Journal of Energy Research and Reviews

Volume 14, Issue 2, Page 33-39, 2023; Article no.JENRR.100964
ISSN: 2581-8368

Comparison of CO_2 Emission between Methanol and Gasoline Internal Combustion Engine

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/JENRR/2023/v14i2281

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/100964

Original Research Article

Received: 04/04/2023
Accepted: 06/06/2023
Published: 14/06/2023

ABSTRACT

The internal combustion engine, as a huge amount of global thermal machinery, serves a wide range of industries. At the present stage, internal combustion engines will still play an irreplaceable role for a longer period of time. Taking into account the trend of CO_2 emissions in China in recent years, this paper briefly analyzes the impact of adopting methanol fuel and traditional gasoline fuel on carbon emissions. The results show that the reasonable optimization of vehicle energy structure is very important to realize energy saving and emission reduction and reduce atmospheric CO_2 compared with traditional fuel vehicles.

Keywords: Methanol fuel; gasoline; CO_2 emission.

1. INTRODUCTION

With the progress and rapid development of China's market economy and information technology and the continuous improvement and increase of China's automobile resources, the serious clean energy and environmental issues are gradually becoming the focus of the world's attention, and low-carbon transportation will

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undoubtedly be an important way for countries around the world to solve the clean energy and environmental problems caused by the current global atmospheric temperature and regional environmental changes [1-4]. According to the statistics of the Traffic Management Bureau of China's Ministry of Public Security, in 2020, the number of new motor vehicles in the country will reach 372 million, including 281 million new cars [5]. According to the report, China's crude oil imports will be 10.87 million barrels per day (542 million tons) in 2020, with a foreign oil dependency of 73.5% [6]. In addition, motor vehicle exhaust is the main component that makes up the haze, and automobile exhaust is an increasingly serious problem for air pollution. Some compounds in vehicle exhaust, such as particulate matters, nitrogen oxides, SO_3, etc., not only cause serious pollution damage to the environment and air, but also may cause greater harm to people's health and lives [7]. Optimizing traditional fuels can effectively improve the emission of automobile exhaust, and using methanol fuel can effectively alleviate the problem of oil energy shortage in China on the one hand, and reduce the problem of environmental pollution on the other; promoting the use of methanol fuel has a positive effect on improving farmers' income, driving the development of agriculture and related industries, and increasing employment opportunities, etc [8]. It is the basic strategy of China's energy development to find the ideal fuel to replace petroleum and promote the diversification of fuels. China has abundant coal resources, and using coal resources as raw materials to manufacture methanol, especially for the poor quality coal that cannot become power coal for direct combustion, can be used as an important raw material to prepare methanol for clean use. The development strategy of using methanol instead of gasoline as fuel for vehicle engines can effectively reduce China's dependence on foreign oil imports, and the development strategy of methanol instead of gasoline is of great economic and social significance to improve China's energy consumption structure and refined oil consumption structure [9].

The trend of China's total carbon emissions in recent years is shown in Fig. 1, by analyzing the database of China's total carbon emissions in recent years [10]. It can be seen that the general trend is that the total carbon emission has been showing an increasing trend, but through various energy-saving and emission reduction measures, the increasing trend of China's carbon emission has become more moderate in the past ten years, which proves that the energy-saving and emission reduction measures adopted at present have an important role in reducing CO_2 [11].

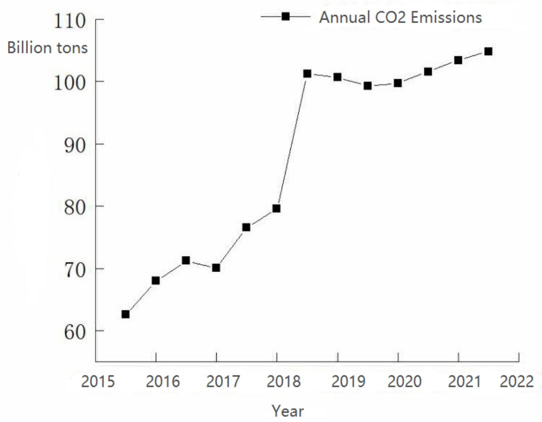

Fig. 1. China's total carbon emissions in recent years towards

2. METHODOLOGY

Automotive fuels are made from crustal resources through multiple complex industrial processes, and the process by which different raw materials are ultimately made into automotive fuels differs [12]. Gasoline is made from crude oil transported through pipelines through distillation and fractional distillation processes to eventually reach the gas station, while methanol is made from coal or natural gas through industrial coking and tertiary conversion [13]. The two forms of energy transfer using gasoline and methanol fuel are different and the process is shown in Fig. 2.

In recent years, with the emergence of new energy vehicles, to a certain extent to alleviate the situation of energy tension, the most representative is the development of electric vehicles, but due to the lack of technical development, China's power battery technology development bottleneck problems encountered has not yet broken through, the core problem has not been solved, as the most widely used lithium-ion battery composition after the energy density is only 80wh/kg, the power supply system Performance is relatively backward [14]. Although China is a large producer of batteries, the country's power battery supporting enterprises more than hundreds of manufacturers throughout the country, but the core technology of power batteries do not have a competitive advantage, the production of power batteries required by the positive and negative electrode material technology patents have long been monopolized by foreign countries, diaphragm, electrolyte and other foreign highly dependent, the domestic battery production process performance is poor, the power battery composition technology is backward [15].

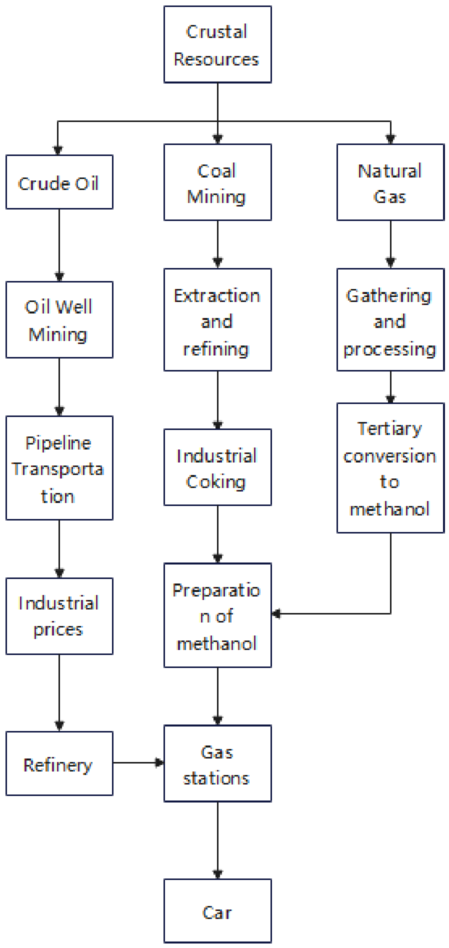

Fig. 2. Gasoline and methanol fuel energy transfer forms

Although there have been new energy vehicles with Tesla and other major representatives, there are hydrogen energy cars, solar cars and electric cars, etc., but due to the current core technology development is not mature enough, resulting in its high production costs, low efficiency of electrical energy supply and can not achieve the ideal operation, or even greater energy consumption, which in turn increases the difficulty of promoting the use [16].

At present, some developed countries are speeding up the industrialization process of electric vehicles, and the market demand for electric vehicles is showing an increasing trend, but China's electric vehicles are still in the cultivation and development stage. Some domestic new energy vehicle enterprises have launched a series of different styles of new energy vehicles, but the models are mainly concentrated in the field of electric buses. The main focus is on the modification of the original model, which has failed to reach mass final production, and there are very few mass production models developed in the field of private passenger car passenger car prototypes, which are not much available for consumers to choose from [17].

And most cities lack operational infrastructure planning, especially the layout of infrastructure in public areas such as charging piles is restricted by many factors such as the selection of landing points, which is not conducive to the construction of an intelligent charging and switching service network system for electric vehicles [18]. The investment in charging and switching infrastructure service construction is huge and the recovery period is too long, coupled with the relative lack of subsidies from the national and local governments for infrastructure construction and the lack of corresponding supporting policies for the operation of charging and switching facilities, social capital is not active enough, and few enterprises are willing to take the risk to try to develop in this area [19]. The technical system of charging facilities is not perfect, and the technical standards at the national level are relatively backward [20]. The lack of energy reserves in the power grid and the failure of power battery utilization and recycling technology make the lack of mutual operation certification between electric vehicles and charging and switching infrastructure [21].

In terms of the current development trend, rational optimization of the energy structure of vehicle engines is of positive significance for reducing energy consumption and addressing environmental issues. This study compares the CO_2 content in the exhaust gas of a domestic vehicle after adopting two different energy sources [21].

CO_2 content in the exhaust gas of a domestic vehicle after comparing the adoption of two different energy sources, and analyzing which specific energy situation is adopted, the vehicle has less CO_2 emission. A brief technical routes of the study is shown in Fig. 3.

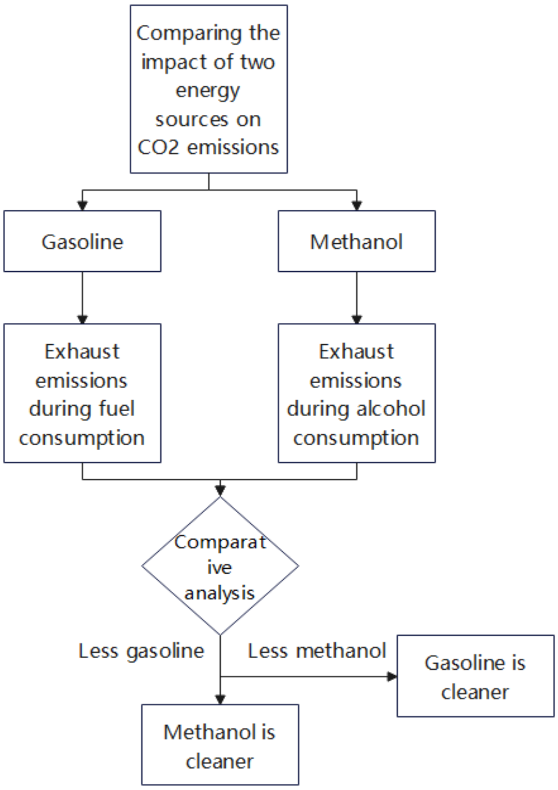

Fig. 3. Specific analysis process

By analyzing the relative amount of CO_2 in the tailpipe emissions of the C-Class when using different energy sources, the comparison was made to determine which of the products of combustion is relatively cleaner when using methanol or gasoline, and finally a conclusion was drawn to determine the cleaner energy source.

3. RESULT AND DISCUSSION

3.1 Performance Characteristics of Methanol Fuel

3.1.1 Physical and chemical properties of methanol

Methanol is a colorless, transparent, highly volatile, flammable and water-soluble liquid. Methanol has the molecular formula CH_3OH and contains 50% of its own oxygen, which facilitates complete combustion of the fuel. The boiling point is 64.7℃, which is lower than gasoline and easy to mix with air; the ignition limit of methanol is 7.3%~36.9%, which is easier to ignite than gasoline; the octane number of methanol is 110, which is higher than gasoline and has good anti-explosion property, which is conducive to improving the compression ratio of the engine and enhancing the efficiency; methanol is easily soluble in water, easily degradable and does not cause any damage to the soil. Methanol is easily soluble in water, easily degradable, and does not pollute soil and rivers; methanol is liquid at room temperature, so it is convenient to transport, store and refill.

3.1.2 Corrosive property of methanol

Methanol contains high oxygen content and has strong chemical activity. The oxidation of methanol produces trace amounts of organic acids, which cause acidic and electrochemical corrosion of some non-ferrous metals such as aluminum, copper, lead and zinc. Therefore, corrosion inhibitors, corrosion inhibitors, antioxidant stabilizers and other additives should be added to methanol fuel to weaken the corrosion effect on metals. Methanol combustion emissions of water vapor increased, in addition to acidic substances such as formic acid, the two together to accelerate the exhaust pipe, especially the corrosion of the weld, so the exhaust pipe should be molded as much as possible to reduce the welding technology.

3.1.3 Methanol has a high latent heat of vaporization

The latent heat of vaporization of methanol is 1109k J/kg, which is 3.7 times higher than that of gasoline (310 kJ/kg), and it needs to absorb more heat when vaporizing. After methanol enters the engine cylinder, the temperature inside the cylinder will drop, which further reduces the volatile energy of methanol and makes it difficult for the mixture to reach the minimum ignition limit, especially in winter when the low temperature causes starting difficulties. Some technical measures are needed to solve the problem of low temperature cold starting difficulty of methanol vehicles.

3.1.4 Methanol production technology and abundance

China mainly adopts coal to produce methanol, which can not only be produced by high sulfur poor quality coal and coke oven gas, but also be co-produced by nitrogen fertilizer plant. Coal-based fuel methanol has the advantages of good fuel properties, abundant production raw materials, mature technology and basic production facilities of considerable scale already. Therefore, the use of methanol as an alternative fuel for transportation is in line with our national conditions and has good sustainability.

3.1.5 Solubilizing effect of methanol on rubber and plastic

Methanol is a polar organic solvent, which can make plastic parts swell and become sticky; make rubber parts swell, harden and become brittle and other early aging phenomena. The swelling effect of methanol makes the rubber and plastic parts in the fuel supply system age prematurely, causing poor sealing and oil leakage. Therefore, it is necessary to add anti-swelling agents to methanol fuel, and to use modified rubber and modified plastic parts with alcohol resistance. Such as sealing gasket using purple copper gasket; oil pump using strong methanol corrosion resistance phosphorus deoxidized copper as the oil pump rotor; oil tank and oil pipe to use alcohol-resistant rubber such as tetrapropylene fluorine rubber and neoprene; oil pump screen and bracket to use alcohol-resistant plastic, etc.

4. COMPARATIVE ANALYSIS OF CO_2 EMISSIONS USING DIFFERENT FUELS

By comparing the CO_2 emissions of C-Class cars with two different fuels, the CO_2 emissions per 1 mol of fuel burned completely under ideal conditions are investigated as follows.

4.1 CO_2 Emissions from Fuel Vehicles in Circulation

The increasing scale of motor vehicles is accelerating global energy consumption and greenhouse effect. At present, the issue of energy saving and emission reduction of automobiles has become a hot topic of discussion in many fields around the world. In response to the challenges posed by the energy crisis and the greenhouse effect, many countries have introduced measures to shift their traditional vehicle strategies.

According to the Global Economic Database, the overall calorific value of a fuel refers to the total amount of heat generated by the full combustion of 1kg of fuel.

The chemical reaction equation for the combustion of octane (C_8H_{18}), the main component of gasoline, is:

$$2C_8H_{18}+25O_2=16CO_2+18H_2O$$

Based on the calculation of atomic conservation, we can assume that the CO_2 produced by the complete combustion of 1 mol of octane is 8 mol, and the CO_2 produced in the ideal state is 2300g.In other words, the CO_2 produced by a car for every 1L/100km of gasoline burned is approximately M1 = 23.0g/km.

4.2 Methanol Vehicle Circulation Range CO_2 Emissions

The main difference between cars using methanol as the main fuel and conventional internal combustion locomotives is the power source, and methanol can be manufactured synthetically from coal, oil, natural gas, biomass, etc. The chemical calorific value of methanol fuel is about 1111kJ/kg and its molecular formula is defined as CH_4O, the simplest saturated mono-alcohol in structure. The chemical reaction equation of methanol in combustion is defined as:

$$2CH_4O+3O_2=2CO_2+4H_2O$$

According to the calculation of atomic conservation, the CO_2 produced by the complete combustion of 1 mol of methanol is assumed to be 1 mol, and the density of methanol in an ideal state of 1L is calculated as 0.791 kg/L. The CO_2 produced by a car is about M2=10.9g/km per 1L/100km of methanol combustion. The above brief analysis of CO_2 emissions from the use of gasoline and methanol is shown in Fig. 4.

Compared with traditional engines, the output power can be increased by 8-12% and the torque can be increased by 12-16% when using methanol engines, thus showing excellent aerodynamics. Methanol is easily soluble in water, easily degradable, and does not cause pollution damage to the environment such as soil and water flow, and it is chemically stable as a liquid at room temperature, so it is easy to transport and store. As an oxygenated compound, methanol can be fully combusted, and the combustion speed is faster than gasoline, and the combustion capacity is better, the combustion duration is shorter, and the latent heat of evaporation is larger, so the thermal efficiency of the engine can be improved. Methanol itself contains up to 50% oxygen, and the self-oxygenation effect occurs during the combustion process, thus reducing the chance of oxygen deficiency during the combustion process, which is conducive to the full combustion of the fuel, and also helps to achieve in-engine purification and reduce the generation of conventional gases such as CO, HC and NOX, etc. The octane number of methanol is about 110, which is higher than that of gasoline, reflecting better anti-explosion properties, thus helping to improve the compression ratio of the engine. The energy utilization efficiency is better than that of conventional gasoline, and it has strong economy.

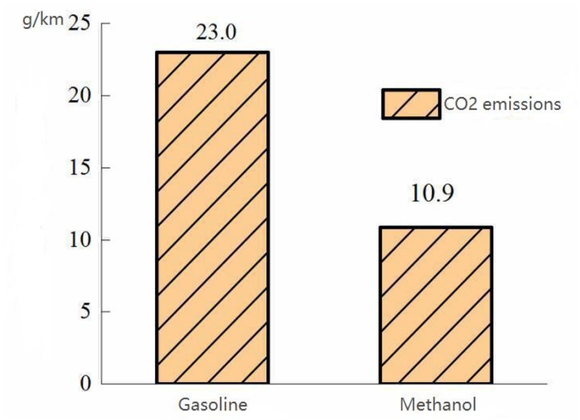

Fig. 4. CO_2 emissions when using two energy sources

The advantages of methanol fuel, such as high thermal efficiency, strong thermal efficiency, good driveability, good starting function and economy, are important for reducing pollution, saving oil, safety and convenience. When using methanol as fuel, the ignition advance angle and injection advance angle can be adjusted to the best angle in order to obtain higher thermal efficiency and greater output power. Since the carbon content of methanol is lower than that of gasoline, the main components of the exhaust gas produced after full combustion in the cylinder are water vapor and CO2, which do not contain sulfide, thus greatly reducing the emission of carbon particles and CO, which has less impact on the environment, and the manufacturing process of methanol can be refined by food crops, while promoting the development of modern agriculture in China.

5. CONCLUSION

When methanol fuel is used, the CO_2 emission in exhaust gas is less than that of traditional fuel vehicles, which is environmentally clean and can lead to an overall improvement in vehicle engine emissions.

Compared with traditional fuel cars, a reasonable choice of different energy structures and a reduction of gasoline use have a more positive significance for reducing CO_2 emissions.

Throughout the development of methanol vehicles, the business model is particularly important for the development of methanol vehicle industry. A comprehensive and systematic research and analysis of the application of methanol vehicles is needed in order to get more capital into the research and development of this field. Meanwhile, the development of methanol fuel can effectively alleviate the energy tension in China as well as be an effective way to maintain the ecological environment of the earth. The adoption of methanol as a fuel is of great significance to improve the energy structure and reduce carbon emissions in China.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
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