The current status and future development trends of oil-free compressor

Yi Zhang\(^1\) and Xun Qiao

School of Mechanical Engineering, Xijing University, Xi’an 710123, PR China

\(^1\)E-mail: 389909110@qq.com

Abstract. Air compressor is the main generator of air pressure. This paper mainly introduces the technical status, use classification and development trend of existing compressors. The development and gap of oil-free air compressor at home and abroad are described.

1. Selection of engine types

1.1. The concept of air compressor

Air compressor is a kind of machine that compresses air to increase gas pressure or transport gas. It seems to be a device that converts the mechanical energy of the prime mover into gas pressure energy. It is a pneumatic generating device of compressed air.

1.2. Application of air compressor

Compressor, as a kind of general equipment, is widely used in military, transportation, petrochemical, electric power, metallurgy, food, medicine, diving, fire fighting, ship, air tightness detection, marine survival training, gas separation, hazardous material treatment and other fields [1].

1.3. Classification of air compressors

Compressors can be classified according to their working principle, compression medium, exhaust pressure and series.

- According to the working principle, it can be divided into volume type and speed type.
  - Volume type is divided into: rotary type and reciprocating type: rotary type is divided into screw type, slide type, rotor type; reciprocating type is divided into piston type and diaphragm type.
  - Velocity type is divided into centrifugal type, axial flow type, jet type and scroll type.
- Pressing medium: low pressure, medium pressure, high pressure and ultra high pressure.
- By series: unipolar, bipolar and multilevel.

2. Development of compressor

2.1. Developing trend

Air compressor has a long history. The advancement of liquid supply technology promotes the rapid development of various industries, that is, the increasing demand for compressors and the continuous improvement of compressor technology level. Sulzer Company of Switzerland first developed oil-free lubrication compressor, which provides a theoretical pioneer for the study of oil-free lubrication of compressors. Since then, many countries have continuously studied the piston compressor, and more
and more new industries, new materials and new technologies have emerged. Large capacity, high pressure, high efficiency, low noise, good reliability and miniaturization are the development direction of piston air compressor nowadays [2].

Over the past ten years, swing piston compressor has developed rapidly, mainly due to the breakthrough of sealing ring material, making the life of the compressor have a qualitative leap. However, compared with oil lubricated reciprocating piston air compressor, there is still a big gap in service life and working reliability. The main reason is that under the same parameters, the working temperature of oil-free compressor is higher than that of oil-lubricated compressor, and too high temperature is a major factor leading to the decrease of the life of sealing ring. In addition, the easy damage of the valve is a major problem that has puzzled the quality of compressor products for a long time. How to improve the life and reliability of the fragile parts has become an urgent problem for this kind of compressor [3].

In order to study the valves which can satisfy the requirements of high speed compressor, the valves must satisfy the requirements of life and quality. In the process of compressor design, piston dynamics, thermodynamic calculation software and compressor simulation software should be used to improve the accuracy of simulation calculation and make the simulation process close to the actual working process of compressor, so as to improve the research and development of new products. The success rate; in addition, we need to use the three-dimensional modeling and simulation design software to build the virtual prototype model, and carry out motion analysis in the three-dimensional model. The parameters are set based on the actual working process, so that the simulated data can be closer to the actual data. In addition, problems can be found in the design stage of new products, and the compressor simulation software can also draw the motion parameters curve according to the needs, which can facilitate the comparison of compressor performance and shorten the design cycle. This is the main development direction in the future. At present, the main shortcomings of our country and the developed countries such as the United States, Germany, Japan and so on are the poor research of basic theory in our country, among which, the valve material of piston compressor can be embodied [2]; because of the lack of basic theory, the product development ability is low and the effect is not good. Developed countries have invested a lot of time and money in the application and analysis software of three-dimensional simulation modeling software, and they started relatively early. The fundamental reason why China lags behind developed countries in product development is that our investment in this area is not enough to stimulate development; the level of technology and equipment and experiment can not keep up with the development of society, and the technology content of products is low [4]. The quality reliability is poor and the types are few. Compressors manufactured in China can not meet the needs of domestic users in terms of quality, performance and service life. The key components of compressors are still in the imitation stage. There are very few patents of independent intellectual property rights in our country, which lead to the production of compressors can not reach standardization and serialization, and the reliability of manufacturing equipment needs to be improved. At present, domestic piston compressor manufacturers take the compressor with high efficiency, good reliability, low cost and low noise as the basic goal. Therefore, scientists and technicians must speed up the pace of learning new technology and mastering new technology. The state should increase investment in science and technology to support the development of new technology, so as to enhance the position and competitiveness of compressor enterprises in the international market [5].

2.2. Research status and development trend abroad

By using thermodynamics and dynamics theory, foreign researchers synthetically simulate and predict the performance of air compressor under actual working conditions in product design, and use computer automatic control to optimize energy-saving and on-line operation of compressor, so as to better realize its Mechatronics characteristics.

The piston compressor is mainly driven by rotary motor, linear type, swashplate type and rotary type.
Traditional piston compressor mainly uses rotary motor to drive crank-connecting rod mechanism, which converts the rotary motion of motor into reciprocating linear motion of piston.

Linear compressor drives piston reciprocating motion by linear motion of motor. There are three main types of compressor: electromagnetic vibration, linear motor and linear stepping motor. It has the advantages of simple structure, small size, light weight, high efficiency, low vibration and noise, and it is a new refrigeration compressor component in the refrigeration field.

The high pressure air compressor developed by HIPPAG Company is widely used in military equipment. France, Japan, Britain, Brazil and Korea have gradually shifted their research from aerospace or military fields to civilian areas.

Swashplate compressor is mainly used in automotive air conditioning system. Its technology is relatively mature and its efficiency is slightly lower than that of rotary compressor.

2.3. Current research situation and development trend in China

Compressor technology started late in China. In the 19th century, high pressure gas was needed to drive all kinds of mining machinery. Therefore, many domestic enterprises began to introduce compressors and began to research and manufacture them. In the 1950s, compressor manufacturing industry came into being in China. In 1952, Shenyang Air Compressor Factory successfully built the first piston compressor. In the early 1980s, it began to study oil-free lubrication compressor. Now compressor technology has accumulated more than 60 years of production and design experience in China. At present, domestic air compressors mainly use large air compressors. This kind of compressor is the key equipment of large compressor, and it is also a reflection of a country’s manufacturing capacity in compressor. With the development of many years, the technical design of compressors in our country has been greatly improved. Compressors are developing towards integration, batch, industrialization and intellectualization on the premise of guaranteeing quality and service life. But at present, when choosing compressors, many enterprises still consider imported compressors first, because imported compressors have reliable quality, long service life and mature technology, which make users get higher profits. The key reason for this phenomenon lies in the quality gap of the key moving parts on the compressor [5]. There is little research on miniature air compressor in China, especially in special application field or military industry field. However, Ultra, RIX and German Bao Hua have accumulated many years of design and use experience in the research of miniature and miniature air compressor. The product technology maturity is very high, and has a lot of practical applications. So there is a big gap between domestic and foreign research technology foundation and application experience.

3. Advantages of oil-free compressor

3.1. Development status of oil-free air compressor

With the increasing demand for clean and non-polluting gases in medical and food industries, oil-free compressors have entered a stage of rapid development [6]. Oil-free lubricated air compressor is widely used in petrochemical, fertilizer, pharmaceutical and other industries [7]. Oil-free compressor can produce guaranteed oil-free air to achieve true pollution-free, air quality in line with zero-grade oil-free standards, so that no additional use of filters to remove oil components will be required. Oil-free air is suitable for automobile manufacturing, food and beverage processing, chemical industry, electronics, petroleum and natural gas, textiles, pharmaceuticals, papermaking and power plants and other industries with strict air quality requirements [8]. Fully oil-free piston compressor means that there is no lubricant in the crankcase, and other parts do not store lubricant. The rotation and friction between moving parts such as crankshaft, connecting rod, piston and cylinder are mainly ensured by the rotation of bearings and the material of piston rings. The advantage of fully oil-free piston compressor is that there is no lubricant in compressed air and compressed air is clean, which is suitable for hospitals and food industry. The disadvantage of industrial use is that it can not achieve high pressure [4].
3.2. Development prospect of oil-free compressor

Oil-free air compressor first of all, the material of the machine itself does not contain oily substances, and it does not need to add any lubricating oil when working, so it greatly improves the quality of the exhausted air, and also guarantees the safety of the necessary equipment for users. But in reverse, the oil-free air compressor also has its shortcomings, that is, the life is too short [9]. Therefore, how to improve the life of all-oil-free air compressor has become a development direction worthy of study [10]. The materials used in oil-free air compressor are relatively oil-free air compressor and much more expensive. How to reduce the cost is also a problem to be overcome in use.

4. Conclusions

The application of air compressor is very extensive, and all countries are increasing investment in research. We should make full use of advanced new materials and new industrial achievements, computer technology, processing level, lubrication technology and develop industrial infrastructure to develop high-quality air compressor. The quality of the gas discharged by the oil-free air compressor is very important. The impurities in the gas should be reduced, but the filtering part should be improved without increasing the cost. Gas temperature should also be suitable, there should be a cooling part, but the content of water vapor in the gas can not be increased, so as to reduce the corrosion of seals and compressors and their follow-up work, so as to improve the life of oil-free air compressors. At the same time, the improvement and application of materials should also be constantly developed. In this way, oil-free lubricated air compressor can meet the needs of prolonging life and reducing costs.

Acknowledgements

The present study was financially supported by the Shaanxi Provincial Education Department (Grant No. 17JK1156) and Xijing University Special Research Foundation (Grant No. XJ17T09).

References

[1] Fang Xiaojui 2009 Research and Development of Piston Compressor Design Selection System Wuxi: Jiangnan University
[2] Yu Yongzhang 2000 Technical Manual of Volumetric Compressor Beijing: Machinery Industry Press
[3] Bi Wenyang, Jiang Zhinong and Liu Jinnan 2013 Fault simulation experiment and diagnosis of reciprocating compressor valve Fluid machinery 41(6) 6-10
[4] Xu Jun 2010 Design and development of 15T2 semi-oil-free piston air compressor Nanjing University of Technology
[5] Lang Qingyou 2015 Improvement and Analysis of Piston Air Compressor Shenyang University of Technology
[6] Zhang Shuai 2018 Design of two-stage bilateral large displacement oil-free scroll compressor Nanchang University
[7] Zeng Yu 2010 Ways to Improve the Service Life of Piston Ring Support Ring of Oilless Lubricated Reciprocating Piston Compressor Compressor Technology (04) 26-27
[8] Fu Tingzhen and Lin Yuchen 2016 Oil-free air compressor technology brings pure gas source to the food industry Food safety guide (07) 72-73
[9] Wu Guangzhong 2018 Optimum design of small direct piston type oil-free air compressor Compressor technology (06) 36-38+29
[10] Tian Zhengfang 2014 Structural Research and Design of Small Twin Screw Air Compressor Wuhan University of Technology