

# Patent Map of Linear Motor Technology for Intelligent Manufacturing

Zhilan Chen\*

College of Mechanical and Electrical Engineering  
Shanghai Jianqiao University  
Shanghai, China  
12077@gench.edu.cn

Ming Wang

College of Mechanical and Electrical Engineering  
Shanghai Jianqiao University  
Shanghai, China  
mingw828@163.com

**Abstract**—Linear motor is a new type of motor, which plays a key role in all fields of intelligent manufacturing and is widely used in intelligent manufacturing production. This article used IPC (International Patent Classification) classification method and data collection. All patent information hiding in the technological field of the numerical linear motor is mined. The corresponding patent map is drawn, issues related to research linear motor technology in the global scope of the patent layout, key technology and research focus are studied. The technology industry development trend, key technology areas and competition mechanisms are analyzed, in order to draw valuable conclusions on the intelligent manufacturing and industry development.

**Keywords**—Linear Motor, Patent Map, Patent Data, Intelligent Manufacturing

## I. INTRODUCTION

Linear motor is a new type of motor, which plays a key role in all fields of intelligent manufacturing[1,2]. Linear motor technology can directly transform electrical energy into mechanical energy, turning the rotation into a straight line motion. As a new type of electric drive device, it can adapt to the needs of various high-speed machining. Linear motor drive motor drive system with traditional mechanical device has many unique advantages, such as ultra high-speed and ultra-low speed, but also can achieve very high acceleration, and almost no maintenance, no backlash, high precision work[3]. Only the motor can accomplish linear motion without gear coupling or pulley, the useless, will reduce the performance and reduce the service life of the mechanical parts removed, can directly drive the workbench to move in a straight line. At present, linear motor technology has been widely used in intelligent manufacturing, construction, metal metallurgy, transportation and other industries[4].

Patent map as an image of mining tools, patent data hiding information is easy to understand and analysis of the powerful, is of great importance to the analysis and development trend of the technology[5,6], but also has a significant impact on the survival and development of enterprises. This article through the Shanghai intellectual property (patent) public service platform, access to 1966 to 2017 to published at home and abroad on the linear motor technology patent data, draw the corresponding linear motor technology patent map, and then analyzes all kinds of patents in technical field, in order to obtain a value for the future development trend of linear motor technology conclusion.

## II. GLOBAL PATENT LAYOUT ANALYSIS OF LINEAR MOTOR TECHNOLOGY

The world's first linear motor technology patent application filed by the British in 1922, Noel Pemberton Billing, the patent is communication equipment improvement[7,8]. Therefore, the linear motor technology is developed. This study by the Shanghai intellectual property (patent information retrieval) system of public service platform, choose "ti: (linear motor technology) or ti: (Linear motor)" search this keywords respectively on the domestic and foreign patent database, from 1966 to 2016 were patented linear motor technology in the world within the scope of the 67796. In the above patents, 60857 foreign patents, 6939 domestic patents, these data are the basis for analysis of this article. Draw the linear motor technology patents at home and abroad distribution, patent technology analysis technology map, analysis chart, patent technology hot transition diagram and a series of patent map, and from the technical research and development scale, technology and industry development trend, key technology, geographical distribution and competition mechanism and other aspects of patent analysis, in order to draw a value for the future development of linear motor technology trend[9,10].

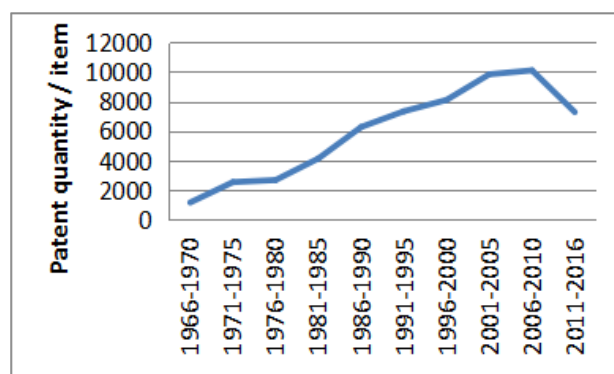


Figure 1. Distribution of foreign patents of linear motor technology with the year

Fig. 1 takes five years as a unit, which indicates the distribution of foreign between patents and the annual distribution and the distribution of foreign patent of linear motor technology. From Figure 1, the patent number and year relationship, can be found from the beginning in late 70s, the linear motor technology began to develop rapidly, the linear motor technology patent is the peak period from 2001 to 2010 ten years, the peak number of patents exceeded 10 thousand, the number of linear motor technology patents in recent years the release rate slowed. Even so, 7274 patents were issued during the 2011-2016 year period of five.

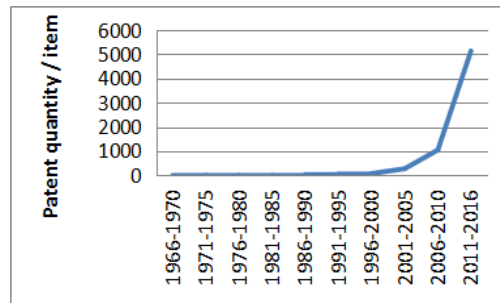


Figure 2. Distribution of domestic patents of linear motor technology with the year

Fig. 2 takes five years as a unit, which indicates the distribution of domestic between patents and the annual distribution, and the patent distribution diagram of linear motor technology at home and abroad. China's research on linear motor technology started relatively late. It began to study from the late 80s of last century. The total number of patents in 40 years from 1966 to 2005 was 445. But in the past ten years, the technical research of linear motor technology has developed rapidly in China. The number of patents from 2006 to 2010 was 1048, and the number of patents from 2011 to 2016 was 5135. This shows that in the past five years, the number of patented motor technology in China has accounted for 74% of the total number of patented linear motor technology in the past forty years. Therefore, the domestic research in the field of linear motor technology is at a white hot stage, but there is still a gap between the total number of patents issued and the number of patents issued by developed countries.

### III. PATENT MAP ANALYSIS OF LINEAR MOTOR TECHNOLOGY

#### A. Patent Distribution in Major Technical Fields.

According to the international patent IPC technology classification, 67796 patents related to the linear motor technology are obtained, and the types of IPC technology involved are mainly 8 aspects, as shown in Table I.

TABLE I IPC CLASSIFICATION OF LINEAR MOTOR TECHNOLOGY

Sort	IPC code	Chinese explanation	Patent quantity
1	A	Human life needs	3200
2	B	Work; transportation	21283
3	C	Chemistry; metallurgy	974
4	D	Textiles; paper making	1067
5	E	Fixed building	2171
6	F	Mechanical engineering; lighting; heating	8770
7	G	Physics	10567
8	H	Electrical science	19589
9		Other	175
	Total		67796

From the data in Table I show that in the 67796 patent, B class and H class is transportation and electrical, G class F class is physics and construction. The number of the patent four categories accounted for IPC classification technology most, respectively 21283, 19589, 10567 and 8770.

#### B. Patent Number and IPC Distribution by Country.

According to the 8 classifications of IPC, the number distribution relationship of the linear motor technology in each country is constructed, as shown in Fig. 3.

We can see from Fig. 3, the number of Japanese linear motor technology patents accounted for 34.52% of the total world, means that the patent technology of linear motor is more than 1/3 the world from Japan, from the reflection of the Japanese in linear motor technology patent monopoly. Followed by the United States accounted for 14.20% of the number of patents, China and Germany linear motor technology patent gap is only 0.71%. According to the current development rate of China in recent years, there is a chance to overtake Germany, and the number of patented linear motor technology will become the third largest power in the world.

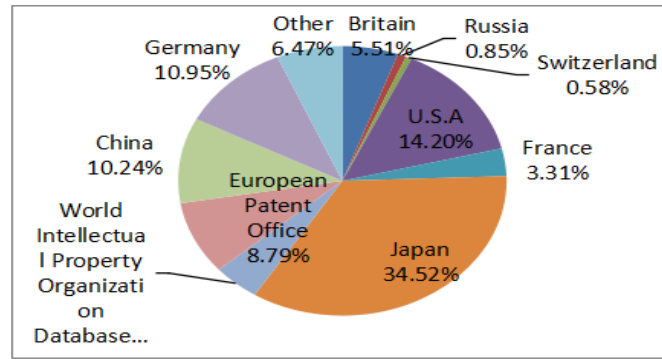


Figure 3. Percentage of patents for linear motor technology by countries

### C. Domestic and Institutional Patent Quantity Distribution.

Table II shows the number of patents in the linear motor technology of the top 10 institutions at home and abroad.

TABLE II DISTRIBUTION OF PATENT NUMBER OF LINEAR MOTOR TECHNOLOGY AT HOME AND ABROAD

Domestic	Patent quantity	Abroad	Patentquantity
Harbin Institute of Technology	31	LG ELECTRONICS INC [Korea]	891
Tsinghua University	18	SIEMENS AG [Germany]	599
Zhejiang University	16	BOSCH GMBH ROBERT [Germany]	313
Huazhong University of Science and Technology	15	SAMSUNG ELECTRONICS CO LTD[Korea]	269
Beihang University	14	YASKAWA DENKI SEISAKUSHO KK [Japan]	199
Shenyang University of Technology	13	THK CO LTD [Japan]	167
Shanghai Jiao Tong University	11	HITACHI LTD [Japan]	164
Shenzhen Han precision electromechanical Co., Ltd.	10	MITSUBISHI ELECTRIC CORP [Japan]	163
Southeast University	10	CANON KK [Japan]	163
Southwest Jiao Tong University	8	HYUNDAI MOTOR CO LTD [Korea]	135

As can be seen from Table II, in addition to the Shenzhen branch of Han Precision Machinery Co., Ltd. for enterprise organizations, the domestic linear motor technology, the number of patents in the top ten institutions are from the university. The Harbin Institute of Technology is ranked first, the number of patents with 31, followed by Tsinghua University, Zhejiang University, Huazhong University of Science and Technology, Beihang University and other 985 schools, the number of patents and has little difference. This shows that the domestic research on linear motor technology is mainly concentrated in Colleges and universities, and the participation of enterprises is relatively small. This is a question worth considering.

Table II also shows that foreign institutions linear motor technology patents are the top ten enterprises. In the top ten enterprises, there are three companies from South Korea, there are five companies and two from Germany, Japan, the rest of the enterprise. Ranked first LG company mainly developed electronic devices, there are 891 patents, second German SIEMENS enterprises, there are 599 patents, third German BOSCH company, there are 313 patents. Although South Korea's LG company patents are relatively large, but five Japanese companies linear motor technology patents have an absolute advantage. From this point of view, the whole world of linear motor technology, Japan still occupies a leading position.

### D. Compared with the Number of Patents between 5 Years and 45 Years

Fig. 4 shows the percentage of patents obtained in linear motor technology in the previous 45 years, and Fig. 5 shows the percentage of patents obtained in linear motor technology in the last 5 years.

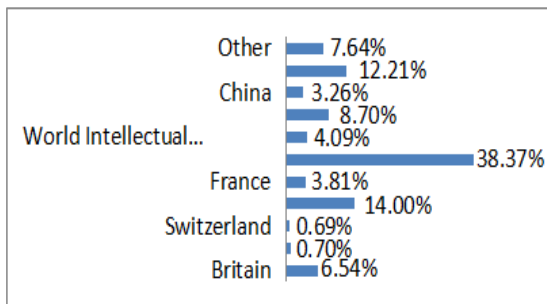


Figure 4. Countries accounted for patent in 45 years

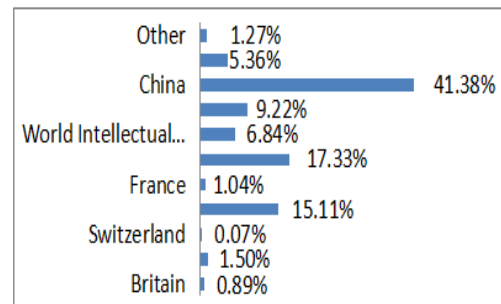


Figure 5. Countries accounted for patent in 5 years

Comparing the trends of Fig. 4 and Fig. 5, we can see clearly that in the past five years, except for the United States and

China, the proportion of linear motor technology patents has increased, and the rest of the countries have shown a downward trend. Chinese patents accounted for ratio growth trend is very obvious, from the original 3.26% to 41.38% growth, in other words, the patent technology of linear motor by more than 2/5 of the global China, this shows that nearly five years China in linear motor technology R & D the more investment, the more technological achievements. Power of traditional linear motor technology aspects in recent five years, such as Japan and Germany share ratio has obvious downward trend, respectively, down from 38.37% to 17.33%, 12.21% to 5.36%, the United States has in linear motor technology than the growth rate is not much, only 15.11% growth.

#### E. Compared with Migration Technology between 5 Years and 45 Years.

Fig. 6 shows the percentage of patents in 8 categories of linear motor technology in the world over the past 45 years, and Fig. 7 represents the percentage of patents in the 8 linear motor technology classes in the world in IPC in the last 5 years.

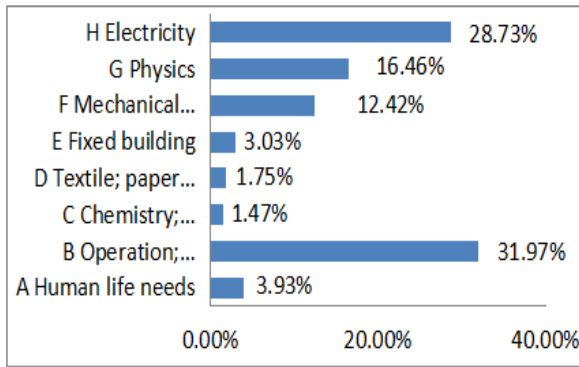


Figure 6. IPC classification patents in 45 years

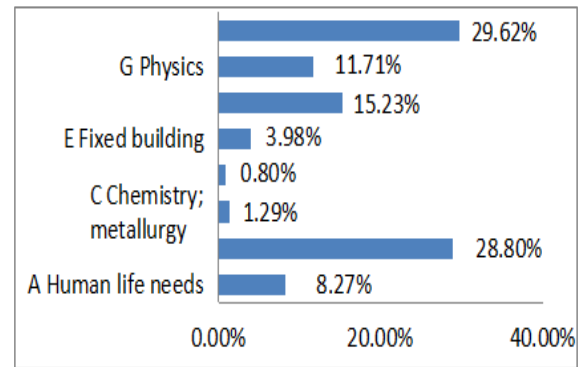


Figure 7. IPC classification patents in 45 years

Comparing the percentages of fig. 6 and Fig. 7, we can find that the proportion of patented motor technology patents in the last five years of IPC has changed significantly over the past 45 years. In the past five years, the B class transportation industry and the H power electronics industry have maintained a large proportion compared with the previous 45 years. In the first 45 years, the proportion of B patents accounted for 31.97% of the total, more than 28.73% of the proportion of H patents. But in the past 5 years, the proportion of H patents accounted for 29.62%, slightly more than B class patents accounted for 28.80% of the amount, which indicates that the development of linear motor technology and investment started toward H power electronics industry transfer.

In nearly five years, compared with the previous 45 years, the proportion of the aspect of patented linear motor technology in human life increased from 3.93% to 8.27%. It is a sharp rise. The research shows that category aim a hot research and technology transfer of nearly 5 years of growth. Category A thermal power engineering increased from 12.42% to 15.23%, and technology transfer increased slightly. The category G dropped from 16.46% to 11.71%, indicating that technology migration has begun to decline slightly. However, C and D have not been the focus of the research of linear motor technology and the direction of technology transfer, and their proportion has been on the downward trend in the past 5 years.

#### IV. CONCLUSION

(1) Through the patent retrieval, data mining and research analysis of linear motor technology, a series of patent technology maps of linear motor have been produced. From the global layout point of view, the birth and development of linear motor technology for the mid 60s of last century, the beginning of this century, linear motor technology reached peak. From the layout of China, the birth of linear motor technology for the late last century, in recent years, linear motor technology showed a substantial upward trend.

(2) according to the international patent classification IPC technology, research the linear motor technology is mainly in four aspects: category B transportation accounted for 31.47%, category H power electronics industry accounted for 28.97%, Category G physical industry accounted for 15.63%, and category F mechanical engineering industry accounted for 12.97%.

(3) from the degree of national importance, Japan occupies a dominant position in the field of linear motor technology, and its number of patents is twice as large as that of the second. This indirectly indicates that Japan is still the global leader in the field of linear motor technology. At the same time, a number of enterprises from different angles in the application of linear motor technology research. In the past 5 years, China has greatly increased the number of patented motor technology patents, the gap in the number of German patents in the third place is decreasing, and is expected to surpass germane.

(4) In the past 5 years, the research and development of linear motor technology has gradually shifted towards the H power electronics industry. At the same time, the patent of linear motor technology of human life needs is also the focus of research and technology transfer growth.

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