. As an example, in 1998, the coke output of Shanxi Province was high-up to 57 million tonnes, with a coke price of only US$60-70 per tonne. After the restructuring, Shanxi coke output decreased to about 49.6 million tonnes during 1999 and 2001, then because of the good market, the coke output picked up after 2002, and the coke price increased to US$82-83 per tonne for 10.5% ash and US$78-80 per tonne for 12% ash in July 2002. Third, since 2002, the benefits accruing from the coke industry are much higher than in the previous few years. One important reason is that the decrease of China coke output pushed up the international coke price, especially in 2002 and 2003. It rose drastically up to US$240 in December 2003.

In summary, the restructuring of the coke industry has generated good effects on cokemaking sector. While we note that because of the tight coke market, some additional coke ovens have been on the book to be built or will be constructed; therefore, in order to keep sustainable development of cokemaking industry, we have to take effective measures to regulate the behavior of related plants.

2.03 Task Three: Summary of Major Past Work of the Cokemaking Industry

Together with Professor Polenske, we have done several years research since 1998 on Shanxi Province cokemaking sector, focusing on its technological structure, energy efficiency and environmental pollution. Up to 2002, we have conducted eight sample surveys in Shanxi Province: (1) TVE plant manager surveys in 1998, 2000, and 2002; (2) SOE plant manager surveys in 1999 and 2001;and (3) local official surveys for TVE in 1998, 2000, and 2002.

In the report, we review the evolution of Shanxi TVE Cokemaking technologies between 1998 and 2002, the personal quality of the employees, productivity trends, energy efficiency, and also the awareness change of environmental pollution of the managers. We also conducted a detailed comparison of cokemaking plants between Shanxi TVEs and State-Owned Enterprises (SOEs). We briefly introduce them as follows.

First, the technology of the cokemaking TVEs in Shanxi Province improved a lot compared with 1998. Most indigenous coke ovens have been closed. Accordingly, machinery coke oven and some advanced modified coke oven, such as SJ-96, were then widely adopted.

Second, the energy efficiency has increased a lot since 1998. Coke plants with a coal-input coefficient of coke between 1.4 and 1.6 accounted for 31.1% and 20.5% of total surveyed in 2000 and 2002, respectively, which is much lower than the 43.0% in the 1998 survey. Of the total number of plants surveyed in 2002, 60.6% have a coal-input coefficient of coke less than 1.4, much higher than the 26.6% in the 1998 survey.

Third, the production scale has gradually expanded since 1995. For example, in 1995, there were 1,276 plants, and this decreased to 680 plants in 2000, while the total coke output from the TVEs has remained relatively constant (20.5 million tonnes in 1995 and 20.1 million tonnes in 2000);

Fourth, the personnel quality of cokemaking TVEs leaves much to be desired. Most employees in the surveyed cokemaking TVEs have only 6-12 years of school, i.e., they are at the middle school level. Although some of technicians and administrators are highly educated with over 12 schooling years, still many workers, and a few technicians and administrators have a low level of education, with fewer than six years of school, which is only at a primary school level.

Fifth, the number of total cokemaking employees decreased rapidly from 94,908 in 1995 to 54,116 in 2000, while the output changed very little, showing that the productivity of cokemaking TVEs rose.

Concerning the comparison between TVE and SOE cokemaking industry, mainly:

First, SOEs are far more environmental/energy efficient (amount of pollution produced/energy used per unit of output).

Second, TVEs use technologies that are more economically efficient, employ more workers, and require lower investment capital than SOEs.

Third, the production scale of TVEs is smaller than that of SOEs.

Fourth, the quality of employees in SOEs in terms of education and on-the-job training is better than that of TVEs.

Fifth, the average income per employee in SOEs is greater than that in TVEs.

Other work includes those done by experts from Shanxi Science and Technology Bureau, Shanxi Environmental Protection Bureau, Shanxi Economic and Trade Commission and Shanxi Township and Village Enterprise Bureau, who conducted the "Study on Environmental, Economic and Technical Benefits Evaluation of Different Coke Ovens" during 1999 and 2000. They focused on the then current

situation of the Shanxi cokemaking industry and problems confronted, the future direction of cokemaking, and, most important, an evaluation method of coke ovens.

The report is attached in attachment 3.03.

2.04 Task Four: Analysis of Market Supply and Demand of Coke

Internationally traded coke is playing a growing role in meeting the global coke demand. Since the late 1990s, China has dominated the global coke market and exported more than half of the total traded coke. Basically, the coke price is determined by the price of coking coal, the freight rates, and the coke supply and coke demand in the world market.

We examine the present and future of the world coke market from the coke price, coke demand and supply, coke production, coke export and impacts of other industries on coke market, finally make a forecast of world coke market. Our main findings include:

2.4.1 Coke Price Increases Drastically

The structure of global coke supply has changed and become more and more dependant on China's supply in the past decade. Since 1994, China has been the largest coke producer in the world and dominated the international coke market. The coke production in other countries, particularly in developed countries, decreased substantially. In 2000, the total exports from China exceeded 15.2 million metric tonnes and accounted for about 48% of the total exports in the international market. In 2003, China's share increased to more than 50 percent of the total world exports and is expected to reach 60 percent in the next five years.

As the benchmark of the international coke market, the Chinese metallurgical coke price has tripled in the last three years, peaking at US$150-160 (free-on-board-f.o.b.) per tonne for 10.5 percent ash coke and at US$140-145 per tonne for 12 percent ash coke in April 2003. After a slow down over the summer months in 2003, coke prices passed the US$150 per tonne f.o.b. level again in September 2003, reaching US$240 (f.o.b.) per tonne in December 2003. At the same time, the ocean freight rates are also increasing rapidly. It is expected that the demand for ocean freight will remain high over the short term. Moreover, the price of coking coal is also surging because of supply shortages, causing the increases of coke production cost.

2.4.2 Coke Demand Increases and Supply Decreases

Coke demand depends on: (1) the total requirement for steel production, which is strongly affected by the economic growth in various parts of the world, (2) The amount of steel that can be produced in electric arc furnaces (EAFs), (3) blast-furnace requirements for coke and how successful operators are in minimizing the amount of coke used, (4) the development of other steelmaking processes, such as pulverized coal injection (PCI), that do not involve coke, and (5) the amount of non-steel related use, such as the use in chemical industries.

The global coke consumption is increasing mainly due to the increase in China's domestic demand from its steelmaking industry, while other major coke consumers do not decrease their consumption. Japan is the second largest coke consumer after China. Generally, Japan's domestic coke production was able to meet the domestic demand, but the country started to have a net import from the world market from 1996. The United States is the third largest coke consumer in the world. Since 1994, the country has become the second largest coke importer in the world. India imports coke mainly from China. According to Coal Controller's Organization's report, India imported 2.4 million tonnes of coke in 2000-2001 and 2.88 million tonnes of coke in 2001-2002, increasing by 19 percent. Germany is the largest coke importer in the world. From 1995 to 2001, its total coke production decreased from 11.1 million tonnes to 7.3 million tonnes, and the coke imports increased substantially.

Coke supply depends on: (1) supplies of coking coal, (2) productive capacities and the locations of coke ovens, (3) effects of environmental regulations and their enforcement, (4) age of the coke ovens, which affects productivity, coke quality, and long-term production, and (5) investment in refurbishing existing capacity and/or the construction of new ovens. Because of the following factors, coke supply in the world market decreased sharply.

a. Increase of Direct Cost of Coke Production

Due to environmental pollution and safety accidents, many Chinese coal mines were shut down, which results in the output decrease of coking coal, China imported 1120 thousand tonnes of coking coal from January to August 2003. In 2003, spot prices of coking coal have increased by US$15 to US$20 (f.o.b.) per tonne. For 2004, it is estimated that the coking coal price will increase by another US$10 to US$15 per tonne, which means that the f.o.b. price will be around US$60 for Australian and Canadian coking coal. Commodity freight transportation costs are also increasing.

b. Environmental Protection and Environmental Regulations

From 1998, China began to enact and enforce some strict environmental regulations on coke production. Thus, provincial authorities closed many small and heavy-polluting coke plants. This is a similar situation in developed countries, since 1998, Japan has closed 480 thousand tonnes of coke capacity, and the United States has closed more than 4.2 million tonnes.

c. Coke-Export Restrictions

Due to the highly increased domestic demand, the Chinese government is suspending new export licenses in order to reduce the coke price/availability pressure on Chinese steel plants. Analysts estimate that China issued 13 million tonnes of coke export license in 2003, but she is expected to issue licenses for only 9.1 million tonnes in 2004. Another indirect restriction of coke export is the adjustment of the export rebate rate: the export rebate rate of coke decreases the most, from 15% to 5%.

Concerning other countries, Russia is another major coke producer. In 2002, the total production of coke in Russia was about 30.9 million tonnes, accounting for more than thirty percent of the total in Europe. Since 1998, the production capacity in Russia has decreased by 0.3 million. Comparatively, the capacity in other Eastern European countries, including the Czech Republic, Poland, Romania, and Ukraine, decreased much faster. Their capacity has decreased by more than 3.7 million tonnes in total. This is also primarily due to the aged coke ovens and environmental concerns.

2.4.3 Forecast of the Coke Market

In terms of the future of the world coke market, we expect that the total coke supply in the international market will be reduced in the short term; in the long term, with the new investment in production capacity, we expect that the coke supply in the international market would maintain a stable level. We estimate that the annual growth rate of world steel production would be around three to four percent in the short run and two to three percent in the long run. In the future five to ten years, coke will remain an essential material to make steel, particularly, high-quality steel. Given the decreasing coke intensity, we estimate the world coke demand would increase only slightly by one to two percent per year; we expect coke prices to be US$180 to US$240 per tonne, or even higher in the short run and US$100 to US$150 (2003 real dollar) per tonne in the long run.

2.05 Task Five: Marketing and Distribution System of Cokemaking Industry

The means of marketing and distributing coke is critical, extensively affecting the coke output and exports. To select an appropriate way to market coke, distributors should take account both of the plant and the market condition. There are various marketing methods, generally including: (1) direct distribution, (2) commission agents, (3) broker distribution, and (4)joint marketing. Currently, with the development of the internet, some new marketing methods, such as direct email marketing, and on-line marketing are emerging.

Because of the limited scale and management of cokemaking TVEs, most cokemaking plants adopt direct distribution. From the 2003 sample survey in Shanxi cokemaking TVEs, we found that 97 plants, out of the 110 plants we surveyed, adopt direct distribution, accounting for 88.2% of total surveyed. Among those that adopt direction, 96 plants sell their coke directly to consumers, of which 12 plants sell their coke both directly to the customers and through their own agents in various regions. One plant only markets coke through its own agents. In these plants, the reasons they adopt direct distribution are greatly different, but we classify them into the following two categories:

a. Larger plants that have perfect marketing network or with self-run import-export authority or have both;

b. Medium and small-scale cokemaking plants. Due to the limit of labor force or capital, many plants adopt direct distribution. In addition, from the perspective of scale economies, direct distribution is much more effective for a medium or small-scale plant to use than to set up its own agents.

Of the qualified surveyed plants, 21.8% sell coke through commission agents. In addition, more and more plants begin to use joint marketing. Marketing companies put some invest in their production and sell their coke to the consumers, mainly overseas. For example, Shanxi Township Enterprises Coke Supply & Marketing Ltd (Stecoke) and Shanxi Provincial Coke Group Co. LTD are professional enterprises mainly engaged in the business of production, transportation and sales of coke. Stecoke owns 8 branch companies, and Shanxi Provincial Coke Group Co. LTD has 15 large cokemaking plants as its shareholders.

The marketing method a plant manager selects also depends on the market situation. Currently, coke demand is outstripping coke supply, and direct distribution gains an advantage over other distribution methods both at home and abroad, because it is a little difficult for the consumers to buy better-quality coke if they do not take an initiative.

Internet marketing is become more and more popular in large companies. Although this is not common for Shanxi cokemaking TVEs, some major companies begin to use this method by making their own website: for example, Antai Group (http://www.antaigroup.com/), Sanjia Coalification Company (http://www.cnsjcoke.com/), Yingxian Coal-carbonization Company (http://www.yingxiancasting.com), and so on. Sanjia is selling coke through the internet.

2.06 Task Six: Compilation of Inventory of Major Cokemaking Equipment Manufacturers

To facilitate the growth of China's coke sector, cokemaking plants need access both to domestic and international cokemaking-support organizations. Here, we present information that we obtained through telephone interviews, internet searching, and literature reviews. These organizations are composed of three categories: (1) cokemaking-technology providers, (2) cokemaking-equipment producers, and (3) cokemaking associations. We primarily focus on the cokemaking-technology providers mainly given the importance of coke oven technology in the cokemaking process and the information-release style of other organizations.

Cokemaking-technology providers are very important to the plants. We list the main ones, who are from China, Canada, German, Indian, Scotland, United States, and Ukraine.

a. China, including Anshan Cokemaking & Refractory Engineering Consulting Corporation (ACRE), Anshan Research Institute of Thermal Energy (ARITE), Shanxi Provincial Design Institute of Chemistry Engineering, The Second Design Institute of Chemical Industry;

b. Canada, such as The CANMET Energy Technology Centre--Ottawa Canada (CETC-O);

c. Germany, including Deutsche Montan Technologie GmbH (DMT), The KOCH Group, ThyssenKrupp EnCoke GmbH (TKEC);

d. India, such as Central Fuel Research Institute, Metallurgical and Engineering Consultants (India) Ltd. (MECON);

e. Scotland, John M. Henderson & Co Ltd;

f. United States, Including Koppers, Inc., UEC Technologies LLC and Sun Coke Company; and

g. Ukraine, mainly GIPROKOKS Institute--Ukraine.

For each provider, we list their scope of business in the cokemaking sector, and their contact information.

In terms of the cokemaking related associations, there is no global cokemaking association, but many countries have their own cokemaking association.

a. China: Chinese Cokemaking Industrial Association,

b. United States: American Coke and Coal Chemicals Institute – ACCCI, Eastern States Blast Furnace and Coke Oven Association from USA, and the newly founded association in USA in January 2004-The Association for Iron & Steel Technology (AIST), and

c. United Kingdom: The Coke-Oven Managers' Association (COMA, United Kingdom)

Concerning cokemaking-equipment manufacturers, we only list some of them. Actually, Cokemaking equipment is not sophisticated in terms of manufacturing. Most of the manufacturers, such as MITSUBISHI Corp, Mitsui Corp., etc., can produce the equipment according to sketches provided by contractors.

2.07 Task Seven: Assessment of Prevailing Coke Oven Technologies and Selection of Pilot Demonstration Plants in Cokemaking TVE

In general, traditional machinery coke ovens have great advantages in recovering by-products, such as coal gas, coal tar and raw benzene, but in terms of environmental pollution, they are not as good as most of the modified coke ovens. Modified coke ovens, however, do not recover by-products and consume more refined coal per tonne of coke than do the machinery coke ovens. The newly designed "clean" coke ovens have very good environmental protection characteristics and most can also recover some heat. In detail, the three categories of ovens have considerably different techniques.

We conducted comparisons among the popular coke ovens adopted by the Shanxi Province cokemaking TVEs. The coke oven type covers 58 type, JNK98-43D, TJL4350A and TJL4350D, "clean" coke oven such as QRD-2000, improved SJ-96, and so on.

a. Energy consumption: the "clean" coke ovens have a higher coal consumption per tonne of coke than that of TJL4350A and TJL4350D. Because of the side-coal-loading technique, TJL4350D is much more energy efficient than the TJL4350A.

b. Investment cost. On average, the investment per tonne of coke of the "clean" coke oven varies between 300 and 400 RMB yuan, TJL4350A is similar, while the investment per tonne of coke of TJL4350D rose to about 690 RMB yuan because it introduced coal tamping technology.

Table 1 Comparison among some major coke ovens

Technical Index	QRD-2000	QRD-2002	TJL4350A	TJL4350D	58 type	Improved SJ-96
1. Dry coal per ton of coke (tonne)	1.35	1.338	1.3	1.24		1.315
2. Investment per ton of coke (RMB yuan/tonne)	332	364	335	689.73	305	41.3
3. Coal-tamping method	Tamping with machine	Tamping with machine	No tamping	Tamping with machine	No tamping	Tamping manually
4. Loading coal density (tonne/m^3)	1.1-1.2	1.05-1.1	0.76	0.95-1	0.75	0.84-0.92
5. Processing Process Method	Negative Pressure	Negative Pressure	Positive Pressure	Positive Pressure	Positive Pressure	Negative Pressure
6. Recovery of by-products	Heat	Heat	Coal gas, Coal tar, and Raw benzene	Coal gas, Coal tar, and Raw benzene	Coal gas, Coal tar, and Raw benzene	Heat

In summary, we think that compared with traditional machinery coke ovens, both "clean" coke oven, such as QRD-2000 and QRD-2002, and newly designed machinery coke ovens, such as TJL4350A, TJL4350D oven types have good potential in Shanxi cokemaking TVEs. They are much better in environmental-pollution control and the investment per tonne of coke is much lower than that of traditional large-machinery coke ovens. Most important, the coke quality produced by these ovens is also good. Thus, given the current situation when the environmental problems are the major concern of the national and provincial governments, we propose encouraging the use of "clean" coke ovens in main cokemaking areas in Shanxi Province. In the long run, however, because they combust all the tar and chemicals and those products can never be recovered, if China or other countries start to have shortages of these products, the advantages of the "clean" coke ovens is not so great. So, we should also be far-sighted and make a major effort to improve the environmental pollution of large machinery coke ovens.

As to the selection of demonstration plants, we have decided on a "clean" coke-oven plant, the Gangyuan Company in Qingxu County that adopted QRD-2000 type. As to another pilot plant, through comparative analysis and discussion with Shanxi TVEs officials and experts, we think that Sunlight Cokemaking Group is suitable for demonstration for its technology (JNK43-98D), energy-saving and

management.

2.08 Task Eight: Needs of Cokemaking TVEs for Technical Assistance

In fact, China have excellent experts in developing new type coke ovens, while in affiliated equipment of coke ovens and specific technologies during the production process, it is very necessary to introduce advanced techniques and equipment.

Through field trip, sample survey and interviewing engineers in Shanxi cokemaking plants and experts in Shanxi Province, we determined that the cokemaking TVEs need technical assistance in the following aspects.

1. Specific technologies during the production process, including:

a. Tightness of Coke Oven Door.

In machinery coke oven, the tightness problem of coke oven door is not well solved. The factors that affect the tightness of coke oven door are mainly the following: First, in the early stage of coking, lots of raw coal gas generates from the coke oven, which creates great pressure difference between the edge of coke oven door and outside and therefore affects the tightness of coke oven door. Second, due to the temperature difference, the swelling capacity between inside and outside of the coke oven door is also different, which cause the distortion of coke oven doorframe. Third, similar to coke oven doorframe, coke oven door is easy to distort too, which creates crevice between coke oven door and doorframe. From our field survey, we found that all machinery coke ovens are facing this problem, whether they are newly built or have been used for years. Lots of smoke emerged from the holes besides the door, which heavily polluted the air, while this phenomenon could be avoided. According to the foreign researchers, in the cokemaking company of the United States, there is no smoke discharging from the coke oven.

b. Overburning problem of coke

In "clean" coke ovens such as QRD-2000, although they can produce high-quality coke with little pollution, they have an unsolved issue. In producing 100 tonnes of coke, about 4 tonnes of coke melts in the coke oven, which is a very high lost. If a "clean" coke oven plant like Gangyuan Company, produces 400 thousand tonnes coke per year, it will lose 16 thousand tonnes coke.

c. Blockage of flame path in coke oven

This is a problem closely related to the overburning of coke and also one problem occurred in "clean" coke oven. If the air inlet is too large, it is prone to cause overburning and melting of coke, on the contrary, if the air inlet is too small, the coal for cokemaking will not be completely combusted, then the combined coke oven gas generating on the top of the coke oven including coke oven gas several other kinds of chemicals, has to be back to the bottom of the coke oven to be burnt again. Because of high temperature, some of the chemicals may be decomposed to carbon or something related and adheres to the flame path, causing its blockage and further affects regular combustion in the coke oven.

How to control the size of the air inlet and further optimize heat supply of the coke oven is an urgent task to both the "clean" coke ovens and other kinds including machinery coke ovens. Heat supply is a common issue encountered by almost all kinds of coke ovens.

d. Distortion of tunnel grid and division board

As mentioned in 1.c, optimization control of heat supply system of the coke oven is an urgent task to most cokemaking plants. Due to the temperature instability in the coke oven, the refractory materials have to adapt to the abrupt variation of the temperature. The refractory materials, however, have quite distinct expansion coefficient against different temperature. Subjected to the instable high temperature all the time, the refractory materials are very prone to distort. The distorted refractory material, in turn, could not maintain its resistant performance to high temperature, and cause more unstable temperature, which forming a vicious spiral.

Except for the high temperature, another important aspect against distortion is the character of refractory materials, so it is very necessary to find an appropriate material that can endure the high temperature.

2. Affiliated equipment, especially pollution treatment equipment in coal-loading process and coke-unloading process

2.1 Characteristics of pollutants

Compared to "clean" coke oven and advanced modified indigenous coke ovens, one of the main shortcomings of machinery coke ovens is heavy pollution, especially in the process of coal-loading and coke-unloading.

Coke oven charging and pushing emission are scattered from many places and widely covered the top of the oven. In the meantime, it also has the characteristics of continuity, gustiness and contingence

coexisting, and floating dust source point. Coke oven charging and pushing emission consists of many kinds of harmful pollutants, for example BAP (benzopyrene), which was listed as a kind of carcinogen by the national government in 1987. In addition, because the emission contains some coal tar, the dust has high viscosity, and usually the temperature is high with open fire, it is difficult for treatment.

2.2 Current treatment techniques and future needs of TVE cokemaking plants

At present in China, treatment techniques for emission include: (1) independent ground dedusting station for coke oven charging emission, and coke oven pushing emission respectively; (2) combined ground dedusting station for both coke oven charging and pushing; and (3) dust depression hood. Compared to ground dedusting stations, the dust depression hood can gather about 75%-85% of the emission, the ground dedusting stations can collect and purified over 90% of the total emission. While the investment of ground dedusting station is very high, almost half of that of the coke oven, that is why only several plants install ground dedusting station in China.

We found that in one cokemaking plant in Anshan Iron and Steel Company, the dust depression hood was installed. Although it is not so good as the ground dedusting stations in gathering the emission, it does reduce the total emission sharply. In Shanxi TVEs, it is unpractical to ask them to install ground dedusting stations, so dust depression hood will be a nice alternative in current stage. Our final target, however, is to install ground dedusting stations in most of the plants in order to cut down coke oven charging and pushing emission. Emission control technologies are an urgent need of cokemaking plants.

3. Technology for coal mixture

Coking coal resource is not as rich as people think, and high-class, free milling coking coal resource is becoming less and less.

At present, in order to guarantee the quality of metallurgical coke, high-class coking coal usually accounts for over 50% of the coal for cokemaking, especially in large machinery coke ovens because most of them do not make coal-tamping before loading to the coke oven, which greatly limit the use of other soft coal types. In our sample survey, 14 plants only use coking coal for cokemaking, accounting for 12.7% of qualified surveyed plants. About 41% of the qualified surveyed plants use coking coal with the percentage over 50%. Some plants, most of which adopt advanced modified coke oven such as

SJ-96, can produce coke with less coking coal, usually 30%-40% of total coal consumption.

In current situation, the percentage of coking coal consumption in cokemaking industry is too high considering more and more precious coking coal resources. So **how to reduce the coking coal percentage in coal mixture** is very crucial to the sustainable development of this industry and related metallurgical industry. Many experts from both research institutions and plants conducted a number of coal mixture test by using other types of coal. These tests help reduce the per capita consumption of coking coal, but not to an extent that can make full use of other soft coal types. Therefore, under the condition of maintaining the quality of metallurgical coke, how to further decrease the percentage of coking coal and enlarge the coal types for cokemaking, is a very important task that the researchers and plants have to undertake.

In conclusion, the technical needs of machinery coke ovens focus on environmental pollution treatment technology, tightness of coke oven door and coal mixture. "Clean" coke ovens, however, have more specific problems because this kind of oven is in preliminary stage, many problems have to be gradually solved in the production process. The technical problems are closely related to the heat-supply control system, for example, distortion of main refractory materials, overburning problem of coke, blockage of flame path and so on.

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(2 of 2)

UNIDO Contract No. : 03/120

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Attachment 3.01

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3.01 Current Profile of TVE Cokemaking Industry in Shanxi Province

Contents

1. Introduction

Shanxi Province is the biggest coke base of China, its coke output exceeds 50 million tonnes, accounting for 33 percent of the national total output and its coke capacity reaches 80 million tonnes. At present (2003) Shanxi Province supplies 70% of domestic coke consumption in China. As to export, coke export from Shanxi accounts for 70% of China coke export and over 40% of world coke export (*Shanxi TVE Bureau, 2003*). Different from other provinces, most of the coke in Shanxi Province is

produced by TVEs. During the past several years, Shanxi cokemaking industry especially TVEs went through rapid changes. As we noted earlier, because of governmental policies issued in 1999, most of the modified coke ovens were closed, and traditional large-machinery coke ovens and new type ovens that are called "clean" or "non-recovery" coke ovens have been established.

In order to know the current situation of Shanxi cokemaking industry in TVE, under the support of the United Nations Industrial Development Organization (UNIDO), the Shanxi TVE Bureau conducted a detailed official survey on the basic situation of cokemaking TVEs. They designed a survey form in September 2003 and sent to local TVE Bureaus of all regions of Shanxi Province. They mainly include the number of establishments, volume of production, output value, technologies (by coke oven type) in the survey form, and expected to get the entire profile of the cokemaking industry. The survey was finished at the end of October 2003.

Although we hope to get the entire information of Shanxi TVE cokemaking industry, especially the total coke output, total number of the plants and the total employment, the data we get from the survey are smaller than expected. For example, the surveyed forecasted coke output of Shanxi TVEs is 33.4 million tonnes in 2003, while according to Shanxi TVE Bureau, the total coke output in Shanxi TVEs reached to 63.43 million tonnes in 2003. There is a large gap between the surveyed and estimated coke output. We discussed this problem with Shanxi TVE Bureau officials, their analysis below may explain the problem.

Since 2002, the price of coke has increased dramatically, both in the domestic and international market. Such a good price stimulates the production of Shanxi cokemaking plants, especially that of TVEs, which face fewer restrictions than the SOEs. Because of the boom of the market, many disqualified cokemaking plants are still producing coke. These plants can be classified as two types: the first one is that the coke ovens they adopted are not listed in the 1999 industrial policy, issued by the State Economic and Trade Committee of China[1], that should be closed, but are not those whose use should be encouraged either. They do not have the production permission of the Shanxi Provincial Economic and Trade Committee and other related agencies; the second type are those that have been ordered to shutdown but actually they do not obey the policy but continue to produce coke due to the rising coke price.

[1] In 1999, the State Economic and Trade Committee issued a policy, ordering the elimination of the most backward production processes, and announcing a catalogue of the processes that should be eliminated.

In our survey, these plants may not report their information. Although we did not get the expected data, we also gathered very valuable information of the current situation of Shanxi cokemaking TVE, for example, the structure of prevalent coke oven types, which basically embodies the technological level of this industry in Shanxi Province.

The following chapters are those results we got from the above survey by Shanxi TVE Bureau.

2. Current Situation of Surveyed TVEs in Shanxi Province

The cokemaking sector has become the key sector of the Shanxi local economy and been the main source of financial income, foreign exchange earnings, and local farmer's income. In addition, the boom of the cokemaking sector has brought about the rapid growth of transportation, the metallurgical sector, and other tertiary sectors. According to the survey, there are about 589 cokemaking TVE plants in Shanxi in 2003, of which 174 plants adopt traditional machinery slot coke ovens, 8 plants employ "clean" coke ovens, and 407 of them adopt modified coke ovens, which used to be very popular in the 1990s in Shanxi TVEs. The total estimated coke output of all surveyed in 2003 may reach to 33,402 thousand tonnes. Table 1 shows detailed current situation of Shanxi TVE cokemaking sector.

Table 1 Current Situation of Surveyed Shanxi Cokemaking TVEs in 2003

Unit: thousand tonnes, million RMB yuan

	Number of Plants	Production Capacity	Coke Output	Coke Output value	Value-added
Total	589	45,052	33,402	19,347.2	5,780.3
Machinery coke ovens	174	30,652	22,182	13,892.2	4,080.7
"Clean" coke ovens	8	2,600	1,850	540.0	97.2
Modified coke ovens	407	11,800	9,370	4,915.0	1,602.4

Source: Survey results conducted by Shanxi TVE Bureau in October 2003.

Table 1 indicates that although modified coke ovens still dominate in number, accounting for 69% of the total TVE cokemaking plants, their output is quite small, representing only 26% of the total coke output of TVE. In contrast, 22,182 thousand tonnes of coke is produced by traditional machinery coke ovens, accounting for 66.4%. Compared to the above two types of coke ovens, the output of "clean" coke ovens is relatively low. From our field survey to Shanxi province, we found that local officials and

cokemaking expert think the "clean" coke oven is relatively good in many aspects, especially in respect to its environmental-protection properties. Thus, although only a few cokemaking plants build this kind of oven, it may have a great potential for spreading in main cokemaking areas.

According to the survey, there are 268 cokemaking plants with sales revenue over 5 million RMB yuan in Shanxi TVEs, of which 160 plants adopt traditional machinery coke ovens. Their total employment is 78,082. To those plants with sales revenue less than 5 million RMB yuan, we did not obtain the exact number of employees. In these plants, the situation is fairly complex, because some of them are ordered closed, but they are still producing, and some of them are very small plants that have no good accounting data; therefore we had difficulty in gathering this information.

3. Dominant Coke Ovens in Shanxi TVE

As shown in section 2, traditional machinery coke ovens produce most of the coke in Shanxi Province, "clean" coke ovens are now being built like bamboo shoots after a spring rain, while there are still many modified coke ovens in production.

Because of the industrial policy issued by the State Economic and Trade Committee in 1999, the Shanxi provincial government and other related departments took great efforts in the restructuring of cokemaking TVEs. Since 1999, over 5000 small coke ovens were closed in Shanxi Province, these ovens produced 12 million tonnes of coke. In the meantime, some traditional large-scale machinery coke ovens, with battery height over 4.3 meters high, were established. The proportion of coke produced by traditional machinery coke ovens rose to 47% in 2002 from about 32% in 1999. By the end of 2002, 85 machinery coke-oven plants have been built or on the books to be built; they have a gross designed capacity of 45.5 million tonnes of coke. For example, the total coke capacity of Antai Group in Jiexiu City (JN-60-6) is 2.2 million tonnes, Xiaoshan Group in Jiexiu City can produce 1.8 million tonnes of coke per year, Maosheng Group in Jiexiu City established machinery coke ovens with an annual coke output of 1 million tonnes; Sun Group in Hejin City 1.1 million tonnes of coke, Jinye Group in Gujiao City 1.1 million tonnes of coke, and so on.

In the meantime, local agencies also developed a new type coke oven, called a "clean" coke oven, the main advantages of which are good environmental protection, tamping coal loading, and recovery of heat[1]. Now, some cokemaking plants in Shanxi Province have established this kind of coke oven, for

example, Gangyuan Cokemaking Company Lt. in Taiyuan with 0.4 million tonnes of designed coke capacity, Xinggao Cokemaking Company Lt. in Gaoping City with 0.4 million tonnes of designed coke capacity.

Table 2 shows the main coke-oven types in Shanxi cokemaking TVEs and the rough estimated proportion of their coke production in 2003.

Table 2 Main coke oven Types in Shanxi Province cokemaking TVEs, 2003

Coke type	Estimated proportion of coke production (%)
Machinery coke ovens	
58 type	26.9
JNK43-98	9.1
JNK43-98D	8.9
TJL4350A	4.1
TJL4350D	2.4
70 type	6.3
66 type	1.8
Red Flag	4.3
"Clean" coke ovens	
QRD-2000 (Heat recovery)	1.1
DQJ-50 (No recovery)	0.9
Modified coke ovens	
TJ-75 type	2.6
JKH-89 type	2.2
SJ-96 type	5.5
96 joint type	6.6

Source: Survey results conducted by Shanxi TVE Bureau in October, 2003.

From Table 2, we can see that in traditional machinery coke ovens, the 58 type is the dominant one, accounting for almost 27% of total coke output. Large plants have adopted the JNK43-98 and JNK43-98D types. "Clean" coke ovens are at initial stage of adoption. Although modified coke ovens were ordered to shut down, some "advanced" modified coke oven, such as TJ-75, SJ-96, are still in production.

4. Changes of Shanxi Cokemaking TVEs since 1999

Two main changes have affected the TVE plants since 1999: (1) fluctuations in the numbers, and (2) alterations in the coke-oven structure.

4.1 Fluctuations of number of plants, coke output, and output value

Shanxi cokemaking TVEs have gone through very rapid changes since 1999. Compared to the number of cokemaking plants and structure of coke ovens, the variation of total coke output is much smaller, but because of the market, the coke-output value and value-added fluctuate widely. Table 3 shows detailed information.

Table 3 Cokemaking sector changes in the past five years

Year	Number of Plants	Coke output (Thousand tonnes)	Coke output value (million RMB yuan)	Value-added (million RMB yuan)
2003	589	33,402	19,347.2	5,780.29
2002	683	34,980	14,560.0	5,780.29
2001	680	31,345	9,940.6	2,852.05
2000	1,076	34,320	15,685.2	4,290.65
1999	1,516	31,188	9,533.81	2,661.30

Source: Survey results conducted by Shanxi TVE Bureau in October 2003.

After the implementation of the 1999 industrial policy, many small-scaled plants were closed, the number of TVE plants changed very rapidly, declining from 1,516 in 1999 to 589 in 2003. Total coke TVE output, however, did not change much, it increased from 31,188 thousand tonnes in 1999 to 33,402 thousand tonnes in 2003.

4.2 Changes of coke-oven structure

In fact, the 1999 industrial policy affected the coke-oven structure most. With the implementation of the policy, modified coke ovens were closed one by one, in Qingxu county, Taiyuan city, alone over 80 modified coke ovens were demolished, and began to build some major large-scale cokemaking plants and expand large-machinery coke ovens. Enlarging the plant's scale is not only the requirement of industrial policy and environmental control, but also creates scale economy.

Table 4 Coke-oven structure by number of plants and coke output

		2003	2002	2001	2000	1999
Number of Plants (unit)	Machinery coke ovens	174	148	127	160	153
	"Clean" coke ovens	8	4	2	1	1
	Modified coke ovens	407	531	551	897	1260
Proportion of total(%)	Machinery coke ovens	29.5	21.7	18.7	14.9	10.1
	"Clean" coke ovens	1.4	0.6	0.3	0.1	0.1
	Modified coke ovens	69.1	77.7	81.0	83.4	83.1
Coke output (thousand tonnes)	Machinery coke ovens	22,182	18,160	12,735	13,120	9,618
	'Clean" coke ovens	1,850	380	150	50	50
	Modified coke ovens	9,370	16,440	18,460	20,350	19,760
Proportion (%)	Machinery coke ovens	66.4	51.9	40.6	38.2	30.8
	"Clean" coke ovens	5.5	1.1	0.5	0.1	0.2
	Modified coke ovens	28.1	47.0	58.9	59.3	63.4

Source: Survey results conducted by Shanxi TVE Bureau in October, 2003.

In 1999, coke output of modified coke ovens accounted for 63.4% of the total surveyed, while it decreased to 28.1% in 2003. In contrast, machinery coke ovens produced 66.4% of coke in Shanxi TVE in 2003, much higher than 30.8% in 1999. Although the proportion of "clean" coke is still low, compared to only 1.4% of total in number, they produce 5.5% of the total TVE coke output.

5. Sample Survey of 2003 Shanxi Cokemaking TVEs

In order to well understand the TVE cokemaking industry in Shanxi Province more specifically in plants level and trace the changes of this industry in Shanxi Province in the past several transitional years, we did a sample survey from October to the end of December 2003. We sent out 150 questionnaires to the plants, and 131 forms were returned, after certification we determined that 110 questionnaires were qualified for tabulation. Concerning those that are disqualified, some of them supply inconsistent information, some plants obviously fill in the questionnaires randomly because several plants have very similar information.

In the sample survey form, we mainly covered the following information: coke oven selection, detailed export destination, marketing method and channel, policies, coal mixture, specific technologies of different kinds of coke ovens including coal-loading method and coking time, by-products,

employment and pollution. In the following paragraph, we conducted a summary analysis of major findings.

5.1 Future Coke Oven Selection

As shown in the results of the official survey done by Shanxi TVE Bureau at the end of last year, modified coke oven, such as TJ-75 type, and small machinery coke oven like Red Flag type, small 58 and WJ 663, are still widely adopted by Shanxi TVE plants managers. As to large and medium-size coke ovens, like JNK43-98D, and other newly designed machinery coke ovens such as TJL4350A and TJL4350D, more and more plants built these ovens. As to "clean" coke oven, QRD-2000 is the main one, 5 plants adopt this type.

While concerning the future selection of coke ovens that are suitable for local situation, the situation proves to be quite different. Regarding the reasons to select a certain coke oven type, most plants said that good environmental protection characteristics, and industrial policies are the main factors for future coke oven selection. Chemical-products recovery is also an important reason.

As to specific coke oven type, JNK43-98D, TJL4350D, Joint Environmentally-Friendly Oven and QRD-2000 are the top four types, the plants that will adopt them accounting for 10.9%, 10.0%, 9.1% and 8.2% of Qualified Surveyed Plants (QSP), respectively (*table 5*).

Table 5 Future selection of coke oven types

	Percentage (%)[1]
JNK43-98D	10.9
TJL4350D	10.0
Joint Environmentally-friendly Oven	9.1
QRD-2000	8.2
Small 58	5.5
TJL4350A	5.5
SJ-96	4.5
QRD-2002	3.6
91 type	1.8
DQJ-50	0.9
YX-21QJL-1	0.9

Note: 1. The percentage of cokemaking plants adopting a certain type to QSP

Future coke oven selection by the plants also reflects the debates of potential technical direction

between large machinery coke ovens and "clean" oven. Now, there are two different viewpoints in Shanxi Province, experts from environmental protection field as well as those who strongly advocate to enlarge the cokemaking coal types, insist that "clean" coke oven should be encouraged to build. Some experts proposed to built more large machinery coke ovens in Shanxi Province, on one hand, this oven type can recover chemical products, on the other hand, to adopt this kind of oven accord with the national industrial policy. Besides, they argued that large machinery coke oven could use other soft coal types too.

5.2 Coke production and coke sale

5.2.1 Coke output of surveyed plants increased in the past five years

Due to the rising market price, most plants increased their coke output. The coke output of QSP went up sharply in 2002 and 2003, to about 13627.8 and 16593.5 thousand tones (*table 6*). If we consider the plants that did not fill in the estimated coke output of 2003, while we got their coke output through field survey and other sources, the surveyed coke output of 2003 may exceed 18000 thousand tonnes. In the surveyed plants, over 90% plants increase coke output in 2003.

Table 6 Coke output of QSP in the past five years Unit: 1000 tonne

Year	1999	2000	2001	2002	2003 (estimation)
Coke output	5982.6	7937.3	9976.0	13627.8	16593.5

5.2.2 Coke sale and benefit variation

Because of the increasing coke demand and price both in domestic and international market, and the coke output value went up drastically in the past two years. Because of the incompleteness of data among the plants in the survey form in output value, we only compare the average output per ton of coke instead of discussing the total coke output value. The average coke output value per ton of coke remained about 325 RMB during 1998 and 2000, there was a slight turnaround in 2001 and 2002, to about 340 and 380 RMB yuan respectively. In 2003, however, it soared to 610 RMB yuan, increasing by 60% than 2002.

Concerning the coke supply and demand situation, 87% of QSP manager think that coke demand exceeds or equal to supply. As for operating situation, the percentage of the plants that got profit in

during 2002 and 2003 is much larger than previous years. In 2002 and 2003, about 76.4% and 69.1% of QSP got profit. In 1999, 2000 and 2001, however, only 38.2%, 39.1% and 56.4% reported profit, respectively.

5.2.3 Coke exports destination and marketing method

Due to strict environmental policies and aged coke ovens, the coke output of several developed countries such as the United States, Japan, Germany decreased sharply in the past several years while the coke demand increased. Besides, CIA countries are also reducing coke output (*see attachment 3.04 in detail*). So, these countries especially developed countries are more and more dependent on coke import, most of which from China.

The overseas coke destination of most plants is mainly the United States, Japan, Gemany, Brazil, Korea and India (*Table 7*). 12% of the plants export coke to Japan, and 8% of them to the United States.

Table 7 Coke Destination in abroad

Country	The United States	Germany	Japan	India	Brazil	Korea	Iran
Percentage (%)	8.0	6.0	12.0	4.0	7.0	6.0	2.0

Regarding marketing method of coke, most of the plants use direct distribution method, both in domestic and overseas market, accounting for 88.3%. 21.8% of the plants sell coke through commission agents (*table 8*). Most large-scale plants have self-own import-export authority and set up their own offices in major consumer's location and transfer stations (*See attachment 3.05 for detail*).

Table 8 Marketing methods in surveyed cokemaking TVEs 2003

Marketing method	Direct distribution	Commission agents	Others
Percentage (%)	88.2	21.8	5.4

5.3 Specific coke oven technology

In order to have a clear profile of the specific techniques of different kinds of oven, we included the information of coal input coefficient (coal consumption per tonne of coke), coal-loading method.

Coal input coefficient is rather diverse among different types of coke oven. Even in the same type of oven, the coal input coefficient is not the same probably because of the oven situation, management, coal type and so on, but we summarized as the follows.

a. Modified indigenous coke oven consumes 1.35-1.45 tonne of refined coal per tonne of coke. As for

individual type, that of TJ-75 is about 1.3, that of SJ-96 is 1.4-1.5, and that of improved SJ-96 is 1.25-1.3.

b. Machinery coke oven use 1.1-1.5 tonnes of refined coal per tonne of coke. Different from modified indigenous coke oven, machinery coke ovens are more technical in operation, the coal input coefficient depends more heavily on the quality of workers and production managerial skill. Therefore, among different kinds of machinery coke oven, there is a much larger gap in coal input coefficient. TJL4350D use 1.1-1.2 tonne refined coal per tonne of coke, the coal input of Red Flag, however, varies between 1.2 and 1.5.

c. "Clean" coke oven usually has a coal input coefficient at 1.3.

As for coal loading method, most machinery including Red Flag, WJ 663, and 70 type use top-coal-loading technique, several types including JNK43-98D, TJL4350D employ side-coal-loading method with coal tamping. "Clean" coke oven usually use side-coal-loading method with tamping, for example, QRD-2000 (*see attachment 3.07 for detailed information*). All modified coke oven adopt side-coal-loading, usually manually.

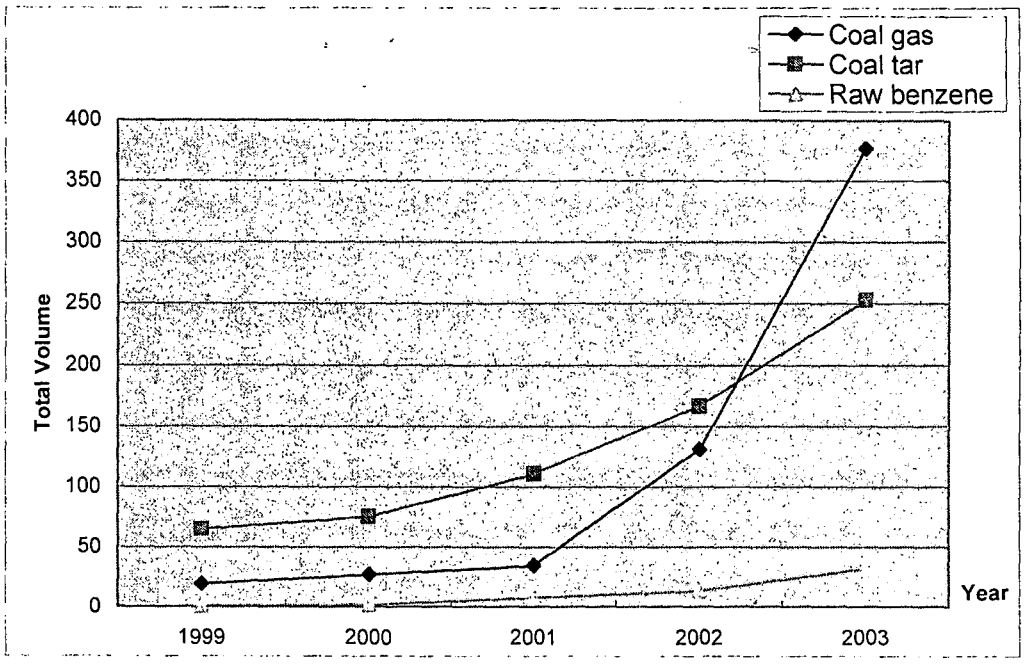
5.4 By-products recovery increased sharply

Since the wide adoption of large and medium-scale machinery coke oven, more and more by-products could be recovered (*Table 9, Figure 1*). Figure 2 clearly shows the sharp increase of total output of main by-products in QSP. In 2003, total coal tar volume rushed to 376.89 million cubic meters, almost threefold as that in 2002. Some plant has the capacity of coal tar deep-processing, the output of coal tar rose rapidly too, in 2002 and 2003, the coal tar output increased by 52% and 50% than previous year, respectively.

Table 9 By-products recovery in QSP (1999-2003)

Year	1999	2000	2001	2002	2003 estimation
Coal gas (million m^3)	19.35	27.18	34.84	130.91	376.89
Coal tar (thousand tonne)	65.17	75.40	110.95	166.84	252.93
Raw benzene (thousand tonne)	0.85	1.77	7.92	13.61	32.34

Figure 1 By-products recovery in QSP (1999-2003)



5.5 Structural change of employees

As mentioned above, because it is not easy to operate, machinery coke oven demand more skillful technicians in production process. With the construction of many large and medium-scale machinery coke ovens and the increase of coke output by machinery coke oven, the percentage of technical staff is expected to increase. Table 10 gives the structural change of employees in QSP. It is found that about 80% of employees are workers. That of technical staff is lower than 10%, while in the past several years, the percentage is increasing especially since 2002, from 8.61% in 2002 to 9.96% in 2003, showing that the quality of employees improve with the upgrading cokemaking technology.

Table 10 Employment structural change in QSP (1999-2003)

Year	1999	2000	2001	2002	2003 (estimation)
Production worker (%)	79.4	80.0	80.4	80.9	79.2
Technical staff (%)	8.51	8.75	8.57	8.61	9.96
Administrative staff (%)	12.1	11.3	11.1	10.5	10.8

5.6 Pollution treatment

With the implementation of environment regulations, more than three-fourth of QSP measure pollution. Most of the plants (65%) depend on local environment protection agencies to monitor the pollutants, 11.8% have their own measuring equipment. The pollutants they monitor are mainly total suspending

particle (TSP), SO_2, COD in waste water. Along with the restructuring of coke oven technology, the local government and related departments strengthen the treatment of environmental pollution. The plants also take an initiative in pollution treatment, otherwise the plants would probably be confronted with closure. From 1999 to 2003, the percentage of the plants that take pollution measurement of QSP increased rapidly, from 30% to 58%.

6. Concluding Remarks

Cokemaking industry in Shanxi Province came through a deep technical change in the past several years, especially after 1999. The restructuring of this industry greatly affects the production, market of coke, and other related aspects including environmental pollution, employment of local farmers. In summary, technical structural adjustment are regulating this industry, the energy efficiency is increasing, the environmental situation which the governments concern is becoming better in Shanxi Province especially in cokemaking areas, and the coke market is now flourishing.

UNIDO Contract No. : 03/120

UNIDO Project No. : EG/CPR/99/G31

Activity Code: 450D32

P. O. No. : 16000473

Attachment 3.02

Recent Governmental Policies/regulations and Impacts on Cokemaking Industry

of

The Final Report

to

the United Nations Industrial Development Organization (UNIDO)

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Provision of Services for the Execution of a Coking Sub-sector Survey

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Prepared by

Academy of Mathematics and Systems Science, the Chinese Academy of Sciences(CAS)

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April 15, 2004

3.05 Recent Governmental Policies/regulations and Impacts on Cokemaking Industry

Contents

To avoid low-level repeated construction in the field of industrial production, a series of policies and regulations were promulgated by national or provincial governments and related national agencies. These policies affect cokemaking industry variously, particularly, the industrial policy issued by State Economic and Trade Commission in 1999 about eliminating undeveloped production ability affects most. In this report, we compiled the main policies and regulations relating to cokemaking industry in recent years and conducted analysis of their impacts.

1. Brief Review of Recent Policies and Regulations

Recent policies and regulations relating to cokemaking industry are listed as follows.

a. The Catalogue of Elimination of Heavy-Polluting Technologies and Equipment (the First Series) (Guo Jing Mao Zi, No. [1997]367)

The Catalogue was jointly enacted by State Economic and Trade Committee, National Environmental Protection Agency and former Ministry of Machinery on June 5, 1997. In the list of "Elimination of Heavy-polluting Technologies and Equipments", the first item is "75 and 89 type modified indigenous

coke oven", shutdown deadline of which is the end of 1999. At the same time, the production scale for cokemaking plants must be larger than 200 thousand tonne of coke and the height of battery higher than 2.8 meter.

b. The Catalogue of Preventing Redundant Projects in Industrial and Commercial Investment Field (the First Series).

Generally called the 14th Order, the Catalogue was enacted by State Economic and Trade Committee on August 9, 1999. The Catalogue covers 17 industries, in which new investment is not allowed. The first industry is iron and steel related, including *indigenous (incl. modified indigenous) cokemaking technology* and *coke oven projects with battery height less than 4 meters*

c. The Catalogue of Elimination of Less Advanced Production Capacity, Technology and Products (the Second Series).

Called the 16th Order, the Catalogue was issued by State Economic and Trade Committee on December 31, 1999. The Catalogue covers 8 industries including iron and steel, non-ferrous metal and light industry, 119 items in which indigenous (incl. modified indigenous) cokemaking technology was ordered to eliminate by the end of 2000.

The 6th order of *The Catalogue of Elimination of Less Backward Production Capacity, Technology and Products (the First Series)* had been formerly issued by State Economic and Trade Commission on Jan. 22nd, 1999, in which 10 industries, 114 items are listed. The 32th order of The Catalogue of Elimination of Less Backward Production Capacity, Technology and Products (the Third Series) was also issued by State Economic and Trade Commission on Jun. 2nd, 2002, in which 15 industries, 120 items relating to fire control, chemical industry, metallurgy are listed.

d. Implementation Measures of Cokemaking Restructuring in Shanxi Province

In order to carry out *'The Instructions for industrial restructuring in Shanxi Province'* (Jinfa [2003] No.16), Shanxi Provincial Party Committee and Shanxi Provincial Government issued the file '*Implementation Measures of Industrial Restructuring in Shanxi Province*' at the end of 2003(Jin Zheng Fa No. [2003]28), in which '*Implementation Measures of Cokemaking Restructuring in Shanxi Province*' (the Measures) is an important part. Total volume control for cokemaking industry was stressed in the Measures. The second item of the measures says that "the coke output must be controlled

under 65 million thousand tonne by 2005, total volume of pollutants discharged by cokemaking reduce by 40% compared with 2002". The 12th item put forward that "the less backward coke ovens (including Red flag series, 70 type, 66 series type and modified indigenous coke oven) that don't accord with the national industrial policy must be shut down unconditionally"

In turn, the shutdown deadline for different type ovens is:

By June 6, 2004, all the modified indigenous coke ovens (including indigenous coke oven);

By December 31, 2004, all the small machinery coke ovens (including controlled area);

By June 30th, 2005, all the coke ovens in controlled area (except gas and heat supply item)

e. Guidelines for Upgrading and Renovation of Cokemaking Sector, drafted by Shanxi TVE Bureau in about 2000

The Guidelines was issued by Shanxi TVE Bureau in order to promote the healthy development of cokemaking TVEs industry in Shanxi Province. The Guidelines put forward that the battery of newly constructed coke oven must be higher than 4 meter, the output of single ovens must reach 400 thousand tonnes, and definite establishments for chemical products recovery and pollution treatment must be equipped.

f. Management Rules and Regulations of Coke in Shanxi Province, will be enacted in 2004.

2. Background of Policy-making

Policies and regulations relating to cokemaking industry issued centered on industrial restructuring, technical upgrading and pollution abatement, in order to control the coke output in a rational level

Comparing to other provinces, Shanxi Province possesses rich coal resources, especially in various high-quality coal type for cokemaking, which facilitate the development of cokemaking industry. Since the reformation and opening-up policy, cokemaking industry has developed rapidly and become a pillar industry of Shanxi Province. From 1980 to 1998, the coke output increased from 3.21 to 57 million tonnes, by 17.76 times.

The increasing coke output was mainly produced by indigenous or modified indigenous coke oven, instead of machinery coke oven. For example, 62% of the total volume was produced by indigenous

coke ovens and modified indigenous coke ovens in 1985, while in 1997, the percentage escalated to 85%. Since 1999, the implementation of state industrial policy causes the decrease of coke production. According to incomplete statistics, there are 3147 cokemaking enterprises in Shanxi Province in 1996, in which 2416 enterprises adopt indigenous (including modified indigenous) coke ovens, less than 10 plants built middle or large-scale machinery coke ovens. By the end of 2001, however, the number of large machinery coke ovens increased to 27 and small machinery coke ovens to 119, while modified indigenous coke oven reduced to 1320. Undeniably, indigenous coke ovens and modified indigenous coke ovens used to make contributions to the economic development and employment. Then, because of its low invest, low demand of staff quality, quick production capacity and easiness in operation, indigenous coke ovens and modified indigenous coke ovens were widely adopted by village and township enterprises. The rapid increase of indigenous coke ovens and modified indigenous coke ovens met the demand of iron and steel industry, contributing to the development of industry and, fulfill the capital accumulation for cokemaking industry.

But the wild expansion of indigenous coke ovens and modified indigenous coke ovens generated many serious problems, mainly embodying as follows: a. out-of-order competition that causes massive loss of economic interests; b. serious environmental pollution; c. low energy efficiency; d. low-level repeated construction, etc. These problems seriously impact the sustainable development of cokemaking industry, coal industry and other relevant industries.

Oversupply of coke emerged in Shanxi Province in about 1991 after ten years of development. Until 1995, coke overstock reached to 15 million tonnes, and increased to 17.8 million tonnes in 1997. In international market, the FOB price of Chinese coke dropped to US$50 in 1998 because of the oversupply of coke. Coke export was completely in disorder, wild competition among domestic cokemaking enterprises offered opportunities for foreign businessmen to demand a lower price. For example, as much as 15.2 million tonnes coke were exported in 2000 but only gained US$915 million. The average coke price of Chinese exported coke was 30% lower than that by other countries, causing the loss of precious resources. In the viewpoint of resources, almost all the indigenous and modified indigenous coke ovens directly burn the chemical products such as coal tar, gas and raw benzene, while surplus coke oven gas is directly discharged into the air, creating serious environmental pollution. In

Shanxi Province, 72 counties (cities or regions), accounting for 61% of the total number of that in Shanxi, have cokemaking enterprises. In these areas, the total suspending particles was once high up to 800mg/m^3, and COD in surface water seriously exceed the national standard. Air pollution capacity and water pollution capacity caused by cokemaking industry, used to account for 30% and 40% of the total capacity of Shanxi Province respectively. Because of the less advanced techniques, the coal input coefficient (coal consumption per ton coke) of indigenous coke ovens and almost all of the modified indigenous coke ovens is 200kg higher on average than that of large machinery coke ovens.

The Chinese Government and related agencies, Shanxi Provincial Government and relevant departments attached much importance to the problems caused by cokemaking and other relative industries. In order to protect resources and environment, and, to keep a sustainable development, it is necessary and urgent to eliminate less advanced techniques, upgrade the technology level and to optimize the industrial structure. On the other hand, it is very critical to realize total volume control in order to regulate domestic and international market and, to stabilize Chinese coke price. Therefore, trusted by State Economic and Trade Committee, experts in Chinese Cokemaking Association drafted the file on reconstructing guidelines of cokemaking industry. According to the state industrial policy, relevant departments in Shanxi Province issued related regulations to implement the policy. They carried out "'7.1' shut-down program" in 1999 and "'6.5' shut-down program" in 2000. Shanxi Provincial Government and Shanxi Economic and Trade commission promulgated several managing methods to facilitating the reconstructing of cokemaking industry.

3. Impacts of Recent Policies and Regulations

Recent above policies and regulation generated wide impacts on cokemaking industry, including its production, technology upgrading and export.

In January 2001, State Economic and Trade Commission stressed again that indigenous coke ovens and modified indigenous coke ovens must be closed before June 30 2001. Many indigenous coke ovens, modified indigenous coke ovens and less advanced small machinery coke ovens were closed. Statistics shows that 709 indigenous coke oven plants, 628 modified indigenous coke oven plants and 354 improved modified indigenous coke oven plants were shut down by January 2004, including 1200 small

TVEs (*http://www.stecoke.com/*). At the same time, some large machinery coke ovens were rebuilt or expanded in some major cokemaking plants, these ovens were demanded to install equipment for chemical products recovery and pollution treatment. Besides, new coke oven types have been developed in Shanxi Province, for example, 'clean' heat-recovery coke ovens, represented by QRD-2000 type, have been built and put into production. Cokemaking industry came through a deep renovation in Shanxi Province in the past several years. From the point of view of sustainability, industrial policies are helpful to the sustainable development of cokemaking industry.

3.1 Coke output changes in recent years

The restructuring of cokemaking industry began after the implementation of 1997 industrial policy (Guo Jing Mao Zi (1997) No.367), many small coke oven were closed, especially after 1999. Some large coke oven projects however, did not form production capacity then, which caused a rapid drop of coke output. In Shanxi Province, the output of coke reached the top in 1998, then decreased annually until 2002 (*see table 1 and figure 1*).

Table 1 Coke output in recent years in China and Shanxi Province

Unit: 10000 tonne

Year	China	Shanxi	Shanxi TVE
1995	13501	5298	
1996	13650	5397	
1997	13900	5279	4733
1998	12800	5703	5030
1999	12110	4960	4348
2000	12180	4967	4331
2001	13130	4959	4331
2002	14237	5851	5232
2003	17800[1]	7200	6343

Source: China Statistical Yearbook (1996-2003), Shanxi Statistical Yearbook, Shanxi Statistical Abstract, and unpublished data of Shanxi TVE Bureau

[1]Source: http://www.stecoke.com/chinese/shownews.asp?newsid=2553

Figure 1: Coke output in recent years in China and Shanxi Province

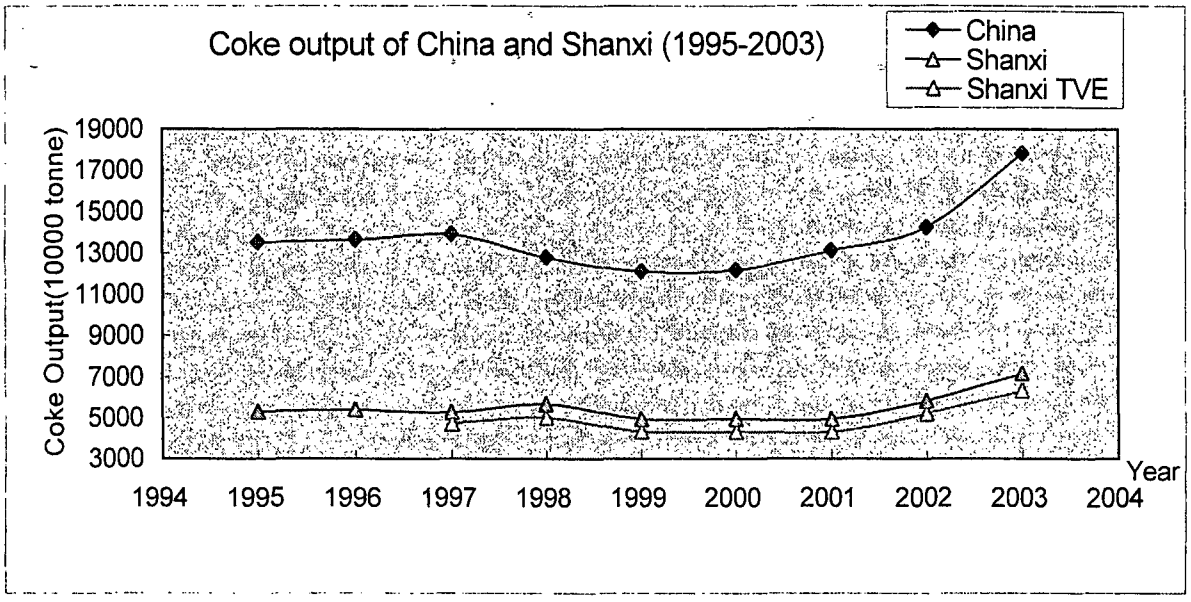


Table 1 shows that China's coke output peaked in 1997(139 million tones) and changed obviously since 1998. Compared to 1997, coke output reduced 11 million tonnes in 1998 and further dropped to 121.1 million tonnes in 1999. Coke output of Shanxi changed similarly to that of the country, while it reduced more in ratio because the closed indigenous cokemaking ovens account for a large percentage. In 1998, the coke output was 57.03 million tonnes, while in 1999, it was 49.6 million tonnes. Because of the coke output decline and the vast domestic demands by rapid development of industry relating to iron and steel, coke demand outstripped supply in international market from the later half year of 2001. Hereinafter, coke output increased sharply in 2002 and 2003, by 8.4% and 11.5% than last year respectively. Driven by economic interests, coke output in Shanxi Province soared in the last two years and some closed indigenous, and modified indigenous coke ovens began production again. To avoid disordered competition as emerged at the end of last century and protect precious coking coal resources, Shanxi Provincial Party Committee and Government put forward that the total coke output should be controlled less than 65 million tonnes.

3.2 Impacts on technology structure

Since 1999, cokemaking technologies developed rapidly, the technical installation and energy-saving techniques improved a lot. Some plants built large machinery coke ovens with 6 meters of battery height, and the production capacity vary between 0.5-1 million tonnes per year. In chemical products

recovery, many plants install recovery equipment and some even expand their production scope to related industries and products, such as town gas, industrial kiln, methanol production and power generation.

As to coke oven structure, Shanxi Province changed the dominance of indigenous coke ovens and modified indigenous coke ovens. Although small machinery coke ovens still account for a large percentage, large and medium machinery coke ovens have been built or are being built (*see table 2*).

Table 2 Main large and medium machinery coke oven type in Shanxi Province

Coke oven Type	Battery height (mm)	Major plants
JN-60-6	600	Jiexiu Antai Group
JNK43-98D	430	Qingxu Meijin Group, Hejin Sunlight Group
SC43-98D	430	Shanxi Xiandai Coke Company, LTD
TJL4350D	430	Linfen Townstar Group
JN43-80	430	Changzhi Iron and Steel Company, Taigang Cokemaking Plant

Jiexiu Antai Group built JN-60-6 coke oven with coke output at 2.2 million tonnes per year, they also adopted dry coke quenching technique. Jiexiu Maosheng Group adopts JNK43-98D coke oven and can produce 0.96 million tonne coke per year. This type uses side-coal-tamping technique, which effectively increases the coke intensity and reduces the ration of coking coal to a minimum percentage. SC43-98D not only has the advantages of JNK43-98D, but also makes improvements in chemical-products recovery. The first phase of Shanxi Province major projects in Nine-Year period---the most advanced JN60-89 type with large volume has been put into production in Shanxi Cokemaking Group in Hongdong and the No. 1 coke oven has been put into production

In addition, Shanxi provincial design institutes developed "clean" coke oven with hot coal-loading and coke-unloading technique entitled DQJ-50 type, and conducted test production in Houma Industrial Zone in 2000. Then after modification of DQJ-50, the type is formally named as QRD-2000 type. At present, several plants have constructed this type of oven, including Taiyuan Gangyuan Coke Group, Gaoping Xinggao Coke Company, and some plants in Shandong Province. According to Shanxi Provincial Chemical Design Institute, they have signed contracts with five companies to build this type of oven.

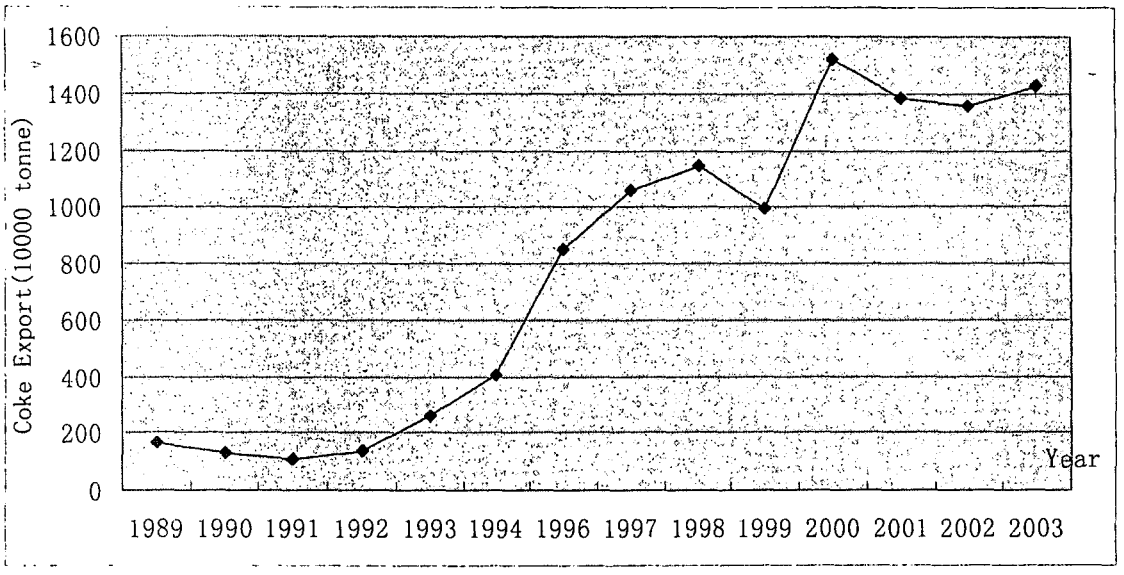
3.3 Impacts on coke market

As discussed in *section 2*, the coke price is very low at the end of last century. From our field survey in the past years, many cokemaking TVEs ran in deficit during 1998-2000. The situation of large machinery coke oven plants was a little better because they could make some money by selling chemical products such as coal tar and raw benzene. After the restructuring, however, total coke output was effectively controlled, the market became regulated and the Chinese coke became competitive again in international market. FOB price in Tianjin port has been the benchmark price of international market, Chinese coke recapture the dominance in coke price.

In a short term, the reduction of Chinese coke output greatly affected international coke market, driving the coke price up. The Chinese coke output reached to 142.79 million tonnes in 2002, equal to the total coke output of the other six major coke producers including Japan, Russia, USA, Germany, UK and France, accounting for 40% of global coke output. China export 13.57 million tonnes of coke in 2002, accounting for 68% of traded coke. In recent years, because of increasing demand of domestic iron and steel industry, Chinese coke export decrease gradually, peaking at 15.2 million tonnes in 2000 and dropping to 13.86 and 13.57 million tonnes in 2001 and 2002, there is a little return in 2003, 14.25 million tonnes (*figure 2*). Since the beginning of 2002, coke price rises successively, the price of metallurgical coke with 10.5% ash soared to US$300 in February 2004 from US$69 at the end of 2001. The coke price of Shanxi Cokemaking Group in Hongdong County, for example, increased to an average 870 RMB yuan in 2003 from 360 RMB yuan in 2002[1]. The increase of coke price depends on various factors, for example, the increased price of coking coal, the increase of freight ratio, while as a whole, the reduction of Chinese coke output is a critical driving force of soaring coke price.

[1] Source: http://www.china5e.com/news/meitan/200312/200312310066.html

Figure 2 China's Coke Export since 1989



Source: China Statistical Yearbook (1990-2003), of which the export of 2003 is from an article of Xu Guangcheng (*http://www.cnljxh.com/zj-xgc.shtml*).

The tight market creates good economic benefits to cokemaking industry. Since the second half year 2002, the economic benefits of cokemaking industry picked up notably, much faster than that of iron and steel industry. Statistical data indicate that in 2002, the sales revenue of China's cokemaking industry reached to 25.8 billion RMB Yuan, increasing by 38% than 2001, total profit is high up to 0.4 billion RMB yuan, increasing by 67% than 2001[1]. Concerning Shanxi Cokemaking industry, the sales revenue and profit reached to 21.96 billion RMB yuan and 1.26 billion RMB yuan in the first 11 months of 2003, increasing by 110%, and 515% than the same period of last year, respectively[2].

4. Emerging Problems and Future Policy Implementation

In summary, the restructuring of the coke industry has generated good effects on cokemaking sector. While we note that because of the tight coke market, some additional coke ovens have been on the book to be built or will be constructed. From the perspective of both capacity and the supply of coking coal, the governments have to take further measures to regulate the construction of new coke ovens.

Statistics shows that there are 54 newly built coke ovens that were put into production in China in 2003, with 23.21 million tonnes of new coke capacity, in which Shanxi Province constructed 24 coke

[1] Source: http://www.coke-iron.com/industryrefer/show.asp?id=312
[2] Source: http://www.china5e.com/news/meitan/200312/200312310066.html

ovens, coke capacity reaching 8.65 million tonnes, Hebei Province built 6 coke ovens which can produce 2.55 million tonnes of coke. Recent data indicated that currently there are 1900 machinery coke ovens in China, with 164.47 million tonnes of coke production capacity. In addition, 183 machinery coke ovens are being built with 68.21 million tonnes of coke capacity. Therefore, in the following two years, the coke production capacity of machinery coke ovens of China is expected to escalate to 230 million tonnes[1]. According to experts, they think that it is not necessary to built new coke ovens because in the near future the enlarging coke capacity may exceed coke demand, so it is enough for the market if the plants can make full use of current capacity,

Concerning the coking coal resources, in the following several years, the supply of coking will be short of demand. The coking coal stock decreased sharply in 2003, and newly formed coke production capacity in 2003 needs more coking coal, so the demand of coking coal in 2004 will remain high. If the coke output is estimated to be 180 million tonnes in 2004, the refined coal consumption of cokemaking industry will be high-up to 250 million tonnes. Although some coal mines can increase the output of coking coal after the restructuring of coal mines nationally, the gap between supply and demand of coking coal is still large. Given that they can import some coking coal from other countries, while the current price of coking coal is too high, with C. I. F. price over 800 RMB yuan per tonne, and at the same time the freight rate is increasing, the plants can not afford to import a lot of coking coal.

Therefore, in order to keep sustainable development of cokemaking industry, we have to take effective measures to regulate the behavior of related plants.

[1]Source: http://www.cnljxh.com/zj-xgc.shtml

UNIDO Contract No. : 03/120

UNIDO Project No. : EG/CPR/99/G31

Activity Code: 450D32

P. O. No. : 16000473

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3.03 Summary of Major Past Work of Shanxi Cokemaking Industry (1998-2002)

Contents

1. Introduction

Cokemaking is the second biggest consumer of coal in the People's Republic of China (China). According to the 2001 National Coal Balance Sheet, 154 million tonnes of coal was used in cokemaking, or 12.2% of the total national coal consumption (*SSB, 2003, p.268*). This is only lower than that in power generation, which consumed 45.7% of coal in 2001. As an important industrial material, coke in China is mostly used by the metallurgical, chemical engineering and machinery sectors, accounting for about 74%, 9.6% and 3.0% of total coke consumption, respectively[1].

Shanxi Province is famous for its coal reserves and production, its coking coal reserves account for 50% more in total coking coal reserves of China, and it is also the dominant region for producing coke in China. Therefore, energy efficiency and pollution emissions in cokemaking in Shanxi, directly influence China's overall energy efficiency and environment pollution.

Since the 1980s, township and village enterprises (TVEs) have been the main producers of coke, the coke output of which accounts for about 40% of total coke output of China at present. However, mainly because of the shortage of funds and obsolete equipment, the energy efficiency of cokemaking TVEs is still rather low. Nonetheless, the by-products of cokemaking, such as coal gas and coal tar, are not usually

[1] Source: qsy.eastday.com/epublish/gb/paper409/ 1/class040900019/hwz1068878.htm

recycled in the TVEs, especially in indigenous and modified indigenous coke production. Directly emitted waste gases and water, therefore, pollute the local, regional, and, even, national environment. In fact, if the by-products, such as benzene refined from coal tar, were recycled, TVE plants could produce more valuable products than just coke. The low energy efficiency and by-products emitted by cokemaking TVEs, therefore, waste natural resources, increase economic opportunity costs, and threaten rural and national sustainability in China.

Shanxi Province is the main coal-production region of China, and it is also the dominant region for producing coke by TVEs in China. Of the total 2001 coke output of China, 37.3% is produced in Shanxi, of which TVEs account for about 85%. Cokemaking has been a major revenue resource of local government, 17% of the value added tax and 33% of revenue tax come from the cokemaking industry in Shanxi Province. Shanxi çokemaking TVEs account for most of the environmental pollution in the cokemaking sector in China; therefore, Shanxi cokemaking TVEs directly influence the energy efficiency and environmental pollution in Shanxi Province and, even, in China.

Since 1995, following national regulations, the Shanxi Provincial Government began to close all indigenous cokemaking TVEs that have high energy consumption and pollution emission, and the government planned to close most of the modified and small-machinery cokemaking TVEs by the end of 1999. In addition, they planned to establish a "Clean Energy Region of Shanxi" based on large-machinery cokemaking enterprises. In 1999, the State Economic and Trade Committee, together with other relevant ministries, imposed strict regulations on the cokemaking sector, ordering that all indigenous coke-ovens and most modified coke-ovens must be shut down by the middle of 2000, exactly by June 5, 2000, which is called the '6.5 shut-down program'. In addition, most plants committed themselves to renovating oven technologies and other related equipment in order to meet national and provincial environmental regulations. These renovations also enhance their competitiveness in the market. Thus, the Shanxi Province cokemaking industry is currently in a rapid transition stage.

Our multidisciplinary team, which consists of chemical engineers, economic planners, and physicists, started in 1998 to conduct a detailed study on cokemaking in Shanxi Province. Our research team has been supported by the Alliance for Global Sustainability (AGS) and National Natural Science Foundation of China (NNSFC), and assisted by some government agencies, such as the National TVE Bureau under the Ministry of Agriculture of China, Shanxi Provincial TVE Bureau, and Shanxi Statistical Bureau. The team members include faculty and students from the Multiregional Planning (MRP) Group at the Massachusetts

Institute of Technology (MIT), Swiss Federal Institutes of Technology (ETH), the Chinese Academy of Sciences, the University of Tokyo (UT) and Taiyuan University of Technology (TUT).

The following is a brief summary of the most relevant aspects of that research.

2. Cokemaking Surveys in Shanxi Province

Because of the lack of data and inconsistency between different data sources, our first priority is to do a cokemaking TVE survey covering coke-oven technology, coke-plant production scale and employment, regional allocation, and, for comparison, we also conducted sample surveys of cokemaking on State-Owned Enterprises (SOE) in Shanxi Province. Since 1998, we have conducted eight sample surveys in Shanxi Province: (1) TVE plant manager surveys in 1998, 2000, and 2002; (2) SOE plant manager surveys in 1999 and 2001;and (3) local official surveys for TVE in 1998, 2000, and 2002.

2.1 Survey preparation

Conducting a survey is actually a relatively complicated work if we expect to get excellent results. Before each survey, we have conducted training of the surveyors. First, all members of the AGS cokemaking team exchanged preliminary copies of the survey questions; Second, the MIT staff spent several days reviewing the questions with the Institute of System Sciences (ISS) staff and training those who would be directly in charge of the survey, including: explaining each question on the questionnaire, considering the situations we may encounter when actually conducting the survey, and determining how to deal with the situation if the interviewees gave ambiguous or even wrong information; Third, ISS staff met Shanxi Province local officials from each governmental level, including prefectures, cities, towns and villages and trained those who were responsible for cokemaking. According to the local situation, for each survey, we usually train 26 local officials from the coke-producing regions.

Cokemaking technology in Shanxi Province, especially in TVEs, is relatively complex. Currently, there are more than fifteen kinds of coke-ovens in production and even more existed before 2000, which caused difficulties in selecting plants to be surveyed. In order to guarantee the scientific structure of the surveys, we gave considerable thought to the method of sampling. We adopted a layered stochastic sample method, in which we mainly consider oven type, its regional allocation and coke output etc. We then distributed the questionnaires to the relevant modified-indigenous coke-oven, small-machinery coke-oven and indigenous

coke-oven plant managers according to the proportion they were of the total universe. Because modified indigenous coke ovens were very popular in Shanxi Province prior to 2000, those plants that adopted these ovens account for a large proportion of our sample.

There were two phases in the survey. First, members of the ISS survey team directly and personally interviewed plant managers and local officials to get the baselines for the survey (e.g., these included 29 plant managers and 10 local officials in the 1998 survey). Second, because of travel and other complications in remote mountain regions, ISS staff could not go to all these areas, rather, they trained local officials in Taiyuan, the capital of Shanxi Province; then, those officials conducted the survey and distributed survey forms to cokemaking TVEs and to local governments by regular mail (230 survey forms to plant managers and 40 survey forms to local officials in 1998).

2.2 General information of the surveys

In order to understand the current situation of the Shanxi Province cokemaking industry, the cokemaking research team, led by Professor Karen R. Polenske, designed a detailed survey questionnaire, mainly including the following main parts: (1) General situation, focusing on coke-oven type and its properties, output, reasons for oven selection, ownership of the plant; (2) By-products, including the type of by-products they recycle and, quantity of by-product output and its market situation; (3) Coal consumption and coke production, focusing on coal type and volume of each type of coal, coke type and its market; (4) Facility and equipment, including methods and frequency of upgrading equipment, frequency of repairs and the coal-input coefficient of each oven type; (5) Financing, such as how they finance their fixed assets and flow assets, taxes and fees they distribute; (6) Employment, including number of employees, occupational structure, training, and education level, and safety measures; (7) Pollution, focusing on types of pollutants measured. Since 2000, we added a section on water use because Shanxi Province is very short of water. In addition, in order to understand the changes in technology and energy efficiency, we asked for data for the previous five years in 2000 and 2002 surveys.

Except for the 1999 SOE survey, which was a pilot SOE survey, the other surveys are rather large. In 1998, there were an estimated 1800 plants in Shanxi Province, and we distributed 259 survey forms to the plants and 50 to local officials. Of these, members of the survey team obtained the survey information through personal interviews with 29 plant managers and 10 local officials. For the others, we mailed the survey forms by regular mail. Of the total of 245 cokemaking TVE plants managers and 45 local city

(county), town, and village officials who returned the forms, we certified that 158 cokemaking TVE managers and 27 local officials forms (64.5% and 60.0% of those survey returned) were sufficiently complete for us to conduct the tabulations. These certified plants produced 5,175 thousand tonnes of coke in 1997, about 10.9% of the total TVE coke output in Shanxi Province. The plants included large-scale and small-scale, high- and low-pollution, and high- and low-energy-efficiency facilities (*Chen, Pan, et. al. 1999*).

In 2000, we surveyed 258 TVE cokemaking plants and 40 local officials, of which the survey team personally interviewed 8 plant managers. Of the 208 cokemaking TVEs and 31 local city (county), town, and village officials who returned the forms, we certified that 164 cokemaking TVE and 22 local officials (78.8% and 71.0% of those returned) forms were sufficiently complete for us conduct the tabulations. These certified plants produced 11,238 thousand tonnes of coke in 2000, about 25.9% of the total TVE coke output in Shanxi Province (*Chen, Yang, et. al. 2001*). Compared to the 1998 TVE survey, the surveyed coke output is much larger for many reasons. One of the important reasons is that the ratio of large-scale plants increased because many small-scale plants were ordered closed because they had low energy efficiency and heavy pollution.

In 2002, we distributed 250 survey forms to cokemaking TVE and 40 to local officials by regular mail. Of 175 cokemaking TVEs and 37 local city (county), town, and village officials who returned the forms, we certified that 127 cokemaking TVE and 35 local officials forms (72.6% and 94.6% of those returned) were sufficiently complete to conduct the tabulations. These certified plants produced 12793 thousand tonnes of coke in 2002, about 24.5% of the total TVE coke output in Shanxi Province (*Chen, Yang, et. al. 2003*).

The basic information of the surveys is shown briefly in table 1.

For the SOE survey, in the1999 pilot survey, we visited 8 SOE cokemaking plants personally and did not distribute any survey forms by mail. Through this survey, we have an overall impression of SOE cokemaking in Shanxi Province, including its technology, management, and quality of the employees. In 2001, we surveyed 55 SOE cokemaking plants and got 49 qualified copies after certification. These certified plants produced 8,010 thousand tonnes of coke in 2001(*Chen, Yang, et. al., 2002*).

3. Evolution of Shanxi Province Cokemaking from the Surveys

From the surveys, we can trace the changes of cokemaking TVEs in Shanxi Province, we have several

findings listed below. Here we have to emphasize that all the conclusions are based on the above surveys, indicating the past situation before 2002, not the current situation, of TVE cokemaking industry in Shanxi Prvince.

Although many TVE have constructed and are constructing small-machinery coke ovens, we found that modified indigenous coke ovens are the main type from our survey, of which the TJ-75 type, 91 type, and (SanJia) SJ-96 are very popular. For example, in 2000 survey, 26.8% of surveyed plants adopted TJ-75 type, 20.7% adopted 91 type and 22.6% used SJ-96 type, much higher than other coke oven types. Most cokemaking TVEs are medium and small-scale ones (i.e., with an annual coke output of less than 100 thousand tones. The number of large-scale plants with annual coke output over 100 thousand tonnes account for only a very small part, less than 15%. As to by-products, only a few plants recovered a small part of the by-products, such as coal tar and coal gas. The energy efficiency of cokemaking TVEs is relatively low, although in the past several years local officials and plant managers took great efforts to upgrade the coke-oven technology. Thus, Shanxi cokemaking TVEs have a great potential to save energy and resources.

Table 1 Basic Information of TVE survey of 1998, 2000 and 2002 in Shanxi Province

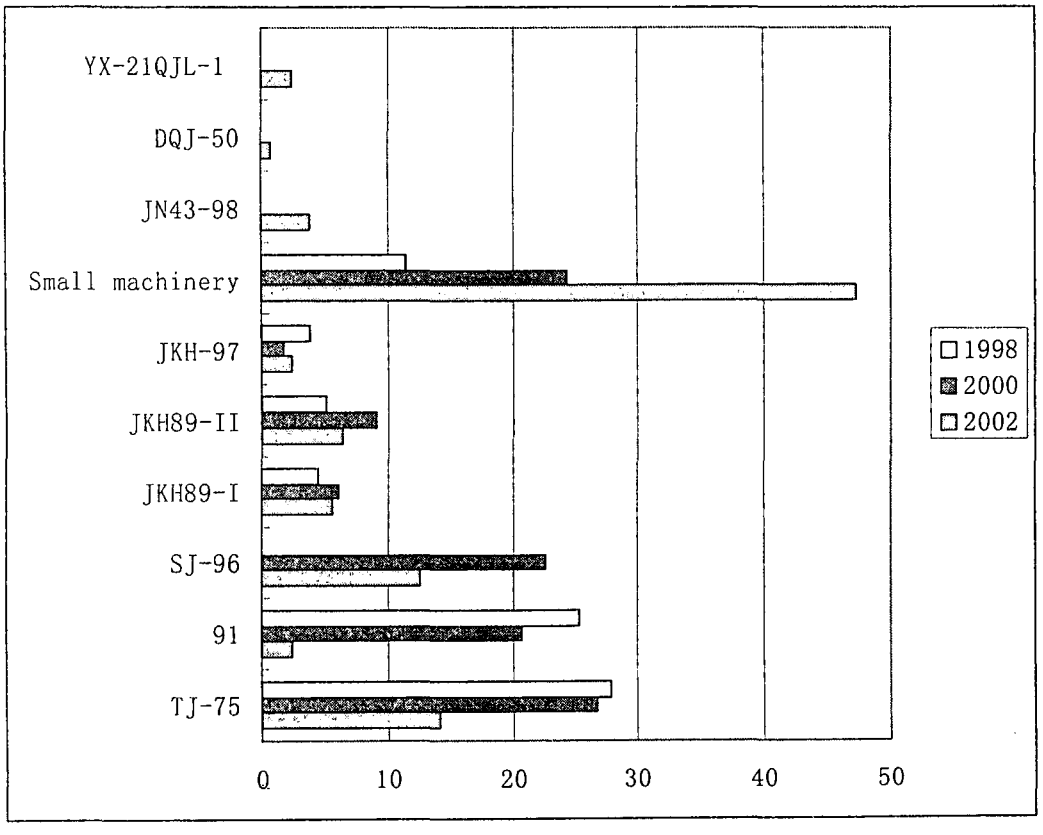
	Plant manager survey					Local official survey		
Survey Year	Number of Distributed survey forms	Number of Survey forms returned	Number of Survey forms complete for tabulations	Surveyed Coke output		Number of Distributed survey forms	Number of Survey forms returned	Number of Survey forms complete for tabulations
				Output (Thousand tonnes)	Proportion of total TVE coke output in Shanxi Province			
1998	259	245	158	5175	10.9	50	45	27
2000	258	208	164	11238	25.9	40	31	22
2002	250	175	127	12793	24.5	40	37	35

From the 2002 survey, we can see that Shanxi cokemaking TVEs experienced a lot of changes both in technology and other aspects, especially after 2000.

First, the technology of the cokemaking TVEs in Shanxi Province improved a lot compared with 1998. Most indigenous coke ovens were closed. Accordingly, machinery coke oven and some advanced modified coke oven, such as SJ-96, are widely adopted. 24.4% of surveyed plants employed machinery coke ovens in 2000, much higher than that in 1998 (see figure 1).

Up to 2000, the output of machinery coke oven surveyed accounted for 41.2% of total surveyed. In addition, at least three large machinery coke ovens, with coke output more than 600 thousand tonnes and with 4.3 meters high batteries, have been put into production.

Figure 1 Coke oven structure change



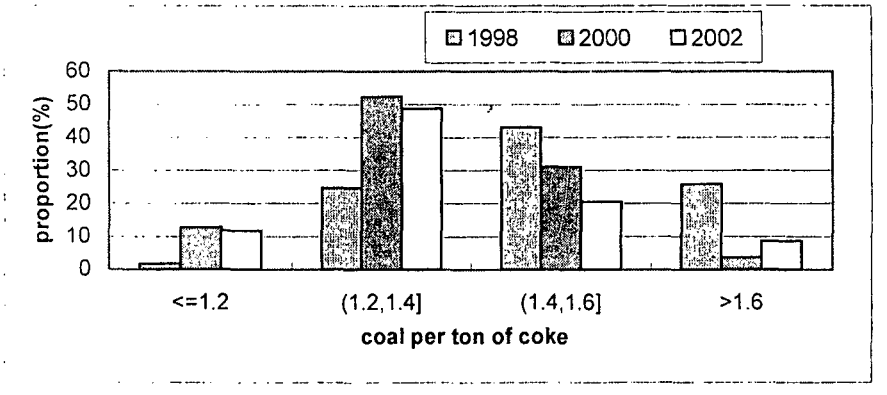
Source: From our surveys of TVE cokemaking sector in Shanxi Province in 1998, 2000 and 2002
Note: The number on the X axis is proportion that of the number of each type of coke oven on the total number surveyed, that on the Y axis is the name of coke oven type.

Second, the energy efficiency has increased a lot since 1998. Coke plants with a coal-input coefficient of coke between 1.4 and 1.6 accounted for 31.1% and 20.5% of total surveyed in 2000 and 2002, respectively, which is much lower than the 43.0% in the 1998 survey. Of the total surveyed in 2002, 60.6% have coal-

input coefficient of coke less than 1.4, much higher than the 26.6% in the 1998 survey.

It's inspiring to find that as many as 12.8% and 11.8% in 2000 and 2002, respectively, of the surveyed TVEs consume less than 1.2 tonnes of coal to produce one tonne of coke, which is at the same level as that of large SOEs (*See figure 2*). This increase in coal efficiency is caused by many reasons, the most important being improvements in oven technology. Although some indigenous coke ovens can produce coke with fairly good quality, since 1995 especially since 2000, the government has closed more and more indigenous coke oven, thus increasing the energy efficiency of the whole industry.

Figure 2 Changes of energy efficiency in Shanxi Cokemking TVEs between 1998, 2000 and 2002



Note: The number on the Y axis is the proportion of the number of plants.

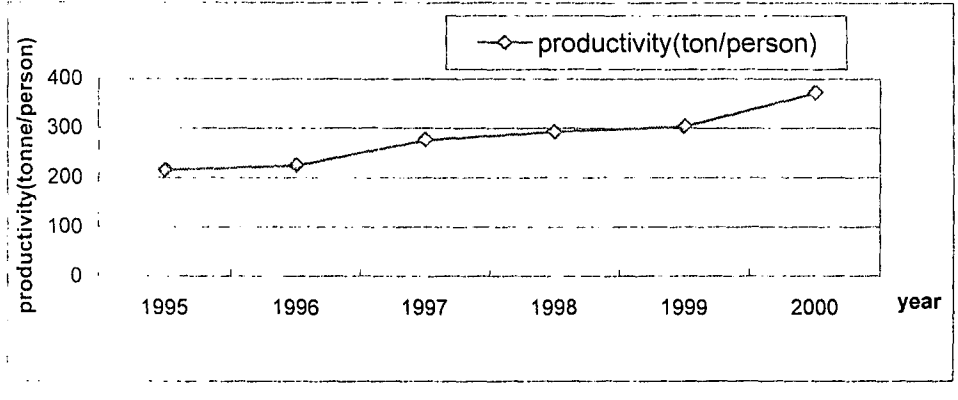
Third, the production scale has gradually expanded since 1995, as we can see from the fact that the total number of TVE cokemaking plants decreases rapidly. For example, in 1995, there were 1,276 plants, and this decreased to 680 plants in 2000, while the total coke output from the TVEs has remained relatively constant (20.5 million tonnes in 1995 and 20.1 million tonnes in 2000); In addition, the number of employees has decreased from 94,908 coke workers in 1995 to 54,116 in 2000. From our 2000 and 2002 surveys, we recorded more large plants with annual coke output above 100 thousand tones. In 2002, they accounted for 33.9% of the total number of surveyed plants, much higher than the 7.9% in 1995. In general, however, medium and small cokemaking TVEs still account for the greatest proportion of plants by the number of plants, for example, the number of TVEs with annual coke output between 20 to 100 thousand tonnes is 42.1% of the total number of TVEs.

Fourth, the personnel quality of cokemaking TVEs leaves much to be desired. We found that most employees (proportion>50%) in the surveyed cokemaking TVEs have only 6-12 years of school, which are at the middle school level. Although some of technicians and administrators are highly educated with over

12 schooling years, still many workers, and a few technicians and administrators have a low level of education, with fewer than six years of school, which are only at a primary school level. Compared with the results in the 1998 and 2000 surveys, this situation changed a lot since 2000 after the coke-oven restructuring. While those employees with fewer than 12 years of education still dominate, such an education level of the employees is, and will continue to be one of the restrictions on improving the level of the TVE management and technology unless some measures are taken to overcome the problem. Advanced technology needs highly educated workers in order to make full use of its capacity.

Fifth, the number of total cokemaking employees decreases rapidly from 94,908 in 1995 to 54,116 persons in 2000, while the output changed very little, showing that the productivity of cokemaking TVEs is rising. Figure 3 indicates the trends of productivity from 1995 to 2000.

Figure 3 Productivity Trends of Shanxi Cokemaking TVEs



Source: Calculated by the author from the survey results

Figure 3 shows that in 1995, the productivity is 215.8 tonnes/person, i.e., one employee can only produce 215.8 tons of coke on average annually, while by 2000, it has risen sharply to 372.1 tonnes of coke per employee.

As regards to the coke market, most of Shanxi Provicne coke produced by TVEs is sold to other regions, such as Liaoning Province, Hebei province, and overseas such as Europe, India, Japan, and the United States. In 1998, 27% of the coke surveyed was exported abroad, and in 2000, 43% was exported China plays a very important role in global coke market. By 1997, China became the largest coke producer in the world. Of total coke traded in the world, China contributes almost 80%, a large share of which comes from Shanxi Province[1]. In 2001, Shanxi Province produced 49,870 thousand tonnes of

[1] *Source: www.chinacoal.gov.cn/coal/jryw/020517x1.htm*

coke, and exports of Shanxi coke account for 72% of total coke export of China and 40% of total global coke supply[1]. In 2002, China export 13,570 thousand tonnes of coke, of which 9480 thousand tonnes coming from Shanxi Province TVE cokemaking plants (*Shanxi TVE Bureau, 2003*).

The TVE managers have been aware of environmental problems, with more and more plant managers paying attention to measuring pollutants. Also, the newer TVEs are more energy efficient and thus less environmentally polluting than the older ones mostly because they have installed newer energy-efficient ovens.

At the end of 2003, we did a new sample survey in cokemaking TVEs of Shanxi Province. In this survey, the main points are different from that of surveys in the past fives, in which coke oven structure, detailed export destination, marketing method and channel, policies, coal mixture, specific technologies of different kinds of coke ovens including coal-loading method, coking time, are emphasized in last-year survey. We can see that the coke oven structure is quite different from years before 2002, the percentage of large and medium machinery coke oven increased a lot, and several "clean" coke oven plants were put into production in 2003. Please refer to attachment 3.01 for detailed information.

4. Comparison between Shanxi Cokemaking TVE and SOE

Based upon our careful review of the TVE and SOE survey data, we assembled the following major findings concerning cokemaking for the past several years (1998-2002):

(1) SOEs are far more environmental/energy efficient (amount of pollution produced/energy used per unit of output), than TVEs, but the TVEs are more economically efficient. In the 2001 SOE survey, 42.9% of surveyed coke-making SOEs have a coal-input coefficient of coke less than 1.3, and nearly 33% of the plants have it between 1.3 and 1.4. Only about 20% of the plants have it over 1.4. At the same time, most surveyed TVEs have a coal-input coefficient of coke between 1.4 to 1.6, and about 25% have a coal-input coefficient of coke over 1.6. Thus, compared with TVEs, SOEs have a relatively low coal input coefficient of coke.

(2) TVEs use technologies that are more economically efficient, employ more workers, and require lower investment capital than SOEs. SOEs use technologies that are more energy efficient, employ

[1] *Source: http://www.daynews.com.cn/mag6/20020925/ca1312.htm*

fewer workers, and require larger investments than TVEs.

(3) The production scale of TVEs is smaller than that of SOEs. Among the TVEs, the majority of coke is still produced in small and medium-sized coke plants, using modified indigenous ovens. For most of these plants, quality and cost are higher priorities for coke-oven selection than the full recovery of environmentally hazardous by-products. Most of the SOEs are large or medium-scale ones, among which over a quarter of them produce more than 200 thousand tonnes of coke annually. SOEs are larger in scale and more advanced in technique than TVEs. Taking the 2000 survey as an example, large SOE plants with coke output of more than 100,000 tonnes account for 36.6%, of which 20.4% have an annual coke output more than 200,000 tonnes, while for TVEs, this proportion is only 7.3%. Over one-third of the TVE plants are very small, with annual output less than 20,000 tonnes. As regards to the number of employees, most (65.3%) SOEs have more than 200 employees, and large SOEs plants with over 1000 employees account for 16.3% of surveyed SOEs. In TVEs from the 2000 survey, however, 68.3% of surveyed plants have employees less than 200.

(4) The quality of employees in SOE is better than that of TVE. Taking technical staff as an example, employees in nearly 70% of the plants (with the proportion of the level to total employees more than 50%) are above junior college level (over 12 years of schooling) in the surveyed SOEs, while in TVEs this ratio is only 26.8%. There is a rather larger difference in production workers, with the employees in almost 86% of SOEs (with the proportion of the level to total employees more than 50%) having middle-school education level (6 to 12 school years); in the TVEs, however, only 52% of them. On the one hand, we do find these facts not surprising, because TVEs are often run by peasants, and most worker come from nearby towns or villages. On the other hand, this lack of education will become a great challenge to TVEs that try to improve their competitive position in the coke market.

(5) The average income per employee in SOEs is greater than that in TVEs.

Through the consecutive surveys, we uncovered two trends in the TVE cokemaking sector in Shanxi Province. First, the newer TVEs are more energy efficient and less environmentally polluting than the older ones, but still not as energy efficient as the SOEs. Second, the newer TVEs employ far fewer manual workers than the older ones.

Based upon first-hand survey data, our team also developed a process-flow model (*Polenske, et. al. 2002*), and a transportation model of Shanxi cokemaking TVE (*Kraines, Steven B. 2002*). Using the Shanxi input-output table, we constructed National TVE and non-TVE table and Shanxi TVE and non-TVE table for 1995. Dr. Yang Cuihong (1999), Ali Shirvani-Mahdavi (1999), and Guo Wei (2000) employed these tables to analyze the economic and environmental characteristics of cokemaking sector and their chain effects with other sectors. In addition, they also compared the differences in energy efficiency, economic index, and management between TVEs and SOEs.

Through a case study of Shanxi cokemaking plants, Chen Hao (2000) did a detailed technological evaluation of then prevalent coke ovens in his thesis in 2000. In his paper, he also conducted a policy analysis and set forth useful suggestions. For example, he suggested that the governments should reemphasize the environmental standards to cokemaking plants and stipulate the deadline for them to meet the standard, and that it is very important that Shanxi Province regulates the total coke output.

Experts from Shanxi Science and Technology Bureau, Shanxi Environmental Protection Bureau, Shanxi Economic and Trade Commission and Shanxi Township and Village Enterprise Bureau did research 'Study on environmental, economic and technical benefits evaluation of different coke ovens' during 1999 and 2000. They focus on the current situation of Shanxi cokemaking industry and faced problems, the future direction of cokemaking, and most important the evaluation method of coke ovens.

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UNIDO Contract No. : 03/120

UNIDO Project No. : EG/CPR/99/G31

Activity Code: 450D32

P. O. No. : 16000473

Attachment 3.04

Analysis of Market Supply and Demand of Coke

of

The Final Report
to

the United Nations Industrial Development Organization (UNIDO)

for the Contract

Provision of Services for the Execution of a Coking Sub-sector Survey

related to the Project

Energy Conservation and Greenhouse Gas Emissions Reduction in Chinese Township and Village Enterprises – Phase II

Prepared by

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April 15, 2004

3.04 Analysis of Market Supply and Demand of Coke

Contents

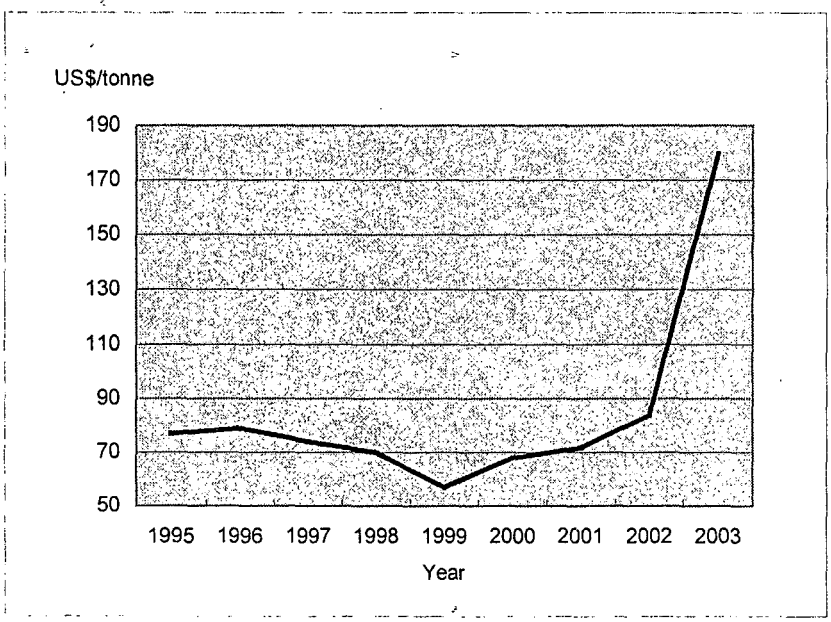
1. Backgroud

Metallurgical coke is a crucial material for making steel, particularly, high-quality steel. Internationally traded coke is playing a growing role in meeting the global coke demand. Since the late 1990s, China has dominated the global coke market and exported more than half of the total traded coke. Basically, the coke price is determined by the price of coking coal, the freight rates, and the amount of coke supplied on the world markets, and the amount of coke demanded in iron and steel production and other manufacturing. For various reasons, from 2002 all the determining factors except world coke supply increased dramatically and resulted in rapidly increasing coke prices. On the supply side, since the early 1990s, the world coke production as well as the production capacity has decreased constantly primarily due to the strict environmental regulations in both developed and developing countries. Consequently, the coke price has been rising drastically in 2003.

1.1. Volatility of Coke Prices in the International Market

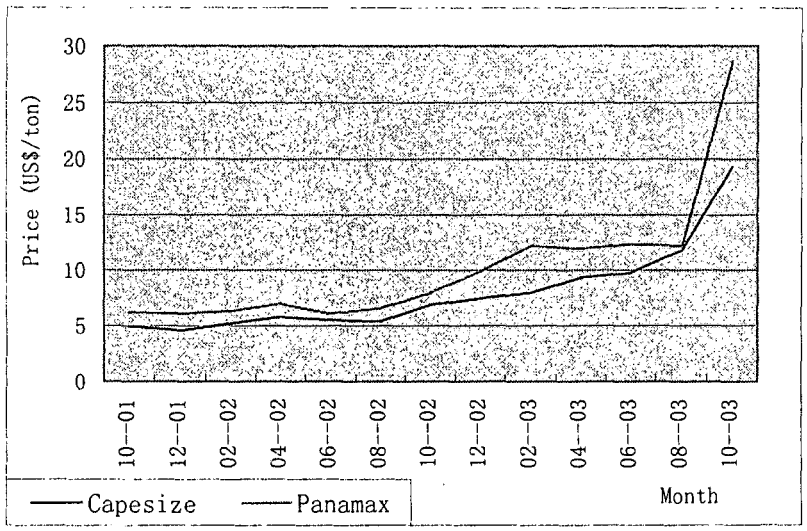
As the benchmark of the international coke market, the Chinese metallurgical coke price has tripled in the last three years, peaking at US$150-160 per tonne for 10.5 percent ash coke and at US$140-145 per tonne free-on-board (f.o.b.) for 12 percent ash coke in April 2003 (Figure 1).[1] After a slow down over the summer months in 2003, coke prices passed the US$150 per tonne f.o.b. level again in September 2003, reaching US$240 per tonne f.o.b. in December 2003. At the same time, the ocean freight rates are also increasing rapidly (Figure 2). It is expected that the demand for ocean freight will remain high over a short term. Moreover, the coking-coal price is also surging because of the tight supply of coking coal. As of the end of 2003, the coking-coal price has increased by more than 50 percent to about US$80 per tonne in the international market. (Sources: Coal Trader International, August 18, September 18, 2003; Coal Americas, September 08, 2003; Platts International Coal Report November 17, 2003)

[1] In midNovember, the coke price rose as high as US$185/tonne (Tex Report, November 12, 2003).



Source: Patrick Cleary, CRU International, Met Coke World Summit 2003
Note: f.o.b. China, 10.5% ash, average annual values

FIGURE 1. CHINA COKE PRICES SINCE 1985



Source: Dry Bulk Newsletter, November 2003

FIGURE 2. SAMPLE OCEAN FREIGHT RATES, SEPTEMBER 2003

1.2. Coke as an Essential Material to Make Steel

The objective of the coking process is to produce a high-strength coke at minimum cost, which will then be used in a blast furnace. The cost of coke is said to represent about 15-20% of the total cost of making steel, which is a significant proportion (IEA Coal Research, 2001). There are two major processes for the steel making: Basic Oxygen Furnace (BOF) and Electric Arc Furnace

(EAF). In 2000, about 60% of the global iron/steel output comes from the BOF process, in which pig iron/hot metal is produced from iron ores in a blast furnace and then treated in a BOF to produce crude steel (IEA Coal Research, 2001). In the process, coke is an essential ingredient used in blast furnaces because of its strength in holding the ore burden. EAF production, by contrast, generally does not involve the use of coal and coke (except for coal used in coal-fired power plants). It uses recovered scrap and accounts for slightly more than 30% of the global steel production, mainly of lower-grade steel than that produced by BOF. Other processes, such as open hearth, for the production of pig iron do not require coke, but these currently account for only about 7% of production in the world and are economic only under limited circumstances (IEA Coal Research, 2001). Table 1 lists the percentages of crude steel production in 2000 by process for three major countries: China, Japan, and the United States, and the world.

TABLE 1. CRUDE STEEL PRODUCTION BY PROCESS, 2000

Country	*Crude Steel (million tonnes)*	*BOF (%)*	*EAF (%)*	*Open Hearth (%)*	*Other (%)*
China	123.7	66	16	2	16
Japan	94.2	70	30	0	0
USA	97.3	54	46	0	0
World	786.4	60	33	4	3

Source: International Iron and Steel Institute, 2000
Notes: BOF = Basic Oxygen Furnace; EAF = Electric Arc Furnace

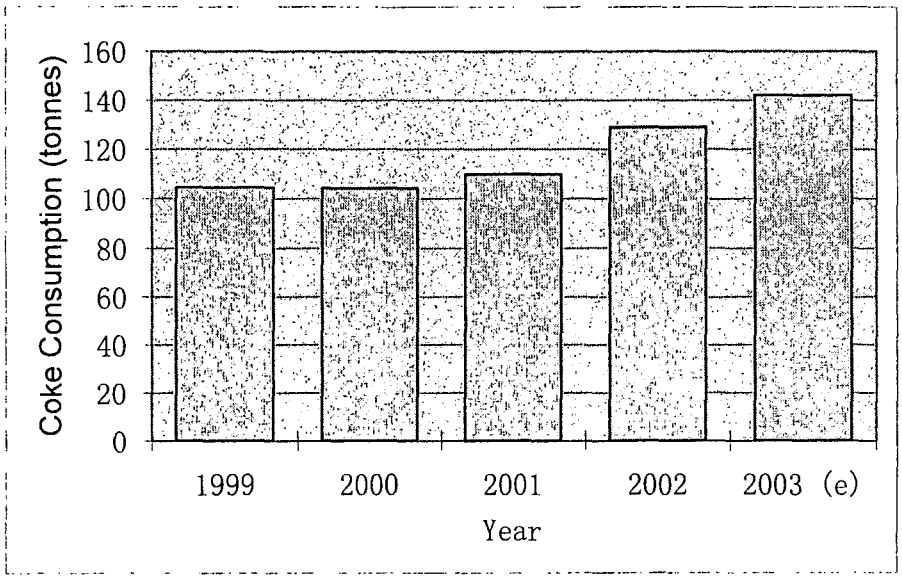
Steel is a critical material in many industries. Construction and manufacturing industries (including automobile, machinery, electric-appliance industries, etc.), all require high-quality steel, and, in turn, need a vast quantity of coke. Since the late 1990s, China has been the largest world producer of coke and crude steel (IEA, 1999. IEA Coal Research Center, 2001). Out of nearly 1,400 million tonnes of China's coal production, about 14% is used for coking (IEA, 1999). Since the late 1990s, China has also dominated the world coke-export market, exporting coke to many countries, including Europe, India, Japan, and the United States.

1.3. Increased Demand and Decreased Supply

On the demand side, coke demand depends on: (1) the total requirement for steel, which is strongly affected by the economic growth in various parts of the world, (2) The amount of steel that can be produced in EAFs, (3) blast-furnace requirements for coke and how successful operators are in minimizing the amount of coke used, (4) the development of other steelmaking processes, such as PCIs (Pulverized Coal Injection), that do not involve coke, and (5) the amount

of non-steel related use, such as the use in chemical industries. (IEA Coal Research, 2002)

The global coke consumption is increasing mainly due to the increase in China's domestic demand from its steelmaking industry. As the largest coke-consuming country in the world, China's demand has increased constantly over the last several years and shows an accelerating trend (Figure 3).



Source: Patrick Cleary, CRU International, Met Coke World Summit 2003

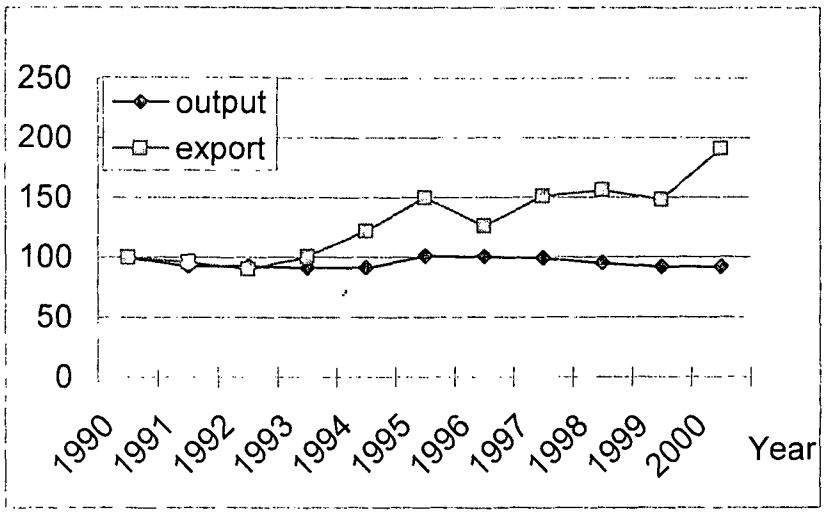
FIGURE 3. CHINA COKE CONSUMPTION 1998-2003

The supply of coke depends on: (1) Supplies of coking coals, (2) productive capacities and the locations of coke ovens, (3) effects of environmental regulations and their enforcement, (4) age of the coke ovens, which affects productivity, coke quality, and long-term production, and (5) investment in refurbishing existing capacity and/or the construction of new ovens (with new technology). (IEA Coal Research, 2002)

From April through September 2003 world crude-steel production has been running 8-11% above a year earlier, with the highest capacity utilization rate of 83.5% since 1989 (http://www.steelonthenet.com/frameTRE.html). The world's coke consumption essentially keeps up with the increased hot-metal production. However, the growth of world coke production is not compatible with the rising demand. Between 1995 and 2000, world coke output decreased by 9% despite the 12.7% increase in steel output. Partially as a result of this coke production and consumption gap, the global coke market has been tighter.

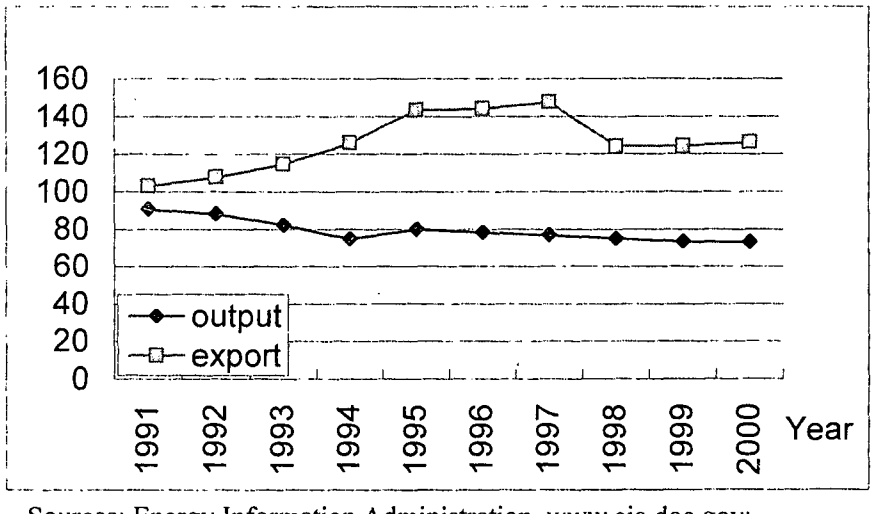
Historically, the amount of coke traded internationally represents only about five percent of its total usage. Recently it increased to nine percent. Comparing the production and export of coke around the world, we see different trends (Figure 4). Between 1990 and 2000, world coke

production has declined by 8%, while the export of coke has increased by 90%, with fluctuations though. Because industrialized countries have closed many cokemaking plants mainly due to the cost and environmental concerns (Table 2), they have become more and more dependent on the international coke market. As shown in Figure 5, excluding exports from China, the world total production of coke actually decreased over the past decade and the total exports only increased by around 30%.



Sources: Energy Information Administration, www.eia.doe.gov;

FIGURE 4. WORLD COKE PRODUCTION AND EXPORT TRENDS 1990-2000
(1990 = 100)



Sources: Energy Information Administration, www.eia.doe.gov;
China statistical Yearbook, 1990-2002;
China Energy Statistical Yearbook, 1991-1999

FIGURE 5. WORLD COKE PRODUCTION AND EXPORT TRENDS, 1990-2000 (excluding China, 1990 = 100)

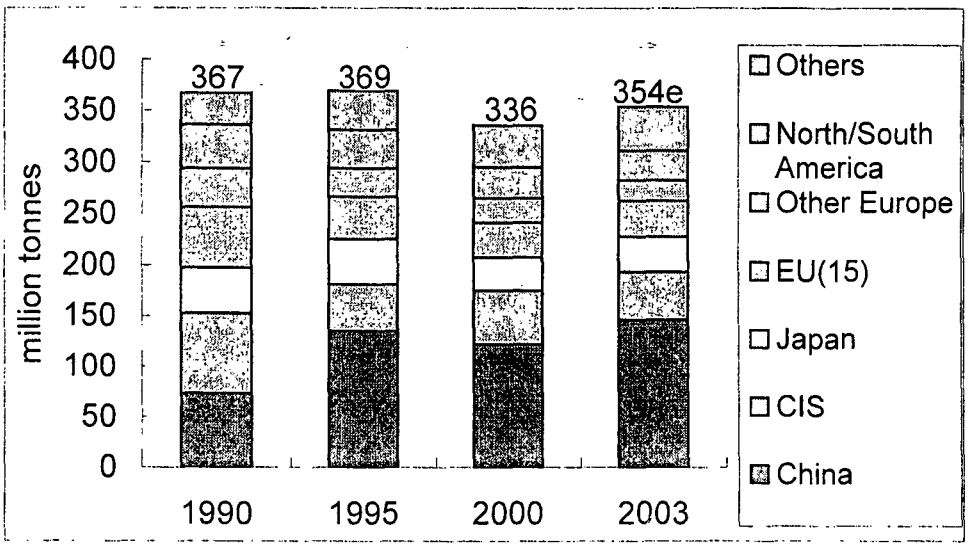
TABLE 2. CAPACITY CLOSURE OF COKE PRODUCTION SINCE 1998

(1000 tonnes per year)	
North America	4,265
Western Europe	7,733
Eastern Europe/CIS	4,027
Rest of the World	1,265
World excluding China	17,190

Source: Patrick Cleary, CRU International, Met Coke World Summit 2003

1.4. China's Dominance in Coke Pricing in International Market

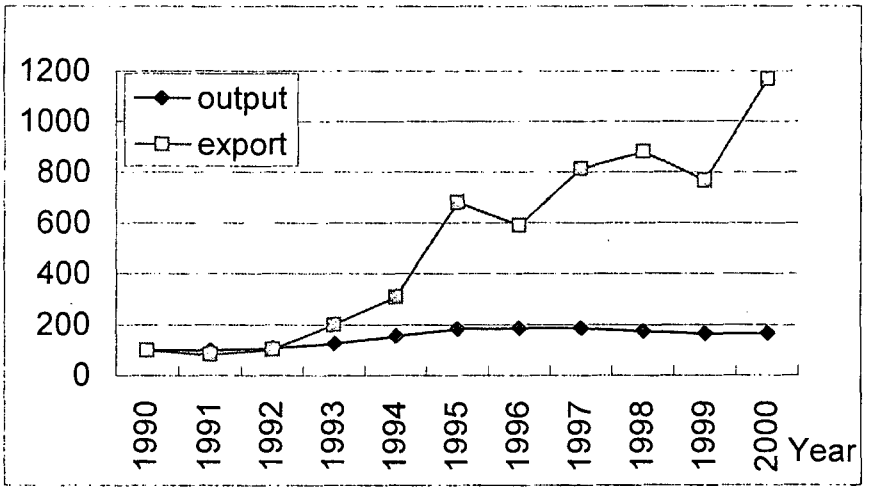
The structure of global coke supply has changed and become more and more dependant on China's supply in the past decade (Figure 6). Since 1994, China has been the largest coke producer in the world and dominated the international coke market. The coke production in other countries, particularly developed countries, decreased substantially, resulting in the highly increased demand in the international market. In the short run, however, plans for new coke capacity outside of China are few (Cleary, 2003). The result will be the even greater dependence on China than before. In 2000, the total exports from China exceeded 15.2 million metric tonnes and accounted for about 48% of the total exports in the international market. In 2003, China's share increased to more than 50 percent of the total world exports and is expected to approximate 60 percent in five years (Cleary, 2003).



Source: The International Market for Metallurgical Coke International Pig Iron Secretariat, IPIS, 37th Members' Meeting, Lausanne, Switzerland, 1113 June, 2003, Presentation by RAG Trading GmbH

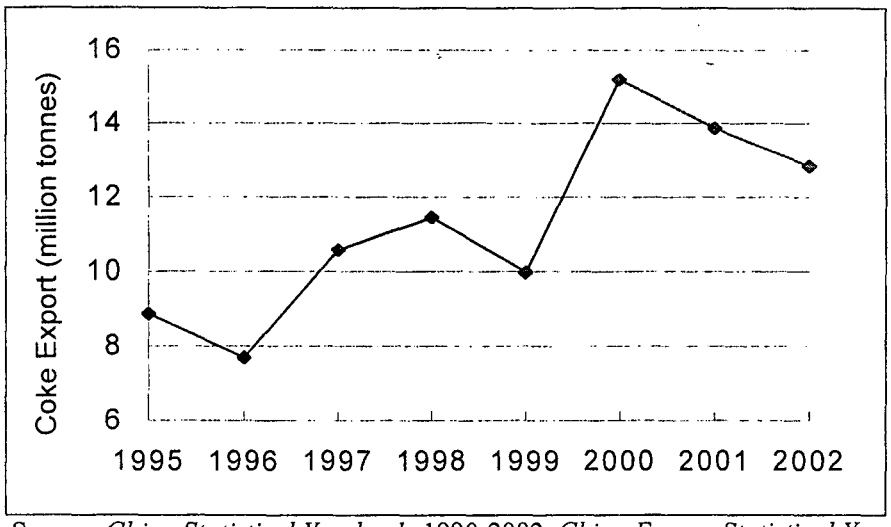
FIGURE 6. WORLD COKE PRODUCTION, 1995-2003

However, due to the strict implementation of environmental policies, China's coke production has decreased since 1998 with a slight turnaround after 2001 (Figure 7). By contrast, China's exports have continued to increase until 2001, when it started decreasing slightly partially due to the rapidly increasing domestic demand (Figure 8), which we will discuss in the next section.



Source: China Statistical Yearbook, 1990-2002; China Energy Statistical Yearbook, 1991-2002

FIGURE 7. CHINA COKE OUTPUT AND EXPORT TRENDS, 19909-2000
(1990 = 100)



Source: *China Statistical Yearbook,* 1990-2002, *China Energy Statistical Yearbook,* 1991-2002

FIGURE 8. CHINA COKE EXPORT 1995-2002

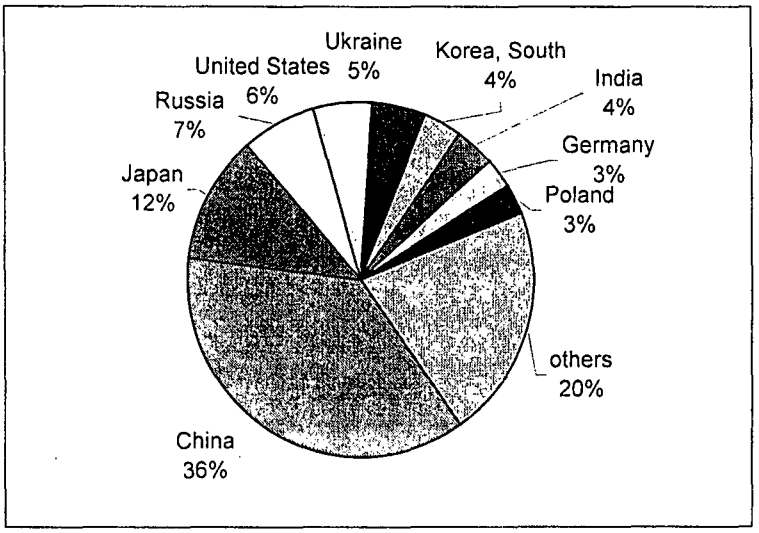
2. Key Factors Faced by Coke Market

Because China dominates the international coke-export market, our research focuses on the supply from China and the demand from major coke-importing countries. Based on our previous research, we find four key factors faced by the global coke market: (1) China lowered its coke production and exports because of the surging domestic demand, their concerns for environmental protection, and the insufficient capacity of the domestic and ocean transportation systems. (2) Due to the high costs, including the environmental cost and environmental regulations, industrialized countries, such as the United States and Japan, have reduced their coke production. (3) Global coke demand continues to increase due to the increasing demand by the metal products industry. (4) New technologies to produce coke in a cleaner way or to shift the demand in coke or steel to alternative materials are still too expensive to implement or they are unavailable.

2.1. Supply of and Demand for Coke in China

As the largest coke producer and supplier in the international coke market, China dominates the global coke trade. In 2000, China's coke production accounted for 36 percent of the total world output (Figure 9), and in 2003, China supplied more than half of the world's total coke exports. The global dependence on China's coke supply has increased since the late 1990s. For instance, the United States imported 3.27 million tonnes (3.78 million short tons) of coke in 2002, of which

45.3 percent came from China (U.S. Department of Commerce Bureau of the Census, "Monthly Report IM 145").



Source: the Internet. http://www.eia.doe.gov

FIGURE 9. WORLD METALLURGICAL COKE PRODUCTION, 2000

As shown in the following Figures 10a and 10b, China was the largest coke exporter in 1995, while Germany was the largest coke importer. By 2002, China was exporting more than 50 percent of the total coke in the world market, and researchers predict the percentage will reach 60 percent in the near future (CRU, 2003).

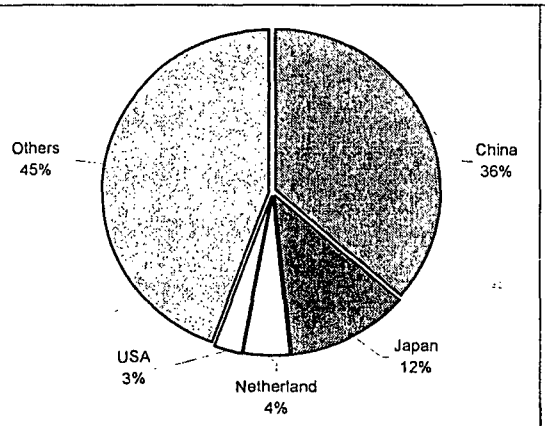


FIGURE 10a WORLD COKE EXPORT MARKET, 1995

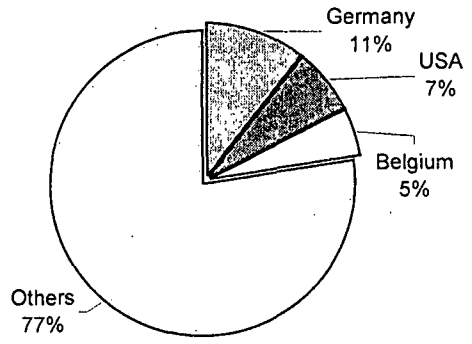


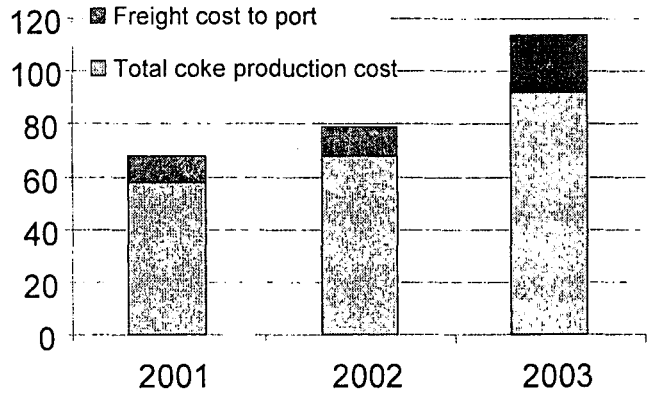
FIGURE 10b WORLD COKE IMPORT MARKET, 1995

Source: *China Coal Industry Yearbook 1997*, p. 334

2.1.1. Increased Direct Cost of Coke Production

The production cost of coke consists of the costs associated with coal preparation, coal

washing, coal sorting, coal transporting, and cokemaking. For coke that is exported, there is also the cost of transport to the coast and of ocean shipment to the customer overseas. Thus, whether or not the cost of coke in China will partially rise depends on the need for investment in new ovens and the pricing of rail and ocean freight. Also, labor costs in China are relatively low (Figure 11) and are expected to rise.



Source: Patrick Cleary, CRU International, Met Coke World Summit 2003

FIGURE 11: CHINA COKE PRODUCTION AND FREIGHT COST (US$per tonne)

Coking coal in China is not as rich as people think, the exploitable reserves of coal is 145 billion tonnes, the proportion of coal that can be used for cokemaking is only 27.65%, including 5.81% prime coking coal, 13.7% gas coal, 3.53% rich coal, 4.01% lean coal (Figure 12).

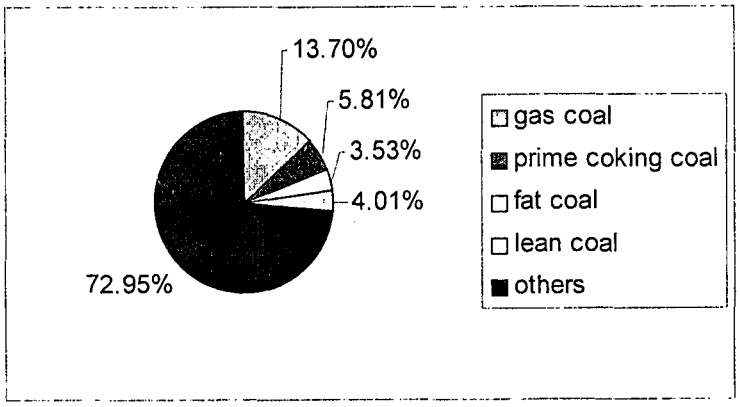


FIGURE 12: CHINA COAL RESERVE STRUCTURE

Because of energy inefficiency and continuous safety accidents, the Chinese government implements strict policies, many small-scale coal mines were closed since 2000, which greatly reducing the output of coking coal. The coking coal is far from meeting the demands of cokemaking industry, China imported 112 ten thousand tons of coking coal from January to

August 2003, 100 ten thousand tons more than the same time of last year. In 2003, spot prices of coking coal have increased by US$15 to US$20 per tonne f.o.b. For 2004, it is expected that the coking coal price will increase by another US$10 to US$15 per tonne, which means the f.o.b. price will be around US$60 for Australian and Canadian coking coal. The devaluation of the U.S. dollar is adding risks to the current market. Since early in 2003, the exchange rates of the U.S. dollar to the Canadian dollar and to the Australian dollar have decreased by 10%, which further increased the coke price in the international market. (Domenico Maiello, 2003, "International Coal Trade and Price Developments in 2003": United Nations Economic and Social Council Economic Commission for Europe-Committee on Sustainable Energy)

2.1.2. Environmental and Safety Regulations Limit Supply

From 1998, China began to enact strict environmental regulations and to enforce them. Thus, many small and heavy-polluting coke plants were shut down. At the same time, increased safety concerns pushed central and local governments to tighten the safety regulations and closed many small coalmines. As a result, China's coke production decreased by 6.7 percent that year. In 1999, it continued to decrease, and the coke production remained very low up to 2001. The enforcement of these regulations is helping to determine the production and trade in the global coke market.

2.1.3. Domestic Demand Increases with Rapidly Growing Economy

Steel production from blast furnaces is the driving force for the demand for coke. The coke consumption in the Metal Products sector accounts for more than three quarters of the total consumption (Table 3). With the rapidly growing economy, particularly the rapid urbanization and fast development in manufacturing industries, steel is in great demand in top four markets: construction, manufacturing, machinery, and transportation, which account for more than 90 percent of the total steel consumption in China (Table 4).

TABLE 3. CHINA COKE CONSUMPTION BY SECTOR AS PERCENTAGE OF TOTAL COKE CONSUMPTION, 2000

Rank	Sector ID	Sector Name	Percent
1	10	Metal Products	77.1
2	8	Chemical Industry	10.4
3	11	Machinery and Equipment	3.0
4	9	Building Materials and Non-metal Mineral Products	2.9
5	14	Services	1.8
6	2	Mining and Quarrying	1.5
7	1	Agriculture	1.4
8	7	Coking, Gas and Petroleum Refining	0.6
9	6	Production and Supply of Electric Power, Steam, and Hot Water	0.4
10	3	Foodstuff	0.3
11	5	Others (including paper-making)	0.3
12	12	Construction	0.2
13	13	Transportation, Post, and Telecommunications	0.1
14	4	Textile, Sewing, Leather, and Furs Products	0.1

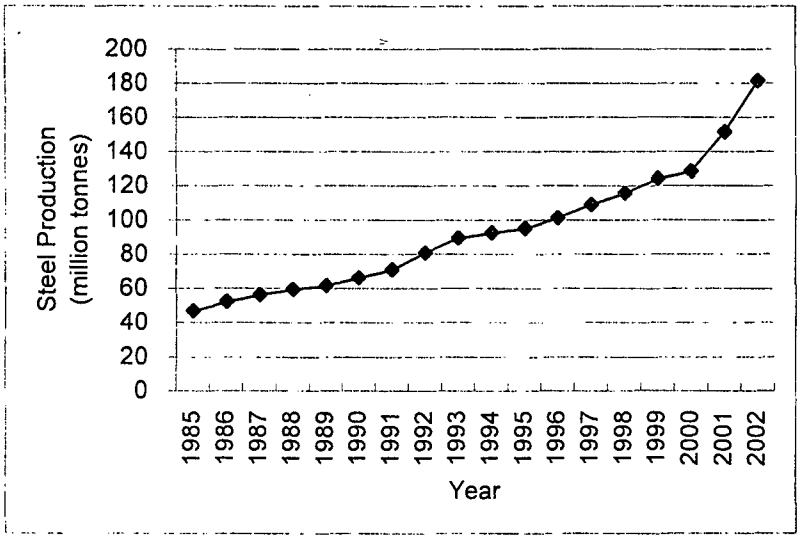
Source: Yu Li. Master Thesis. MIT Center for Transportation and Logistics.

TABLE 4. CHINA STEEL CONSUMPTION BY MARKET, 1997

Consuming Industries	Steel Consumed (1000 tonnes)	Percent
Construction	45,110	42
Manufacturing	37,950	35
Machinery	9,821	9
Transportation (Railroads and other)	7,151	7
Electrical machinery	3,451	3
Mining, quarrying, lumbering	2,660	2
Oil and gas	2,445	2
Total consumption	108,589	100

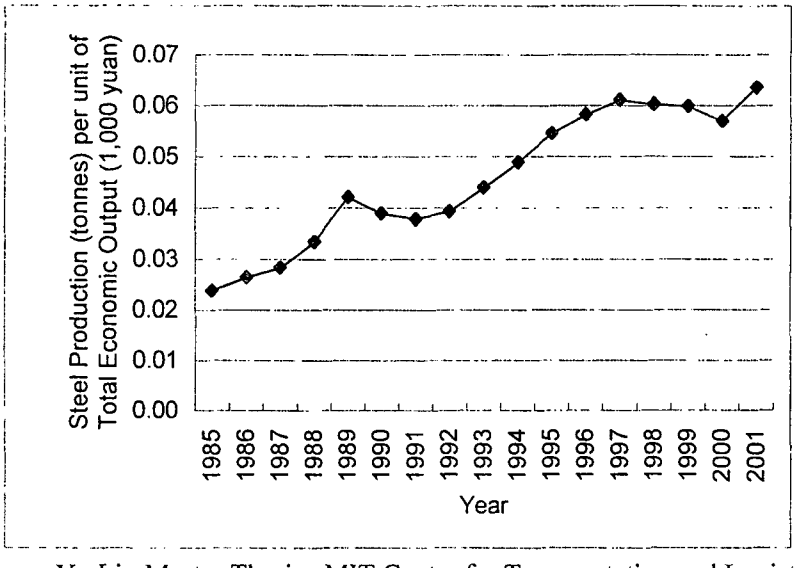
Source: Yu Li. Master Thesis. MIT Center for Transportation and Logistics.

As shown in Figure 13, steel production keeps increasing in China. For 2002 alone, the total production increased by 20 percent. Also, Figure 14 shows an increasing China's steel intensity (measured by steel production per unit of total economic output) in the past 17 years. With the expected GDP growth rate at more than seven percent in next several years and given the upward trend of steel intensity (increasing by five to six percent per year), the steel consumption in China's economic system, including both final demand and intermediate consumption, is expected to keep growing. According to a report by UBS Warburg (2003), China's domestic steel production is expected to increase by about nine percent per year for 2004 and 2005, which we consider as a conservative forecast. We forecast the growth rate would be around 12 percent.



Source: *China Statistical Yearbooks* 1990-2002

FIGURE 13. CHINA STEEL PRODUCTION, 1985-2002



Source: Yu Li. Master Thesis. MIT Center for Transportation and Logistics.

FIGURE 14. CHINA STEEL INTENSITY, 1985-2002

Figures 15a-d show the steel production and consumption by country in 1992 and 2002. Clearly, China's global shares in both steel production and consumption have increased substantially: the production increased from 11 percent to 20 percent in 10 years, while the consumption increased even further, from 12 percent to 26 percent in the same period. These figures highlight the increasing importance of China in the global steel industry as a major producer and consumer.

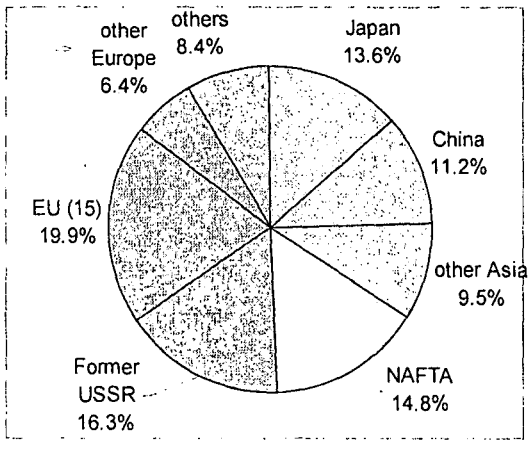


FIGURE 15a. STEEL PRODUCTION IN 1992

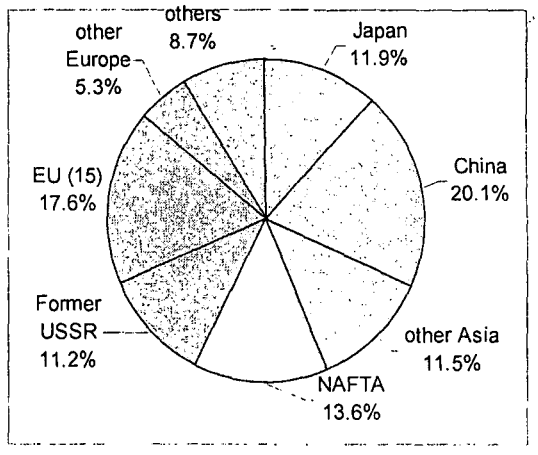


FIGURE 15b. STEEL PRODUCTION IN 2002

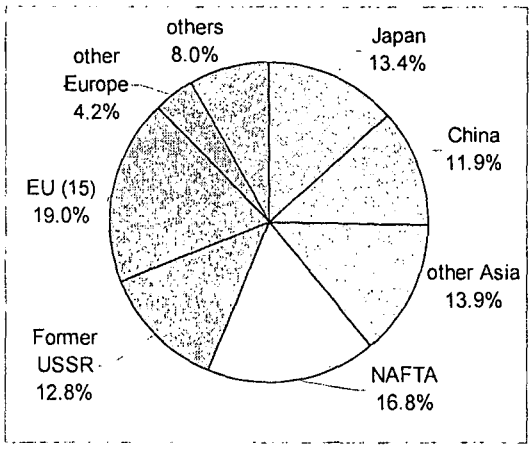


FIGURE 15c STEEL CONSUMPTION IN 1992

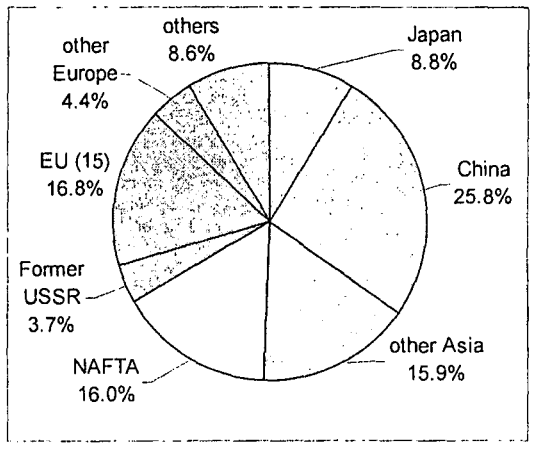
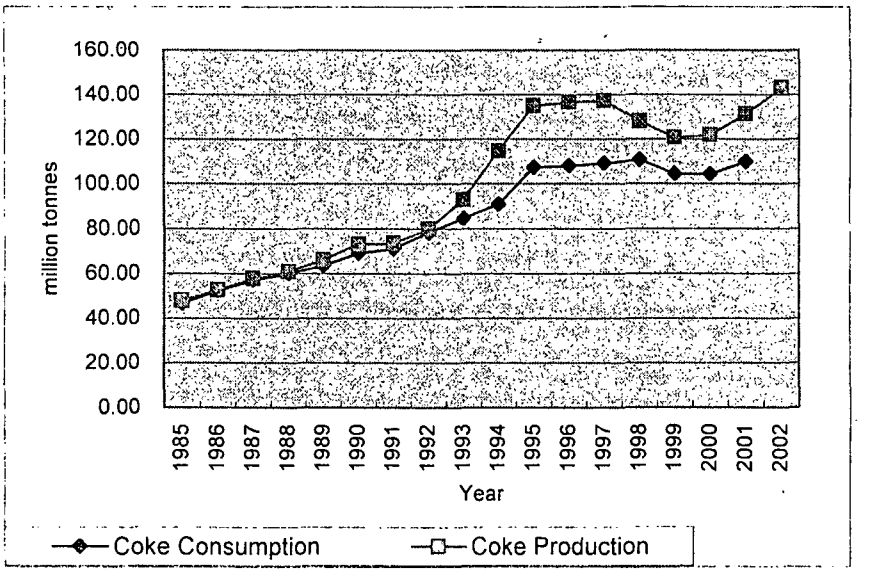


FIGURE 15d. STEEL CONSUMPTION IN 2002

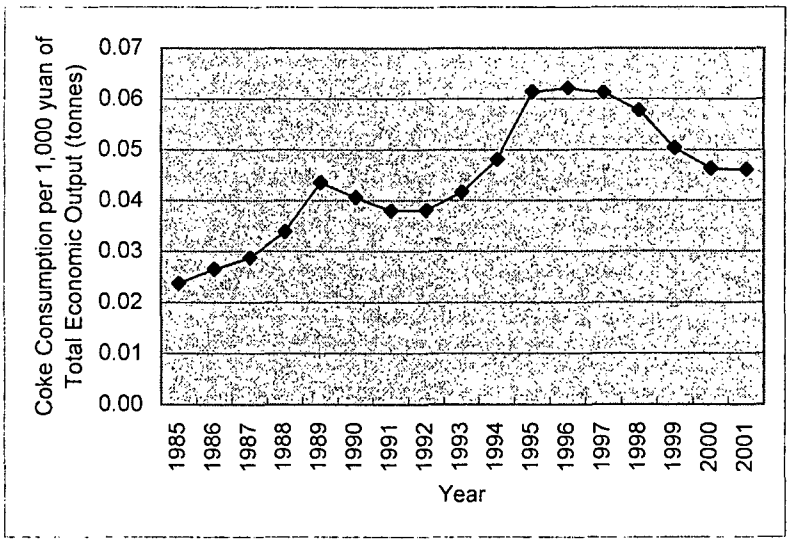
Source: International Iron and Steel Institute (IISI), 2003

As an essential material to make steel, the total domestic coke consumption in China increased steadily from 47 million tonnes in 1985 to 107 million in 1995 (Figure 16), and then remained at a stable level between 100 million and 110 million tonnes. This is primarily due to the decreased coke intensity (defined as annual coke consumption divided by the annual total economic output). The coke intensity in China increased from 25 tonnes per million yuan in 1985 to 61 tonnes per million yuan in 1995 and then decreased to 46 tonnes per million yuan in 2001, dropping by 25 percent within six years (Figure 17). However, since the late 1990s, Chinese domestic demand of steel has been growing dramatically. Construction (railway systems, urban development, etc.) and manufacturing (automobile, machinery, electric-appliance, etc.) industries all require high-quality steel and, in turn, a vast quantity of metallurgical coke. As a result, the surging domestic coke demand has been limiting the export capacity of China's coke suppliers and pushing the coke price in international markets higher.



Source: *China Statistical Yearbook 1986-2002*

FIGURE 16. COKE CONSUMPTION AND PRODUCTION IN CHINA



Source: Yu Li. Master Thesis. MIT Center for Transportation and Logistics.

FIGURE 17. COKE INTENSITY IN CHINA, 1985-2001

2.1.4. Coke-Export Restrictions

Another issue related to international coke market is export quotas and licensing[1]. China imposes quantitative and other forms of restrictions on the export of certain commodities. These include domestic resources that might be depleted and are in short supply or need conservation in China, and goods destined for countries or regions with limited market capacity and whose exports therefore need to be restricted. Items under quantitative restrictions are subject to quota management. Those under other forms of restrictions are subject to import licensing control. For commodities subject to export quota control in general trade, exporters must apply for an export license by presenting an export-quota certificate. For the export of commodities subject to export licensing, exporters must apply for an export license by presenting the export contract.

The 2003 Catalogue of Commodities Subject to Export Licensing Management published by China Ministry of Commerce went into effect on 1 January 2003. The following are two control measures related to coke exports. (1) The 52 categories of commodities listed in the catalogue are subject to export control by means of quotas, quota bidding, utilization of paid quotas, free quota bidding, and licenses. Commodities subject to export quotas: corn, rice, wheat, cotton, tea, sawn wood, live cattle (to Hong Kong and Macau), live pigs (to Hong Kong and Macau), live chickens (to Hong Kong and Macau), raw silk, grey fabric, coal, **coke**, crude oil, refined oil, rare earth, antimony ore, antimony (including antimony alloys) and antimony products, antimony oxide, tungsten ore, ammonium para-tungstate and ammonium meta-tungstate, tungsten trioxide and blue tungsten trioxide, tungstic acid and tungstates, tungsten powder and its products, zinc ore, zinc and zinc-based alloys, tin ore, tin and tin alloys, silver, carbon steel plates (to the United States), and paraffin. (2) Unless otherwise specified, all export commodities listed in the catalogue are subject to global export licensing.

Another indirect restriction of coke export is the adjustment of export rebate rate. On October 13 2003, Ministry of Finance of China and State Administration of Taxation issues The Notice of Export Rebate Rate Adjustment for Export Goods, mainly focusing on resource-intensive goods, the export rebate rate of coke decrease most, from 15% to 5%. Due to the adjustments of export rebate rate, in January China's exports of coke and semi-coke products went down 52.3 per cent on a year-on-year basis; coal exports were down 28.6 per cent, product oil exports 48 per cent, and steel billets 49.5 percent.

Due to the highly increased domestic demand, the Chinese government is suspending new licenses in order to reduce the coke price/availability pressure on Chinese steel plants, which are

desperately looking for more coking coal and coke for their surging steel production. Analysts estimate that China issued 13 million tonnes of coke export license in 2003, but she is expected to issue only 9.1 million tonnes in 2004. (Japan Echo Fax News No. 390, December 24, 2003) The expected reduction in the export quota will further tighten the international coke market in the short term, i.e., one year. In the long term, i.e., five years, we can expect the situation to be improved because of the increased investment in coke-making capacity and the decreased coke-consumption/steel-production ratio.

2.1.5. Insufficient Transportation Capacity

The capacity of the domestic transportation systems, particularly of the railway system, has often been the bottleneck in coal and coke trade. Generally, coke transportation has a lower priority than coal in shipping scheduling, resulting in a large amount of coke being shipped by truck from inland plants to major ports (e.g., Tianjin and Qinhuangdao) for ocean freight. The cost and timing of the shipments are often unpredictable, thereby increasing the total cost of exported products. Recently, the Chinese government tightened transportation regulations and further increased transportation costs of coking coal and coke. (Stecoke.com, 2003) Adding to the problem is the current recovery of U.S. and European economies, which is increasing the demand and thereby augments ocean-freight shipments and prompts increases in shipping costs.

2.2. Supply and Demand in Other Major Industrial Countries

Although the demand and supply in China are the dominant factors to determine the coke price in the international market, to fully understand the global coke market, we also need to study the supply and demand in other major industrial countries.

2.2.1. Decreased Supply and Increased Demand in Global Coke Market

World coke production is currently 350 million tonnes per year. The production is falling in North America and in many European countries, but rising in Brazil and in the Asian Pacific countries. The total world coke production decreased from 366 million tonnes in 1995 to about 354 million in 2003 (Table 5).

[1] The following two paragraphs are summarized from an online government document (China Ministry of Commerce, http://www.mofcom.gov.cn/, November 2003)

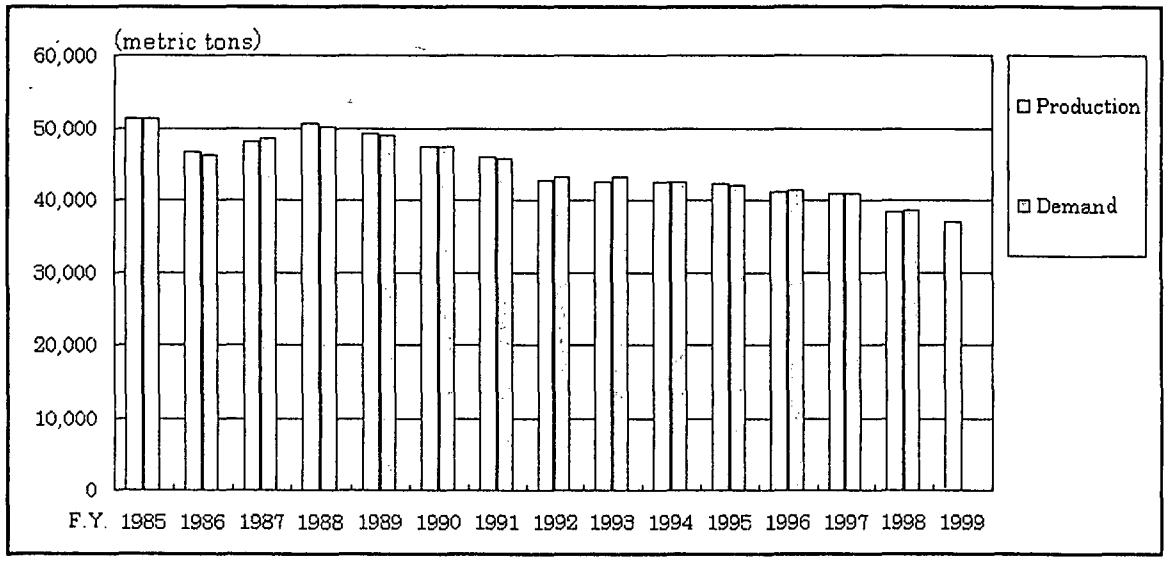
TABLE 5. WORLD, USA, AND CHINA COKE PRODUCTION, 1991-2000
(million tonnes)

Year	World	USA	China
1991	335.9	21.8	73.5
1992	335.4	21.2	79.8
1993	331.1	21.0	93.2
1994	330.9	20.6	114.8
1995	366.4	21.5	135.0
1996	363.1	21.0	136.4
1997	359.8	20.0	137.3
1998	344.8	18.1	128.1
1999	332.9	18.1	120.7
2000	333.1	18.9	121.8
2001	N/A	17.19	131.30
2002	357.0	15.22	142.0
2003	354.0[e]	N/A	170.0

Source: www.eia.doe.gov, *China Statistical Yearbook 1990-2002,* RAG Trading GmbH, 2003, *Met coke world summit, 2003.*
Note: N/A = not available, e=expectation

Asian-Pacific

Japan is the second largest coke consumer after China. In Japan, both coke production and consumption have decreased steadily since the late 1980s. Generally, Japan's domestic production was able to meet the domestic demand (Figure 18), but the country started to have a net import from the world market from 1996. Due to the stringent environmental regulations and the aging of existing coke batteries and plants, Japan is observing a declining production of coke. Since 1998, the country has closed the coke capacity by 480,000 tonnes. The annual coke exports are maintained at the level of 1.9-2.9 million tonnes, while the imports are 5.4-7.3 million tonnes per year (The Internet: http://www.sxcoal.com/). The country is expected to have a large shortage of coke in 2010 when many aged coke ovens are closed (The Internet: http://www.stecoke.com, 2003). For the similar reasons as in Japan, Australia, a major coking-coal producer and exporter, has closed 785,000 tonnes of coke production capacity since 1998.



Source: Japan Information Network. http://jin.jcic.or.jp/stat/stats/07IND37.html

FIGURE 18. JAPAN COKE PRODUCTION AND DEMAND

India is a coke producer and a coke importer. In 2001, India produced 11.7 million tonnes of coke, accounting for 3.4 percent of the world total volume (International Energy Agency, 2004). Within the last two years, India's coke production increase quickly, indicated by increased coking coal demand by Indian coke ovens (Table 6, http://coal.nic.in/bud03-04chap2.pdf).

TABLE 6: INDIA COKING COAL DEMAND BY COKE OVENS (million tonnes)

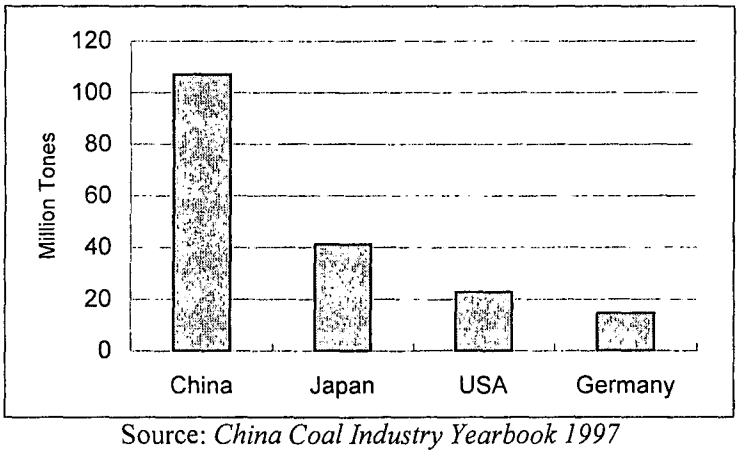
	2000-2001	2001-2002	2002-2003
Coking coal	0.50	0.83	1.50

India imports coke mainly from China to meet domestic demand of Pig-Iron manufacturers and Iron & Steel sector consumers using mini-blast furnace. According to Coal Controller's Organization's report, India imports 2.4 million tonnes of coke in year 2000 to 2001 and 2.88 million tonnes of coke in year 2001 to 2002, increasing by 19 percent (Indian Ministry of coal, 2004, The Internet: http://www.coal.nic.in/eximp.html). However, report shows that there is still shortfall of supply over demand of 3,122,200 TPA for coke in India although India's coke production capacity increases. Recently some Indian steel mills setup and plan to setup coke ovens given the high coke price in world market and high deficit of supply. (http://www.indiainfoline.com, 2004).

North America

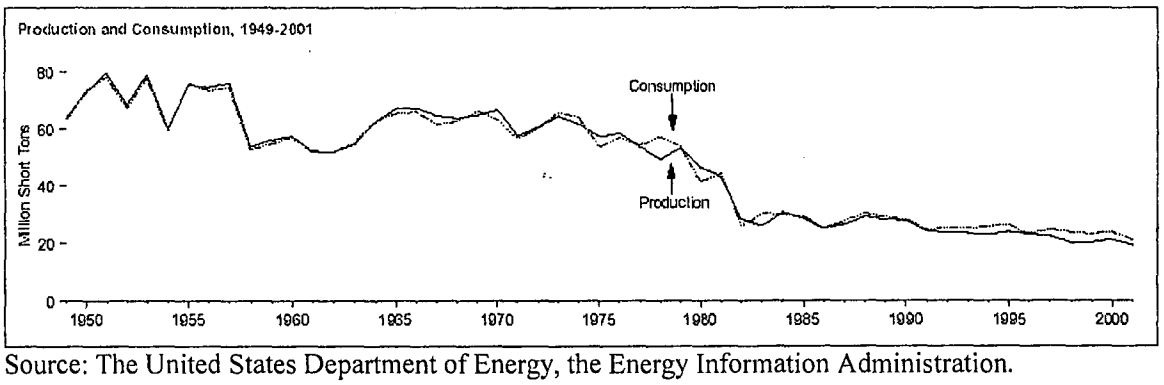
After China and Japan, the United States is the third largest coke consumer in the world (Figure 19). Its coke output declined from 42 million tonnes in 1980 to 17 million tonnes in 2001, primarily due to similar reasons as in Japan. Since 1998, the country has closed more than 4.2 million tonnes of coke production capacity. The export of the US was 0.97 million in 2001, and the import was 2.1 million tonnes, so the net import was about 1.1 million tonnes.

Only five steelmakers have excess coke production in 2002 in North America and the declining trend of coke production capacity is expected to continue (Source: The Internet: http://www.goradv.com). Thus, the current deficit in domestic U.S. coke supply is likely to widen and make steel producers more dependent on imported coke (Figures 19 and 20). Since 1994, imports have accounted for about 10 percent of the total U.S. coke consumption, and the country has become the second largest coke importer in the world.



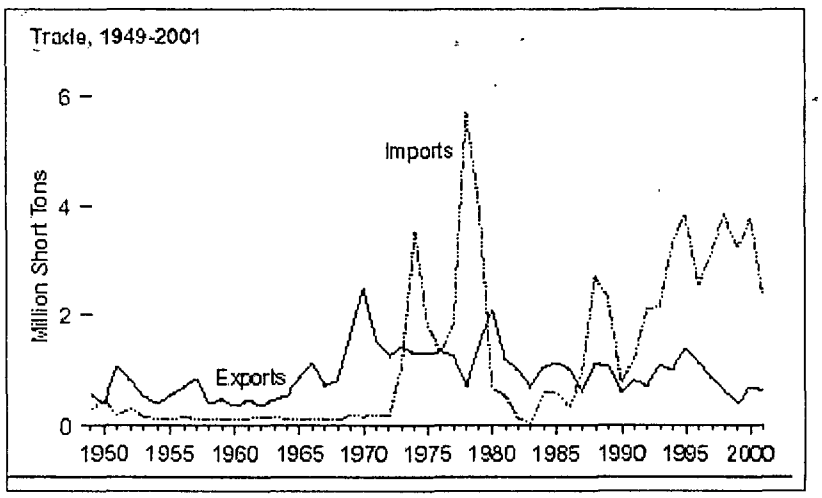
Source: *China Coal Industry Yearbook 1997*

FIGURE 15. TOP FOUR GLOBAL COKE CONSUMERS, 1997



Source: The United States Department of Energy, the Energy Information Administration. "International Energy Outlook 2003"

FIGURE 20. COKE PRODUCTION AND CONSUMPTION IN THE UNITED STATES



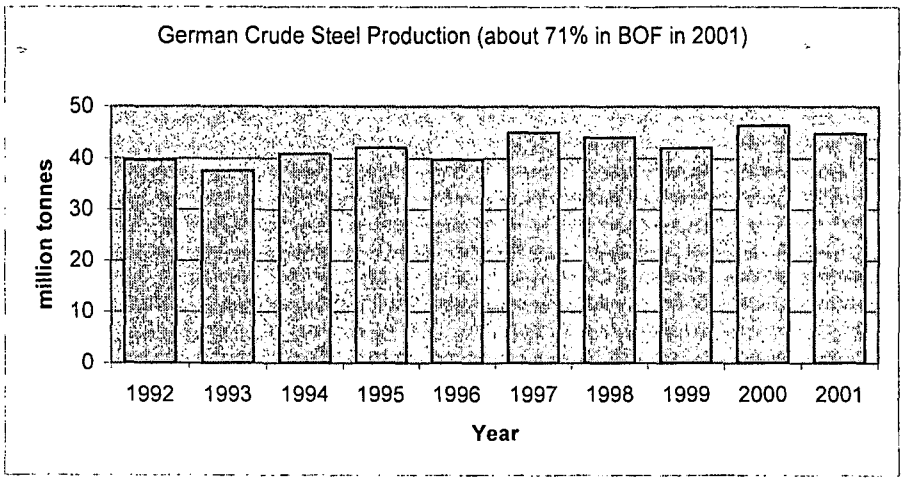
Source: (same as Figure 20)

FIGURE 21. COKE IMPORTS AND EXPORTS OF THE UNITED STATES

Europe

Since 1998, six major western European countries (Belgium, France, German, Italy, Portugal, the United Kingdom) have closed many coke plants with the total capacity of more than 7.7 million tonnes. Excluding Germany, the annual import of the rest five countries has been more than three million tonnes since the late 1990s. In 2001, France imported 1.3 million and Italy imported 0.5 million of coke. (CRU, 2003, The Internet: http://www.sxcoal.com/). According to the International Energy Outlook 2003 of American Energy Information Administration, Western Europe's coke production capacity continues to decrease due to the expected closure of some of older coke batteries (EIA, 2003, The Internet: http://www.eia.doe.gov).

As the fourth largest coke consumer in the world, Germany is the largest coke importer in the world. From 1995 to 2001, its total production decreased from 11.1 million tonnes to 7.3 million tonnes, and the import increased substantially. In 1999, the country imported 3.9 million tonnes of coke, while in 2001, the import increased to 6.8 million tonnes (BGR, 2003; The Internet: http://www.sxcoal.com/). On the demand side, the crude steel production in Germany in the past decade increased from about 40 million tonnes in 1992 to 45 million in 2001 (Figure 22). Although the percentage of steel production by BOF decreased from 77 percent in 1992 to 71 percent in 2001, it has remained at that level for the past several years (IISI, 2002). The demand for coke is expected to remain strong in Germany and the import of coke may keep increasing in the short term.



Source: http://www.worldsteel.org/media/ssy/iisi_ssy_2002.pdf.

FIGURE 22 . GERMANY STEEL PRODUCTION

Russia is another major coke producer. In 2002, the total production of coke in Russia was about 30.9 million tonnes, accounting for more than thirty percent of the total in Europe (The Internet: http://www.sxcoal.com/). Since 1998, the production capacity in Russia has decreased by 0.3 million. Comparatively, the capacity in Other Eastern European countries, including Czech Republic, Poland, Romania, and Ukraine, decreased much faster. Their capacity has decreased by more than 3.7 million tonnes in total. This is also primarily due to the aged coke ovens and environmental concerns.

Ukraine, as one of the top 5 coke producers in the world, produced 16.6 million tonnes of coke in 2001, which accounts for 4.9 percent of the world production (International Energy Agency, 2004) and is roughly kept in 2002. In 2003, Ukraine's coke production increased by 12 percent to 20.697 million tonnes induced by large demand increase of domestic steel industry, which increased 8 percent in 2003 , and foreign customers (The Internet: http://www.russiannj.com, 2004). However, Ukraine faces coke deficit. Report shows that during the second half of 2003, Ukrainian metallurgical enterprises experienced coke deficit of 80-140 thousand tonnes (The Internet: http://www.ukrbiz.net, 2004).

2.2.2. Driving Force: Increased Global Steel Production

Similar to the Chinese domestic situation, steel production is the driving force of the demand for metallurgical coke in other countries. Global steel production increased from 720 million tonnes to 850 million during the ten years of 1992-2001 (Table 7). Although the increase is

mainly due to the production increase in China, other major developing countries, such as India, are also observing increased domestic steel output. In addition, steel production in major industrialized countries, such as the United States, remains strong, increasing by one percent per year over the last decade.

On average, the world steel production observed an annual growth rate of about two percent. Excluding China, the world steel production had an average annual growth rate of 0.5 percent during the decade (The Internet: http://www.eia.doe.gov, 2003; The Internet: http://www.stecoke.com, 2003). However, the world steel production increased sharply by 6.2 percent in 2002, which is, again, primarily due to the increase in China. The country observed a striking annual growth of almost 20 percent (The Internet: http://www.stecoke.com).

TABLE 7. WORLD, USA, AND CHINA STEEL PRODUCTION
(million tonnes)

Year	World	USA	China
1991	733.6	79.7	71.2
1992	719.7	84.3	81.1
1993	727.5	88.8	89.7
1994	725.1	91.2	92.8
1995	752.3	95.2	95.5
1996	750.0	95.5	101.3
1997	798.9	98.5	108.9
1998	777.2	98.7	114.6
1999	788.5	97.4	124.0
2000	847.4	101.8	127.2
2001	849.6	90.1	152.3

Source: www.eia.doe.gov, *China Statistical Yearbook 1990-2002*

3. Forecast for Coke Market

Based upon the analysis and data in Part 2, we forecast global coke supply and demand. Then, based on the world forecast, we estimate coke prices.

3.1. Forecast Global Coke Supply

As shown in Table 5, the total world coke supply actually decreased over the past several years. If China were excluded, the decrease would have been even further. Facing the expected increased shortage of coke, major coke-consumer countries have been increasing their production capacity by building new coke ovens. For example, China completed 34 ovens in 2002, increasing the coke production capacity by 8.9 million tonnes. In 2003, China built more than 40 ovens with the capacity of 14 million tonnes. In addition, Germany is building two coke ovens with the total capacity of 2.5 million tonnes, and 1.3 million was realized in 2003. India is building small-scale coke ovens with the capacity of 0.7-0.8 million tonnes available in 2003. Considering that ovens are being closed and the other factors discussed in Part 2, we forecast that the world coke production would remain at the current level of 350 tonnes in the future two to three years, with the possibility of a slight decline. (The Internet: http://www.stecoke.com, December 2003)

3.2. Forecast Global Coke Demand

As discussed earlier, steel production is the driving force for the coke demand. World steel production was 730 million tonnes in 1993 and increased to 930 million in 2003 (expected), which is primarily due to the increase in China. Without China's steel consumption, researchers expected there would be little growth in world steel demand (Holecek, 2003).

Based on the analysis in Part 2, we estimate that the annual growth rate of world steel production would be around three to four percent in the short run and two to three percent in the long run. In the future several years, we expect that coke is still an essential material to make steel, particularly, high-quality steel. Given the decreasing coke intensity, we estimate the world coke demand would increase slightly by one to two percent per year.

3.3. Forecast International Coke Market

As coke domestic supplies in most countries other than China have been declining, we estimate the demand of these countries for international traded coke would increase if they remain steel and iron production. As the dominant exporter of coke, China generally gives domestic demand higher priority in terms of coke supply. Therefore, we expect that coke supply in the international market to be in shortage in the short term.

On the demand side, in 2002, coke traded in the international market reached 18.4 million tonnes with 41 percent of coke trade goings to Europe, 15 percent to the United States, 13 percent to Brazil, and 12 percent to Japan. Given that the supply in these developed countries keeps decreasing, we estimate the demand for coke in the international market will increase by three to four percent per year in the future several years.

On the supply side, China exported 12.6 million tonnes, about 68 percent, and Japan exported 2-3 million tonnes in 2002. In 2003, China's export was flat at 13 million tonnes (Marcus, 2002). Given the rapidly increasing domestic demand, we estimate that China will increase coke production but reduce coke exports. Without considering China's export-license, we estimate that the country's annual export would maintain at the 13 million tonnes level in the following two years, with the possibility of slight decrease. As discussed in Part 2, however, with the export license management, the export may be less than 10 million tonnes in 2004 and thereafter. At the same time, coke exports from Japan, another major coke exporter, are expected to keep declining (Japan Information Network, August 2003). Thus, we forecast that the total coke supply in the international market will be reduced in the short term. In the long term, with the new investment in production capacity, we expect that the coke supply in the international market would maintain a stable level.

3.4. Forecast Coke Price

Given the above discussion of world demand and supply, we believe that the current price leap will be sustained for a period of time. In the next one to two years, we expect the price in the international coke market to be maintained at a high level, say, around US$200 per tonne, but we

believe that the current price leap is temporary and, in the long run, the growth of steel production will be stabilized, and the price of coke will decline. Recently, the Chinese government has already started implementing a total-output control policy (Zhao, 2004) with various administrative tools: (1) banks would not issue loans to new steel plants, (2) the government would not approve plant construction plans, (3) the government would control production permits, etc. All these measures would be effective in controlling the expansion of steel-making capacity and, in turn, reduce the demand for metallurgical coke.

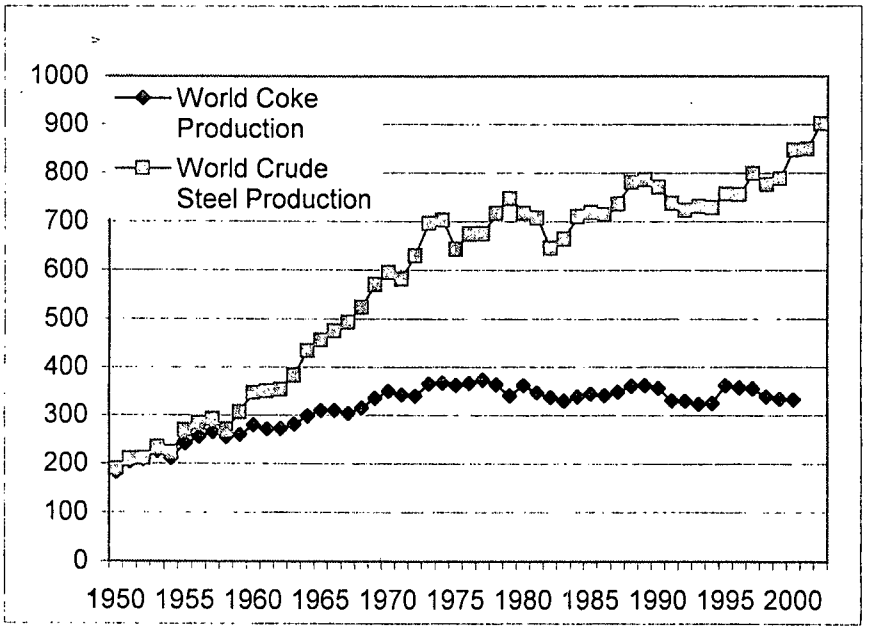
Marcus (2002) estimates that the cost to produce metallurgical coke in the United States might average about US$120 per tonne. Given that it costs about US$15 per tonne to bring Chinese coke to a U.S. port and then US$15 per tonne to get it to the USA steel plant, the Chinese coke should be priced less than US$90 per tonne to break even. However, given the situation in 2002, Marcus estimates the coke price would be US$125 per tonne in the first half of 2003. According to Coal America (2003), the coke price in 2004 is expected to be US$150 per tonne plus increased transportation cost. Thus, the price would be about the US$180 or even higher. In the long run, many researchers (CRU, 2003; The Internet: http://www.stecoke.com, 2003; Marcus, 2002; Li, 2004) believe that the coke price will fall back to a level with the range from US$90 to US$120 per tonne. Our estimates are US$180 to US$240, or even higher, per tonne in the short run and US$100 to US$150 (2003 real dollar) per tonne in the long run.

4. Other Issues

In this section, we discuss two related issues on coke demand and price.

4.1. Pulverized Coal Injection as a New Competitor

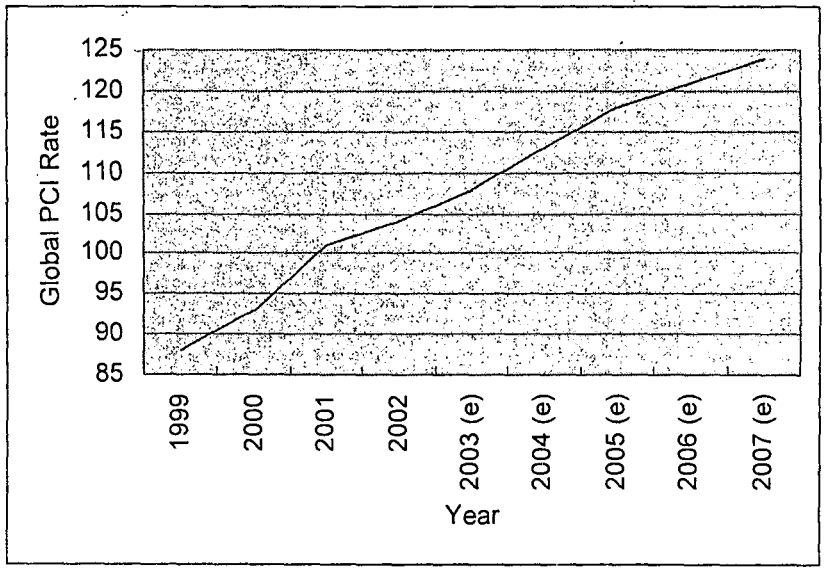
Shen (2004) summarizes the problems with the current coking technology: (1) limited coking coal reserve, (2) huge investment needed, (3) long construction period of coke oven, (4) heavy pollution, and (5) many coke ovens are very old. As a cost-saving technology, pulverized coal injection (PCI) technology involves the forced injection of pulverized coal into the base of a blast furnace to provide the chemical-reduction agents and heat necessary to convert iron ore to pig iron. This process lowers the quantity of coke required to produce pig iron in blast furnaces. The application of PCI technology in world steel production partly explains the inconsistent upward trend of coke consumption and steel production: rapidly increasing steel production does not incur the similar fast-growing coke consumption (FIGURE 23).



Source: For steel: ISII World Steel "Trends and Statistics". Downloaded on 10/8/2001 from http://www.worldsteel.org/trends_indicators/countries_98.html
For coke: Compiled by Nils Anderson, Jr. and Energy Information Administration, International Energy Database

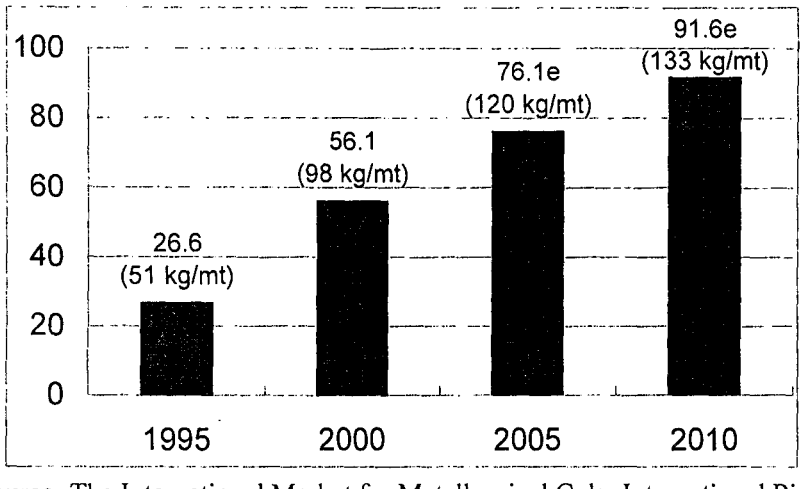
FIGURE 23 . WORLD COKE PRODUCTION AND STEEL PRODUCTION, 1950- 2002 (million tonnes)

The global PCI rate is expected to increase at an annual rate of 4.5 percent (Figure 24). The global total use of PCI in steel production is expected to continue growing in the next several years (Figure 25), which is helping to reduce the demand for metallurgical coke.



Source: Patrick Cleary, CRU International, Met Coke World Summit 2003

FIGURE 24 . CRU Forecast of the PCI Rate



Source: The International Market for Metallurgical Coke International Pig Iron Secretariat, IPIS, 37th Members' Meeting, Lausanne, Switzerland, 11th -- 13th June, 2003, Presentation by RAG Trading GmbH

FIGURE 25 . Global Use of PCI 1995-2010[e] (million tonnes)

4.2. World Supply and Trade of Coking Coal

Coking coal maintains its role as an unfungible component for the production of pig iron in the blast-furnace process. Research indicates that the present trade of 200 million tonnes per year is expected to grow to more than 230 million tonnes per year by 2020. Actually, the hard-coking-

coal demand has already exceeded availability worldwide. (Domenico, International Coal Trade and Price Developments in 2002)

Due to the increased domestic demand, China imports coking coal from Austrilia, New Zealand, and Canda. The imported coking coal to China in the first eight months in 2003 is 1.12 million tonnes, increasing by more than five times since 2002 (Stecoke.com, 2003). Also, the quality of China's domestic coking coal is declining. As a major component of coke price, the recent increase in the coking-coal price has pushed the coke price much higher than before. The lastest quoted coking coal price has reached US$80 per tonne, more than 300 percent higher than what it was, around US$20, last year (Sun, 2004).

5. Conclusion

In this report, we examine the present and future of world coke market. In 2003, the tension of world coke supply and demand deteriorated and price increased dramatically. Coke price increase results from a series changes in the field of coke and coal production, coke demand, export and environmental regulations, transportations in different countries these years.

In terms of the future of world coke market, we expect that the total coke supply in the international market will be reduced in the short term; in the long term, with the new investment in production capacity, we expect that the coke supply in the international market would maintain a stable level; coke prices are expected to be US$180 to US$240, or even higher, per tonne in the short run and US$100 to US$150 (2003 real dollar) per tonne in the long run.

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UNIDO Contract No. : 03/120

UNIDO Project No. : EG/CPR/99/G31

Activity Code: 450D32

P. O. No. : 16000473

Attachment 3.05

Marketing and Distribution System of Cokemaking Industry

of

The Final Report

to

the United Nations Industrial Development Organization (UNIDO)

for the Contract

Provision of Services for the Execution of a Coking Sub-sector Survey

related to the Project

Energy Conservation and Greenhouse Gas Emissions Reduction in Chinese Township and Village Enterprises – Phase II

Prepared by

Academy of Mathematics and Systems Science, the Chinese Academy of Sciences(CAS)

Shanxi Township and Village Enterprise Bureau (Shanxi TVE Bureau)

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Zhou Zongli

April 15, 2004

3.05 Marketing and Distribution System of Cokemaking Industry

Contents

The means of marketing and distributing coke is critical, extensively affecting the coke output and exports. To select an appropriate way to market coke, distributors should take account both of the plant and the market condition. There are various marketing methods, generally including: (1) direct distribution, (2) commission agents, (3) broker distribution, and (4) joint marketing.

1. Traditional marketing ways

Direct distribution is that industrial enterprises sell their products directly to the target consumers, not through any middlemen. This method can reduce the number of marketing channels and price, and can get market information directly from the consumers, but also increase the input of the enterprises, distracting them from production. Specifically, direct distribution has different patterns, such as setting up one's own monopolistic stores or chartered chain stores, finding a direct marketing front in retailer's shop, and so on.

Commission agent is that industrial enterprises trust their products to other middlemen. This method

has two types, one is that the middlemen do not undertake any risk in capital investment and marketing but get commission according to agreements, the other is that commercial enterprises buy exclusive rights of selling the products of industrial enterprises but have to take risk together, this is popular in developed countries with well-run market economy.

Broker distribution means the supplier and distributor communicate through broker and reach to agreement, while the broker does not manage the products and take any risk, he only get the commission for information.

Joint marketing means that, according to the principle of willingness and mutual benefit, more than two different units jointly establish affiliated institution to run a certain marketing business through agreement or contract, and distribute benefit.

Currently, with the development of the internet, some new marketing methods, such as direct email marketing, on-line marketing are emerging.

2. Marketing and distribution ways of Shanxi Cokemaking TVEs

Because of the limited scale and management of cokemaking TVEs, most cokemaking plants adopt direct distribution, there are some plants selling coke through commission agents though. In addition, more and more plants begin to use joint marketing, with marketing companies putting some investment in their production and sell their coke to the consumers, mainly overseas.

2.1 Direct distribution

From the 2003 sample survey in Shanxi cokemaking TVEs, we can see that 97 plants, out of the 110 plants we surveyed adopt direct distribution, accounting for 88.2% of surveyed (Table 1). Among the plants that adopt direct distribution, 96 plants sell their coke directly to consumers, of which 12 plants sell their coke through both directly to the customers and their own agents in various regions. One plant only markets coke through their own agents.

Table 1 Marketing methods in surveyed cokemaking TVEs 2003

Marketing Method	Direct distribution	Commission agents	Others
Percentage (%)	88.2	21.8	5.4

Source: 2003 Sample Survey on Shanxi Cokemaking TVEs done by the contractors

Of the plants that select direct distribution, 58 plants only use direct distribution method to market coke. In those plants, the reasons they adopt direct distribution are greatly different, but we classify them into the following two categories.

a. Larger plants that have perfect marketing network or with self-run import-export authority or have both, such as Shanxi Antai Group, Sanjia Coalification Co. LTD, Shanxi Xiaoshan Group, Taiyuan Yingxian Coal-carbonization Group. These companies have good reputation both at home and abroad, and most of their coke is exported to other countries, they have established stable relationship with overseas coke consumers or agents. Take Antai as an example, it has self-run import-export authority and all its coke are export directly to the consumers in Japan (29%), Italy (22%), Sweden (21%), Brazil (9%), USA (5%), Holland and Bulgaria (4.21%) and India (2%) (2002 data). They have branch offices in other countries/regions such as the United States of America, Brazil, Germany, Hongkong, and major domestic cities including Beijing, Tianjin, Haikou, Shenzhen, Zhuhai. Similar to Antai Group, Taiyuan Yingxian Coal-carbonization Group export all coke to Japan (40%), USA (25%), Brazil (20%) and Germany (15%) (Source: *2003 Sample Survey on Shanxi Cokemaking TVEs done by the contractors*). 'Yingxian Brand' coke has been a product exempting from inspection in Japanese market for a long time. Xiaoshan Group is the top 500 enterprises of China's TVEs in scale of operation, it has established marketing network in major regions and some countries.

b. Medium and small-scale cokemaking plants. Due to the limit of labor force or capital, many of these plants adopt direct distribution. In addition, from the perspective of scale economies, direct distribution is much more effective for a small or medium plant to use than to set up its own agents.

Some plants also adopt different marketing methods according to the consumers. As regards to those large, major consumers, most plants sell their coke directly. To those minor consumers, however, commission agents are generally adopted. In our sample survey, 21.8% of surveyed plants adopt commission agents for coke distribution.

2.2 Joint marketing

From our field survey to cokemaking plants and related marketing agencies, we found that joint

marketing has become one of the important marketing methods in Shanxi Province. Coke marketing companies are playing more and more active role in coke distribution and production.

Shanxi Township Enterprises Coke Supply & Marketing Ltd (Stecoke) is a professional enterprise mainly engaged in the business of production, transportation and sales of coke (*www.stecoke.com*). Stecoke owns 8 branch companies, of which 6 plants get direct investment from them and 2 plants are allied coke plants. In addition, Stecoke has 15 railway stations for the delivery of coke, its depots spreading all over the producing areas, and its great strength in railway transportation effectively guarantees the transportation of coke from Shanxi Province to outside. In recent years, Stecoke has chosen several most prospective plants and invested in them or supported them in some other ways, thereby can control the supply of over 1.5 million tonnes coke. According to the Stecoke General Manager, they sell over 2 million tonnes coke in 2003. Basically, it operates the coke of their affiliated plants, while sometimes they also sell some coke buying from other coke plants in order to to meet the demands of consumers.

Shanxi Provincial Coke Group Co. LTD is another large coke marketing company. It was founded in October 2002, incorporating by former Coke Branch of Shanxi Provincial Coal Transportation and Marketing Company, Coke Export Service Center attached to Shanxi Provincial Foreign Trade Commission, Shanxi Provincial Metallurgical Material Company and Shanxi TVEs Coke Company. Currently, 15 large cokemaking plants are shareholders of this company, supplying 6 million tonnes coke per year.

2.3 Effects of market on distribution ways

The marketing method a plant manager selects also depends on the market situation. Currently, coke demand is outstripping coke supply, and direct distribution gains an advantage over other distribution methods both at home and abroad, because it is difficult for the consumers to buy better-quality coke if they do not take an initiative. From our survey, we knew that in order to purchase coke, some purchasers even wait in the cokemaking plants with cheque or even cash, otherwise the coke would be sold to other companies.

2.4 Other marketing methods

Internet marketing is becoming more and more popular in large companies. Although this is not

common for Shanxi cokemaking TVEs, some major companies begin to use this method by making their own website: for example, Antai Group (http://www.antaigroup.com/), Sanjia Coalification Company (http://www.cnsjcoke.com/), Yingxian Coal-carbonization Company (http://www.yingxiancasting.com), and so on. Sanjia is selling coke through the internet.

UNIDO Contract No. : 03/120

UNIDO Project No. : EG/CPR/99/G31

Activity Code: 450D32

P. O. No. : 16000473

Attachment 3.06

Compilation of Inventory of Cokemaking-Support Organizations

of

The Final Report

to

the United Nations Industrial Development Organization (UNIDO)

for the Contract

Provision of Services for the Execution of a Coking Sub-sector Survey

related to the Project

Energy Conservation and Greenhouse Gas Emissions Reduction in Chinese Township and Village Enterprises – Phase II

Prepared by

Academy of Mathematics and Systems Science, the Chinese Academy of Sciences(CAS)

Shanxi Township and Village Enterprise Bureau (Shanxi TVE Bureau)

Karen R. Polenske

Zhou Zongli

April 15, 2004

3.06 Compilation of Inventory of Cokemaking-Support Organizations

Contents

To facilitate the growth of China's coke sector, cokemaking plants need access both to domestic and international cokemaking-support organizations. Here, we present information that we obtained through telephone interviews, Internet searching, and literature reviews. These organizations are composed of three categories: (1) cokemaking-technology providers, (2)cokemaking related associations , and (3) cokemaking-equipment producers. We mainly focus on the cokemaking-technology providers mainly given the importance of coke oven technology in cokemaking process and the information release style of other organizations. Within each category, the information we provide

varies depending upon our limited access to particular non-published sources.

1. Cokemaking-Technology Providers

In the field of cokemaking-technology service worldwide, especially of coking-oven design, Germany is playing a leading role. The advantages of their cokemaking technologies are prominent in the area of producing high-quality coke with low environmental pollution and effective recovery of coke by-products. Most of the important cokemaking technology providers abroad, especially the independent ones, are from Germany. Besides Germany, Japan also provides considerable services in terms of coal utilization and by-products, but Japan usually exports its technology embedded in equipment, instead of offering technology services directly. The United States is good at management, but its plants do not usually make full use of coal, i.e., they have less recovery of coke by-products than in other countries..

As for cokemaking-technology providers, we list the main ones, who are from China, Canada, German, Indian, Scotland, United States, and Ukraine.

1.1 CHINA

a. Anshan Cokemaking & Refractory Engineering Consulting Corporation (ACRE)

ACRE in short, with its foundation in 1953, is a leading engineering company specialized in research and engineering design for cokemaking, refractory and town-fuel-gas projects. ACRE has been ranked the 27th of the 100 top engineering companies in China for comprehensive capability. Among the more than 80 million tonnes of coke produced by machinery coke oven, that designed by ACRE account over 95%.

ACRE is qualified for:

- Class A of engineering design
- Class A of project contracting and construction supervision
- Class A of environmental impact assessment
- Foreign business right awarded by the Ministry of Foreign Trade & Economic Cooperation of China

ACRE has been awarded by CHINA DESIGN (BEIJING) QUALITY System ASSURANCE CENTER the "Certification for Quality System (GB/T19001-1994 idt ISO9001:1994)". ACRE has 18

special designing divisions, including cokemaking, chemical engineering, gas transportation, process hot working, civil engineering, electricity, automatization, ventilation, heating power, water supply and drainage, and so on. It specializes in undertaking the design, consultation, baking furnace, supervision and engineering contract service for cokemaking, town gas, refractory material and municipal engineering fields.

The company now has a technical staff of 1067, among which there are 34 professer-level senior engineers, 302 senior engineers, 496 engineers, forming a strong technical strength. With its rich practical experience and a contingent of technical personnel for directing and supervising construction, erection, heating-up, start-up and production adjustment of cokemaking and chemical, refractory and town-gas project, ACRE enjoyed high prestige both at home and abroad.

Since its foundation in 1953, ACRE has designed more than 150 of large-scale and medium-scale cokemaking and chemical plants, more than 100 refractory plants and town-fuel-gas projects in about 30 cities in China.

For about 10 years, ACRE has been engaged in international trading business on equipment and materials, especially refractory exportation. So far, ACRE has supplied the foreign clients with coke oven refractories, magnesia-carbon bricks, magnesia bricks, insulating bricks etc.

The Global Environmental Fund Organization of the United Nations has appointed ACRE as the head unit of the technical expert group in China for landfill gas recovery and utilization projects.

ACRE always stresses on the comprehensive economical benefit and would like to provide clients both at home and abroad with advanced technology and excellent services.

Scope of business

- Engineering designs for different coke ovens, vertical retorts and gas generating stations, coke-making plants
- Engineering designs for industrial and domestic coal gasmaking plant, oil gasmaking plant and town-gas distribution piping network
- Engineering designs for gas purification and chemical products processing system with different processes
- Engineering designs for refractory plants, cement plants and glass works in different capacities; and designs for projects of superduty basic bricks, superduty high alumina bricks, superduty

silica bricks, unshaped refractories, electro-fusion products, long nozzles, slide gates, light-weighted insulating refractory products, high purity magnesia, various synthetic sinters and active lime, etc.

- Engineering designs of kilns and furnaces for raw material calcining and refractory product burning as well as specialized equipment for refractory industry
- Engineering Designs of thermal power station and urban central heating piping system
- Development and application of CAD software
- Monitoring, control and treatment of waste water, emission and environmental impact assessment for cokemaking plants, gas works and refractory plants
- Designs for industrial and civil architecture engineering
- Supervision for construction, installation and erection of coke ovens and coal gasifiers, and their heating-up, start-up, production adjustment and coke oven proper appraisal
- Feasibility study, technical consultation and technical transfer for cokemaking plants, gas works and refractory plants
- Three combination supply process and technology for steam, electricity and gas
- Supply of refractory products, coke oven machinery, doors and castings, etc. with technical services such as inspection and testing.

Contact Information

Address: No.27, Nanshengli Road
Anshan, Liaoning,China

Tel: 0412-5532835

E-mail:acre@mail.acre.com.cn

http://www.acre.com.cn/

b. Anshan Research Institute of Thermal Energy.

Founded in 1976, Anshan Research Institute of Thermal Energy (ARITE) was the key institute of the former Ministry of Metallurgy, it locates in Anshan city, Liaoning province. ARITE is composed of branch division of hot working, institute of automatization research, and institute of engineering design.

ARITE has 406 employees, in which 237 of them are scientific and technical personnel (of which 86 are senior designer). Up to the end of 2001, ARITE has finished 208 pieces of scientific payoffs, of which 15 items were awarded prize of national level, 85 items were patenting. ARITE is the counterpart on the Chinese side of Coke Branch Technical Committee, Technical Committee of Solid Fuel under the International Standard Organization (ISO TC27/SC3).

The main research field covers metallurgy hot working and coal processing, mainly on the technical development of the following four aspects including coal processing and chemical products, new pattern carbon material, energy-saving technology of metallurgy, and comprehensive utilization of resources and environmental protection. ARITE provides engineering design, engineering consultation and general contracting mainly in the fields of industrial furnace and kiln, finery and arc furnace, coal chemistry, and energy-saving technology.

Main products and services in the cokemaking sector:

- Coal blending and cokemaking
- Production technique of special class and first class foundry coke
- Winnowing and conditionint treatment technique of coking coal
- Preparation of needle coke of coal series
- Production technology of foundry coke
- Production of ferroalloy coke and other carbon reductant
- ZJL-40 test coke oven
- Cokemaking waste water treatment method with water coal liquid
- Coke reactivity
- Preparation technique of interphase
- Goniophotometer of Aoya degree of expansion
- Goniophotometer of gelatinouslayer index
- Goniophotometer of caking index
- Quick intelligent sulpher determination apparatus
- ZGK series of drum
- Jet coal gas treatment process of coking waste water

Contact information

Address: No. 43, Lv Hua Jie

Tiedong District, Anshan, Liaoning, 114004

Tel: 0412-5839015

http://www.arite.com.cn/

c. Shanxi Provincial Design Institute of Chemistry Engineering

Attached to Shanxi Provincial Economic and Trade Commission, Shanxi Provincial Design Institute of Chemistry Engineering provides engineering design, engineering consultation and general contracting mainly in petrochemical engineering, cokemaking industry, municipal engineering and architectural engineering. QRD-2000, a kind of clean coke oven adopted in several cokemaking companies is designed by this institute, the coke oven type has been patented in 2002 (patent No.: is ZL01270184 •X)

Main products:

- Cokemaking process design
- Engineering geologic examination
- General contracting
- Architectural engineering design
- Environment effects evaluation
- Pressure vessel design
- Coalification design of synthetic ammonia carbamide

Contact information:

Address: No. 3, Dong Yi Xiang, Hou Wang Street

Jinci Road, Taiyuan 030024, Shanxi, P.R. China

d. The Second Design Institute of Chemical Industry

Formed in 1958 and located at Taiyuan City Shanxi Province, the Second Design Institute of Chemical Industry is a member institution of China National Chemical Engineering (Group) Corp., mainly provides engineering design and turnkey projects. The technical advantages cover the following fields: petrochemical industry, organic and inorganic chemical engineering, coal chemical engineering, medicine and pesticide, environmental protection and geologic examination, especially in:

- Coal chemical engineering
- Town coal gas

- Cokemaking industry
- Fertilizer
- Phenol and acetone
- Nitric acid

They have undertaken over 200 key construction projects from national and provincial levels. They have operating right directly to foreign companies, spreading its business to the companies of the United States, Germany, Japan, the United Kingdom, France, Sweden and Korea. They have 18 quality certificates including first-class quality of engineering design, turnkey contract projects, engineering consultation, engineering supervision and so on.

Contact information:

Add: No. 9, Kang Le Street, Xin Jian Road, Taiyuan 030001, Shanxi, P. R. China

Tel: 0351—4041584, 4048442

Fax: 0351—4186061

Email: sedin@public.ty.sx.cn, sinoht@public.ty.sx.cn

1.2 CANADA

The CANMET Energy Technology Center--Ottawa, Canada (CETC-O)

CETC-O, located in Ottawa, Canada, is a key research arm of Natural Resources, Canada and is one of Canada's main organizations in the field of energy, science, and technology, offering laboratory facilities that meet world standards.

Main products in the cokemaking sector:

Under CETC, the Energy Technologies for High Temperature Processes Program Group (ETHTP) conducts on a fee-for-service basis, Research and Development (R&D) investigations, standard tests and analysis of pulverized coal injection (PCI), coke-making processes, and related by-products. Current research interests include coal injection into blast furnaces, extending the life of coke ovens, and improving the quality of coke.

Contact Information:

Website: www.cetc-ctec.gc.ca
Mailing address: Natural Resources Canada
CANMET Energy Technology Centre
1 Haanel Drive
Nepean, Ontario
Canada K1A 1M1
Tel: (613) 996-0089
Fax: (613) 995-9728
E-mail: jprice@nrcan.gc.ca

1.3 GERMANY

a. Deutsche Montan Technologie GmbH (DMT)

With headquarters in Essen, Germany, the Deutsche Montan Technologie GmbH (DMT) group is composed of 15 associated companies in Argentina, Australia, Chile, Korea, People's Republic of China, Poland, and Russia. As an independent technology-service provider with emphasis on raw material, safety, and infrastructure, DMT has projects in 40 countries. The DMT Quality Management System according to DIN EN ISO 9001 has been certified by Germanischer Lloyd since 1996.

Main products in the coking sector:

- Field measurements
- Coke- and coal-quality monitoring
- Development of measuring methods and processes
- Health and safety/environmental measurements
- Fuel technology and process engineering

Contact Information:

Website: www.dmt.de
For Coke Service
Name: Dr. Friedrich Huhn
E-Mail: modernfuels@dmt.de
Phone: +49 (0)201 / 1 72-15 88
Fax: +49 (0)201 / 1 72-13 13
For head office
Deutsche Montan Technologie GmbH
Am Technologiepark 1

45307 Essen, Germany
Phone: +49 (0) 201 1 72-01
Fax: +49 (0) 201 1 72-14 62

b. The KOCH Group

The KOCH Group in Wadgassen, Germany, develops and implements technologically advanced solutions for industrial plants. KOCH has the following15 subsidiaries, branch and representatives offices: (1) KOCH Transporttechnik GmbH, (2) KOCH Austria, (3) KOCH do Brasil, (4) KOCH Chile, (5) KOCH Czech, (6) KOCH Leipzig, (7) KOCH Malaysia, (8) KOCH Maroc, (9) KOCH Nigeria, (10) KOCH Paris, (11) KOCH de Portugal, (12) KOCH Sarreguemines, (13) KOCH USA, (14) KOCH South Africa, and (15) KOCH de Venezuela. KOCH also has world-wide partnerships, for example, with the leading manufacturers of coke-oven batteries.

Main products in the coking sector:

In the coking plant technology sub-area, KOCH has more than 25 years of know-how in the design and construction of coking-plant facilities. The central part of the KOCH coking-plant technology is the patented stamp-charging technology--a procedure that at present is cost-effective for the production of high-quality coke from low-quality coal. KOCH also provides coal- and coke- handling-technology support.

Contact Information:

Website: http://www.kochtrans.com
Mailing address: KOCH Transporttechnik GmbH
Karl-Koch-Strasse 1
D-66787 Wadgassen, Germany
Telephone: +49 (0)6834 470-0
Tele/fax: + 49 (0)6834 470-339
E-mail: info@kochtrans.de

c. ThyssenKrupp EnCoke GmbH (TKEC)

As a leader in coke technology worldwide, ThyssenKrupp EnCoke GmbH (TKEC), in Bochum, Germany, is an engineering company for turnkey plants in the fields of the steel industry and environmental protection. The focal point of its activities is the cokemaking technology. Through

overseas affiliates and agencies, TKEC has spread its business to North America, South America, Africa, Asia, and Australia. Affiliated to the business line of ThyssenKrupp Technologies AG, the company is integrated into the ThyssenKrupp group operating worldwide.

Main products in the coking sector:

- Feasibility Studies
- Construction and installation
- Technical support in operation and maintenance
- Training of customer's personnel
- Quality assurance
- Consulting on planning and financing
- Basic and detailed engineering
- Procurement and delivery of equipment
- Project and cost controlling
- Job-site supervision
- Commissioning and performance tests

Contact information:

Website: http://www.tkencoke.com/english/frameset.htm
Mailing address: ThyssenKrupp EnCoke GmbH
Christstraße 9 1111
Bochum
44789
Germany
P. O. Box 10 18 49/50
ZIP Code 44718
Phone: +49 (0) 234 317-0
Fax: +49 (0) 234 373 21
E-mail: info@tkt-tkec.thyssenkrupp.com

For affiliate in China:
Anshan Hua De Engineering Ltd.
Mailing address: No. 27 Nanshengli Road
114 002 Anshan Liaoning
PR China
Tel: (00 86) 412 - 553 74 41
Fax: (00 86) 412 - 553 49 44

1.4 INDIA

a. Central Fuel Research Institute

Central Fuel Research Institute, Dhanbad, India, operates under the Ministry of Science and Technology, India. The Institute is intended to promote technology development and transfers in the area of fuel utilization.

Main products in the coking sector:

- conducting quality assessments of coal resources;
- generating basic process know-how for coking coal
- prescribing coal blends for cokemaking in the steel industry,
- designing non-recovery coke ovens for foundry and domestic coke.

Contact information:

Website: http://www.cfrindia.com/about.htm
Mailing address: The Director
Central Fuel Research Institute,
P.O. FRI, Dhanbad – 828108
Jharkhand, INDIA
Phone: (091) (0326) 238111, 2381001, and 2381010
Fex: (091) (0326) 2381113
E-mail: dnb_dcfri@sancharnet.in

b. Metallurgical and Engineering Consultants (India) Ltd. (MECON)

Metallurgical and Engineering Consultants, Ltd. (MECON), is an enterprise of the Government of India. It provides consulting and detailed engineering and technical services to the Indian iron and steel industry, including in the area of design of equipment and systems for coke ovens and blast furnaces. It handles consultancy assignments and turnkey contracts at home and abroad.

Contact information:

Website: http://www.meconlimited.com
Mailing address: Metallurgical & Engineering Consultants (MECON) Ltd
Ranchi - 834 002
Phone: (91 651) 501 216
Fax: (91 651) 502 194
E-mail: mecon-rnch@hub.nic.in

1.5 SCOTLAND

John M. Henderson & Co Ltd

John M. Henderson & Co Ltd. is a long-established engineering company in Angus, Scotland, that offers a complete package to the mechanical handling, oil, and steel industries worldwide. John M. Henderson has been involved in the design, manufacture, and installation of coke-oven machinery for over 40 years.

Main products in the coking sector:

Design, manufacture, and installation of more than 100 coke-oven machines, including:

- Screwfeeder Charge Cars
- Bellflow Charge Cars
- Cokeside Machines
- Cokeside Emission Controls
- Pusher Machines
- Transfer Cars
- Coke-Quenching Cars
- Water-Jet Door Cleaners
- Jamb Cleaners
- Door Extractors

Contact information:

Website: http://www.johnmhenderson.co.uk/prod-coke.htm
Mailing address: John M Henderson & Co Ltd.
Kings Works,
Sir William Smith Road,
Kirkton Industrial Estate,
Arbroath,
Angus.
Scotland.
DD11 3RD.
E-mail: contracts@johnmhenderson.co.uk
Tel: +44 (0) 1241 870774
Fax: +44 (0) 1241 875559

1.6 UNITED STATES

a. Koppers, Inc.

Koppers, with headquarters in Pittsburgh, Pennsylvania, is an international company and a leading

integrated producer of chemicals, carbon compounds, and treated wood products for the aluminum, steel, chemical, plastics, railroad and utility industries. Koppers is the world's largest distiller of coal tar.

Main products in the coking sector:

Koppers Harmarville Technical Center's Distillate Programs provide comprehensive services to develop quality and performance improvements of coal-tar products distilled from crude coke-oven tars.

Contact Information:

Website: www.koppers.com
For Technical Center
Mailing address: Koppers Inc.
Harmarville Technical Center
1005 William Pitt Way
Pittsburgh, PA 15238
Phone: (412) 826-3970
Fax: (412) 826-3999

b. Sun Coke Company

The Sun Coke company, with headquarters in Knoxville, Tennessee, has served the steel industry for the past 40 years and produces approximately two million short tons of coke per year from its plants in Vansant, Virginia, and Indiana Harbor, Chicago,. It offers heat-recovery technology combined with unique financial, operational, and environmental advantages for coke and steel makers.

Main products in the coking sector:

Based on clean heat-recovery technology, SunCoke helps build, own, and operate a coke plant.

Contact information:

Website: http://www.suncoke.com/
Mailing address: SunCoke Company
1111 Northshore Drive
Landmark Center, N-600
Knoxville, Tennessee 37919-4093
USA
Email: SunCokeInfo@sunocoinc.com

Phone: 865-558-0300
Fax: 865-558-3281

c. UEC Technologies LLC

UEC Technologies LLC, with headquarters in Pittsburgh, Pennsylvania, is the technology-transfer company of the U.S. Steel Corporation. As one of the business units of UEC Technologies LLC, UEC Tech Services includes business- development planning, training, engineering services, maintenance programs, and a variety of products and equipment.

Main products in the coking sector:

The coal and coke lab at UEC Technologies LLC specializes in metallurgical-coal and coke testing, analyzing individual coals, and evaluating the coals' potential in metallurgical coal blends and blending effects. It owns technologies of Lo-Mo Process (Low-Moisture Coke-Quenching) and Phosam and Phosam-W Processes.

Contact Information:

Website: http://www.uec.com/index.htm
For UEC Technologies
Mailing address: UEC Technologies
600 Grant Street
Pittsburgh, PA 15219-2800
Phone: 800-842-8877 or (412) 433-7000
Fax: (412) 433-7519
email: uectechnologies@uss.com

For UEC Labs
Mailing address: UEC Labs
4000 Tech Center Drive
Monroeville, PA
Phone: 866-LABS-UEC or 412-825-2400

1.7 UKRAINE

a. GIPROKOKS Institute--Ukraine

Giprokoks Institute is in Kharkiv, Ukraine and designs cokemaking equipment. It was founded in

1929 and is the only institute in the Ukraine and the CIS countries to design in the field of cokemaking. Giprokoks was awarded the Certificate of the International Expert Committee in cokemaking. Their technological developments meet the world standards for the field and are protected by the numerous certificates and patents and more than 50 licenses.

Main products in the coking sector:

Giprokoks fulfills feasibility reports, techno-economic evaluations, basic and detail engineering documentation, drawings, etc. for all facilities at the cokemaking plant. Giprokoks is in the progress of developing new efficient and ecofriendly coke-oven batteries, coke dry-quenching plants, selective coal- crushing units, as well as pollution-free and power-saving technologies.

Contact Information:

Mailing address: 60 Sumska vul.
Kharkiv, 61002
Ukraine
Phone: +380 572 15-60-42; 15-60-52; 15-60-95
Phone/Fax: +380 572 14-39-82
E-mail: giprokoks@ic.kharkov.ua

2. Cokemaking related associations

The coke sector has its own associations in some countries, which we detail below. As far as we know, there is no global coke association, different from the steel industry. However, because many iron and steel corporations own coke plants, the International Institute of Iron and Steel (IISI) holds some global coking-technology communications[1].

2.1. Chinese Cokemaking Industrial Association

Established in November 1994, the Chinese Cokemaking Industrial Association registered in Ministry of Civil Administration and former Ministry of Metallurgy. The association covers five industries, including metallurgy, chemical engineering, coal, town gas and light industry. It is composed of experts

[1] In 2000, IISI published *Cokemaking Technology*, which includes ten papers presented at the Technical Exchange Session of the IISI Committee on Technology (1998). Papers focus on innovations in cokemaking technology and outstanding improvements in conventional cokemaking. This book also includes three regional reports on environmental aspects of coke ovens and technologies.

from cokemaking company, relevant universities and institutes, and individual well-known experts in cokemaking. Up to now, it has 112 member institutions distributing over 27 provinces, autonomous regions and municipalitiesdirectly under the Central GovernmentIn 2003, coke output of member institutions account for near to 80% of the total coke output produced by machinery coke oven.

The aim of the association is to connect the cokemaking companies with governments at all levels, to implement the industrial policies more smoothly. They have done a lot of work on gross quantity control of coke output, elimination of indigenous coke oven, coordination of coke export, environmental treatment, preparation and revision of industrial technical standards, personnel training for enterprises, and consulting service.

There are four special interest committees, including coke and coal resource, cokemaking, coal carbonization and chemical products, and the last, coke and environmental protection.

Contact Information:

http://www.cnljxh.com/

Address: No. 46, Dong Si Xi Da Jie, Dongcheng District, Beijing 100711

Tel: 010-65260403, 010-65133322-1719

Fax: 010-65265081

Email: ljxh@metal.net.cn

2.2. American Coke and Coal Chemicals Institute – ACCCI

Formed in 1944, the American Coke and Coal Chemicals Institute (ACCCI) currently represents eight of the nine independently owned and operated U.S. "merchant" coke producers; several integrated steel companies that produce coke; and, all five of the U.S. and one Canadian coal chemicals companies that refine coal tar.

Contact Information:

Website: http://www.accci.org/
Mailing address: 1255 23rd Street NW
Washington, DC 20037
Phone: 202/452-1140
Fax: 202/833-3636
e-mail: information@accci.org

2.3 Eastern States Blast Furnace and Coke Oven Association

Organized in 1921, the Eastern States Blast Furnace and Coke-Oven Association is a not-for-profit corporation with individual members. The purpose of the organization is to promote good fellowship among its members and to provide a means for the presentation of papers, and open discussion of innovations, and challenges pertaining to the blast-furnace and coke-oven industries.

Contact Information:

Website: http://www.eastern-states.org/
Mailing address: Eastern States Blast Furnace and Coke Oven Association
James Richardson, Chairman, Membership Committee
P.O. Box 14523
Pittsburgh, PA 15234-0523
U.S.A.

2.4 The Coke-Oven Managers' Association (COMA, United Kingdom)

The Coke-Oven Managers' Association (COMA) was founded in 1915 in the United Kingdom with the objective of advancing the interests of the coking and by-product recovery industry in any or all of its branches. COMA holds regular technical meetings during the winter months and publishes annually a year book.

Contact Information:

Website: http://www.coke-oven-managers.org/
E-mail: coma@coke-oven-managers.org

2.5 The Association for Iron & Steel Technology (AIST)

The Association for Iron & Steel Technology (AIST) was established on January 1, 2004. It is the combination of two organizations, the Association of Iron and Steel Engineers (AISE) and the Iron & Steel Society (ISS).

AIST is committed to presenting superior technical meetings, conferences, exhibits and publications to better serve those involved in the iron and steel community, including steel manufacturers, suppliers, consumers and academics. AIST has the following eleven Technology Divisions, among which cokemaking is under Iron Producing Division:

I. Iron Producing
II. Electric Steelmaking

III. Oxygen Steelmaking
IV. Continuous Casting
V. Rolling and Finishing
VI. Process Metallurgy and Product Applications
VII. Process Automation, Control and Technology
VIII. Material Handling and Facilities
IX. Maintenance and Reliability
X. Project and Plant Management
XI. Safety and Environment

Contact Information:

Website: http://www.aistech.org/
Mailing address: AIST
Association for Iron & Steel Technology
186 Thorn Hill Road
Warrendale, PA 15086
Phone: 724-776-6040
Fax: 724-776-1880
email:info@aistech.org

3. Cokemaking-Equipment Manufacturers

Coking equipment is not sophisticated in terms of manufacturing. Most of the manufacturers, such as MITSUBISHI Corp, Mitsui Corp., etc., can produce the equipment according to sketches provided by contractors. The followings are some of the manufacturers. From 3.4 on, we obtained the company list of cokemaking facilities providers through www.SteelLinks.com.

3.1. Cokemaking-Equipment Manufacturers from China

a. DHI & DCW Group Company Ltd.

Formed in December 2001, DHI & DCW Group Company Ltd. is composed of Dalian Heavy Industry Group which is the best company in China's heavy industry, and Daqi Group. It provides key technical arrangements for main industries, including metallurgy, port, mine, energy, transportation, aviation & spaceflight, chemical engineering and urban construction.

Main products for coking sector:

Mechanical equipment for 58 type coke oven, 66 type, 80 type, 90 type; Mechanical equipment for

side-loading and tamping coke oven, large volume coke oven with 5m and 5.5m of height; Design and manufacturing of mechanical equipment for coke oven with 6m height; Design and preparation of dry coke quenching technology. DHI & DCW is the only domestic company that has the qualification to design and manufacture 6m coke oven.

Other Products:

- Handling machinery, including stacker, reclaimer, stacker reclaimer etc., with handling capacity between 100t/h～6000t
- Metallurgical and mine car, such as mixed hot metal car with capacity between 150t～450t, Side Car at BOF and EAF, electric slag car, tilting disulphur buggy ladle, casting car, electric flat car, sintered ore car
- Metallurgical and mine car, such as mixed hot metal car with capacity between 150t～450t, Side Car at BOF and EAF, electric slag car, tilting disulphur buggy ladle, casting car, electric flat car, sintered ore car
- Port Machine
- Bridge crane, crane for iron and steel works, frame crane
- Continuous casting equipment, rolling equipment

Contact Information

Website: www.dhidcw.com.cn

Address: No. 169, Ba Yi Road, Xi Gang District
Dalian 116013, P. R. China

Tel: 0411-4604201 4644201

Fax: 0411-4604760

E-mail: info@dhidcw.com.cn

b. Shougang Electric and Machinery Engineering and Research institute (SGINST)

SGINST is a comprehensive institute specializing in the fields of design, research, new production development and technical service, which is in a position to enter into the design on complete heavy duty metallurgical, electric and mechanical equipment. It has a strong technical force, involving metallurgical technology & equipment, casting & forging, electric automation, power equipment

hydraulic cooling & low-temperature technology, constructional engineering, metal structure, hot-air system, water supply & discharge environmental protection equipment, etc. Our institute's computer department is well equipped with a complete set of computer hardware and software.

SGINST possesses a number of technological patents, such as flat surface secondary enveloping toroidal worm drive, heavy spun casting machine, flag wave device, etc, and the know-how, such as high-speed bar flying shears hydraulic coupling, etc. SGINST has undertaken a number of engineering designs for Shougang Corp., including new-type 6M coke oven equipment, billet and slab continuous casting machine and workshop, hot milling plant, high-speed wire-rod mill, complete bar mill, heavy blast furnace blower & heavy centrifugal air-compressor, oxygen-compressor, complete equipment's of cement plant, etc. SGINST has also gained good reputation both at home and abroad, including steel mill workshop and complete equipment's for Baoding Iron and Steel Corp., complete bar milling equipment's for MASTER, Indonesia and East Steel Co., Ltd., Singapore, and section-steel milling equipment's with an annual production of 80,000 tons for Sri Lanka, etc., and established close relationship with famous companies, such as MESTA of the United States, the Thyssen Stabl AG of Germany.

Contact Information:

Website: http://www.sginst.com.cn/

Address: Jia No.2 Gucheng North Road, Shijingshan District

Beijing100043, P.R.China

TEL: (010)68861361 68862041 68849144

FAX: (010)68861361

c. Anshan Metallurgical and Mine Equipment Manufactory

Anshan Metallurgical and Mine Equipment Manufactory focus on cokemaking, chemical engineering, and so on. The coke cutter of this manufactory has been put into operation in major iron and steel companies, for example, Baoshan Iron and Steel Company in Shanghai, Wuhan Iron and Steel Company, Lingyuan Iron and Steel Company and Ji'nan Iron and Steel company, etc. Its main products are coke cutter, pelletizing disc, screw conveyer, double-spiral classifier, bucket elevator, heat exchanger of blast furnace gas, toothed roll crusher, table feeder, single and double block pusher, scraper conveyor, ball mill, impact screen. It has spread its business to almost twenty provinces in

China, and to Pakistan, Vietnam, Iran, Bangladeshi, Philippines. They possess 123 sets of large-volume precision equipment, including CQ5250 two column vertical boring mill, B2050 double housing plane、T4263 plotting bore, M1450 universal mill and Y9650A lambdoid mill.

Contact information:

Website: http://www.astf.com.cn

Mailing Address: No. 56, Dong Jian Guo Road, Anshan

Liaoning 114031, P. R. China

Tel: 0412-6616222 Fax: 0412-6616111

E_mail:astefa@mail.asptt.ln.cn

d. Wuxi Cokemaking and Coal Gas Equipment Plant

As a pointing plant of ACRE since the beginning of 1980s, Wuxi Cokemaking and Coal Gas Equipment Plant mainly produce specially cokemaking and coal gas equipment. It developed from mainly undertaking cold plate work, machine work for ferrous metal and stainless steel materials at the beginning. Now it specializes in manufacturing gas cooler, mechanized ammonia defecator, complete set of installation for refined naphthalene, and coal-loading and dedusting equipment for coke oven, with different specifications.

It has passed through ISO9002 quality system test. In the past over 20 years, it has supplied high quality coke ovens for more than 200 plants.

Contact information:

Mailing address: Ganlu Town, Wuxi City 214117,

Jiangsu Province, P.R. China

Tel: 0510--8751794 8751793

Fax: 0510--8751577

e. Tangshan Light Machine Manufacturing Plant

Located in Tangshan, Hebei Province, Tangshan Light Machinery Manufacturing Plant can undertake the integrated process design of coke oven, and design and service for other light industries. It can undertake the design, manufacturing, installation and adjusting of equipment for cokemaking plant, including cover ironware for different type of coke ovens, associated facilities, nonstandard products, recovery equipment for chemical products.

Main products for coking sector:

They have supplied coal loading car, coke pusher, coke g80uide, coke quenching car and coal tamping machine for the following coke oven type, such as 58 type, 58 II type, 80 type, 80 II type, 3.3 meters high coke oven, small 58, 66 type, 3.8 and 3.2 meters high coke oven with coal tamping.

Complete set of oven cover ironware, including: Oven door, oven door frame; guard plate; seat and cover of dusting door; seat and cover of fire hole; temperature hole of recuperater; faucet (A DN65, B DN65); valve body of hydraulic seal bridge pipe; commutative switching unit; connecting pipe of bottom flue; bent pipe of flue; self-adjusting edition of main flue; manual-adjusting edition of branch flue; pillow of track of dedusting car; muzzle of high-pressure ammonia.

Complete set of nonstandard parts, including: oven stay and tray; landing station for oven door , reparation; preheater of gas; tonnage cantilever arm; gear drive equipment; self-adjusting butterfly valve (DN500, DN1000); patching machine; manual adjusting butterfly valve (DN1000); replacing station of back backboard of coal chute; diaphragm valve; windlass of repairing station of oven door; water seal trough of gas condensate; batteries; repairing station of oven door; gas dry burner

Recycle equipment for chemical products: volatile ammonia scrubber, actifier, comb spray cooler, decomposer, fixed ammonia scrubber, ammonia dosing vessel, ammonia decomposer, fractionating tower, ammonia condensate cooler, benzole scrubber, potassiumferrocyanide absorbing tower, grid ammonia distillation tower, benzene blowing tower, strong ammonia tank

Contact information:

Headquarters: Website: http://www.chinatqj.com/

Mailing address: No. 138, Gongyuan Dao

Feng Run District, Tangshan 063034

Hebei Province, P. R. China

Tel: 0315-3241323

Fax: 0315-3242384

Sales Department

Hotline: 0315-3242981

Fax: 0315-3245707

Email: xqtqjxszy@heinfo.net

f. Zhenxing Petrifaction Equipment Plant

Located in Honghu city, Hubei Province, Zhenxing Petrifaction Equipment Plant provide necessary parts for cokemaking, petroleum, chemical engineering, oil refining, fertizer, rubber, pharmacy and so on. Its products include storage tank pipe, distributer series, structured packing, internal component series, bulk packing and tray series. It can provide design service for the process such as rectification, resolution, absorption, extraction, heat exchange and abstersion.

Contact information:

Mailing address: No. 108, Zhong Hua East Road, Fuchang, Honghu City, Hubei Province

Tel: 0716-2852072 Fax: 0716-2852410

Email: zhenxing@jz.hb.cninfo.net

g. Ji'nan Metallurgical & Chemical Engineering Equipment Plant

It specializes in producing necessary products for cokemaking and oil refinery industry, including steel or aluminium heat exchanger, cooler, vertical pipe or horizontal pipe primary cooler, pipe furnace, heating furnace, carbon steel, actifier column of stainless steel, benzole scrubber, ammonia washer and so on.

Contact information:

Mainling address: Zhangxia town, Changqing District

Ji'nan 250308, Shandong Province, P. R. China

Tel: 0531-7482034, 7482069

Fax: 0531-7482177

h. Rumo Cast Iron Shareholding Company Ltd.

Located in Zibo City, Shandong Province, Rumo Cast Iron Shareholding Company Ltd specialize in producing oven-protecting equipment, contruction tower crane, coke oven machine.

Main Products for cokemaking sector:

Oven-protecting equipment for 2.8M—6M high coke ovens; ammonia still, benzole scrubber; sinter machine, sinter trolley; grate of spherical heater and blast heater; The material is mainly magnesium iron, gray iron and cast steel.

Contact information:

Mailing Address: Shi Guangliang

No. 3, Zhang Suo Road, Tang Yi Cun, Tangshan Town

Huantai County 256401, Shandong Province, P.R. China

Tel: 0533—8510473

3.2. Gundlach Machine Company

The Gundlach Machine Company, located in Belleville, Illinois, focuses on crushing and grinding technology and markets world-wide through licensees and representatives in Europe, India, People's Republic of China, South Africa, South America, and Taiwan Republic of China, and. It offers coal-cleaning and advanced coke- crushing solutions, respectively, through the Ro-Pro Separator and Cage Paktor. The former can be used to separate the ash-free coal fines prior to washing and maintains separating efficiency in high-moisture applications. The latter can be applied to crush coal to a 3 millimeter (mm) size and is capable of changing the product size without interrupting production.

Contact information:

Website: http://www.tjgundlach.com/index.html

Mailing address: Division of J.M.J. Industries, Inc.
One Freedom Drive, P.O. Box 385
Belleville, Illinois 62222 USA

Telephone: 01 (618) 233-7208

Fax :01 (618) 233-6154

For consumers from China

Mailing address: John Chiu
Eagle Resources, Inc.
49 Parsons Drive
West Hartford, CT 06117

Tel: 860-233-3379

Fax: 860-232-8512

Email: eagleresources@attbi.com

3.3 Rochester Machine Corp.

Rochester Machine Corp. in New Brighton, Pennsylvania, has provided 82 years of machining and fabricating services for coke plants, rolling mills, blast furnaces, etc. It specializes in new plants and equipment, and it rebuilds or repairs mandrels, chocks, gear cases, spindles, couplings, coke-oven doors

and jambs, pusher rams, quenching-car-liner plates and clay-gun nozzle tips.

Contact information:

URL: http://rochestermachine.com/
Mailing address: 1300 Allegheny Street
New Brighton
PA 15066
U.S.A.
Phone: 724-843-7820
Fax: 724-846-9805
Email: info@rochestermachine.com

3.4. Aker Kvaemer ASA

Aker Kværner ASA is a global provider of engineering and construction services, technology products and integrated solutions in several industries. Its expertise includes, coke manufacturing, secondary iron and steelmaking, blast furnaces etc. It has facilities worldwide, including those in Beijing and Shanghai, China.

Contact information:

URL: http://www.kvaerner.com/
For Beijing office:
Mailing address: Level 16 Fuhua, Mansion A
No 8 Chaoyangmen North Avenue
Beijing 100027
Phone: +86 10 65 54 16 99
Fax: +86 10 65 54 26 99

For Shanghai office:
Address: Room 505 POS Plaza
480 Pudian Road
Shanghai, China

3.5 Bricmont, Inc.

Bricmont Inc., located in Canonsburg, Pennsylvania, USA, provides complete engineering for design and construction of industrial furnaces and related equipment, project engineering and detailed design of furnaces and mechanical handling equipment. Project management, cost control, detailed schedule control, procurement/purchasing, expediting/inspection and construction management.

Contact information:

URL: http://www.bricmont.com/

Mailing address: Bricmont Incorporated
An Inductotherm Company
500 Technology Drive
Southpointe Industrial Park
Canonsburg, PA 15317-9584 USA
Phone: 1-724-746-2300 or 1-888-BRICINC
Fax: 1-724-746-9420

3.6 Brock Solutions

Brock Solutions, headquartered in Ontario, Canada, is a North American drives and automation engineering company (formerly known as SAF Drive Systems and S-S Technologies). It delivers: AC / DC drive systems engineering, industrial control system (PLC, DCS, PC) solutions, manufacturing execution system solutions, and etc.

Contact Information:

URL: http://www.brocksolutions.com/
Mailing address: Brock Solutions, Inc.
86 & 88 Ardelt Avenue
Kitchener, Ontario, Canada
N2C 2C9
Phone: 1- (519) 571-1434 or 1- 877-702-7625
Fax: (519) 571-1721
Email: info@brocksolutions.com

3.7 Cable USA, Inc.

Cable USA, located in Florida, specializes in the design, manufacture, and marketing of high temperature and specialty wire and cable products. Their products include high temperature wire and cable, 3000°F industrial cable, soaking pit cables, caster and tundish high temperature cables, single and multiconductor for all "hot side" applications, etc.

Contact Information:

URL: http://www.cableusainc.com/indexie.html
Mailing address: Cable USA, Inc.
Collier Park of Commerce
2584 South Horseshoe Drive
Naples, Florida 34104
Phone: 239-643-6400
Fax: 239-643-4230
E-mail: www.cableusainc.com or info@cableusainc.com

3.8 Capital Engineering, Inc.

Capital Engineering, Inc. is full service engineering with mechanical, civil, structural, and electrical engineering capabilities. Services run the full range from concept development through detail drawings. Specialties include mill machinery, processing machinery; material handling equipment, equipment modernization, piping, foundations and industrial structures for the ferrous and nonferrous metals industries.

Contact Information:

URL: http://www.capital-eng.com/
E-mail: mailbox@capital-eng.com

3.9 CBP Engineering Corp.

CBP Engineering Corp., located in Washington, US, majors in design, fabrication and installation of abrasion and corrosion resistant linings. His products include Basramite cast basalt, alumina ceramics, silicon carbides, AZS, tungsten carbide and trowelable coatings.

Contact Information:

URL: http://www.cbpengineering.com/
Mailing address: 185 Plumpton Avenue
Washington, PA
15301 USA
Phone: 1-800-468-1180 (US & Canada) or 724-229-1180
Fax: 724-229-1185
E-mail: andy@cbpengineering.com

3.10 Centerline Engineering Corporation

Centerline Engineering Corp., located in California, USA, focuses on construction engineering, construction management, design build and turnkey projects for the metals industries. It supplies equipment for melting, casting, long product, and flat rolled facilities. Also, it provides consulting and process studies for melt shops, hot and cold rolling, pickling, galvanizing and finishing.

Contact Information:

URL: http://www.wireworker.com/
Mailing address: 1211 S. Ritchey St.
Santa Ana, CA 92705

Telephone: 714-543-9898
Fax: 714-543-0161
Email: info@wireworker.com

3.11 Datel Engineering Co., Inc.

Datel Engineering Company, located in Ohio, USA, provides project management engineering services and technical consulting to heavy industries and steel making, steel processing, and aluminum industries. It deals with turnkey and fast track projects, water treatment, bag house automation, networking PLC and OS programming, on-site maintenance, construction management, start-up assistance.

Contact Information:

URL: http://www.datelengineering.com/
Mailing address: 511 Progress Road
Dayton, Ohio 45449-2399
USA
Phone: 937-859-0910
Fax: 937-859-6512

3.12 Danser Inc.

Danser Inc., located in West Virginia, USA, has been a solutions provider to the industrial marketplace for over 65 years. It is able to offer: turnkey piping solutions, vacuduct high temperature (2800 Deg F.) ceramic fiber lined ducts, hot work repair services, spiral wound pipe, industrial dampers, and steel fabrication. It provides any level of service: design, fabrication, field installation, and commissioning.

Contact Information:

URL: http://www.danserinc.com/
Mailing address: DANSER, INC.,
PO BOX 4098, MURPHYTOWN ROAD
PARKERSBURG, WV 26104
USA
Phone: 1-304-679-3666
Fax: 1-304-679-3354

3.13 DMS Bliss Corporation

DMS Bliss Corporation, headquartered in Streetsboro, Ohio, USA, design, supply and commission a complete range of downstream facilities for the ferrous and non-ferrous industries including:

processing lines, tube mills, rolling mills, mill modernizations, engineering services, field service process automation and controls, project management.

Contact Information:

URL: http://www.dmsbliss.com/
For China office: CFL_DMS
22A Citic Building
19 JiangGuoMen, Wai DaJie
100004 Beijing
Phone: (10) 65006094
Fax: (10) 65007900

3.14 DTE Coal Services, Inc.

DTE Coal Services, located in Ann Arbor, Michigan, USA, provides coal supply and transportation related services, such as rail car maintenance and repair capabilities, fleet monitoring and management, rail car fleet storage, fleet pooling and coal blending expertise.

Contact Information:

URL: http://www.dtecs.com/
Mailing Address: DTE Coal Services, Inc.
425 South Main Street, Suite 201
Ann Arbor, MI 48104
USA
Phone: 1-734-913-2097
Fax: 734-994-5849

3.15 Eichleay Holdings Inc.

Eichleay Holdings Inc., located in California, USA, provides general construction, design/construct and turnkey services for all phases of the iron and steelmaking processes, including coke plants.

Contact Information:

URL: http://www.eichleay.com/
Mailing Address: Eichleay Engineers Inc. of California
Two Corporate Center, Suite 600
1390 Willow Pass Road
Concord, CA 94520
USA
Phone: 1-925-689-7000
E-mail: BD@eichleay.com

3.16 Fairfield Engineering Co., The

The Fairfield Engineering Company, located in Ohio, USA, provides engineering services, fabrication of bulk handling equipment of coal, coke, DRI alloy and flux materials, and integrated control systems for weighing and batching.

Contact Information:

URL: http://www.fairfieldengineering.com/
Mailing Address: The Fairfield Engineering Company
240 Boone Avenue
Marion, OH 43302
USA
Phone: 1-740-387-3327
Fax: 1-740-387-4869
E-mail: webmaster@fairfieldengineering.com

3.17 Hatch Associates Ltd.

Hatch is a global consulting, engineering, technologies, information systems, project and construction management organization.

The business units and affiliates of the Hatch Group provide a full range of technology-driven, value-adding solutions and services to clients in the mining, minerals, metals, industrial infrastructure and energy sectors through a network of more than 64 permanent offices worldwide.

Contact Information:

URL: http://www.hatch.ca/

For Beijing Office:
Mailing Address: Hatch
310 East Ocean Center
A-24 JianGuo Men Wai Road
Chaoyang District, Beijing
P.R.China 100004
Telephone: (8610) 6567-2316
Fax: (8610) 6567-2317

For Shanghai Office:
Mailing Address: Hatch
Suite B-C, 6th Floor, Bao Qing Building
No.8 Tao Jiang Road
Xuhui District, Shanghai 200031
P.R. China
Telephone: 86 21-6433-5337
Fax: 86 21-6433-6106

3.18 HOH Engineers, Inc.

HOH Engineers, Inc., part of HOH Group in Chicago, USA, provides project management, engineering and construction for the development of effective plant design, installations and operations. Its products also include control of hazardous wastes and emissions.

Contact Information:

URL: http://www.hohgroup.com/hohengineers.html
Mailing Address: 180 North Wabash Ave.,
Chicago, IL 60601
USA
E-mail: info@hohgroup.com

3.19 IIC Industries Ltd.

IIC Industries Ltd. manufactures and repairs blast furnace and coke oven valves, including custom design valves, compressor valves (including O.E.M. replacement parts), and safety valves.

Contact Information:

Mailing address: Mark Cusack
Regional Sales Manager
1908 Dove St.
MI. 48060
USA
Phone : 1- 800-265-7596
Fax : 1- 519-336-4263
E-mail: admin@iicvlve.com

3.20 Midwest Industrial Supply, Inc.

Midwest Industrial Supply, Inc. provides complete turnkey application services, tailor-made for specific site. Its products mainly in the areas of dust control, road stabilization, erosion control, and soil stabilization; winter operating anti-icing strategies.

Contact Information:

URL: http://www.midwestind.com/

3.21 Ohio Valley Scale & Equipment

Ohio Valley Scale & Equipment, located in Pennsylvania, USA, offers a coke oven charge car scale with strain gauges bonded to the rails for accurate weighing of coke oven charge cars statically or in-motion.

Contact Information:

URL: http://www.ohiovalleyscale.com/
Mailing Address: P.O. 641
113 East Mall Plaza
Carnegie, PA 15106
USA
Phone: 1-888-279-6155 or 1-412-279-6155
Fax: 1-412-279-2246

3.22 Raytheon Engineers & Constructors

Complete design, engineering, construction, construction management, process evaluation, and automation services for the ferrous and nonferrous industries, including coke ovens, blast furnaces, environmental systems, and etc.

Contact Information:

URL: http://www.raytheon.com/
Mailing Address: Raytheon Company
870 Winter Street
Waltham, MA 02451-1449
USA

3.23 S/D Engineers, Inc.

S/D Engineers, Inc. is a multi-disciplined engineering and professional services organization. Services include construction management services to the metals industry; specialized services in environmental, automation and process engineering; program management; modeling and simulation, etc.

Contact Information:

URL: http://www.sdengineers.com/
Mailing Address: S/D Engineers, Inc.
2425 Liberty Ave.
Pittsburgh, PA 15222
USA
Phone: 412-562-7500
Fax: 412-562-7501
E-mail: contact@sdengineers.com

3.24 Seifert Technologies, Inc.

Seifert Engineering, Inc. offers design and building capabilities, particularly in the supply of customized prototype and production machinery. Additionally, extended service includes Project

Management for installation of new equipment or retrofitting of existing production lines.

Seifert Engineering takes on turnkey projects and deliver custom machinery to customers. The services include equipment design, manufacturing, assembly, programming, de-bug, installation and training.

Contact Information:

URL: http://www.seifert.com/engineering/default.htm
Mailing Address: The Seifert Group
2323 Nave Road SE
Massillon, Ohio 44646
USA
Phone: (330) 833-2700
Fax: (330) 833-2793
E-mail: Sales@Seifert.com

3.25 Valves Inc.

Valves, Inc. has served industry for nearly 40 years rebuilding all types of valves, and related equipment in various industries, such as coke plants, steel mills, and etc.

Contact Information:

URL: http://www.valvesinc.com/

Mailing Address: Airport Road - P.O. Box 1186

Aliquippa, PA 15001

USA

Phone: (724) 378-0600

Fax: (724) 378-8057

E-Mail: Sales@valvesinc.com

UNIDO Contract No. : 03/120

UNIDO Project No. : EG/CPR/99/G31

Activity Code: 450D32

P. O. No. : 16000473

Attachment 3.07

Comparisons of Cokemaking Technologies in Shanxi Province and Pilot Plants

of

The Final Report

to

the United Nations Industrial Development Organization (UNIDO)

for the Contract

Provision of Services for the Execution of a Coking Sub-sector Survey

related to the Project

Energy Conservation and Greenhouse Gas Emissions Reduction in Chinese Township and Village Enterprises – Phase II

Prepared by

Academy of Mathematics and Systems Science, the Chinese Academy of Sciences(CAS)

Shanxi Township and Village Enterprise Bureau (Shanxi TVE Bureau)

Karen R. Polenske

Zhou Zongli

April 15, 20

3.07 Comparisons of Cokemaking Technologies in Shanxi Province and Pilot Plants

Contents

We provide a brief discussion concerning the differences in technology among the coke ovens and the actual technology of the major coke ovens in Shanxi Cokemaking TVEs.

1. Differences among Current Coke Ovens

In general, traditional machinery coke ovens have great advantages in recovering by-products, such as coal gas, coal tar and raw benzene, but in terms of environmental pollution, they are not as good as most of the modified coke ovens. Modified coke ovens, however, do not recover by-products and consume more refined coal per tonne of coke. The newly designed "clean" coke ovens have very good environmental protection characteristics and most can also recover some heat. In detail, the three categories of ovens have considerably different techniques (*See table 1*).

Table 1 Technical comparisons among coke oven types currently used in Shanxi cokemaking TVEs

Code	Technical Index	QRD-2000	QRD-2002	TJL4350A	TJL4350D	Small 58	66 type	70 type	58 type	Improved SJ-96
1	Designed coke capacity (thousand tonne)	600	400	600	600-680	200	100	40	900	300
2	Total height of battery (mm)	2750	2540	4300	4300	2800	2520	2380	4300	3250
3	Average width of battery (mm)	3596	2812	500	500	420	350	296	407	4600
4	Coke time (h)	73	88	20.5	22.5	16	12	14	16	7 days
5	Loading coal density (tonne/m^3)	1.1-1.2	1.05-1.1	0.76	0.95-1				0.75	0.84-0.92
6	**Dry coal per ton of coke (tonne)**	1.35	1.338	1.3	1.24	1.30-1.32			1.28-1.32	1.315
7	Fresh water use per ton of coke (tonne)	3.9	3.59	3.6	2.56					
8	Electricity use per tonne of coke (tonne)	62.5	92	33	108					
9	Water use per tonne of coke (tonne)			3.85	2.79					
10	Labor productivity (tonne of coke/person)	1119	1047	714	1030					
11	Investment per tonne of coke (RMB yuan/tonne)	332	364	335	689.73				305	41.3

Note: In this table, QRD-2000 and QRD-2002 are "clean" coke ovens, the difference between them lies in two aspects: refractory material and the width of battery, QRD-2000 uses silica brick and QRD-2002 adopts clay brick, the width of QRD-2000 is larger than that QRD-2002. TJL4350A and TJL4350D are newly established machinery coke ovens, small 58, 66, 70 and 58 are traditional machinery ovens, and improved SJ-96 is actually an advanced modified coke oven.

In fact, the "clean" coke-oven is designed based on modified coke ovens, it also absorbs some of the advantages of machinery coke ovens, the degree of mechanization improving a lot. The labor productivity is even higher than some machinery coke ovens, for example, that of QRD-2000 and QRD-2002 reach 1119 and 1047 tonnes of coke per person, much higher than that of TJL4350A, even higher than TJL4350D. The differences among "clean" coke oven and other oven types are mainly the following:

a. Coal-loading method: most traditional machinery coke ovens use a top-coal-loading technique without tamping, while newly designed machinery coke oven, TJL4350D, and "clean" coke ovens adopt a side-coal-loading technique with tamping. This new technique makes the coal much tighter and there is a superior possibility to greatly decrease the proportion of coking coal while guaranteeing the coke quality. The coal density of these ovens, up to 1-1.2 tonne of coal per m^3, is much higher than that of small-machinery coke ovens, the 58 type is only 0.75.

b. Energy consumption: "clean" coke ovens have higher coal consumption per tonne of coke than that of TJL4350A and TJL4350D, and small machinery ovens. Because of the side-coal-loading technique, TJL4350D is much more energy efficient than the TJL4350A.

c. Investment cost: On average, the investment per tonne of coke of the "clean" coke oven varies between 300 and 400 RMB yuan, TJL4350A is similar, while the investment per tonne of coke of TJL4350D rose to about 690 RMB yuan because it introduced the tamping technology.

d. Environmental protection: "Clean" coke oven, including SJ-96, is better than that of machinery coke ovens in environmental protection. Shanxi Environmental Monitor Center, as well as Taiyuan Environmental Monitor Center, monitored several plants during 1998-2000. Table 2 shows in detail. Take particle as an example, the machinery coke ovens discharged much higher volume of particles than that of DQJ-50 and improved SJ-96. DQJ-50 type is the test type of QRD-2000, because most of QRD-2000 type was only put into production last year, so there is no pollution data of this kind of oven. Concerning the emission of BAP, the "clean" coke ovens are much lower than that of machinery coke ovens, they did not detect BAP on the top of improved SJ-96 type, and for DQJ-50, only a little was detected. Machinery coke ovens, however, could not reach the emission standard, but the larger ones with 4.3 meters high battery is better than that with 2.8 meters high, the reach-to-standard rate is 75% and 25% respectively. In environmental protection, "Clean" coke ovens have more advantages over machinery coke ovens.

Table 2 Pollution among different coke ovens

Unit: mg/m^3

Pollution Index \ Coke oven type		4.3 meters high Machinery Coke Oven (furnace top)[1]	2.8 meters high Machinery Coke Oven (furnace top)[2]	DQJ-50 (furnace top)[3]	Improved SJ-96Type (furnace top)[4]
Particle	Concentration	0.210-3.676	0.461-9.550	0.396~0.710	0.1615-0.5912
	Reach-to-standard Rate(%)	83.3	55.6		100
	Standard	3.5	3.5		
Benezene Soluble	Concentration	0.044-2.232	0.620-5.075	0.036~0.126	0.048-0.243
	Reach-to-standard Rate (%)	77.7	40		100
	Standard	0.80	0.80		
BAP	Concentration	0.0002-0.0066	0.0002-0.0106	0.53~14.8(10^{-6})	Did not detected
	Reach-to-standard Rate (%)	75	25		
	Standard	0.0055	0.0055		

Source: Zhou Zongli, Comparison of Cokemaking Technologies, Working Report for UNIDO, November, 2003

Note: 1. Shanxi Cokemaking Group, Hongdong County

2. Cokemaking Plant attached to Taiyuan Chemical Engineering Company

3. Houma Huanda Cokemaking Group

4. Jiexiu Sanjia Coalification Co. LTD

In summary, through comparisons among these ovens and our field survey to the plants, we think that compared with traditional machinery coke ovens, both "clean" coke oven, such as QRD-2000 and QRD-2002, and newly designed machinery coke ovens, such as TJL4350A, TJL4350D oven types have good potential in Shanxi cokemaking TVE. They are much better in environmental-pollution control and the investment per tonne of coke is much lower than that of traditional large-machinery coke ovens. Most important, the coke quality produced by these ovens is also good. Thus, given the current situation when the environmental problems are the major concerns of the national and provincial governments, we propose encouraging the use of "clean" coke ovens in main cokemaking areas in Shanxi Province. In the long run, however, because they combust all the tar and chemicals and those products can never be recovered, if China or other countries start to have shortages of these products, the advantages of the "clean" coke ovens is not so great. So, we should also be far-sighted and make a major effort to improve the environmental pollution of large machinery coke ovens.

2. Brief Introduction of Technology of Major Coke Ovens

The following is a brief introduction of the coke ovens that are prevalent in TVEs in Shanxi Province.

2.1. 58 type

The 58 type coke oven is the one designed by Chinese experts in 1958, then they developed 58-II. Thus, there are two types of 58 type oven, of which the 58-II type is more widely adopted.

The height of the battery of 58 and 58-II type is 4.3 meter, the average width of the battery has two types, one is 450mm, and the other type is 407mm. The average number of batteries is 42 and 65, respectively. As to heating, it has a double-heating oven, adopting double-joint flame paths with the waste gas recycling in the oven.

This is an old machinery coke oven that can be adopted, even after the industrial policy, in China.

2.2. TJL4350A and TJL4350D type

2.2.1 TJL4350A type

TJL4350A was newly designed by the Second Design Institute of Ministry of Chemistry based at Taiyuan. It is based on the JN43-80 type, which is an improved type of the 58-II.

The height of the battery is still 4.3 meters. It adopts a single-heating oven with double-joint flame paths, downward-spray, and a top coal-loading technique. The important improvements of this type embody in the following aspects: (a) It widens the width of battery to 500mm in order to upgrade the coke quality and increase the proportion of large-sized coke; (b) It changes from double-heating to single-heating, not only simplifying the oven structure but also decreasing the building cost of the oven.

TJL4350A has been adopted since 1998, basically in joint ventures, collective enterprises, and private enterprises. The coke-quenching method is wet quenching, the by-products it can recover are coal gas, coal tar, and raw benzene. If the plants do not install supporting facilities to utilize coal gas, most of the gases are burned and discharged through a high chimney (about 100 meters). The life of the principal equipment is about 25 years, that of related machines vary between 15-20 years. The scale has developed to 2 million tonnes of coke now from 400 thousand tonnes in 1998 since the first one was built in Xiaoyi City, Shanxi Province.

Coke ovens that are very similar to TJL4350A in technology are the following:

a. **JNK43-98D**, designed by Anshan Coking and Refractory Engineering Consulting Corporation (ACRE) of China;

b. **SC43-98**, designed by Chemical Engineering Design Institute of Shanxi Province;

c. **SG43-94**, designed by Design Institute attached to Capital Iron and Steel Group

2.2.2 TJL4350D type

The TJL4350D type is an improved one of TJL4350A, designed in 2001 and put into production in 2002. The greatest difference between TJL4350A and TJL4350D is the method of coal loading, the latter adopts side-coal-briquette-loading with tamping. The other techniques are the same.

Along with the scarcity of coking coal, we have to pursue better technology that can use less coking coal, but use more soft coal, such as gas coal, lean coal. Thus, this type of oven not only saves scarce coking-coal resource, but also decreases the cost of raw material. The TJL4350D was developed to meet this demand, at present, its scale has increased from 600 thousand tonnes of coke at the beginning in 2001 to 1.85 million tonnes of coke today.

The TJL4350D coke oven is being built and rapidly put into production in some plants in Shanxi Province, for example, Linfen Town Star Co. Ltd, Maosheng Group in Jiexiu City, Qingxu Yaxing Cokemaking Company Ltd., and the Cokemaking Plant attached to Changzhi Iron and Steel Group. In addition, several plants are still building this kind of oven.

The following types are similar to the TJL4350D in technology.

a. **JNDK43-99D**, designed by Anshan Coking and Refractory Engineering Consulting Corporation (ACRE) of China;

b. **TJL4350G**, designed by Chemical Engineering Design Institute of Shanxi Province;

c. **TJL4350F (double-heating)**, designed by the Second Design Institute of Ministry of Chemistry based at Taiyuan.

2.3. "Clean" coke-oven type

The "Clean" coke-oven design is based on modified coke ovens that were widely adopted in Shanxi cokemaking TVEs, and it combines the merit of heat-recovery coke ovens used in the United States and other countries.

2.3.1 Characteristics of "Clean" coke oven

The technical characteristics of "clean" coke-oven type are mainly: the whole cokemaking process is under negative pressure; the coal is loading from one side with tamping, waste gas and other volatile materials are transformed to electricity energy, no emission of harmful materials; no waste water is discharged.

As regards to the temperature of coal-loading and coke-unloading, there are two types of "clean" coke oven, one is hot coal-loading and hot coke-unloading, the other is cool coal-loading and cool coke-unloading. There are only two types of the latter, i.e., improved SJ-96 and YX-21-Century, which is very suitable to produce foundry coke. The first "clean" coke oven is designed by Shanxi Provincial Chemical Design Institute, entitled DQJ-50 type. In June 2000, an experimental coke oven was built and put into production in Houma City, Shanxi Province. In the same year, Chemical Engineering Design Institute of Shanxi Province designed an improved oven type with hot coal loading, hot coke unloading, heat recovery and coal tamping, called QRD-2000. QRD-2000 applied patent on November 8, 2001 and proclaimed on September4, 2002. The patent number is ZL01270184 • X.

The QRD-2000 type of oven has been built and is being used to produce coke in several TVE plants in Shanxi Province, for example, Gangyuan Cokemaking Plant in Qingxu County, Wenfeng Cokemaking Plant in Fenyang City, Xinggao Cokemaking Plant in Gaoping County, Welfare Cokemaking Plant in Lishi City, Lvliang area.

Environmental officials in Shanxi Province are encouraging the spread of the "Clean" coke oven; our project group is planning to select a plant that adopts this kind of coke oven for demonstration.

The technological characteristics of these coke-oven types are listed briefly in Table 3.

2.3.2 Challenges for cokemaking technology

Through practice over 100 years, traditional cokemaking technology, mainly machinery technology, has been well developed. Because of inherent limits of the technique, however, it faces a series of challenges, especially environmental pollution and resources scarcity.

a. On Environment. The traditional cokemaking technology has been using positive-pressure technology in the process of cokemaking, with a lot of pollutants, mainly particulates, sulfur dioxide, hydroxybenzene, cyanogens, ammonia nitrogen, coal tar, polycyclic naphthalene hydrocarbon, benzene and Bap, discharging into the air. Many developed countries, for example, Canada, Japan, Korea, and the United States, have

taken strict environmental regulations in the cokemaking industry, which is limiting the coke production by these machinery coke ovens.

b. On Resources. Most traditional coke-making technologies used much coking coal. Coking coal resources are becoming increasingly scarce, and developed countries were the first to take action to protect these resources. In China, coking coal is decreasing very rapidly, so that we must also take measures to lower the consumption of coking coal.

Environmental problems and resource shortage forced cokemaking industry to look for a new technical road. As early as the 1990s, many developed countries began to take great efforts to develop clean cokemaking technology: such as "heat recovery coke ovens" by Sun Coke in the United States, "Gigantic Cokemaking Reactor" in the European Community, "Large Coke Oven without Pollution of the 21th Century" in Japan, and so on (*Zhong, 2001*).

Table 3 Major Technological Characteristics of the Above Coke-oven Types

	58 Type	TJl4350A type	TJl4350D type	QRD-2000 Type	Improved SJ-96	YX-21-Century
Basic Type	Traditional machinery type	Newly designed Machinery type	Newly designed Machinery type	"Clean" Coke Oven	"Clean" Coke Oven	"Clean" Coke Oven
Designed Capacity* (thousand tonne)		400	600	400	600	600
Height of Coke Oven(mm)	4300	4300	4300	2750	3250	
Processing Process Method	Positive Pressure	Positive Pressure	Positive Pressure	Negative Pressure	Negative Pressure	Negative Pressure
Coal-loading Method	Top, hot coal-loading	Top coal-loading	Side-coal -briquette-loading	Side-coal -briquette-loading		Top, cool coal-loading
Coal-tamping method	No tamping	No tamping	Tamping with machine	Tamping with machine	Tamping manually	Tamping manually
Coke-unloading Method	Hot, side-coke-unloading	Hot, side-coke-unloading	Hot, side-coke-unloading	Hot, side-coke-unloading		Cool, side-unloading manually
Heating Method	Double-heating	Single-heating	Single-heating			
Recovery of by-products	Coal gas, Coal tar, and Raw benzene	Coal gas, Coal tar, and Raw benzene	Coal gas, Coal tar, and Raw benzene	Heat	Heat	Heat

Note: As to the designed capacity, we have to double-check the available capacity.

All of the above new cokemaking technologies are under test stage except for the "heat-recovery coke oven," at Indiana Harbor, in the United States. They built a Jewell-Thompson type oven in 1997, installing with power generation, desulfurization and dedusting equipment. The capacity is 1.330 million tonne of coke and 87 thousand kilowatts of electricity. Pennsylvania Coke Technology Company (PACTT) developed TSOA/PACTT "non-recovery coke oven" in collaboration with German Thyssen Still Otto, and the demonstrated oven was built in Australia in 1998 (*Shen, 2001*).

2.3.3 Future selection of coke oven

As shown earlier, "Clean" coke ovens overcome several shortcomings of traditional machinery coke ovens, and are much more energy efficient than modified coke ovens. Most important, they can use much less coking coal, while still producing high-quality coke, and can recover heat energy. Important to TVEs, the investment of these ovens is not too high. Thus, "clean" coke oven may have good potential in Shanxi Province. While because of the limited design capacity of this kind of oven, In current situation, we propose encouraging the adoption of "clean" coke oven in main cokemaking areas in Shanxi Province in recent years, especially in those areas that demand high in environmental protection or have relatively smaller pollution capacity, for example, around Taiyuan City, Datong City, Jiexiu City, and medium cokemaking plants.

The practice in developed countries shows that large-machinery coke ovens should not be highly encouraged in TVE cokemaking in China in recent years, although they can recover some by-products. From the perspective of comprehensive energy efficiency, large-machinery coke oven is much better than other coke ovens, although they use much more coking coal and need a lot of investment that is beyond the capability of most cokemaking TVEs. The reality is that, especially in Shanxi Province, even if the plants adopt large machinery coke ovens, most of them do not install chemical products recovery equipment. So, we propose that in some of the large TVEs, they can build large machinery coke ovens like what Antai Group has done, but in order to reduce the pollution as low as possible, they must install corresponding chemical-recovery equipment, and pollution treatment equipment, such as ground dedusting station to collect the waste gas on the top of the coke ovens emerging in the process of coal-loading and coke-unloading, before putting into production.

3. Selection of Pilot Plants and Related Information

As discussed earlier, 'clean' coke ovens have many advantages in technical, environmental, energy-saving and economic aspects. Through field survey trip and comparative analysis, Taiyuan Gangyuan Coke Company gives us deep impression. It has no leak of waste gas, one can not even smell anything on the spot. Gangyuan Cokemaking Plants was one of our pilot plants. The following is basic information in assets structure and technical installation.

Pilot plant 1: Taiyuan Gangyuan Coke Company Ltd. (Gangyuan)

Part 1: Basic Information

The total assets of Gangyuan is 180 million yuan, of which fixed assets is 105.4 million yuan. The occupation of land is 40 hectares (600 mu), of which building area is 6000 m^2. This company was awarded Class AAA in Reputation by Shanxi Provincial Sub-branch of Agricultural Bank of China.

The designed capacity is 400 thousand tonnes while current production capacity is 200 thousand tonnes. The plant mainly produces metallurgical coke, the coke output of this year is 60 thousand tonnes after it put into production since July 22 this year, most of which is exported to Japan, India, Brazil. In addition, the output of refined coal is 120 thousand tonnes this year.

This plant has 406 employees, of which 22 person are administrative staff, accounting for 0.5%, 40 of them are technicians, accounting for 10%. As regards to education level, there are 38 people who receive technical secondary education (12 schooling years) or higher level, accounting for 9% of total employees.

Coal is the main raw production material, of which coking coal mainly come from Lvliang Prefecture, accounting for 35%, and lean coal and fat coal from this county or nearby areas, accounting for 65%.

Part 2: Technical Equipment

The coke oven type is QRD-2000, designed by Shanxi Provincial Design Institute of Chemistry. The designed production capacity is 400 thousand tonnes of coke per year and now that of 200 thousand tonnes has been put into production. In addition, the company has one coke pusher, one coke quenching car and one coal-tamping machine.

As regards to other equipment, the company has a set of coal sorting machine, including jigger

machine, floatation equipment, resonance machine, filter press equipment, which mainly come from Datong, Shanxi Province, Jiangsu Province and other areas of Shanxi Province.

Part 3: Energy-saving Technology

The QRD-2000 coke oven has high degree mechanization, saving 300 thousand tonnes of coking coal. In addition, the number of process in coke production is lower than other coke ovens, reducing electricity consumption by 20%. The company is planning to build power plant using waste coke oven gas, and non-ferrous project (30 thousand tonnes of ferrochrome iron per year). The technical renovation projects are awarded "Two 'High' and One 'Optimal' (Two 'High' means *industrialization of high-technology, modify traditional industries with high technology and advanced suitable technology,* One 'Optimal' is to *optimization major products and technological structure.*) by the State Economic and Trade Committee.

Concerning other pilot plants, through comparative analysis and discussion with Shanxi TVEs officials and experts, we think that Shanxi Sunlight Coking (Group) Limited Corporation are suitable for demonstration for its technology (JNK43-98D), energy-saving and management.

Pilot plant 2: Shanxi Sunlight Coking (Group) Limited Corporation (Sunlight)

Part 1: Basic Information

Shanxi Sunlight Coking (Group) Limited Corporation adopts JNK43-98D, with the total coke capacity 1.6 million tonnes per year. This is a comprehensive plant for coalification. It has a coal washing plant that can produce 3.2 million tonnes of coal washing capacity (the designed capacity is 4 million tonnes of coal). Using the coal slack and coal slurry from its coal-washing plant, they are planning to build a power plant, the designed capacity is 2×12000 kilowatt. The processing plant of coal tar with capacity 100 thousand tonnes is on the book to be built.

The main products of cokemaking plant are coke, purified coal gas, ammonium sulphide, sulpher, heavy benzol, light benzol and coal tar. This plant has formed an industrial chain, except the coke, the plant supplies coal gas to Shanxi Aluminum Plant, and coal tar to its own processing plant to make deep-processing, producing modified pitch, needle coke, of which modified pitch is sent to Shanxi Aluminum Plant as the material to manufacture carbon.

Part 2: Technical Equipment

The coke oven type is JNK43-98D, designed by Anshan Coking and Refractory Engineering Consulting Corporation (ACRE) of China. JNK43-98D is a single-heating coke oven, adopting twinflue, wide battery width (500 mm), wide heat-saving chamber, and downward-spray of coal gas technique. The plant has coke pusher, coke quenching car and coal-tamping machine.

Concerning other equipment, they are the following: coal washing machine including car dumper, train coal-whipper, combined stacker/reclaimer and band conveyer; pollution treatment equipment such as bag-type dust collector for coal preparation, bubble dust collector for coke filter; chemical-products recovery equipment including distillation tower, desulfurization tower, benzol washer.

Part 3: Technical and economic index

The coke production capacity of Sunlight reached 1.6 million tones. They built the coke oven by two phases, of which the first phase construction realized 0.6 million tonnes of capacity, and in the second phase, another 1 million tonnes of coke plant was put into production. We have detailed information for the 1 million tonnes capacity compiled in table 4, from which we can see the main products, consumption, investment and employment.

Table 4 Technical and economic indexes for the second phase of Sunlight

Index	Unit	Volume/number
1. Scale		
Coke output	Million tonne	1
Coke oven type		JNK43-98D
Number of batteries		2×72
2. Output		
Total coke	t/a	957118
Coke fine in sedimentation tank	t/a	16271
Coke oven gas	10^3 m^3/a	372913.2
Light benzol	t/a	11563
Refined heavy benzol	t/a	377
Coal tar	t/a	43537
Ammonium sulphide	t/a	10424
Sulpher	t/a	1156
3. Main raw material		
Refined coal for coking	t/a	1243044
H.P.F desulphurizer	t/a	4.97
4. Consumption		
Production water	10^3 m^3/a	2952.12
Recycle water	m^3/h	5976.4
Power	10^3 KWh	39166
Coke oven gas	10^3 m^3/a	184967.4
5. Investment		
Fixed capital	thousand RMB	292079.6
Interest in construction stage	thousand RMB	11568
Flow capital	thousand RMB	29998.3
6. Employees		
Number of employees	person	370
Production workers	person	352
Administrative staff	person	18

Note: t/a----tonne per year

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UNIDO Contract No. : 03/120

UNIDO Project No. : EG/CPR/99/G31

Activity Code : 450D32

P. O. No. : 16000473

Attachment 3.08

Determination of Needs of the Cokemaking TVEs for Technical Assistance

of

The Final Report

to

the United Nations Industrial Development Organization (UNIDO)

for the Contract

Provision of Services for the Execution of a Coking Sub-sector Survey

related to the Project

Energy Conservation and Greenhouse Gas Emissions Reduction in Chinese Township and Village Enterprises – Phase II

Prepared by

Academy of Mathematics and Systems Science, the Chinese Academy of Sciences(CAS)

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April 15, 2004

3.08 Needs of the cokemaking TVEs for technical assistance

Content

In terms of the cokemaking technologies, Shanxi cokemaking managers have learned a lot from international coke-support institutions and companies. With experiences and lessons from other countries, we input plenty of researchers and equipment to develop new technologies suitable to our practical situation. Some plants, even in cokemaking TVEs, began collaboration with overseas companies from the beginning of 1990s in several ways, including making joint investments and introducing advanced equipment.

In fact, China have excellent experts in developing new type coke ovens, while in affiliated equipment of coke ovens and specific technologies during the production process, it is very necessary to introduce advanced techniques and equipment.

Through field trip, sample survey and interviewing on engineers in Shanxi cokemaking plants and experts in Shanxi Province, we determined that the cokemaking TVEs need technical assistance in the following aspects.

1. Specific Technologies during the Production

1.1 Tightness of Coke Oven Door.

In machinery coke oven, the tightness problem of coke oven door is not well solved. The factors that affect the tightness of coke oven door are mainly the following: First, in the early stage of coking, lots of raw coal gas generate from the coke oven, which creates great pressure difference between the edge of coke oven door and outside and therefore affects the tightness of coke oven door. Second, due to the temperature difference, the swelling capacity between inside and outside of the coke oven door is also different, which cause the distortion of coke oven doorframe. Third, similar to coke oven doorframe, coke oven door is easy to distort too, which creates crevice between coke oven door and doorframe. From our field survey, we found that all machinery coke ovens are facing this problem, whether they are newly built or have been used for years. Lots of smoke emerged from the holes besides the door, which heavily polluted the air, while this phenomenon could be avoided. According to the foreign researchers, in the cokemaking company of the United States, there is no smoke discharging from the coke oven.

1.2 Overburning problem of coke

In "clean" coke ovens such as QRD-2000, although they can produce high-quality coke with little pollution, they have an unsolved issue. In producing 100 tonnes of coke, about 4 tonnes of coke melts in the coke oven, which is a very high lost. If a "clean" coke oven plant like Gangyuan Company, produces 400 thousand tonnes coke per year, it will lose 16 thousand tonnes coke.

1.3 Blockage of flame path in coke oven

This is a problem closely related to the overburning of coke and also one problem occurred in "clean" coke oven. Because of negative pressure operation, there is a dilemma in controlling the size of air inlet. If the air inlet is too large, it is prone to cause overburning and melting of coke, on the contrary, if the air inlet is too small, the coal for cokemaking will not be completely combusted, then the combined

coke oven gas generating on the top of the coke oven, including coke oven gas several other kinds of chemicals, has to be back to the bottom of the coke oven to be burnt again. Because of high temperature, some of the chemicals may be decomposed to carbon or something related and adheres to the flame path, causing its blockage and further affects regular combustion in the coke oven.

How to control the size of the air inlet and further optimize heat supply of the coke oven is an urgent task to both the "clean" coke ovens and other kinds including machinery coke ovens. Heat supply is a common issue encountered by almost all kinds of coke ovens.

1.4 Distortion of tunnel grid and division board

In "clean" coke oven and advanced modified indigenous coke oven, the distortion problem of tunnel grid and division board has not been solved. Form our interview with technical experts in some plants, we found that they urgently hope related experts and agencies can help them to solve this problem.

As mentioned in the above paragraph, optimization control of heat supply system of the coke oven is an urgent task to most cokemaking plants. Due to the temperature instability in the coke oven, the refractory materials have to adapt to the abrupt variation of the temperature. The refractory materials, however, have quite distinct expansion coefficient against different temperature. Subjected to the instable high temperature all the time, the refractory materials are very prone to distort. The distorted refractory material could not maintain its resistant performance to high temperature, and cause more unstable temperature which forming a vicious spiral.

According to a technician in Gangyuan Company, because of the distortion of tunnel grid and division board, the temperature control system is somewhat disordered. Due to the failure in temperature control, the temperature of the tetragenous hole in the hearth has reached to over 300 centigrade, which is much higher than its expected temperature at 100-200 centigrade, causing serious distortion of division board.

Except for the high temperature, another important aspect against distortion is the character of refractory materials, so it is very necessary to find an appropriate material that can endure the high temperature. They have negotiated with several companies who could solve this problem but did not get good results. If the plant can not solve this problem as early as possible, the power plant will be greatly affected, because the temperature of the waste coke oven gas could not be regularly adjusted to a stable level for power generation.

In summary, the latter three problems listed above are closely related to, to some extent, heat-supply control system. Although the plants have their own methods or experiences in controlling the coke oven temperature, how to realize optimal heat-supply control is a common issue to almost all cokemaking plants. This is a key point to increase the coke production efficiency, and to prolong the age of coke oven and its auxiliary equipment.

2. Affiliated Equipment, especially Pollution Treatment Equipment in Coal-loading Process and Coke-unloading Process

2.1 Characteristics of pollutants

Compared to "clean" coke oven and advanced modified indigenous coke ovens, one of the main shortcomings of machinery coke ovens is heavy pollution, especially in the process of coal-loading and coke-unloading because of hot loading and unloading. From our field survey, we strongly feel that the emerging heavy smoke and dust on the top of the coke oven, i.e., the coke oven charging and pushing emission, include some harmful contents, particularly in the coal-loading process.

Coke oven charging and pushing emission are scattered from many places and widely covered the top of the oven. In the meantime, it also has the characteristics of continuity, gustiness and contingence coexisting, and floating dust source point. Coke oven charging and pushing emission consists of many kinds of harmful pollutants, for example BAP (benzopyrene), which was listed as a kind of carcinogen by the national government in 1987. In addition, because the emission contains some coal tar, the dust has high viscosity, and usually the temperature is high with open fire, it is difficult for treatment.

2.2 Current treatment technique and future need of TVE cokemaking plants

Current treatment of coke oven charging and pushing emission are mainly the following worldwide: high-pressure ammonia spray technique for smoke and dust control in coal-loading process; double gas collector and cross-over pipe; Schalke technique for smoke and dust purification in coal-loading process; wet ground station; vehicle-carrying wet washing technique, and so on (*Dai,et.al., 2003*).

At present in China, treatment techniques for emission include: (1) independent ground-dedusting station for coke oven charging emission, and coke oven pushing emission respectively; (2) combined ground-dedusting station for both coke oven charging and pushing; and (3) dust depression hood.

Compared to ground-dedusting stations, the dust depression hood can gather about 75%-85% of the emission, the ground-dedusting stations can collect and purified over 90% of the total emission. While the investment of ground-dedusting station is very high, almost half of that of the coke oven, that is why only several plants install ground-dedusting station in China.

We found that in one cokemaking plant in Anshan Iron and Steel Company, the dust depression hood was installed. Although it is not so good as the ground-dedusting stations in gathering the emission, it does reduce the total emission sharply. In Shanxi TVEs, it is unpractical to ask them to install ground-dedusting stations, so dust depression hood will be a nice alternative in current stage. Our final target, however, is to install ground-dedusting stations in most of the plants in order to cut down coke oven charging and pushing emission. Emission control technologies are an urgent need of cokemaking plants.

3. Technology for Coal Mixture

Although China is abundant in coal resources, coking coal is not as rich as people think. The exploitable reserves of coal is 145 billion tons, the proportion of coal that can be used for cokemaking is only 27.65%, including 5.81% prime coking coal, 13.7% gas coal, 3.53% rich coal, 4.01% lean coal. And in the past over twenty years, with the rapid development of cokemaking industry, the reserve of coking coal decreased sharply. High-class, free milling coking coal are becoming less and less. Besides, the distribution of coking coal is in imbalance, the contradiction between resources distribution and increasing demand is more and more obvious.

At present, in order to guarantee the quality of metallurgical coke, high-class coking coal usually accounts for over 50% of the coal for cokemaking, especially in large machinery coke ovens because most of them do not make coal-tamping before loading to the coke oven which greatly limit the use of other soft coal types. In our sample survey, 14 plants only use coking coal for cokemaking, accounting for 12.7% of qualified surveyed plants. About 41% of the qualified surveyed plants use coking coal with the percentage over 50%. Some plants, most of which adopt advanced modified coke oven such as SJ-96, can produce coke with less coking coal, usually 30%-40% of total coal consumption.

In current situation, the percentage of coking coal consumption in cokemaking industry is too high considering more and more precious coking coal resources. So **how to reduce the coking coal percentage in coal mixture** is very crucial to the sustainable development of this industry and related

metallurgical industry. Many experts from both research institutions and plants conducted a number of coal mixture test by using other types of coal, for example, Anshan Thermal Energy Research Institute collaborated with several cokemaking plants including cokemaking plant of Baotou Iron and Steel Company, chemical engineering plant of Anshan Iron and Steel Company, to make industrial test with briquetted coal (*Wang, et.al. 2002*).

These tests help reduce the per capita consumption of coking coal, but not to an extent that can make full use of other soft coal types. Therefore, under the condition of maintaining the quality of metallurgical coke, how to further decrease the percentage of coking coal and enlarge the coal types for cokemaking, is an important task that the researchers and plants have to undertake.

4. Conclusion

In this report, we make a brief discussion on the current technical needs of different kinds of coke ovens. On a whole, the technical needs of machinery coke ovens focus on environmental pollution treatment technology, tightness of coke oven door and coal mixture. "Clean" coke ovens, however, have more specific problems because, to some extent, this kind of oven is in preliminary stage, many problems have to be gradually solved in the production process. The technical problems are closely related the heat-supply control system, for example, distortion of main refractory materials, overburning problem of coke, blockage of flame path and so on.

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