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Prime traits of diesel engine and its future next stop

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Abstract. These days, with the appearance and advancement of a variety of energy vehicles on the road, such as new energy vehicles, and trams, they are growing in popularity. The benefits of diesel cars have also grown in importance to individuals due to their development. The diesel engine's properties and proposals for its future development and improvement serve as the foundation for this article. The relevance and uniqueness of the diesel engine are first demonstrated by listing its important advantages. Highlight the special benefits of diesel engines and their significance, primarily by comparing diesel and gasoline engines. Then it leads to its flaws and upgrades or fixes provided by the technology and the fuel. Finally, it was determined that the diesel engine is a necessary engine that would not disappear due to the development of new technologies but rather continue to advance and gain significance through time.

Keywords: diesel engine, low emission, high safety, improvement.

1. Introduction

Diesel engine is a term used to describe a particular type of tiny power generation device that uses diesel fuel as its primary propulsion source. The ingenious design is inseparable from the innovation of great men in history. In 1892, German engineer Diesel envisioned that if the air inhaled into the cylinder is highly compressed, its temperature exceeds the spontaneous combustion temperature of the fuel, and then the fuel is blown into the cylinder with high-pressure air to make it burn. Then during 1893-1897, he optimized many aspects of engines, and he finally operated the Rudolf Diesel engines and tried to accomplish the Carnot cycle, but he actually made the isobaric combustion and attained thermal efficiency of 26%. Then the introduction of exhaust gas turbocharging, diesel fuel injection pumps and rotary piston diesel engines promote the development of diesel engines [1].

This improvement made the foundation of modern diesel engines. Nowadays, diesel engines are renowned for their high thermal efficiency, compact structure, strong maneuverability, and easy operation and maintenance. It is versatile because it has been used in many aspects, like cars, marine diesel engines, railway traction, etc. For example, Volkswagen Golf is a typical diesel car whose sales are high in current years, which means the demand for diesel cars is constantly high. Therefore, diesel cars must have some special properties to attract owners. Particularly, diesel engines use different combustion types from gasoline engines. It uses the compression ignition type, which uses compressed air to spontaneously ignite the fuel and create a strict environment. In that case, it enables the machines to attain higher efficiency; however, with the problems of the environment and the development of introduction of other new kinds of cars, like new energy vehicles (NEVs), electric vehicles (EV) and so on. Some disadvantages of diesel engines have become more obvious to the public. Especially the

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pollution they produce. These shortcomings make diesel engines less competitive than other kinds of engines. To resolve the problems the diesel engines meet, the reform and optimization of its system, or the recommendations for society, become even more important.

2. Distinct merits of diesel engine

2.1. High safety

High safety plays an important role in the merits of diesel engines. Low volatile contents are easily volatilized on hot days and cause a fire. However, Diesel oil is difficult to evaporate because it has a lower volatile content like methyl alcohol or ethyl alcohol. These two kinds of liquids are easy to evaporate. In addition, for transportation, the flash point is vital. The flash point is the lowest point at which materials or products flash and burn immediately when they form a mixture with the outside air and come into contact with the flame. Indicating the evaporating tendency of a material or product and its stability after being heated. The normal flash point of diesel engines is 55-65 degrees Fahrenheit, but the gasoline is -40~-12 degrees. Therefore, it is safer to transport products with diesel engines but not gasoline ones.

2.2. Low emissions

Secondly, in light of increasing concern about environmental protection, the amount of emissions has become a more important part for people to concern. Therefore, the low emission of one kind of engine becomes the better choice for car owners. Gasoline and diesel engines are the two main kinds of internal combustion engines. The comparison between diesel and gasoline engines mainly depends on their different combustion modes. Gasoline engines use spark ignition combustion, while diesel engines use the compression combustion mode.

The spark ignition combustion mode relies on an electric spark to ignite a gas mixture, making it easy to burn incompletely. In that case, it will produce a lot of carbon monoxide. However, about the compression ignition type, in that environment, the gas's temperature and pressure will increasingly sharply aerate a pretty high-pressure and high-temperature environment. Therefore, it is less possible to produce CO. Regarding the fuel, the energy density of the diesel engine is higher, and the fuel's energy density will affect the engine's effectiveness and the production of the amount of carbon dioxide. Consequently, diesel engines will produce less carbon dioxide in the production.

2.3. Exceptional durability

The third important quality that clients should consider is durability. Due to the thickness of the tank and the dueling component, diesel engines have an exceptionally long lifespan. Regarding fuel, the diesel engine's fuel has the advantage of not aging. It shows the fresh and the aged surface area of the 1 wt.% Pt powder model catalysts and the mean Pt crystalline sizes evidenced by X-ray diffraction (XRD) [2]. The Zr Si, Zr Si W, and Zr Ti Si W are three components that are good for keeping fresh and are also utilized in some diesel engines, which indicates the extraordinary durability of the diesel engines, based on analysis of the lines of clothing and the aged ones. The diesel engine's tank is particularly thick due to the high temperature and high-pressure atmosphere.

2.4. Low fuel consumption

Lastly, maintaining low emissions is crucial as fuel costs continue to rise. Diesel engines have minimal fuel consumption. Fundamentally, the benefit of the fuel itself cannot be disregarded. Figure 1 shows that the engine using diesel fuel (FDD) had the lowest fuel use per hour, whereas the mixture (HVO5), which contained 5% (v/v) hydrotreated vegetable oil (HVO) and 95% (v/v) FDD, had the highest.

In addition, as we know, diesel engines are used in many applications. Marine diesel engines are a typical example.

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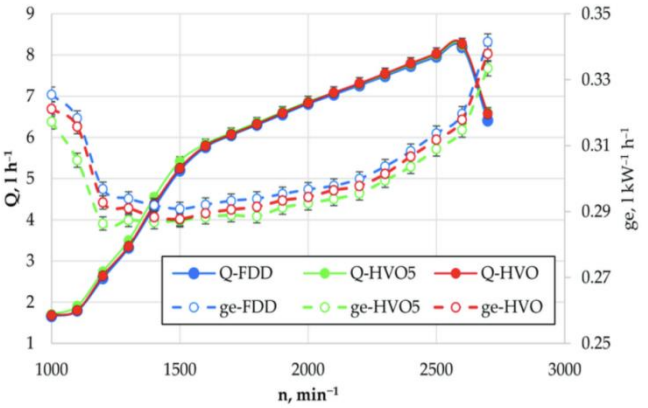

Figure 1: Fuel hourly consumption Q (1 h^{-1}) and specific fuel consumption ge (1 kW^{-1} h^{-1}) data for all three tests fuels based on crankshaft revolutions of the engines [3].

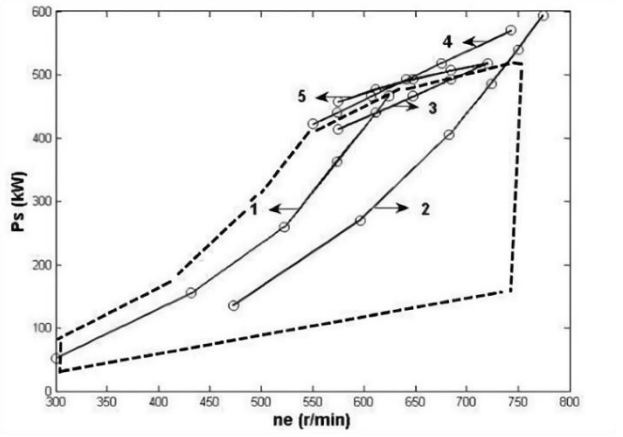

Figure 2. Diesel engine power curves [4].

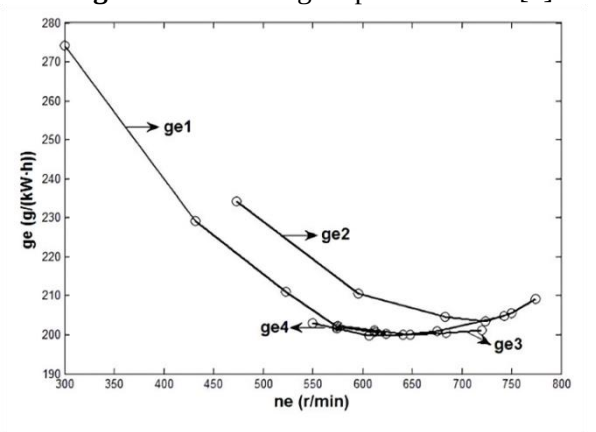

Figure 3. Fuel consumption rate curves [4].

The data on the maximum load speed characteristic test, torque test, and other diesel engine propulsion characteristics tests are included in the test results for the XCW6200ZC medium-speed marine diesel engine used in inland ships. A future diesel engine oil consumption rate curve is created using the results from the engine bench test, and it includes curves for propulsion characteristics and torque linked to the relationship between speed and fuel consumption rate, represented by these graphs ge1, ge2, ge3, and ge4. The fuel usage lowers as diesel engine power increases. As a result, it demonstrates the low consumption of diesel engines.

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3. The emissions of diesel engines and solutions

3.1. Soot emissions

Based on what has been said above, however, diesel engines have many disadvantages, like soot, noise and NOx, which will mainly affect the environment. Firstly, about the soot, the production of soot in the diesel engine is more than the gasoline engines. This is because gasoline engines' air and fuel combination process is carried out uniformly before ignition under nearly stoichiometric (chemically accurate) conditions, and soot release is less. However, since fuel is injected into the air in diesel engines and combustion may occur while fuel is still injected, areas with high fuel concentrations are ideal places for soot, especially at high loads and speeds. [5]. Other elements like hydrogen and oxygen are often present in trace amounts during the high-temperature pyrolysis or burning of hydrocarbons, predominantly carbon, which results in soot formation. It frequently has a soluble organic fraction (SOF) with aromatic molecules and other unburned hydrocarbons as its main components. This soot can harm people's health, especially the respiratory tract, making people susceptible to lung disease. We can use a diesel particulate filter (DPF) and the Bunsen burner to reduce it. By exploiting the Venturi effect, a high-speed fluid flow creates areas of low pressure around it, pulling in neighboring air. The Bunsen burner achieves total combustion of the system by forcing air into the gaseous fuel stream. The Venturi effect in that situation ensures that a Bunsen burner will inject more oxygen into the fuel stream. According to this circumstance, extra fuel will totally burn. [6].

3.2. NOx emissions

Additionally, the emission of NOx is a big problem affecting the environment of diesel engines. Table 1 indicates that the NOx and CO_2 emissions are large. NOx, in particular, can cause great harm to the human body and the environment. It can cause people to get respiratory infections. For the environment, it may cause the formation of acid rain [7].

Table 1. Pollutant emissions from a typical low-speed diesel engine burning low-quality fuel (unit: g/kW·h) [7].

Operating Mode	NOx	SOx	CO_2	PM	VOC
Normal sailing	17	10.5	620	1.7	0.6
Idle or berthing state	13.6	10.6	68.2	2.4	1.8

Selective catalytic regulation (SCR) technology is a useful solution for NOx emissions in diesel engines since it may reduce NOx output. Urea solution injection systems, mixers, SCR reactors, measuring systems, and soot-blowing systems comprise most marine SCR systems. To improve the consistent mixing of exhaust gas and ammonia gas, a static mixer is additionally fitted in the exhaust pipe of the maritime SCR system. It is mainly made up of a few baffles facing various directions. The exhaust gas's airflow is altered, resulting in turbulent flow in various directions. Using this technique, the urea can flow and mix quickly in all directions, improving the cross-section's concentration distribution homogeneity. The mixer can completely combine the exhaust and ammonia gas but will also lose some pressure. In addition, Ammonia (NH_3) is used in the selective catalytic reduction process to eliminate NOx [7,8].

3.3. Trade-off between NOx and soot

Diesel combustion is more energy-efficient than gasoline but results in dangerous NOx emissions. In a typical diesel engine, hazardous emissions are reduced via dilution, a process in which spent, low-oxygen combustion gases from the prior engine cycle are sent back into the air intake. This is called the

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soot-NOx trade-off. A method called premixed compression ignition (PCI) solves this. Lowering the temperature and oxygen content of the fuel-air mixture this process lowers the amount of nitrogen oxides produced. However, not all fuel is burned when the temperatures are lower than typical of this popular NOx-mitigation technique. More soot, or particles of partially burned carbon, are always produced by what is left over. Diesel engineering has struggled with the soot-NOx trade-off time and time again [6]. Encouragement of premixing based on ethanol blend fuel with low evaporation temperature, high latent heat, and low cetane number is one way to handle this problem. Premixing is another method that relies on the fuel's significantly longer ignition delay and low oxygen intake charge [9,10].

4. Conclusions

Diesel engines have significant merits, such as high safety, high efficiency, relatively low emissions compared to other engines, and high economy. Therefore, it can be used in various fields, such as cars and Marine diesel engines. Also, on its derivatives, bio-diesel has corresponding advantages. In addition, the diesel engine also has some corresponding shortcomings, mainly reflected in the pollution of the environment, but we can solve these problems by corresponding means, such as the Bensen burner and DPF, to resolve the problems of the soot. It is because it pushes more oxygen into the combustion system and lets it combust more completely.

Moreover, the technology called SCR is applied to the problems of NOx. This system mainly uses ammonia (NH_3) to decrease the production of NOx. In addition, the soot-NOx trade-off is an important problem that needs to resolve, and the PCI is a good technology for it because it improves the soot-NOx trade-off and keeps the high thermal efficiency. These improved methods can greatly improve the diesel engine's economy, making it more popular with buyers. On this basis, the diesel engine can maximize its advantages through these improved methods, so in the future, the diesel engine will not be replaced by other new energy vehicles or gasoline vehicles but will continue to develop and shine in various fields.

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