LNG heat exchanger technology patent trend analysis

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Abstract. In order to fully grasp the status quo and trend of patent development of LNG heat exchanger technology, based on the wisdom bud patent data platform, the application trend of global LNG heat exchanger technology patents, the distribution of source and destination countries, and the pattern of patent technology from 1987 to 2017 were searched and analyzed. It is found that: 1. Japan, France, the United States, Sweden, Denmark, Canada and other countries have strong technical reserves in this field; 2. China has become the world's largest target area for patent distribution in the field of LNG heat exchangers; 3. China is still in its infancy in the design and manufacture of LNG heat exchangers. There are many technical blanks and the market prospect is broad.

1. Introduction

The LNG industry plays an important role in China's energy transformation, industrial upgrading, environmental protection and sustainable development [1]. There are relatively few related literatures. The domestic LNG heat exchanger technology research and abroad .There is a certain gap, and the market share in the field of oil and gas processing is small [2]. With the huge demand of LNG, the regasification unit has great industrialization prospects and broad market value. As an important link and component of the research and development of regasification equipment, LNG heat exchanger also has immeasurable market space and profit prospects. Therefore, the analysis and research on the patent status of LNG heat exchanger technology in the world is of great significance to the development of China's LNG industry.

Patent is the wind vane of the industry. As a material carrier of technical intelligence, patents cover the latest innovative technical information in all technical fields. By mining technical information, it can effectively reveal the development and development trend of related technologies [3]. The rapid development of foreign LNG heat exchanger technology has promoted the production of a large number of technical invention patents. According to the characteristics of patent data, this paper divides the LNG heat exchanger technology into three technical branches: microchannel forming technology, welding process and overall structure. Using the basic method of patent analysis, the patent application for LNG heat exchanger technology has been applied for nearly 30 years in the world. The status quo and development trends were introduced and analyzed, and relevant development proposals were proposed for relevant industries in China.

2. Analysis of technical application trend of LNG heat exchanger

Patent analysis can reflect the technology development trend in the corresponding industry, help
enterprises to grasp the research and development trend of competitors, better deal with patent infringement disputes, and improve the patent value [4]. Author through wisdom buds patent database to "TA: ((LNG) AND heat exchanger) OR TA: ((LNG AND heat exchanger) OR (LNG AND heat exchanger))" as a retrieval model for retrieval (retrieving date as of December 31, 2017), to retrieve a total of 3221 patents, apply for a patent for invention of 1947, authorized invention patent 895, 379 pieces of the patent for utility model, the collected in the global related patent applications for statistical data according to the time sequence analysis method. The trend of application in the field of technology is based on the time axis and the number of applications as the vertical axis. As the disclosure of invention patents needs to go through substantive examination, the general invention patents are not disclosed until 18 months after the application, so the number of patent applications in 2015 and 2016 cannot objectively reflect this analysis.

2.1 Overall application trends
The trend of patent application can reflect the technological development stage of LNG heat exchanger. Figure 1 shows the annual distribution trend of global patent application in the field of LNG heat exchanger. Before 2001, there were few applications for the invention and authorization of LNG heat exchanger technology, and only a few patents in the field of utility models. However, since 2001, the number of patent applications has increased significantly, especially since 2003. In 2015, 164 invention patents were applied. The number of utility model patents reached 82.

The technology life cycle can be divided into four stages: introduction stage, growth stage, maturity stage and decline stage. It reflects a period of time after a technology or product is derived from basic science or applied science, applied to product design and development, entered the market and exited the whole market. From the perspective of technology life cycle, the patented technology in the field of LNG heat exchanger has experienced the stage of introduction and growth, but has not yet entered the stage of rapid development, and the research and development in this field is still in the growth stage.

![Figure 1. Changes in global patent technology for LNG heat exchangers](image1)

2.2 application trend of technology branch
Figure 2 shows the trend of global patent applications for micro-groove forming technology, welding process and overall structure in the field of LNG heat exchanger. By the end of 2017, there were 281 patents related to micro-channel forming technology in the field of LNG heat exchanger, 1290 patents related to welding process, and 1702 patents related to overall structure. It can be seen from the trend chart that the development trend of the three technical branches in the global LNG heat exchanger field is similar. Before 2001, there were only a few patent applications, and the whole technical field is in the preliminary development stage. From 2001 to 2006, the number of applications increased slightly and was in a slow growth period. From 2007 to 2015, the number of patent applications related to the overall structure in the rapid growth period was similar to that of the welding process.

![Figure 2. Global application trends for micro-channel forming technology, welding process, and structure](image2)
The number of patent applications related to the micro-groove forming technology was less than that of the overall structure and welding process.

3. Distribution of the source country and target country of the global patented technology

The source country and target country data of the patented LNG heat exchanger are shown in figure 3. According to the data from the country of origin of the patent, Sweden ranks the first in the number of patent applications, and is the major contributor to the patented technology of LNG heat exchanger in the world, accounting for 40.14% of the total number of patent applications. Compared with other countries and regions, Sweden has an obvious technological advantage. Alfa Laval, headquartered in Sweden, is one of the world's leading suppliers of LNG heat exchangers. The number of patent applications in the field of LNG heat exchanger technology in China accounts for 22.91% of the total number of applications in the world. However, due to the environmental pressure, government intervention, policy guidance and other factors in recent years, the technical development of LNG heat exchanger has been promoted.

The second tier of Japan, France, the United States, Denmark, Canada and other countries, 7.27%, 3.48%, 1.53%, 0.77%, 0.62%, with shipping market demand, the second tier of national patent applications in the field is not fully characterized in the field of technical strength, the global cutting-edge technology using the technical secret protection is still the main developed countries technology protection measures, technical barriers to all-round blockade of developing countries in LNG technology research and development and technological breakthroughs in the field of heat exchanger.

According to the patent, according to data from the target application for a patent for the first echelon of the Chinese biggest target areas for patent layout, patent applications in China accounted for 31.19% of global target application, shows that global patent distribution goals are important in the field of LNG heat exchanger around China, it is because of China's shipbuilding and maritime power, at the same time in design and manufacture of LNG heat exchanger in our country is still in its infancy, there is more in the field of the technology gap, so LNG heat exchanger has broad prospects in China.

4. Patent technology pattern of LNG heat exchanger in the world

4.1 Distributions of patented technologies

Distribution of patent technology is mainly used to analyze a segmentation technique in the field of patent distribution, the IPC classification is current range of the most widely used international patent document classification and retrieval tools, concrete of the technical scheme of the IPC classification number by filing an application for a patent for design to determine one's profession, so the classification number can be used to determine the content of the patent technology distribution. As shown in figure 4, the patent applications in the field of LNG heat exchanger are mainly distributed in F28: general heat exchange technology.
According to figure 4, the top ten are: f28d9/00: fixed plate or laminated channel heat exchange equipment for two kinds of heat exchange media, with different side contact between each medium and the channel; F28f3/00: sheet or laminated components, sheet or laminated component assemblies; F28f3/04: integral structure and components; F28f3/10: fittings for sealing edges; F28f9/02: header box, end plate; F28d9/02: the heat exchange medium moves at an angle to each other; F28f9/00: shell, union box, auxiliary supporting member of components, auxiliary member inside the shell; F28f27/02: a control or safety device specially designed for heat exchange or heat transfer equipment. It can be seen from the technical distribution represented by the classification number that the main patent application focuses on the structure of heat exchanger, laminated channel of heat exchange medium, seal, control device or safety device.

4.2 Technical patterns
The field of LNG heat exchanger mainly involves three technical branches: micro-groove forming technology, welding technology and overall structure. The research on the global and Chinese patent situation of the three technical branches is of practical significance to the future development direction of relevant technologies in the field of LNG heat exchanger in China.

It can be seen from Figure 5 that the patents related to microchannel forming technology in the global LNG heat exchanger field account for 8.59%, the welding-related patents account for 39.41%, and the total structure-related patents account for 52.00%, from statistical data. It can be seen that the patents in the field of LNG heat exchangers are mainly concentrated on the overall structure and the welding process, and the patents related to the fine channel forming technology are relatively small.

5. Analysis of leading enterprises
According to figure 6 (a), it can be seen that the key enterprises in the field of LNG heat exchangers rank top in the patent application of micro-channel forming technology. Among them, Shanghai lanbin petrochemical equipment co., ltd. ranked first, gansu lanke petrochemical high-tech equipment co., ltd. ranked second, and China shipbuilding industry corporation 71st research institute ranked third. South China university of technology, carrier company and luoyang ruichang petrochemical equipment co., ltd. are in the second echelon; Alpha lavar co LTD, tsinghua university and other top 10 companies.

Figure 6 (b) shows the key enterprises ranking high in the welding process patent application in the field of LNG heat exchanger technology. Among them, Alfa Laval and its subsidiaries rank the first, second and third, and the top ten key enterprises in the world are all Alfa Laval subsidiaries, with strong strength on the whole. Chinese companies have not been able to secure a place in the top 10 for welding.

According to figure 6 (c), it can be seen that the most important applicants in the overall structure patent application of LNG heat exchanger field rank high. Among them, Alfa Laval company and its branches rank the first, second and third, and Alfa Laval branch is almost the top ten key enterprises in
the world, with strong strength on the whole. Kobe steel of Japan ranks fifth in the world and holds one of the top ten positions in the overall structure and technology branch of the global LNG heat exchanger field, while Chinese companies fail to hold a place in the top ten important applicants.

Figure 6. Branch technology patent application key enterprises

6. Conclusions and implications

Through the patent analysis of LNG heat exchanger technology, it clearly reflects the development and change characteristics of LNG heat exchanger technology innovation, understands the development of the industry and technology research and development trends, and finds that Japan, France, the United States, Sweden, Denmark, Canada and other countries have strong technical reserves in this field, and the number of patent applications is stable. China is now the world's biggest goal in the field of LNG heat exchanger patent layout area, this is due to China's shipbuilding and maritime power, at the same time in design and manufacture of LNG heat exchanger in our country is still in its infancy, there is more in the field of the technology gap, so LNG heat exchanger has broad prospects in China.

According to LNG global patent development trend in the field of heat exchanger, suggested that our country enterprise to established European and us companies in the overall structure, fine, molding technology, welding technology or related field of core patents and foundation for further study, in the patent layout and product research and development at the same time to avoid design patent, and from the legal Angle around certain core patent protection scope in order to avoid an action of tort by the patent holder. At the same time, on the basis of studying the patents of these old companies, we will carry out alternative design and breakthrough design, and exchange these patents for the cross-license of the main competitors in the field of LNG heat exchangers, so as to help Chinese enterprises gain a firm foothold in the field of LNG heat exchangers.

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