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Overview of Automotive Engine Performance and New Technologies and Hybrid Vehicles

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Abstract

Automobiles and human life are becoming more and more inseparable, so the research of automobiles and the development of future technologies have become increasingly important. From the initial methods of improving the structure of fuel engines, changing manufacturing materials, and improving fuel quality, people have gradually evolved into the development of pure electric vehicles and hybrid vehicles. The power conversion of automobiles gradually changes from chemical energy, internal energy to mechanical energy to electrical energy, and even nuclear energy to mechanical energy. This paper is to introduce the recent development of new technologies related to automobile engines, as well as the future automotive technology: hybrid electric vehicles.

Keywords

Hybrid Electric Vehicles; Automobile Engine Performance; Energy Saving.

1. Introduction

The automobile is gradually evolving from a passive means of transportation to an active delivery vehicle. However, for automobiles, the most critical issues are safety issues, environmental protection issues, and energy saving. Governments and the scientific community have recognized these problems earlier, so people have gradually evolved from the initial methods of improving the structure of fuel engines, changing manufacturing materials, improving fuel quality and other methods to improve the power performance of engines and vehicles, to the development of pure electric vehicles and hybrid vehicles.

As cars become more and more widely used, cars are no longer just a means of transportation, and people have begun to pursue high-performance cars. However, while improving the performance of automobiles, it also brings many environmental pollution problems. The emergence of new energy vehicles such as hybrid vehicles is a major opportunity to improve this problem. Mr. Yu Zhisheng said in the book "Automotive Theory": hybrid as a technology, in the near future, it will be an important transition technology for fuel cells to replace internal combustion engines, and the opening of fuel cell hybrid vehicles will play an important role. Based on the above, this article aims to analyze the factors influencing the performance of automobile engine systems and briefly introduce the related technologies of hybrid vehicles.

2. Introduction to Engine Technology Development

2.1 The Main Influencing Factors of Engine Combustion Performance

2.1.1 Air-fuel Ratio (Excess Air Coefficient)

The ratio of the actual amount of air supplied by burning 1kg of fuel L to the amount of air required for complete combustion in theory is called the excess air coefficient, and the concept of air-fuel ratio is similar, air-fuel ratio:$L_0 \emptyset_a$

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$$\alpha = \frac{\text{Air volume}}{\text{Amount of fuel}} = \frac{\text{Amount of fuel} \times \emptyset_a \times L_0'}{\text{Amount of fuel}} = \emptyset_a L_0' \quad (1)$$

L_0'It is the air-fuel ratio of fuel stoichiometry when the excess air coefficient is equal to 1.

When $\emptyset_{aP} = 0.8\sim0.9$,the hysteresis period is the shortest, the combustion speed is the highest, and the engine output reaches the maximum. When $\emptyset_a < \emptyset_{aP}$,in the flame zone, due to the lack of oxygen, the flame propagation speed is reduced, the pressure temperature is reduced, the combustion time is prolonged, the heat transfer loss and incomplete combustion loss are increased, so that the power decreases, the fuel economy also decreases, and the emission of CO and HC will also increase. When $\emptyset_{ab} = 1.03\sim1.1$,the combustion rate will be slightly reduced, but at this time, for the injected fuel, the amount of oxygen is sufficient, which can promote the complete combustion of the fuel, so that the fuel consumption rate is the lowest, but the power is reduced, and at this time, due to the high temperature and high oxygen content, the emission of nitrogen oxides is the largest. When $\emptyset_a > \emptyset_{ab}$,with the increase of the excess air coefficient, the laminar flame propagation speed is significantly reduced, the combustion process is lengthened, and the thermal efficiency is reduced, so that the power decreases and the fuel consumption rate increases.

2.1.2 Compression Ratio

The compression ratio refers to the ratio of the upper space volume of the piston when the piston runs to bottom dead center to the upper space volume of the piston when the piston runs to top dead center. That is, the ratio of the maximum volume to the minimum volume.

In principle, if the compression ratio is large enough, the pressure and temperature of the mixture will be higher at the end of compression, the combustion rate will increase, so the combustion efficiency of the engine will become better, but in practice, the compression ratio of the engine cannot be too high, because for the gasoline engine, the compression ratio is too high to produce deflagration, which will cause the engine to burn abnormally, which will damage the engine performance and life. For diesel engines, the mechanical load with a high compression ratio will become larger, so the compression ratio cannot be selected too large.

2.1.3 Gas Distribution Phase

The crankshaft angle corresponding to the intake valve and exhaust valve of the engine according to the moment when the engine's working cycle opens and closes is called the gas distribution phase angle, also called the gas distribution phase. Whether the gas distribution phase is accurate has a great impact on the power, economy and environmental protection of the engine. Inaccurate gas distribution phase will lead to insufficient intake and unsmooth exhaust, which will affect the formation quality of the mixture, cause incomplete combustion, reduce the power of the engine, increase fuel consumption, and greatly increase carbon monoxide, nitrogen oxides and hydrocarbons in the emission pollutants.

2.1.4 Injection and Intake Volume, as well as Injection Pressure and Intake Pressure

The engine runs under different working conditions, and the requirements for the concentration of the mixture are also different. For diesel engines, diesel engines rely on spontaneous combustion of fuel to do external work, and the degree of atomization of diesel will affect the combustion performance of the engine. For gasoline engines, different proportions of fuel mixture should be configured; For diesel engines, the corresponding amount of fuel injection should be controlled. At the same time, appropriate intake pressure and fuel injection pressure should be provided under different working conditions, so as to further improve the fuel economy of the engine and improve the power of the engine to a certain extent.

2.2 Introduction to New Engine Technologies

2.2.1 Electronic Control Technology and Direct Injection Technology in the Cylinder

Electronic control technology is evolved from mechanical control technology, the biggest difference between the two is that electronic control technology can play a real-time regulation under various

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changing working conditions, so as to achieve the engine compression ratio, Comprehensive optimization of performance parameters such as air-fuel ratio, gas distribution phase, intake oil intake and pressure. Microcontroller is the core of engine control technology, and plays a large role in information storage, calculation and output in the process of real-time control [1].

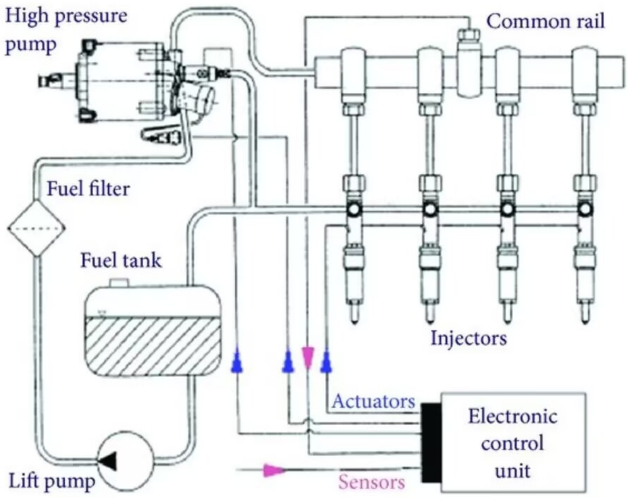

Figure 1. Common rail injection system

Compared with other types of engines, the main feature of in-cylinder direct injection engines is the difference in fuel injection position [2]. The direct injection engine can use the fuel in the cylinder to directly inject fuel in the cylinder, and directly mix with the gas in the cylinder to achieve the conversion of heat energy, which has many similarities with the direct injection diesel engine. At present, the cylinder direct injection engine is also a relatively good form of engine with relatively good energy-saving effect.

2.2.2 Compression Ratio Improvement with Variable Compression Ratio Technology

Through the increase of the compression ratio, the engine power performance is improved, while the fuel consumption is correspondingly reduced, in theory, the greater the compression ratio of the automobile engine, the better. However, the effect of deflagration needs to be considered in actual automobile manufacturing, because the ignition engine currently used has a certain limitation on the compression ratio, and cannot cause deflagration of the engine [3].

The SVC engine developed by Swedish engineer Saab to change the compression ratio to control the engine's fuel consumption. Its core technology is to install a wedge slide between the cylinder block and the cylinder head, and the cylinder block can move along the slope of the slide, so that the relative position of the combustion chamber and the top surface of the piston changes, changing the passenger volume of the combustion chamber, thereby changing the compression ratio [4].

2.2.3 New Combustion Technology

(1) Homogeneous charge compression ignition technology (HCCI).

HCCI significantly increases the compression ratio. When the compression stroke of the gasoline engine is almost over, the gasoline is injected into the cylinder through the direct injection nozzle, because the HCCI engine compression ratio is higher than that of the ordinary gasoline engine, so the small oil droplets ejected have time to form a uniform distribution in the cylinder when the compression stroke is completed, at this time the pressure of the cylinder is enough to make the evenly distributed oil droplets automatically compress ignition, and all the fuel is ignited at the same time, thus Improve the efficiency of fuel use, and because it adopts compression ignition, the mixture can be made thinner, and when the mixture is chemically reacted, the reaction speed and acceleration of each point are consistent, so it has the characteristics of explosive combustion. HCCI engines have low combustion temperatures and low heat transfer to the combustion chamber walls, which can

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reduce the transfer of radiant heat and greatly reduce the formation of nitrogen oxides. Another feature is the short combustion cycle [5].

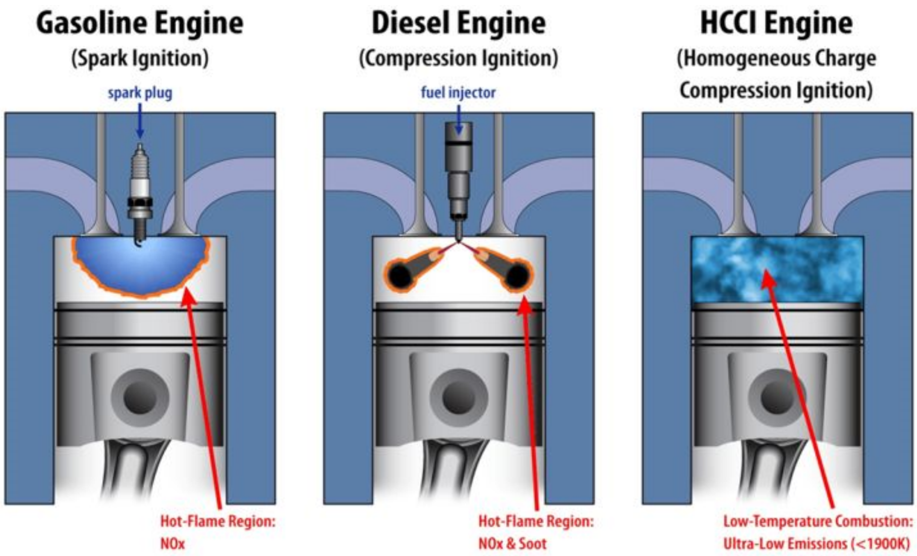

Figure 2. HCCI engine compared to conventional gasoline and diesel engines

(2) Stratified combustion technology and lean combustion technology

Stratified combustion technology in the cylinder realizes stratified combustion through secondary oil injection. When the piston of the intake stroke of the engine is moved to the bottom dead center, the ECU controls the fuel injection nozzle to inject a small amount of oil, so that a thin mixture is formed in the cylinder; A second injection is performed at the end of the piston compression stroke, so that an area with a higher relative concentration of the mixture is formed near the spark plug, and then this part of the concentrated mixture is used to draw the lean mixture in the cylinder.

Lean combustion technology is a technology that uses lean mixture to drive the engine to do work, lean combustion not only realizes the full use of fuel, but also greatly reduces the loss of engine ventilation, and can also reduce pollutant emissions.

(3) Biomass to Liquid Fuel (BTL)

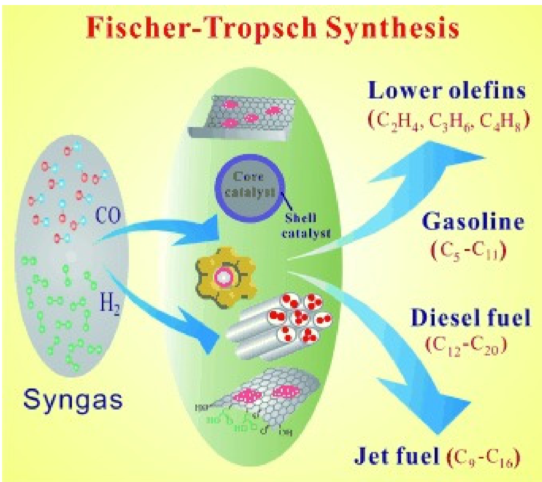

Figure 3. Fischer-Tropsch reaction schematic

BTL is actually a synthesis gas that turns biomass energy into CO and H_2 then reacts with Fischer Tropsch (Fischer-Tropsch reaction) to make synthetic fuel. This fuel source is abundant, renewable, and also has the properties of gaseous fuel, HC, CO and nitrogen oxides after combustion emissions

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are small, and the emitted carbon dioxide can be absorbed by plant photosynthesis, fundamentally solving the greenhouse effect problem, but also does not contain sulfur, will not cause acid rain [5].

3. Hybrid Electric Vehicle Technology Development

3.1 Classification of Hybrid Vehicles

For hybrid electric vehicles (HEV), according to the energy coupling method of combining the power source, it can be specifically divided into three types, namely parallel hybrid vehicles, series hybrid vehicles and hybrid vehicles. Hybrid vehicles can be classified as a percentage of the total output by electric power, which can be divided into three types of hybrid vehicles: mild, medium and heavy.

3.1.1 Structural Classification

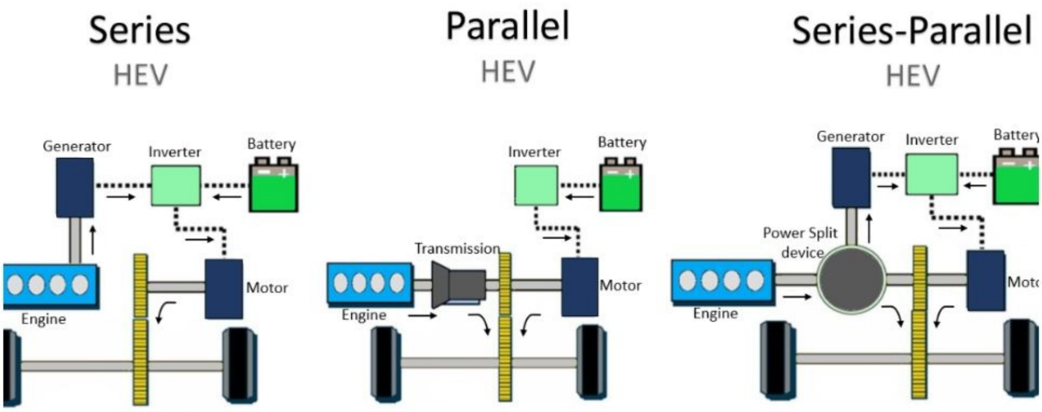

Figure 4. HEV types

Combined with the connection form between the motor, engine and transmission system of a gasoline-electric hybrid vehicle, the structural form of hybrid vehicle can be divided into the following three types, including hybrid (Parallel-Series) type, parallel type and series type.

3.1.2 Mix Degree Classification

Combined with the mixing degree of gasoline-electric hybrid vehicles, that is, according to the proportion of electric power in the total power, gasoline-electric hybrid vehicles can be specifically divided into light, medium and heavy hybrids.

3.2 Introduction to the Structure of Hybrid Vehicles and Analysis of Working Principle

The structure of series hybrid vehicles is relatively simple, the engine drives the generator to generate electricity, the generated electrical energy is provided to the motor through the motor controller, and then the motor is converted into kinetic energy to drive the vehicle. The power battery regulates the electrical energy generated by the generator and the electrical energy required by the electric motor to meet the power demand of the car under various driving conditions. In the event that the generator stops working or the electrical power is insufficient, the battery can provide electric energy for the motor.

In the case of parallel hybrid systems, the system drives the vehicle via the respective drive lines of the internal combustion engine and electric motor. The electric motor and the combustion engine are arranged in parallel, and the power can be provided separately or in combination. In a parallel hybrid system, the electric motor is also a generator, and its function is to bring the engine as close as possible to the most efficient state, so as to achieve the effect of fuel saving. However, when the system plays a power assist role, it is limited by the capacity of the battery.

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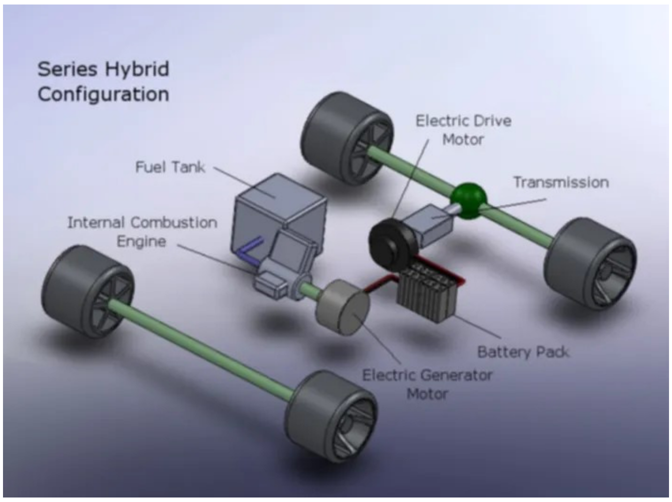

Figure 5. Series Hybrid Configuration

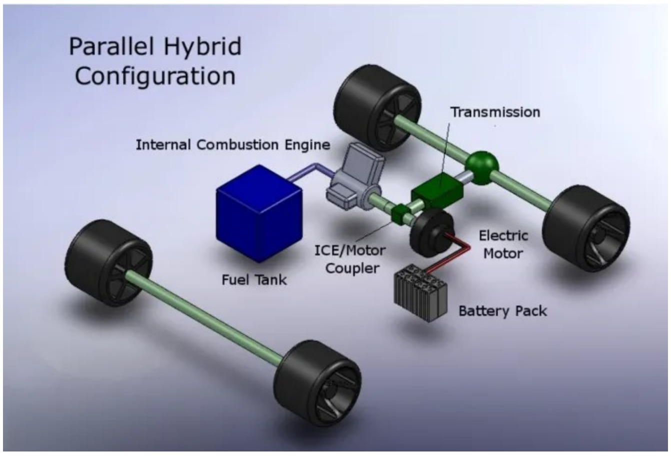

Figure 6. Parallel Hybrid Configuration

The parallel-Series hybrid system is relatively complex, and it combines the advantages of series and parallel construction. Compared to series hybrid vehicles, it increases the transmission route of mechanical power. Compared to parallel hybrid vehicles, it increases the transmission route of electric energy.

3.3 Advantages in the Development of Hybrid Vehicles

3.3.1 Relatively Lower Operating Costs and Higher Retention Rates

With the continuous increase of gasoline prices, fuel vehicles have become a high consumable, resulting in a large number of users turning to hybrid vehicles, and the depreciation of fuel vehicles in the second-hand car market is serious, on the contrary, the retention rate of hybrid vehicles is higher.

One of the biggest advantages of hybrid vehicles over gasoline vehicles is that they are cleaner, have higher fuel efficiency, and can travel longer distances with the same fuel consumption than gasoline vehicles.

3.3.2 Higher Energy Utilization and Work Efficiency

For hybrid vehicles, the compensation effect of its energy storage elements smoothes the fluctuation of the working conditions of the internal combustion engine, and can absorb and store electric energy in the general driving of the car, and provide electric energy when high power is required, so that a small engine can be used in the hybrid drive system, and the working point of the engine can be in the optimal working area with high efficiency.

Hybrid electric vehicles can save fuel by shutting down the internal combustion engine when the car is parked and waiting or taxiing at low speeds. And when the car decelerates and coasts or brakes urgently, the generator can be used to recover part of the braking energy and convert it into electrical energy to store in the battery, thereby further improving the fuel economy of the car.

3.3.3 Hybrid Vehicles Perform Better than Pure Electric Vehicles

The battery capacity of hybrid vehicles is further reduced, which can reduce the quality of the whole vehicle and facilitate lightweight design. At the same time, hybrid vehicles use auxiliary power drive, which is conducive to alleviating the range limitation of pure electric vehicles and helping to improve power. Real-time and dynamic optimization control strategies are adopted in hybrid vehicles to make the components of the whole vehicle work in the best condition and the highest efficiency area [6].

Acknowledgments

In general, the three biggest problems facing today's automobiles - environmental protection issues, energy saving problems and safety issues - have been improved to some extent through the development of hybrid vehicles. Traditional engines will not disappear with the development of electric vehicles, on the contrary, the combination of traditional engines and electric motors may have a greater guiding role in the development of automobiles. The development of automobiles may still face many unknown problems, ever-changing, we need to pay attention to environmental protection, energy saving and safety issues, so that automotive technology can get a qualitative leap.

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