Analysis of the Research Status of Internal Combustion Engines

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Abstract. Since the internal combustion engine came out in the 1960s, it has become a relatively perfect machine through continuous improvement and development. Internal combustion engine has many advantages, such as thermal efficiency, high power, wide speed range, convenient matching and good mobility, so it has been widely used. All kinds of automobiles and tractors, agricultural machinery, engineering machinery and small mobile power stations in the world are powered by internal combustion engines. Ships, conventional submarines and some small aircraft are also propelled by internal combustion engines. The number of internal combustion engines in the world ranks first in the power machinery and plays a very important role in human activities. In the aspect of human technology, any successful invention can not be achieved overnight. The development of the internal combustion engine is the same. The internal combustion engine has gone through many stages of development and has been improved one after another. This paper mainly introduces the historical development of heat engines, and the improvement and use of different types of heat engines in the development.

Keywords: Piston internal combustion engine; Steam engine; Internal-combustion engine.

1. Introduction

Due to its high performance and high power, the internal combustion engine plays an important role in the engineering field and has a unique position. In 2017, various internal combustion engine power plants in China consumed 270 million t of commercial fuel oil, including 77.38 million t of gasoline, 167.17 million t of diesel oil, as well as lubricating oil and fuel oil, accounting for 64% of China's total oil consumption [1]. The internal combustion engine supports six development fields of China's 10 emerging industries, including aerospace equipment, advanced rail transit equipment, marine engineering equipment and high-tech ships, high-end computerized Numerical Control (CNC) machine tools and robots, energy-saving and new energy vehicles, and agricultural machinery and equipment [2]. With the low carbonization and zero carbonization of energy and the electrification and intelligent development of power plants, internal combustion engines are facing fierce competition from pure electric power and fuel cell power [3]. In the context of electrification, finding a sustainable development path for internal combustion engines is a must-answer question for internal combustion engines and related industries [4].

In this paper, the development of different types of internal combustion engines will be studied, and the problems and areas that need improvement in the current development of various internal combustion engines will be pointed out in detail.

2. Development history

In the 18th century, the first industrial revolution marked by the invention of the steam engine took place in Europe, which was also the first appearance of the internal combustion engine. In 1764, Watt improved the steam engine, making it widely used. In 1860, lenuva designed and manufactured the first practical gas engine by imitating the steam engine. In 1862, Rosa proposed the first four stroke working cycle. In 1876, Otto successfully created the first reciprocating piston four stroke internal combustion engine, which was easily fueled by gas and ignited by flame. In 1881, Clark successfully developed the first two-stroke gas engine. With the development of oil, gasoline and diesel have

attracted people's attention. In the following years, the development of internal combustion engines has been rapidly improved, entering the fast lane of internal combustion engine development. With the continuous maturity of related technologies, the internal combustion engine has gradually reached the leading level.

3. Research status of different types of internal combustion engines

3.1. Piston internal combustion engine

The piston internal combustion engine originated from the power obtained by the explosion of gunpowder. Because the combustion of gunpowder was difficult to control, it did not succeed. In 1794, the Englishman stritt put forward the concept of obtaining power from fuel combustion and first proposed the concept of mixing fuel and air [6]. In 1833, a device that directly used the fuel pressure to push the piston to do work was introduced, and this technology successfully promoted the development of the internal combustion engine.

3.2. Steam engine

At the end of the 17th century, French engineer baben designed a single cylinder steam engine. Subsequently, British engineer Safari invented the steam pump, which was a practical steam engine, which was called "friend of miners" at that time and was used for mine drainage. However, their thermal efficiency is too low. In 1706, the British engineer Newman absorbed the advantages of these steam engines and built a new steam engine. However, during the operation of Newcomen steam engine, the cylinder needs to be heated with steam repeatedly and then cooled with cold water. Figure 1 shows a schematic diagram of the structure of the steam engine [7].

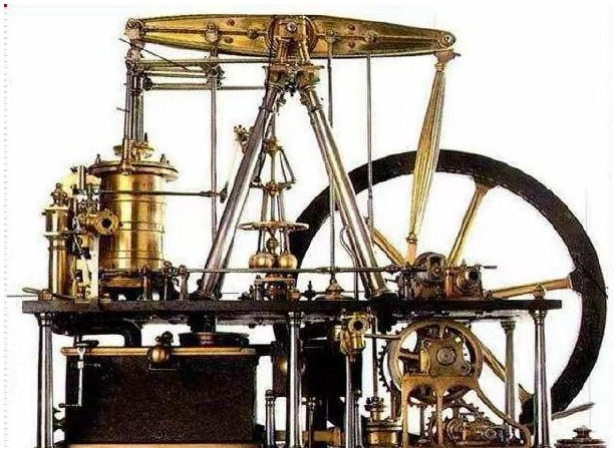


Figure 1. Schematic diagram of steam engine structure.

In 1763, J. watt (1736-1819) was engaged in instrument repair at the University of Glasgow. When he repaired the Newgate steam engine for teaching, he found through experiments and calculations that only a quarter of the steam was used for work and the rest was wasted. To solve this problem, he consulted the chemist J. black (1728 - 1799) of the same university. Blake first proposed the concept of specific heat in 1756, and found that substances need to absorb or release heat when they change from one state to another. Inspired by Blake, Watt found out the reason for the low efficiency of newcomer: in each cycle, cold water is injected to cool the cylinder and piston, and all the steam in the cylinder is condensed, and then the cylinder and piston are reheated to the steam temperature, which wastes a lot of heat. In May 1763, Watt found a simple and effective method: adding a condenser outside the cylinder to discharge the waste steam after the piston was driven to do work to the condenser for condensation. In this way, the cylinder and the piston can always be kept in a high temperature state, thus greatly saving heat [8-9].

3.3. Internal-combustion engine

In 1872, Otto established DEUTZ engine company and began mass production of internal combustion engines. In 1885, Karl Benz, a German engineer, assembled two bicycles and installed a single cylinder four-stroke internal combustion engine at the rear of the car to design and manufacture a three wheeled car [8]. And obtained a patent on January 29, 1886. In 1886, the German engineer Gottlieb transformed a four-wheel carriage. With the help of Maybach, the steering device was installed on the front wheel, the driving device was installed on the rear wheel, and the first vertical engine was placed in the middle of the body, creating the first four-wheel car. The engine is a gasoline carburetor type electric ignition, with a power of 0.368 kW and a rotational speed of 750 rpm. In 1897, the first practical high-pressure compression type automatic ignition internal combustion engine, i.e. compression ignition diesel engine, was manufactured. In 1936, Mercedes Benz produced the first car equipped with diesel engine. Figure 2 is the first internal combustion engine [10].



Figure 2. Internal-combustion engine.

In 1957, German Wankel invented the rotor piston engine. A general engine is a reciprocating engine. When working, the piston moves in a reciprocating linear motion in the cylinder. Using the crank connecting rod mechanism, the linear motion of the piston can be successfully converted into rotational motion, so as to achieve an improvement in the structural design, but the structure of the rotary engine is different [5]. The rotary engine eliminates the useless linear motion, and has no crankshaft, connecting rod and valve train. Its parts are 40% less than that of the reciprocating piston gasoline engine. It has the advantages of light weight, small volume, high speed and large power. In 1976, Toyo and Wankel signed an agreement to obtain the right to produce rotor engines. An electronically controlled six inlet rotary engine has been developed. This engine uses a microcomputer to control the engine load state, automatically adjust the idle speed device and the exhaust gas recirculation device to make the engine work smoothly, thereby reducing fuel consumption and exhaust gas emission. In 1902, Mr. Robert Bosch invented the world's first spark plug with a high-voltage electromagnetic ignition system [3]. In 1922, he invented the mechanical injection device. In 1927, he invented the diesel engine injection pump.

Through continuous efforts, the internal combustion engine runs more smoothly, the shaking is less intense, the economy is better, and the horsepower is more sufficient. However, due to the adverse impact of environmental pollution, the requirements for exhaust emissions are becoming higher and higher. The elimination of old-fashioned internal combustion engines has become inevitable, and more technologies to make full use of energy are also under constant research and development [10].

3.4. Natural gas engine

In the 1930s, the world's first engine with natural gas as the main power source was produced. Since then, the natural gas engine has experienced three rapid developments. The first great development occurred after the Second World War. At that time, oil became a relatively scarce resource. In order to solve the problem of fuel emission application of internal combustion engines, considering the characteristics and advantages of natural gas with cleanness and wide reserves, engineers and technicians began to use natural gas as a fuel for internal combustion engines [1]. However, due to the limitations of the technology and production conditions at that time, the storage

and carrying of natural gas were not convenient, so that the development of natural gas was very slow for a long time.

The second relatively rapid development occurred in the mid-1970s. After the Middle East War and the oil crisis, countries realized that their future development could not rely too much on oil resources, so natural gas was once again valued. People began to realize that natural gas will not emit black smoke after combustion, and the environmental protection value of natural gas as a fuel has been recognized by people, thus obtaining another development opportunity [10].

At the end of the 20th century and the beginning of the 21st century, the natural gas engine ushered in the third rapid development. As the global oil price continued to rise and the demand for energy increased sharply, the governments of various countries greatly increased the development and support of alternative fuels for engines. Natural gas was the most typical representative of alternative fuels at that time.

3.5. Natural gas engine



Figure 3. Natural gas engine.

Figure 3 is a natural gas engine. Ammonia engine is also a piston type two-stroke engine. The difference is that ammonia gas tank and water tank are installed on the engine body, and air passages are respectively opened on the piston and connecting rod and penetrate each other to form an integral air passage. A change-over valve is set between the crankshaft and connecting rod [4]. When the piston is in the downward formation, the connecting rod channel and the gas tank press the air into the cylinder working chamber to push the piston downward. When the piston is rising, the connecting rod is communicated with the water tank. Due to the great solubility of ammonia in water, a negative pressure collective is formed in the working chamber when it is dissolved, and an air channel is opened at the lower part to make the piston bottom bear atmospheric pressure. There is no combustion and no pollution during operation.

3.6. Hydrogen engine

Liquid hydrogen: hydrogen is liquid under certain pressure and temperature, with small volume and high energy density. Its unit heat value is about 3 times that of gasoline. However, liquid hydrogen has high requirements for the design of storage containers and thermal insulation safety [3].

Metal hydride: the metal hydride generated by the reaction of special metal and hydrogen is heated to release hydrogen as fuel. Its hydrogen storage density is suitable for the storage requirements of onboard fuel. Another advantage is that it is not easy to explode during storage and release and has good safety. However, the performance of the hydrogen storage alloy will decay with time. With repeated use, the metal will be modified, and the hydrogen storage and hydrogen release capacity will decrease. Figure 4 shows the temperature variation of the adiabatic flame of the hydrogen-air mixture.

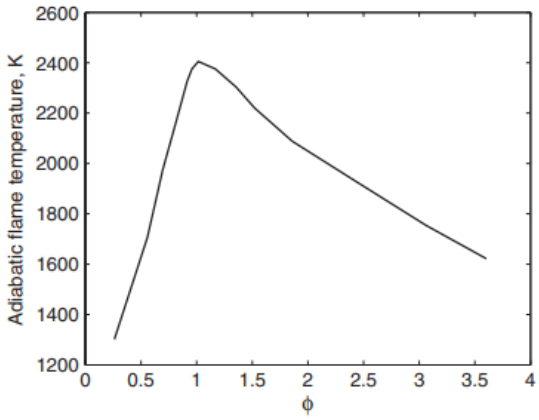


Figure 4. Adiabatic flame temperature as a function of hydrogen-air mixture concentration.



Figure 5. Schematic diagram of the hydrogen engine mechanism.

Figure 5 shows the schematic diagram of the hydrogen engine mechanism. Organic liquid hydrogen storage: this treatment method uses a catalytic device to store the hydrogen in organic liquid such as benzene and methyl cyclohexane, and the hydrogen can be safely stored and transported in these organic liquids. This method is safe in storage and transportation, low in cost and recyclable. However, the hydrogenation and dehydrogenation of organic liquids will consume more energy and require ideal catalysts.

4. Prospect

With the development of electronic technology, the electronic control technology of internal combustion engine will surely achieve a greater application rate. The control surface is wider, the control accuracy is higher, and the intelligent level is higher, so that higher work efficiency and better work effect can be achieved.

The traditional materials used in internal combustion engines are steel, cast iron and non-ferrous metals and alloys. In the process of development, people have put forward higher requirements for its economy, power and emission, so the material requirements of internal combustion engine have been raised accordingly. According to the functional requirements analysis of internal combustion engine, the main improvement directions are thermal insulation, thermal conductivity, wear resistance, corrosion resistance, small thermal expansion and light weight.

Research on internal combustion engines should first consider the requirements in terms of emissions in the future development. With the development of industrial technology, the emission standard requirements for internal combustion engines are gradually increasing. In the future development, the use of clean energy and fuel will inevitably become a new direction and research focus in the field of internal combustion engine development.

5. Conclusion

This paper analyzes the development status of different types of internal combustion engines. The development potential and existing problems of internal combustion engines are analyzed in detail from the research of internal combustion engine performance, emissions, and future development. As a large-scale engineering power plant, the internal combustion engine has an irreplaceable important position in the industrial development. In the future development process, the development of internal combustion engines will continue to develop in the direction of energy saving and emission reduction technologies. Combining internal combustion engine technology with energy saving and emission reduction will inevitably bring new dawn and hope to the development of internal combustion engines. This paper will also provide some reference and reference for relevant engineering and technical personnel.

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