

## **A comparative study of patent development trends in the field of coal coking technology between China and Japan**

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**Abstract:** *this article Innojoy foreign patent retrieval system as data source, from the patent applications, technical field distribution, major research institutions, the main inventor, hot areas of the two countries for deep processing of coking coal and the technical development trend analysis, reveal the deep processing of coking coal and the trend of the development of sino-japanese relations, technology, industry leading enterprises, technology leading institutions, and thus obtain important strategic information and innovation.*

**Key words:** *China; Japan; Coal coking; Patent analysis*

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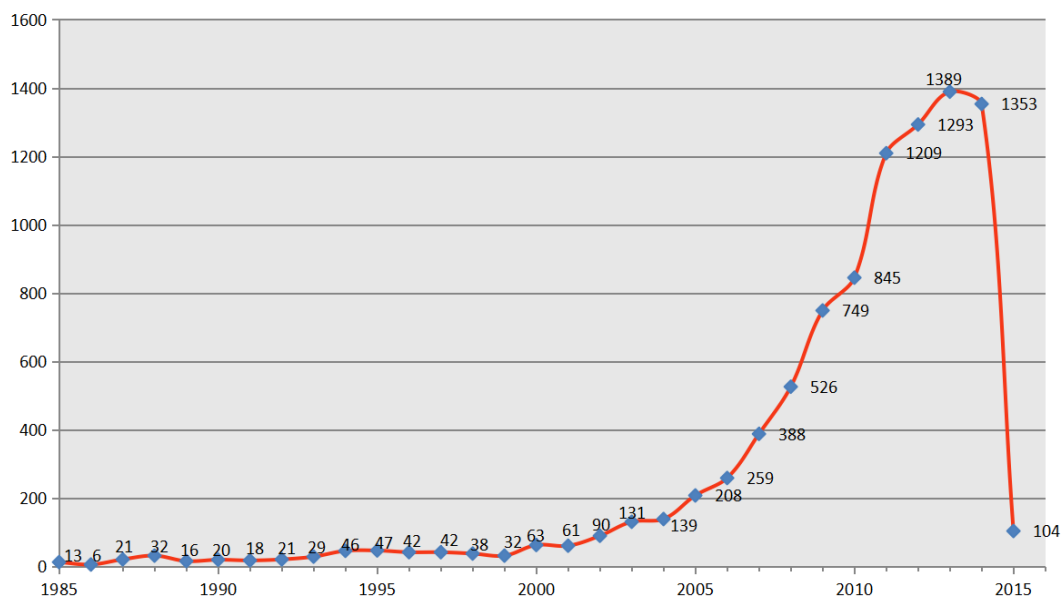
### **I. Introduction**

China is the world's largest producer of coke. In recent years, China's coke output accounts for about 67.71% of the world's total coke output, and its export volume accounts for more than half of the world's total coke export trade. Coal coking and its deep processing industry is one of the processing industries connecting the coal industry with metallurgy and coking industry. Coking takes coal as raw material and coking as the core. When the scale reaches a certain degree, it can recover the by-products of coking and make deep processing as well as the comprehensive utilization of coke oven gas. In recent years, Chinese coking enterprises have made great breakthroughs and made great strides in the aspects of "coking by-products" and "comprehensive utilization of coke oven gas", and have gradually become new economic growth points of coking enterprises. With the continuous adjustment of industrial structure, the continuous development of technology and the accelerated pace of elimination of backward production capacity, coking industry competition is more and more fierce. Whoever has mastered the latest and best coal coking and its deep processing technology can stand in the forefront of the coking industry, go further and develop faster, and become the leader in the field of coal coking and its deep processing.

Patent analysis is one of the important forms of competitive intelligence analysis, is based on the patent search for relevant technology in the field of patent information analysis and processing, the use of statistical methods and techniques of these patent information into and prediction technology intelligence, commanding the whole situation for the enterprise of science and technology research and development, product development, market development decisions. According to the statistics of THE World Intellectual Property Organization, patent information contains 90% ~ 95% of the world's scientific and technological information, and the patented technology basically represents the level of scientific and technological development in a certain technological field. This article attempts through to the coal coking and its deep processing field in both China and Japan technology related patent analysis, reveals the two countries coal coking and its deep processing technology in the field of research and development and related technology of enterprise strength and market development direction, to help China coal deep processing of coking and its related companies to set up the correct development strategy.

In the field of coal coking and its deep processing technology, development of good countries mainly in China, Japan, Britain, the United States, Germany, South Korea, and Russia and other countries give priority to, among them, China accounted for 23.1% of total global patent applications and the world in coal coking and its deep processing technology patent applications in the field of the first place, China as a major power coal resources, in the field of coal coking and its deep processing technology has its own unique advantages. Second, Japan ranks the second with 6,805 patent applications. As a country with extremely poor energy resources, Japan gives full play to its talent and technological advantages, and walks out a development path with Japanese characteristics in the field of coal coking and its deep processing technology. There is much to learn and learn from Japan.

**II. Comparative analysis and research of coal coking patents between China and Japan**  
**2.1 Analysis of annual patent application**  
**2.1.1 Annual patent application in China**



**FIG. 1** Broken line chart of China's Annual Number of Patent Applications (1985-2015)

As can be seen from Figure 1, the first patent application for coal coking and deep processing technology in China was in 1985, and the number of patent applications was not high in the following ten years. In the 17 years up to 2001 (1985-2001), the annual number of patent applications for coal coking has been hovering between 10 and 60, and the annual average number of patent applications is only about 31, the annual growth rate is relatively slow, or even decreased years. Subsequently, the annual number of patent applications in Our country began to show a substantial growth. Since 2003, the number of patent applications has exceeded 100, reaching 131. From then on, the number of patent applications has continued to climb, reaching a peak of 1389 in 2013, and then it has declined slightly.

On April 1, 1985, as China's patent law formally implemented, deep processing of coking coal and the technology in China ushered in the first patent application, an application for a patent for 13, foreign enterprise application account for up to 6 parts, mainly for the patent in the United States, mainly involving delay composition art, coal tar distillation fraction to the preparation of low solid content of asphalt, and one for the coke oven furnace wall high strength three aspects of the preparation method of the coke oven mud, shows that the United States in these technology started early, better development, comparative advantage, but also illustrates the patent system started early in the United States and other countries, is very pay attention to the protection of the patent and layout. Anshan Coking Refractory Research Institute has two pieces, both of which involve a coke oven gas negative pressure exchange cock, which solves the technical problems of gas leakage into the atmosphere, insecurity and environmental pollution.

In 1993, the number of Patent applications in China increased significantly, reaching 29, among which individual applications still accounted for a large proportion. In addition to the patent applications mainly from Shanxi, Liaoning and Hebei, foreign companies mainly from Germany and Japan continued to apply for patents in China. In 1994, the number of patent applications continued to grow substantially, reaching 32, and the number of patent applications by institutions of higher learning increased. In 1995, the number of patent applications exceeded 40, and the regional distribution of patent applications was further expanded, shanxi, Sichuan, Chongqing, Shanghai, Hunan, Shandong, Beijing and other regions have patent applications, which indicates that China's coal coking industry is developing rapidly and the industrial layout is further improved. In the following more than ten years, the number of patent applications for coal coking and deep processing technology is on the whole on the rise, and the patented technology field is also constantly expanding, involving all aspects of coal coking and deep processing technology. I'm not going to do the analysis here. From the annual change of the number of patent applications, it can be seen that China's coal coking industry and its deep processing technology continue to innovate, China's coal coking industry is developing rapidly.

### 2.1.2 Analysis of annual application volume of Japanese coal coking patents

Statistics of the patent applications for coal coking and its deep processing in Japan over the past 30 years (1985-2014) are shown in Figure 2.



**FIG. 2** Annual patent applications for coal coking in Japan

From figure 2 can analyze the following conclusion: Japan coal coking and its deep processing technology started earlier, an application for a patent for the first appeared in 1963, after ten years (1963-1974), patent applications are very few, the annual average patent applications only a few, and in the field of coal coking and its deep processing technology of the most basic patents, in 1975, after the Japanese patent application number start straight line rise, 1975 Japan coal coking and its deep processing technology patent filings by leaps and bounds, 114, 1980, 210 patent applications to achieve the first peak. From 1975 to 1980, the dramatic increase in Japanese national demand had an obvious effect on economic growth. In addition, Japan actively adopted corresponding economic policies, resulting in the rapid development of Japan's coal coking industry and its deep processing industry in the five years. In 1981, the number of patent applications declined slightly, and by 1982, the number of patent applications reached 256. Since then, the number of patent applications has plummeted from 178 in 1991 to 280 in 1993, a record high. After 1993, the annual number of patent applications has been below 200 and is on a downward trend. In general, Japanese patent applications after rapid growth in the 1980 s, and 1980 years later, patent filings annual fluctuation is very big, the curve shape development, until 2006 years later, Japan's annual patent filings began to decline steadily, and it also illustrates the Japanese technology in the field of deep processing of coking coal and its development is more mature.

## 2.2 Analysis of main patent applicants for coal coking

### 2.2.1 Main patent applicant for coal coking in China

MCC ranked first with 730 patent applications, accounting for 24% of the total number of patent applications filed by the top 20 major patent applicants, indicating its strong position in the field of coal coking and deep processing technology. As an oversized enterprise group supervised by the State-owned Assets Supervision and Administration Commission of the State Council, MCC is the pioneer and builder of China's metallurgical industry. MCC has successively undertaken the construction tasks of major national steel industrial bases such as Baosteel, Angang, Wisco and Pangang, making outstanding contributions to the development of China's metallurgical industry. Baosteel Group Co., second only to China Metallurgical Corp., came in second with 354 patent applications, accounting for about 12% of total patent applications filed by patent applicants. After more than 30 years of development, Baosteel has become one of the most modernized and competitive iron and steel joint enterprises. In the field of coal coking and its deep processing technology, Shanghai Baosteel Coking Co., Ltd. is a resource utilization industry matching baosteel's main industry and an important part of Baosteel's strategic development. Wuhan Iron & Steel ranked third with 238 applications, indicating that Wuhan

iron & Steel developed rapidly in the field of coal coking and deep processing technology.

### 2.2.2 Main Patent applicant for Coal coking industry in Japan

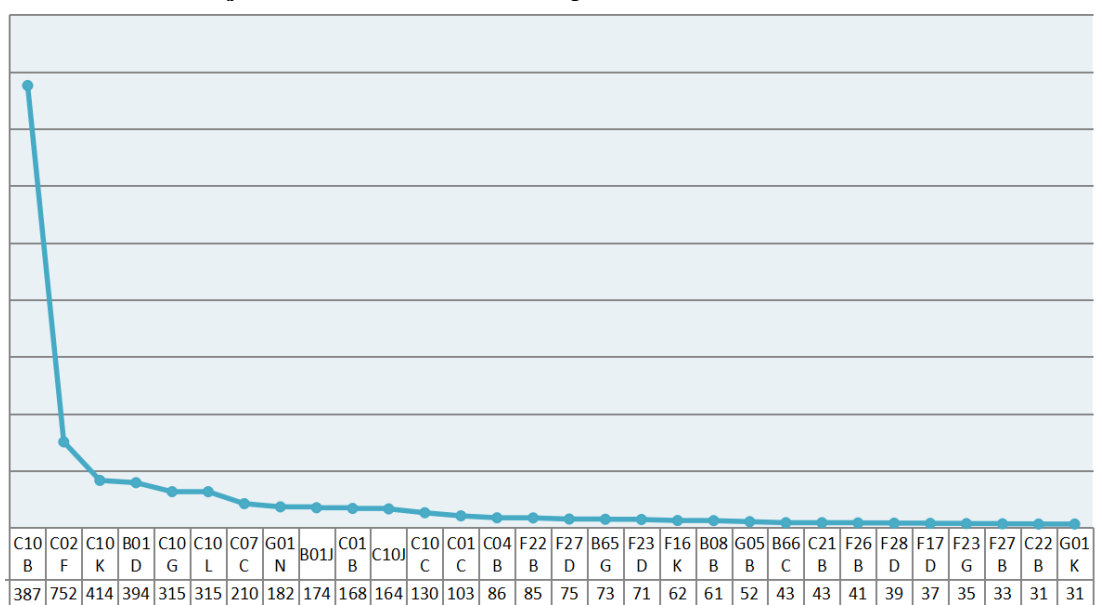
By analyzing the main patent applicants in the field of coal coking and its deep processing technology in Japan, we can further understand the patent distribution in Japan and the number of patent applications of the main competitors, and then understand the strength of the main patent applicants in Japan.

Japanese patent applications in the field of coal coking and its deep processing technology is relatively concentrated, patent applications are mainly concentrated in Nippon steel, JFE steel company and a gold, both of the Japanese coal coking and its deep processing technology application for a patent for more than 58% of the total, is Japan's coal coking and its deep processing technology the core of the most competitive enterprises. Secondly, other companies such as Mitsubishi Group, Kansai Thermal Chemical Company and Sumitomo Group also account for a certain proportion. It is worth noting that Wood, a German company, also has 69 patent applications in Japan, and is one of the main patent applicants in Japan.

Among them, Nippon Steel Sujin ranked the first with 2,159 patent applications, accounting for 31.7% of the total patent applications in Japan, which shows its strong competitiveness. Since the end of 1970s, Nippon Steel has successively developed coking coal pretreatment technologies such as coal drying, coal preheating, coal humidification, DAPS and SCOPE21, which have greatly promoted the improvement of coke quality, effective utilization of non-coking coal and environmental protection. Nippon Steel And Sumitomo Metal after the alliance in the coking field of continuous innovation, so that its coking coal pretreatment and other related technologies have been kept in the world's leading level. JFE Steel ranked second with 1,630 patent applications, accounting for 23.96% of all Japanese patent applications for coal coking and deep processing, and also a competitive company in Japan. In Japan JFE steel company has a number of coal tar deep processing enterprise, occupies the second place of Japan, mainly JFE steel belongs to coking plant with coal tar and crude benzene as raw material, processing production and sales, with China and shandong, shanxi regions such as the extensive cooperation, and participate in the investment in coal tar deep processing and comprehensive utilization of coking products has remained the world's advanced level.

## 2.3 Distribution of coal coking patents in the main technical fields

### 2.3.1 Distribution of major technical fields of Chinese patents



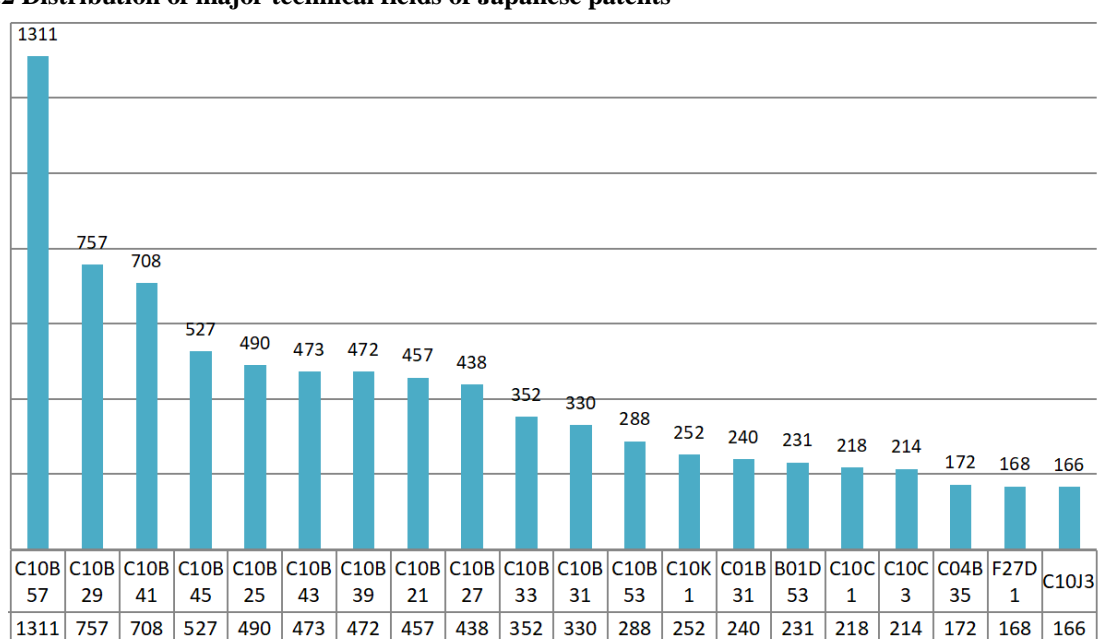
**FIG. 3** Distribution of major technical fields of Patents in China

Through the analysis of IPC technology composition patents in the field of coal coking and its deep processing technology, it was found that the patents involved a total of 687 large groups under 219 small categories, with a total of 1,690 classification numbers. The total number of patents represented by the top 30 subcategories of 219 subcategories is 8098, accounting for 87.7% of the total, which can reflect the overall situation of IPC technology in coal coking and its deep processing technology.

As can be seen from Figure 3, 9,230 patent applications are mainly distributed in the top 30 subcategories of C10B, C02F, C10K, B01D, C10G, C10L, C07C, etc. Carbonization of C10B (carbon materials to produce gas, coke, tar or analogue) class of an application for a patent for up to 3897 pieces, accounted for

about 42.2% of all patent applications, constitutes the deep processing of coking coal in China and the main technology, second, C02F (water, wastewater, sewage and sludge treatment) also occupies a large proportion in the IPC technology, explain our country very the attention to environmental protection technology, especially in the field of deep processing of coking coal and coking wastewater treatment technology research and development and investment. Meanwhile, C10K (purification and modification of chemical compositions containing carbon monoxide combustible gases), B01D (separation), C10L (fuels not included in other categories; Natural gas; Synthetic natural gas derived from methods not included in the C10G or C10K subclass; Liquefied petroleum gas; Use of additives in fuel or fire; Pyrotechnic (igNITer) and C07C(acyclic or carbocyclic compounds) are also one of the hot technical fields of coal coking and its deep processing. In addition C10C (tar; Processing of tar pitch) and C01C(ammonia; Cyanide; Its compound) also is the coal coking and its deep processing technology domain important component.

**2.3.2 Distribution of major technical fields of Japanese patents**



**FIG. 4** Distribution of major technical fields of Patents in Japan

From Figure 4, it can be seen that, different from China's coal coking and its deep processing technologies, which are mainly distributed in coke cooling and quenching as well as waste water treatment, Japan's coal coking and its deep processing patented technologies are mainly distributed in C10B57(other carbonization or coking processes; In this field, the number of patent applications reached 1311, accounting for 19.2% of the total patent applications in Japan. It is the core technology of Japan's coal coking and its deep processing patents. The second is C10B29, which is related to other components of coke oven, accounting for 757. Meanwhile, the number of patent applications for C10B41(safety device, such as signal and control device used in coke unloading) also reaches 708, accounting for a large proportion. It is the key technical field of coal coking and its deep processing patent applications in Japan. In addition, C10B45 (other parts), C10B25 (coke oven door or closed), C10B43 (dust or except fouling), C10B39 (coke cooling or quenching), C10B21 (with combustible gas coke oven heating) and C10B27 (dry distillation gas discharging device) technology is also constitute Japan coal coking and its deep processing fields such as an important component of the patent technology. In addition, "discharging device; "Coke guide device", "Charging device", "Dedicated to the distillation of specific solid raw materials or special forms of solid raw materials", "Purification of combustible gases containing carbon monoxide", "Carbon, its compounds", "separation of body or steam"; Recovery of volatile solvent vapour from gases; Technologies such as chemical or biological waste gas purification and "tar processing" also account for a certain proportion of patent applications.

**III. Implications for China**

Structure of China's natural resources for the lack of gas and oil "" rich coal, with the rapid growth of economic demand, China's oil and conventional natural gas may be early to countries around the world to die, the relative energy shortages accompanied by China's economic and social development for the long term, is given priority to with coal energy structure in the short term is difficult to substantial change, the strategic

position of coal in China's energy industry cannot be ignored. As a non-renewable resource, the deep processing and efficient utilization of coal are particularly important. As an important industry for the efficient utilization of coal, the development strategy of coal coking and its deep processing should not be overlooked.

First, we should pay attention to the advancement of science and technology and the improvement of the quality of our workers, upgrade the coking and deep-processing industries with new and high technologies and advanced and applicable technologies, strengthen skill training, promote its application and mechanization in the industry, achieve high production and efficiency, and accelerate the pace of modernization. To revitalize the coal coking equipment manufacturing industry through the introduction of technology, combination of technology and trade, sino-foreign joint venture, cooperative manufacturing and independent research and development. We will appropriately increase investment in scientific research and technological breakthroughs in coal coking, and accelerate the development of a technological innovation system for the coal coking industry.

Second, strengthen exchanges and pursue win-win cooperation. As a leading country in the field of coal coking and its deep processing, Japan has relatively perfect enterprise management. There are many places worth learning for China's coal coking enterprises. As a powerful country in the field of modern technology, Japan is also an important object of China's cooperation and exchange. To do a good job in the research and analysis of foreign coke and coking products market, and insist on holding regular information release or market seminars and international exchanges, is conducive to the construction of win-win cooperation road.

Third, expand overseas market actively, carry out patent layout in foreign countries. We will encourage the development of export strategies and conduct regular research on foreign markets. Have an edge in market dynamics. Give full play to the productivity benefits brought by the patented technology, strengthen the analysis of foreign patented technology of coal coking, and formulate the layout of foreign patents of enterprises. Master the overall development trend of the world in terms of patent technology.

Fourth, learn from foreign advanced technology to improve the overall level of China's coking and deep processing of coal. After decades of development, China has become the largest coking industry in the world, but it is not a strong coking industry. The industry as a whole is lagging behind. The new "access conditions" for coking enterprises put forward more stringent requirements. China's coking enterprises must optimize their industrial structure and actively learn from foreign advanced technologies in coke, coal tar, coke oven gas and comprehensive utilization of environmental protection and safety. By introducing foreign technical talents or sending domestic talents for further study. Only through constant innovation in both technical and human resources, can we improve our international competitiveness and gain a foothold in the field of international coking and deep processing of coal.

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