Opinion Article

Current Status of RV Reducer Development in China and Abroad

ABSTRACT

RV reducer has a wide range of applications in China due to a series of advantages such as high precision (backlash less than 1 Angle minute), high rigidity, high durability, high output density (strong torque & compact), wide reduction ratio range and low vibration. Due to the large gap between domestic RV reducer and foreign brands, this is mainly reflected in the low level of research and low investment due to low profitability, the domestic RV reducer market relies heavily on imports at present. By reviewing the development status of RV reducer at home and abroad, this paper points out the restrictive factors in the development of domestic RV reducer, the number of patents filed as the main measure for assessing the level of research in China and abroad, and puts forward suggestionsand directions for the development of domestic RV reducer, providing reference for the next development of domestic RV reducer.

Keywords: RV reducer; Development status; Restraining factor; suggestion.

1. INTRODUCTION

RV reducer is a kind of precision reducer which adopts the structure of cycloid pinwheel speed reduction, and its main parts include crank shaft, planetary wheel, planetary carrier, cycloid wheel, sun wheel, pinion shell, etc. It adopts the secondary reducer mechanism of involute cylindrical gear planetary reduction and cycloid pinwheel planetary reduction [1].The RV reducer has the characteristics of small volume, light weight, high rigidity and overloading, etc., and it has good acceleration performance such as small backlash, small rotary vibration and small inertia, which can realize smooth operation and obtain high precision position. RV reducer has a small size, light weight, high rigidity and strong overload characteristics, but also has a small backlash, small rotational vibration, small inertia and other good acceleration performance, can achieve smooth operation and access to a high degree of accuracy of the position, so the world's high-precision equipment drive more RV reducer, such as industrial robots, numerical control machine tools, semiconductor equipment, precision packaging equipment, welding displacements, plasma cutting, tobacco machinery, printing machinery, textile machinery, medical equipment, tracking antenna, radar and other aspects [2]. In recent years, with the domestic "robot fever" heating up, China has become the world's largest robot market. As one of the three core components of robots, RV reducer is one of the three core components of robots. Reducer, its performance directly determines the overall performance level of the robot. In order to make the development of China's robot industry is not restricted by others, it is particularly important to carry out the research of domestic RV reducer.

Fig. 1 .RV Reducer

2. RV REDUCER FOREIGN DEVELOPMENT STATUS

RV gearbox technology originated from Germany, Dr. L. Braren (Laurenz Braun) firstly proposed the use of cycloidal gear profile for precision mechanical transmission in 1926, and founded "Seguler" Co. Dr. L. Braren (Laurenz Braun) firstly proposed to use the cycloid gear profile for precision mechanical transmission in 1926, and founded "Segule" Co., Ltd. in Munich, Germany in 1931, and firstly started the manufacture and sale of cycloid gearboxes, which was transferred to Sumitomo Heavy Industries Ltd. in Japan in 1939.
The concept of RV transmission was first proposed by Teijin Seikico Ltd. in the early 1980's. According to Kuhl's classification, the transmission is a 2K-V planetary transmission. 2003, Teijin Seikico Ltd. and Nabtesco Ltd. merged to form Nabtesco, which has been developing rapidly and has become the leading company in the RV reduction industry. Nabtesco has made rapid progress and has now become a leading company in the RV gearbox industry, with a global market share of 60%, especially in medium/heavy duty robots, where the market share of RV gearboxes is as high as 90% [3].

2.1 RV Reducer Foreign Development Status

Foreign research began relatively early, for the field of precision reducer research has a history of more than 100 years. After more than 100 years of technical precipitation and accumulation, in the research and development, design and manufacture of precision reducers, foreign enterprises have been in the monopoly of the leading position.
Japan's Sumitomo Corporation as the international manufacture of cycloid speed reducer one of the largest enterprises, its product range of good performance, the current proposal of the "multi-differential" gear transmission, can withstand 500 times the instantaneous impact load, the first level of deceleration efficiency of 94%, a wide range of applications. Japan's Nabtesco (Nabtesco) company has long been committed to the research and industrialization of RV reducer, mastered the core technology, in the field in the absolute leading position, RV-N series products are developed and produced by the new model, compared with the previous generation of products with better performance, smaller volume, lighter weight. In addition, South Korea's SEJIN company, on the basis of Japan's RV reducer, developed a new cycloid gear RV reducer (flat high-precision reducer). Dojen cycloid reducer in the United States and the European Slovakia Spinea company's reducer products with excellent performance, are also in the world's advanced level [3].
From the global market point of view, Japan Nabtesco (Nabtesco) and Sumitomo occupy more than 75% of the global RV reducer market, and Europe and the United States occupy nearly 15% of the market [4], in general, the current global RV reducer market is still dominated by Japan and Europe and the United States as the market.
As can be seen from Figure 2, globally, since 1945 to the present, Japan is the first country to apply for RV reducer patent technology, and its patent accounted for about 36.3% of the world; the United States is the second largest country in terms of patent applications, and its patent accounted for about 16.6%; the European Patent Office ranked third, and accounted for about 16.2% [5]. In general the core technology of RV reducer is still in the hands of Japan and Europe and the United States.

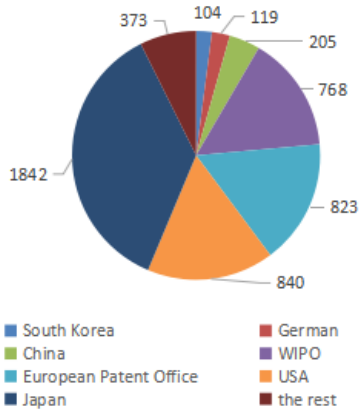

Fig. 2 .Global distribution of patent applications for RV reducers

2.2RV REDUCER DOMESTIC DEVELOPMENT STATUS

China's research on RV reducer began late, the technology is still immature, can not meet the needs of the rapid development of various domestic fields, resulting in the current situation of serious dependence on imports, seriously restricting the development of the domestic robotics industry.
China's earliest RV reducer research is Dalian Jiaotong University Li Lixing team, has put forward a series of RV transmission optimization design theory, and developed a successful prototype of the RV-250AII reducer for robotics [3]. Subsequently, other domestic institutions and enterprises have been involved in the theory and industrialization of RV reducer research, dedicated to the localization of RV reducer, and achieved a lot of research results.
In recent years, as China has issued a series of documents and industrial policies such as "Guiding Opinions on Promoting the Development of Industrial Robotics Industry" and "Made in China 2025" to carry out top-level design, RV gearboxes, as an important part of industrial robots, have been supported by the National Natural Science Foundation of China (NSFC), the National 863 Program, and the National Scientific and Technological Major Special Projects through different channels in terms of policy and funding. The company has provided strong support in terms of policy and funding. Attracted a number of enterprises, including Shanghai electromechanical, Qinchuan machine tools, Zhejiang Shuanghuan Drive, Shandong Shuaike, Nantong Zhenkang and other enterprises are vigorously developing domestic reducer products. Nantong Zhenkang Welding Electromechanical Co., Ltd. has taken the lead in realizing the mass production of RV speed reducers, and its industrial robot joints have been put on the market with the "ZKRV" brand speed reducer. Qinchuan Machine Tool Group Co., Ltd. developed the BX precision reducer to meet the 6kg ~ 300kg industrial robots on the use of reducer requirements. Guangzhou CNC in the RV reducer the two most important performance - precision and stability of the breakthrough, obtained two national invention patents. In addition, China's RV gearbox manufacturing equipment has also made breakthroughs, such as the Beijing Second Machine Tool Factory Co., Ltd. developed a successful follower RV gearbox eccentric shaft grinding machine, Zhengzhou High-end Equipment and Information Industry Technology Research Institute Co., Ltd. jointly with Henan University of Science and Technology and other units to develop a successful RV gearbox cycloid wheel forming grinding wheel gear grinding machine [5], the above equipment is the core of the production of RV gearboxes.
Although China has achieved a breakthrough in the production of RV reducer machine, but in the key performance, such as transmission accuracy, efficiency, motion retention, life, heat and noise, etc., and foreign products still have a large gap, has not yet mastered the core technology, the domestic RV reducer research is still in the initial stage.

3. RV REDUCER DEVELOPMENT CONSTRAINTS

Constraints on the development of China's RV reducer is the primary factor is the short research time, the development of industry is different from other industries, there is no overnight solution. The concept of precision reducer was first proposed by foreign countries, research has been more than 100 years of time, during the completion of the technology and industrial accumulation, not our country overnight can be surpassed, our country from the first time to present the relevant research to the development of only a few decades of time, although many breakthroughs, but with Europe and the United States and Japan and South Korea and other countries there is still a technological gap of about 20 years.

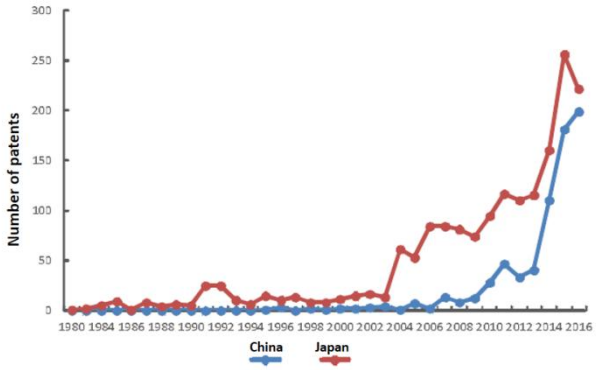

Fig. 3 .Trend of Patent Applications in China and Japan

Foreign technology monopoly is also an important reason for restricting the development of China's RV reducer. As can be seen from Figure 3, the trend of patent applications in China and Japan, Japan has had relevant patent applications since 1985, while China only began to have relevant patent applications in 1997. The relevant applications were filed in China only in 1997. Since 1997, foreign research has been growing rapidly, while domestic research has just begun.

Since 2003, foreign research began to grow rapidly, and although China's related research also began to grow, the growth rate was slower than that of foreign countries, and the technology gap was also opened [6]. Since 2012, both domestic and foreign research began to grow significantly, China's research rate has increased greatly, and Japan's research rate is comparable to enter the period of rapid development. Although we are trying to catch up, but due to the late start, the early development of slow, so that foreign countries have gained technological advantage and formed a technological monopoly, to China's current RV reducer research has caused a A very big obstacle to our current RV reducer research.

In addition, the domestic RV speed reducer market is heavily dependent on imports and China's industrial base is thin also hindered the development of domestic RV speed reducer. In recent years, although the domestic RV reducer has also realized the production of small quantities, and the index parameters are also closer and closer to the international advanced level, but not open the domestic and foreign markets, which is due to various reasons. Can not open the market, can not make a wide range of products used in various fields, can not get timely market feedback to improve products, improve technology, restricting the development of domestic RV reducer.RV reducer itself is not a complex structure, the parts are not much, but because of its work in the process of bearing a large load, the precision requirements of the process of design, analysis, materials, heat treatment, finishing processes are put forward Extremely demanding requirements, and the realization of these processes need to be supported by the entire industrial base. China's industrial development started late in the foundation of a thin base, in many aspects there is still a gap with the world's advanced level, it is difficult to meet these requirements.

4. DOMESTIC RV REDUCER DEVELOPMENT PROPOSALS

The localization of the robot reducer is the most difficult of the key components of the robot, and also has the largest gap with the foreign technology level [5]. In this paper, through the constraints on the development of China's RV gearbox technology factors, and combined with the number of Chinese and foreign patents applied for RV gearboxes and the level of scientific research, a series of analyses, puts forward the following seven recommendations to guide the future of research and development, design and production:

(1) Play a good advantage of China's system, on the basis of in-depth research, do a good top-level design and systematic planning for the development of domestic RV gearboxes. Develop good industry norms, strengthen industry management, and do a good job of talent reserves, laying a solid foundation for the development of the industry.

(2) Increase investment in financial support for relevant research to improve the RV reducer related to basic manufacturing, materials processing industry, materials research and development industry and other related industries, research and development level. For the comprehensive localization of RV reducer to lay a good technical foundation.

(3) on the existing basis to continue in-depth research, and actively innovate. At present, China's RV reducer research is in a period of rapid development, but has not yet mastered the core technology, only continuous in-depth research, in order to completely master the RV reducer design concepts, processing methods, machining processes, precision assembly and other full set of processes. Then on this basis, we can use innovative thinking to fundamentally change the design method to break through the blockade and win the market that really belongs to us.
(4) Launch scientific research on core technology. Domestic enterprises to produce precision reducer is the primary problem of poor accuracy, the machine accuracy to maintain the ability of weak, insufficient load-bearing capacity, the work of the noise is large. Only through scientific research to solve these key problems, the development of China's speed reducer can make substantial progress.
(5) vigorously carry out the RV reducer processing and manufacturing equipment, precision testing equipment and fault detection and handling system research and development. To do a good job, we must first sharpen our tools, only with the performance of these manufacturing and testing equipment related to the performance of the domestic RV reducer to get a greater increase in performance.
(6) grasp the market segments, improve after-sales service, break the market monopoly. China has now realized the RV reducer small batch production, although the performance can not be comparable with foreign advanced products, but can be adapted to the special requirements of our domestic market segments to make innovations to enter the market, and then through the domestic convenient conditions, to provide quality after-sales service to retain customers to break the monopoly of foreign manufacturers of the domestic market for the next step in the expansion of the market to get ready.
(7) Finally, enterprises should take the initiative to seek technical cooperation and exchange with foreign advanced enterprises, and improve their own products and systems by learning from the experience and technology of excellent foreign enterprises.

COMPETING INTERESTS DISCLAIMER:

Authors have declared that they have no known competing financial interests OR non-financial interests OR personal relationships that could have appeared to influence the work reported in this paper.

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