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Comparison of Diesel engine with other engines and NOx scandal

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Abstract. This essay will focus on the comparison of the Homogenous Charged Compression Ignition engine and the Diesel engine. Diesel engine is one of the most widely used engines in the world. It uses fossil fuel such as the gasoline to get power. What is more, it does not need a spark to ignite the fuel. It uses compression method to burn the fuel. However, there is also some problems for this kind of engine, such as the greenhouse effect and the heat loss for this kind of engine. Compared to the Diesel engine, the Homogenous Charged Compression Ignition engine can mix the fuel into a correct ratio before burning. This can improve the efficiency of burning process. It can also improve the energy it released to get more power. There are several solutions to the problem. For example, to reduce the bad effect caused by the fossil fuel, people started to develop the hydrogen fuel. There are also some limitations of the hydrogen, such as expensive cost for producing the hydrogen and the hard storage of hydrogen. Use hydrogen to replace the fuel will face some problems. As a result, improving the efficiency of burning fossil fuel will also be a good choice. The essay also focuses on the scandal of diesel engines, mainly talks about the scandal of the diesel-engine transportation. Diesel engines are the most widely used engine in the world, they will release wastes, pollution and some toxic gases when they are working. Have these scandals been fixed?

Keywords: diesel engine, HCCI engine, the use of hydrogen fuel, hydrogen cell, NOx scandal

1. Introduction

There are many heat engines that are in use today, Diesel engine and the Homogenous Charged Compression engine are two of them. This article will focus on the comparison of these two engines. First is Diesel engine. Diesel engine is one of the most efficient heat engines in the world. It is widely used in many kinds of cars and machines, such as the trucks and the steamer. It can also provide a lot of energy for humans to drive their engines. Of course, the appearance of Diesel engine brought a lot of convenience to people. however, there are still some problems follow by the Diesel engine. The fuel of the Diesel engine is the fossil fuel such as gasoline. When Diesel engine is working, it will consume the fuel and then release some greenhouse gases such as carbon dioxide. According to the diagram below (the VMT stands for vehicle miles travelled in [1].) the distance people that driving the trucks is increased rapidly. This means a large consume of fossil fuel, which would cause a lot of greenhouse gas emissions.

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Also, there are some introductions about the scandal of diesel engines, it will show the diesel engines' potential negative effect to people. According to the research, nearly most of the trucks in Europe are equipped with diesel engine. In 1988, IARC upgraded the carcinogenic hazard level of diesel engine exhaust to the "determined carcinogenic" category. So, finding a solution to reduce the use of diesel engine is very important.

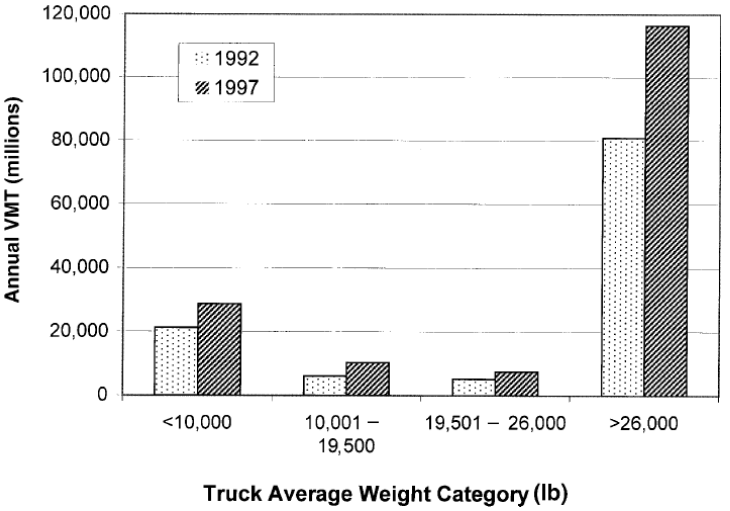

Figure 1. Growth in U.S Diesel Truck VMT by Weight Category.

From Figure 1, people can know that this will also cause some negative impact to the earth like the global warming. As a result, the large number of the use of the Diesel engine, the impact will even get larger.

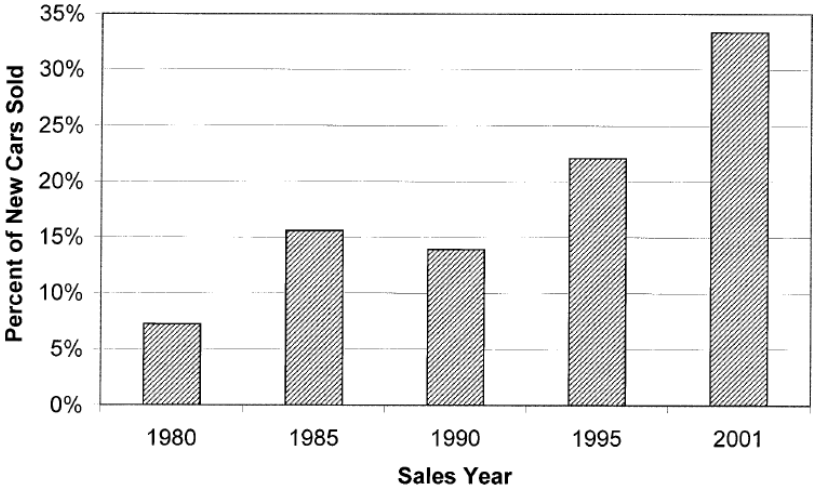

Figure 2 [1]. Diesel Car Sales Penetration in Europe.

The diagram in Figure 2 also shows that more and more people are driving Diesel cars these days. This also shows the necessity of improvement. Nowadays, some people also give an idea of changing the fuel that Diesel engine burns, like hydrogen. There are still some problems of using the hydrogen. Such as the cost of producing hydrogen and the storage of hydrogen. Because of the difficulty of storing the hydrogen, it is one of the most important research issues in the development of fuel cell vehicle in [2]. What's more, although the Diesel engine does not use spark ignition (SI), it still has difficulty achieving the biggest efficiency. The ignition of the Diesel engine also makes it hard to achieve the best

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efficiency. The ignition of this kind of heat engine is through the compression of it. Furthermore, this engine will ignite the fuel inside the combustor without the spark. However, this kind of ignition cannot ensure that the fuel in the engine burns completely. This can also be a problem of the Diesel engine.

The environmental impact of the diesel engine is also obvious. The emissions of the diesel engine will go to almost anywhere, their emissions can make bad influence on the water, air or even soil. During the production of diesel, the hydrocarbon will be released to the air through water tanks, walls or even the pipes into the ground in [1]. These hydrocarbons will finally release CO2 into the air, cause the greenhouse effects to get even worse. What's more, due to the diagram, the NOx, which is harmful to humans' health, will also be released. These disadvantages of the Diesel engine call the need of an improvement.

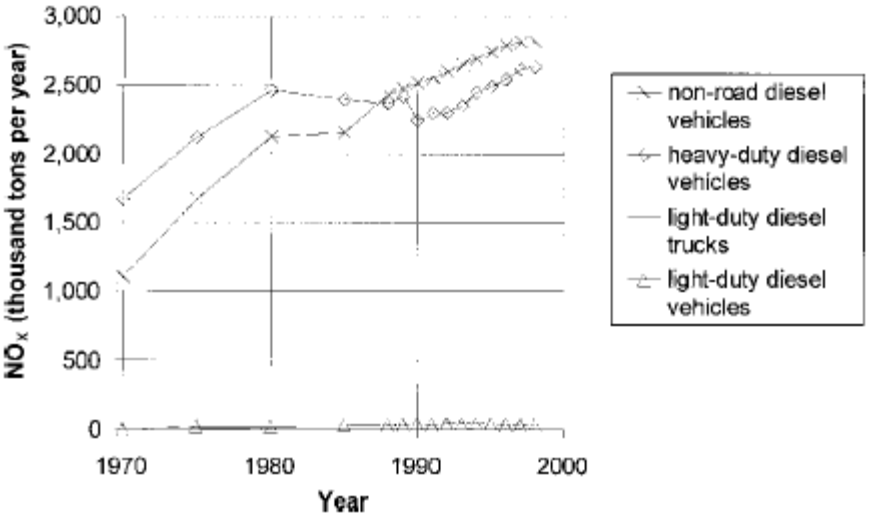

Figure 3. U.S. Nationwide NOx Inventory.

This diagram in Figure 3 shows the increase of the emission of the NOx through the time. There were some improvements these years, like the increase of the non-road diesel vehicles and the decrease of heavy-duty diesel vehicles, but there is still some emission of the NOx.

2. The introduction of the background and the present situation

The Homogenous Charged Combustion Ignition engine is a kind of heat engine that use an injector to provide fuel into the combustion chamber [3]. This is similar to the Diesel engine because they all inject their fuel in this way. This engine will "provide a homogenous mixture of fuel and air" What is more, the HCCI engine's mixture is preconditioned by the exhaust gas recirculation (EGR), sometimes the gas and the fuel will by heated spontaneously [3]. After injecting the fuel and air combination, the combustion chamber is going to finish the final stage of ignition. When the condition in the chamber is enough for burning, the mixture will burn automatically to provide enough energy to move. The proper mixed ratio of the fuel will make it burn more efficiently. However, there are still some limitations of this kind of engine. The HCCI combustion is constrained by various operational limits such as combustion instability limit, combustion noise limit, emission limits and peak cylinder pressure limit. High load limit of HCCI combustion is typically limited by very high combustion noise, and heavy ringing operation can also damage the engine parts. [4] This means that the burning inside the chamber may not as efficient as people think so. It still has some uncertain factor in burning because it may have some heat loss through the chamber. The noise made by the engine during the working may also be a problem. The friction between the parts of the engine will cause some noise. This will also decrease the efficiency and do harm to the stability of the engine because it causes abrasion. What is more, hydrogen fuel is not easy to carry out. Then, the need of using fossil fuel more efficiently becomes more important,

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and that is why improving the HCCI engine is a kind of solution to the problem of Diesel engine. There are also some important following conditions: the quality of mixture and the air/fuel ratio, the scavenging directivity and velocity, the temperature of the combustion chamber walls, the scavenging passage inlet must be located at the bottom of the crankcase [3].

3. Method

3.1. The comparison of these two kinds of heat engine

The Diesel engine uses diesel to gain its power. When this kind of diesel engine starts to work, it will consume the liquid fuel that has injected into the chamber. When diesel burns in the engine, it will start to produce some gas such as NOx and CO. These kinds of gas will make some bad effects to humans' health. There are some improvements for this kind of problems. From the research project in [5], some scientists started to use a kind of oil that can't be used as food to replace the diesel it uses right now. This kind of oil is from the forest and is abundant enough in the India forest. There are many plants in India, so it won't be a big problem to produce this kind of oil if it can have enough potential to replace the diesel. According to the data from [5], the maximum and the minimum CO produced from the burning were 0.004 and 0.016%, this reduces 94 percents and 70 percents compared to the diesel fuel. The smoke that produces from the burning will have less density than burning the fuel, which will reduce to 80% maximum and 20% minimum. What is more, the emission of NOx is also reduced by using this kind of new fuel produced from the plants in India. The temperature of emission did not reduce, probably because "nearly the same quantity of fuel being consumed per hour" is constant between plant-made fuel and diesel fuel in [5]. The HCCI behave in another way.

When HCCI engine starts to work, it will burn its fuel automatically. What's more, the fuel in this kind of engine will be burned more completely because its fuel is burned more evenly inside the chamber. According to [6], the HCCI engine requires a special condition for it to work efficiently. For example, when the fuel is applied to the engine, the fuel and the gas must be mixed in a fixed ratio for one working cycle to another working cycle. What's more, the speed of the remaining gas and direction of it must be controlled. The temperature inside the chamber should be just right for burning. "The scavenging passage must be at the bottom of the chamber" in [6]. The advantages brought by these strict conditions is enormous. As a result, the HCCI engine will burn the fuel smoothly at a constant rate. The energy will be released stably. What is more, the exhaust gas recirculation (EGR) in [6] will be high. This means that this kind of heat engine can reuse the energy and make use of the exhaust gas.

The fuel that the Homogenous Charged Compression Ignition engine will consume at same distance and the energy it would produce.

4. Scandal of HCCI engine and diesel engine

4.1. Some possible improvement for the Homogenous Charged Compression Ignition engine

This comparison will be shown in the diagram. Compared to the diesel engine, the advantages of the Homogenous Charged Compression engine. The disadvantage of the Homogenous Charged Compression engine will also be mentioned about.

For example, people can improve the fuel which are used by diesel engine, use the hydrogen solution to replace them. So, the pollutant (like pollution gases, NOx) can be reduced, the release gases will be vapour and environmental-friendly gases. In addition, people can reduce the engines' heat loss that use more thermal insulation material and increase engine efficiency. In the second part of the essay, this paper will focus on the challenges about diesel engine, this paper will know the hazards of using diesel engines and talk about the solution about these scandals.

4.2. Widely use of diesel engine

European Automobile Manufacturers Association (ACEA) published "Vehicles in use in Europe" on January 20, 2021. Currently, in Figure 3, 6.2 million medium or large sized commercial vehicles

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(trucks,Large commercial vehicles and buses) are registered in the EU. 97.8% of all trucks are equipped with diesel engines. Additionally, only 2,300 trucks are powered by electricity, accounting for just 0.04% of all vehicles [7].

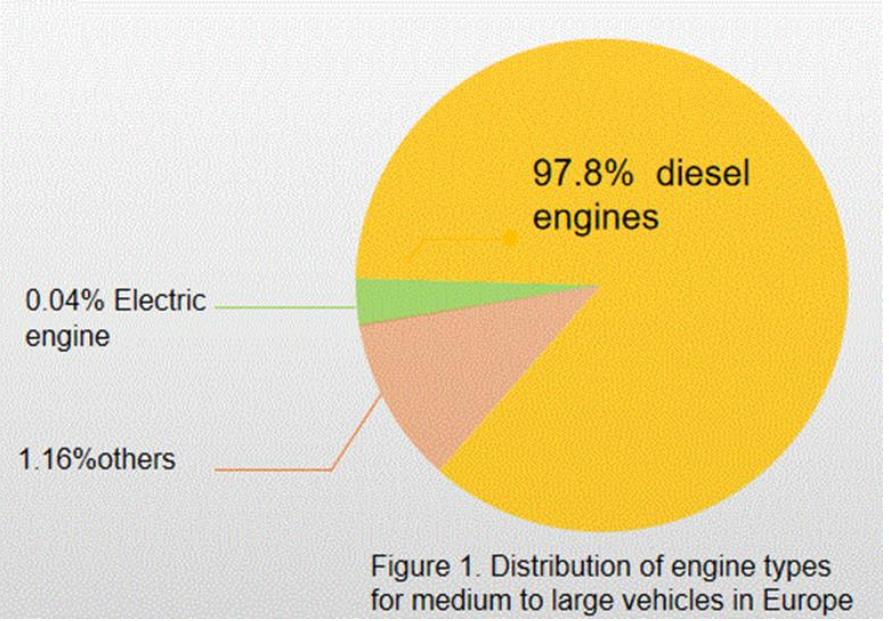

Figure 4. Distribution of engine types for medium to large vehicles in Europe [7].

4.3. NOx

Nitrogen oxides refer to compounds composed of nitrogen and oxygen, the most common such as nitric oxide (NO) and nitrogen dioxide (NO2).

4.4. NOx Damages to human body

Nitric oxide makes up the majority of the nitrogen oxides released by diesel engines, with very little nitrogen dioxide. At typical airborne quantities, nitric oxide is a colourless gas that is not immediately hazardous. On the other hand, an excessive concentration might lead to a central nervous system disorder and impair lung function. In addition, the International Agency for Research on Cancer (IARC) upgraded the carcinogenic hazard level of diesel engine exhaust from the "probable carcinogenic" category assigned in 1988 to the "determined carcinogenic" category [8].

According to the website TheVerge, in 2015 alone, 38,000 people died prematurely from additional pollutants [9]. Plus, according to statistics, in 2015 alone, more than 80% of the world's diesel engine automobile products were sold to the above countries and regions. According to a recent study, daily driving of diesel-powered cars, trucks, and other vehicles with diesel engines in at least ten different countries worldwide has led to nitrogen oxide emissions that are more than 50% higher than those from laboratory testing. [10]. According to statistics, in 2015 alone, more than 80% of the world's diesel engine automobile products were sold to the above countries and regions [10].

Also, according to the ICCT, the researchers found that the diesel engine vehicles emitted nearly 5 million tons of nitrogen oxides in their daily driving process, on top of the 9.4 million tons of nitrogen oxide emissions given by laboratory tests [11]. It is worth mentioning that the additional nitrogen oxides emitted are estimated to kill around 1,100 people in the United States a year, so it is important to decrease the NOx emissions caused by diesel engines in large vehicles.

4.5. Challenge to Fixed the scandal of NOx.

The goods rail industry in the United States has a special chance to take constructive immediate climate action. The goal is to switch from diesel to electric trains. It used to carry more cargo than any other rail

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system in the world and was primarily dependent on diesel fuel, which provided more than 90% of the energy used by the rail industry overall. [12].

Individuals demonstrate that a single boxcar outfitted with a 14-MWh battery and inverter are able to reach a 241-km range—the typical daily distance covered by US Class I freight trains—while consuming half the energy required by diesel trains.

5. Conclusion

Reducing the use of diesel engines, and use environmental-friendly engine is very important, it will be beneficial to people's health and environment. People should realize the harm by NOx, then to find a way, such as use the electric engine replace the diesel engine. Also people can use the method mentioned in the first section of the essay, develop the fuel which are used by diesel engine, use the hydrogen solution to replace them.

Authors Contribution

The writers' names had been organised according to alphabetical order and each one contributed equally.

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