

# Traditional Engines Versus All Kind of Alternatives

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**Abstract.** Nowadays, driven by the transformation of global energy structure and the goal of 'carbon peaking' and 'carbon neutrality', renewable energy industries are growing exponentially, the technical path selection of new energy power systems (including pure electricity, hybrid, hydrogen fuel cells, etc.) has become the core of research in the field of transportation. Although the renewable energy has a mature technology, there are still several issues need to be solved. The internal combustion engine power system still has advantages in terms of long endurance, high-load adaptability and existing infrastructure compatibility. In contrast, the pure electric system is limited by battery life and charging infrastructure coverage, and the hydrogen fuel cell systems faces the bottleneck of high hydrogen storage costs and insufficient layout of hydrogen filling stations. This paper will demonstrate the structure of different kinds of engines, comparison through various factors, and the future developing trend.

**Keywords:** traditional engines, alternative engines.

## 1. Introduction

Among the world, the government are encouraging the research and development on alternative engines. In China, the technology of electric and hybrid engine has developed very maturely, and government are also focusing on hydrogen engine. In recent years, the thermal efficiency of the in-cylinder direct injection hydrogen internal combustion engine developed by Beijing University of Technology has reached the world's leading 46.1%, and has realized industrial development in FAW, Weichai and other companies. In Europe and American, some car companies like BMW are developing hydrogen fuel cell system which has a 25% reduction in volume, and the efficiency has been significantly improved. There is also an increasing amount of government support on hydrogen in the US and Europe. The United State extends the tax credit for clean hydrogen production until 2028, with a maximum subsidy of 3\$ per kilogram of green hydrogen; the EU Hydrogen Energy Bank plans to invest 5.7 billion euros to support development of the industrial chain [1].

This essay includes three main topics, the structure and working principle of different engines, comparison through economy, environment and performance, and the future trends. For traditional engines, the contents will focus on the performance and structure of SI and CI engines, which are two main types of fossil fuel engines in the world. For alternatives engines, the contents will focus on hydrogen engine and hybrid engine.

## 2. Structures of Traditional Engines and Alternative Engines

### 2.1. Traditional Engine

#### 2.1.1. SI engine

The full name of SI engine is called Spark Ignition engine. It is a type of engine in which the combustion takes place by the spark generated by the spark plug. It uses petrol as fuel and works on Otto cycle. In the spark ignition engine, the air-fuel mixture is inserted into the cylinder with the help of carburetor. The compression of the fuel takes place but it has a low compression ratio. The fuel is ignited by the spark generated by the spark plug.

### 2.1.2. CI engine

The full name of CI engine is called compression ignition engine. Instead of using a spark delivered by the ignition system, the diesel engine uses the heat produced by compression air in the combustion chamber to ignite the fuel. Fuel injectors are used to supply fuel directly into the combustion chamber. The fuel is sprayed, under pressure, from the injector as the piston completes its compression stroke [2].

### 2.1.3. Strokes

Four-Stroke: Four piston movements over two engine revolutions for each engine cycle

Two-Stroke: Two piston movements over one revolution for each engine cycle [2].

A four-stroke engine is an ICE, in which the piston completes four separate strokes. These are: Intake stroke, compression stroke, power stroke, exhaust stroke.

## 2.2. Alternative Engine

### 2.2.1. Hybrid engine

Hybrid engine can be classified into parallel hybrids and series hybrid. Parallel hybrids are set up to use the gasoline engine or the electric motor to drive the car. The electric motor gets the nod at lower speeds. After a delayed restart, the gasoline engine joins in and eventually takes over as speed climbs and settles into a cruise [3].

Series engine also uses a primary drive motor that propels the vehicle using regen-collected battery energy at low speeds and scavenges energy when slowing [3]. Once speeds climb and that energy runs low. The engine switches on to drive a second dedicated generator that turns gasoline power into electricity to keep the battery fed.

### 2.2.2. Hydrogen engine

In hydrogen engine, hydrogen is stored in high-pressure tanks or in liquid form, requiring special materials to withstand the pressure and low temperatures. It is then mixed with air and ignited, producing energy that drives the pistons [4]. The reaction can produce nitrogen oxides as a byproduct, which are pollutants formed at high temperatures.

## 3. Comparisons

### 3.1. Performance Comparison

#### 3.1.1. Performance of traditional engine

One of the series problems of traditional engine is the extreme high standard for exhaust emissions which requires expensive and bulky after-treatment of the exhaust gases. Some countries often have strict limit on the amount of carbon dioxide emission. In order to follow the regulations, the car companies have to reduce the output value, which reduces the fuel efficiency and power of the engine. To indicate thermal efficiency, traditional engines require the maximum combustion pressure to be between 12 and 15 crankshaft angles. When the maximum combustion pressure is near the top stop point, the maximum piston force at 0 degrees is greater than at 13.5 degrees. Fuel combustion duration requires 50 to 60 crankshaft angles [2]. However, without considering the fuel costs and environmental impact, traditional engine is the most potential engine that can produce the greatest power.

#### 3.1.2. Performance of hydrogen engine

The unique combustion characteristics of hydrogen that allow clean and efficient operation at low engine loads present difficulties at high engine loads. Here, the low ignition energies of hydrogen-air mixtures cause frequent unscheduled combustion events, and high combustion temperatures of mixtures closer to the stoichiometric composition led to increased NO<sub>x</sub> production [4]. Both effects, in practical application, limit the power densities of H<sub>2</sub> ICEs.

### 3.1.3. Performance of hybrid engine

During low speed, electric motor motivates the car. Electric motor can produce greater acceleration during low speed than petrol engine. Later when the car achieves a higher speed, the petrol engine kicks in and the car runs both on the motor and the petrol engine [5]. Electric motor usually can produce 200-400 horse power, and petrol engine usually produces 200-600 horse power. This combination is controlled by the power control unit which manages the power for the maximum efficiency.

## 3.2. Economy and Environmental Impact Comparison

### 3.2.1. Traditional engine

From the perspective of China's independent oil extraction and actual demand, China relies heavily on imported oil. China's average annual newly discovered petroleum geological reserves available for development were below  $10 \times 10^8$ t from 2016 to 2018 [4]. As the consumption of oil increase rapidly, in order to achieve the balance of supply and demand, the price of oil increase significantly. Also, transporting oil includes a huge amount of costs, such as the protection and container used in transportation. Therefore, the price of oil is relatively high for ordinary people. Considering about the environmental impact, the environmental pollution of gasoline vehicle is a big problem. The exhaust gases emitted by individual cars are caused by insufficient combustion of automobile fuel, and its main components are a combination of different kinds of pollutants such as carbon dioxide and carbon monoxide. The carbon dioxide can cause the greenhouse effect and drive global warming. Excessive inhalation of carbon monoxide can lead to human blood poisoning, which can be fatal in severe cases.

### 3.2.2. Hydrogen engine

Hydrogen engine is the engine that with almost zero emissions. The ability for hydrogen engine to operate with near-zero engine-out emissions is primarily owed to the coupled effect of two characteristics unique of hydrogen. Nitrogen oxides are the only undesirable engine out emissions, formed by the thermal dissociation and oxidation of  $N_2$  in atmospheric air during combustion, and the low lean- flammability limit of hydrogen allows stable combustion of at highly dilute conditions. This coupled effect is that during ultra-lean operation, combustion temperatures are low enough such that  $NO_x$  formation rates are too slow and engine-out emissions are near zero.

Hydrogen has a extremely lower density compared to petrol. For example, 50L of petrol can be stored in a 72L and 84kg tank, whereas the same amount of energy in hydrogen requires a cylindrical tank with 272L and 129 kg [1]. This will increase the storage cost of hydrogen, which makes it unaffordable by people. Also, around the world, the numbers of hydrogen filling stations are less than 1200, which are not able to support a large scale of hydrogen vehicles to operate.

### 3.2.3. Hybrid engine

Hybrid vehicle can include battery electric vehicle. Battery electric vehicle is totally powered by electricity, so there is zero emission. For hybrid engines that are powered both by petrol and electricity, they emit relatively less carbon dioxide and harmful gases compared to traditional engines. Considering about the economy, hybrid vehicles have significant advantages than traditional engine. As the paper mentioned above, electric motor motivates the car during acceleration at low speed. During low-speed acceleration, the engine requires the greatest power, which requires the greatest amount of petrol. Therefore, hybrid vehicle is eco-friendly, especially when driving in urban area.

## 4. Future Trend

Nowadays the traditional engine is still popular among the world, this is mainly due to its stability in performance and considerable price. In the future, traditional engine can improve their thermal efficiency through technological innovation. For example, the Toyota Dynamic Force engine breaks through 50% thermal efficiency, and Volkswagen's fifth-generation EA888 engine adopts VTG

variable cross-section turbine technology to solve the problem of turbine hysteresis [6]. Meanwhile, the application of low-carbon fuels such as biodiesel and methanol and synthetic fuels can make existing fuel vehicles carbon neutral.

The world is experiencing an increase in the investment in hydrogen power. Japan plans to build 1000 hydrogen filling stations in 2025, the global investment in hydrogen energy exceeds 110 billion US dollars. However, the storage and transportation technology are still bottlenecks. Unless these difficulties can be solved in the future, hydrogen power cannot be widely used among the world.

Hybrid vehicles is developing rapidly in recent years. Benefits from its low carbon dioxide emissions and good fuel efficiency, more and more car companies such as Toyota and BMW are producing hybrid vehicles. They will continue to fill the market gap between pure electric and fuel vehicles, and it is expected that the global sales will exceed 7 million in 2030.

## 5. Conclusion

This paper firstly introduces the structure of traditional engines, hydrogen engines and hybrid engines. Comparison between these engines is shown in the second part, it mainly compares about performance, environmental impact and economy. In the last part the paper shows the future developing trend of these three engines. The pollution caused by traditional engine should not be ignored, and the government should encourage more production in hybrid and hydrogen vehicles, in order to reduce the greenhouse effect caused by fuel vehicles. The improvement of new energy vehicles, both in terms of cruising range and battery life in a short period of time, is huge. In this way, the dominance of hybrid engines in the automotive field is about to come.

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