Gaz diesel engine operating modes and environmental efficiency analysis

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Abstract: *The article discusses the benefits of converting diesel to gaseous fuels, such as reducing the toxicity of engine exhaust gases, fuel costs and noise. It is also noted that the conversion of a gas diesel engine is technically simple and, if necessary, it is possible to operate on diesel fuel. The main focus is on improving the efficiency of the diesel engine by adjusting the fuel mixture so that the power of the gas-diesel engine and the diesel engine is the same under all load conditions. The influence of the explosive properties of fuel and its dosage on the characteristics of gasoline is estimated.*

KEY WORDS: *GASEOUS FULE , EXPLOSIVE DOSE , TOXICITY OF EXHAUST GASES , IMPACT ON THE ENVIRONMENT, EFFICIENCY.*

1.Introduction

Modern road and maritime transport is mainly equipped with reciprocating internal combustion engines that pollute the environment with harmful substances: exhaust gases, crankcase gases and evaporation of fuel and lubricating materials. 99% of these harmful substances come from the exhaust gases , which are presented in the form of complex aerosols and depend on the type of fuel, engine design, operating modes and more. It should also be noted that vehicle engines mainly consume liquid fuels of petroleum products with elemental composition - carbon, hydrogen, insignificant amounts of oxygen, nitrogen and sulfur. In this case, atmospheric air is an oxidizer. In the ideal combustion of a stoichiometric hydrocarbon fuel - air mixture, the exhaust gases may contain only nitrogen (N_2), carbon dioxide (CO_2) and water (H_2O). In real conditions, exhaust gases contain a larger number of components, which is caused by the engine's complex operating modes. Thus, the use of petroleum fuels in transport internal combustion engines, due to its negative properties and significant reduction in resources, leads to increased fuel costs and global environmental pollution.

The use of gaseous fuel as an alternative fuel in internal combustion engines began 4 decades ago and has undergone certain stages of development and improvement, including the implementation of a diesel cycle called gas diesel, which allows the use of at least two types of fuel: standard diesel and gaseous fuel. The gas diesel cycle can be carried out without any structural changes to the engine, except for the supply system of gaseous fuel.
Reciprocating internal combustion engines are known to be very economical heat engines in modern times, which makes them widely used in all fields. A significant drawback of these internal combustion engines is that the vast majority of them run on petroleum-based liquid and gaseous fuels, and the prospects for their further development and use are directly dependent on complex changes in gaseous fuels. Compressed natural gas (CNG) is currently actively used in world practice, particularly on ships, as well as as "motor fuel" for mainstream road transport, which according to current forecasts will increase in the near future. CNG has a number of advantages over traditional petroleum liquid fuels, such as: environmental friendliness, economy.

2. Preconditions and means for resolving the Problem

When Diesel is working on non-traditional fuel, a number of difficulties arise in connection with the supply of fuel in the cylinders, the process of mixing, the process of ignition in the combustion chamber in accordance with the requirement of the combustion process characteristics. Qualitative adjustment of the load on the diesel engine should also be considered, where the air-fuel ratio α varies depending on the load: in a wide range up to α = 5 and above at low engine power and idle modes, and α = 1.35–1.25 at full engine load. The range of allowable change of α depends significantly on the properties of the fuel used. Switching the diesel engine to gaseous fuel reduces toxicity and smoke in the exhaust gases, as well as reduces fuel costs. It should be noted that transport diesel engines are usually powered by both compressed natural gas (CNG) and liquefied natural gas (LNG). Usage of liquefied gas significantly increases fuel consumption compared to compressed natural gas.

Diesel engines are converted to both gas diesel and spark ignition. Convertible gas diesel is technically easy to operate, in addition it retains the ability to run on a standard diesel process as needed, i.e., only on diesel fuel. Qualitative load regulation is also used in gas diesel engines. At the same time it is advisable to carry out mixed regulation to avoid the formation of a highly enriched mixture, which is associated with a significant increase in C_nH_m emissions and consequently deterioration of fuel economy.
During the gas diesel cycle, the engine power is improved by 10-15% compared to a standard diesel. In order to maintain the power rating, it is necessary to qualitatively adjust the working mixture during the diesel process in such a way, that a value of α is selected according to any load mode of the engine, which provides power compensation. This can be achieved by assuming that the heat emitted by combustion in each mode of standard engine load would be equal to the amount of heat emitted by combustion in gas diesel engine operating on the same modes. Therefore, the equation will take place:

$$Q_{di}=Q_{gi} \quad \text{or} \quad H_{di}=H_{gi}$$

Combustion heat of working mixture for standard diesel engine $(\alpha>1)$

$$H_{di}=\frac{H_{ud}}{1+a_{di}I_{do}}$$

For gas diesel $(\alpha>1)$

$$H_{gi}=\frac{H_{ug}}{1+a_{gi}I_{do}}+\frac{H_{ud}}{1+a'_{di}I_{do}}$$

where,

- H_{di} and H_{gi} respectively are the amounts of heat released as a result of complete combustion of the standard mixture of standard diesel and gas diesel load;

- H_{ud} and H_{ug} are the lowest thermal capacities of diesel and gaseous fuels;
- a_{di} and a_{gi} are values of air - fuel ratio according to diesel and gas diesel engine load;
- I_{do} and I_{go} respectively, are the amounts of theoretically required air for complete combustion for diesel and gaseous fuels;
- $a'_{di} I_{do}$ the value of air-fuel ratio caused by the amount of explosive fuel in gas diesel;

According to the load changes for standard diesel and similarly for gas diesel loads when they develop the same power the value of the air - fuel ratio will be different in such a case. Hence the fuel consumption will increase and $g_{di}<g_{gi}$. Theoretically, according to the above assumptions, the variability of the parameters will look like the one shown in the figure 1:

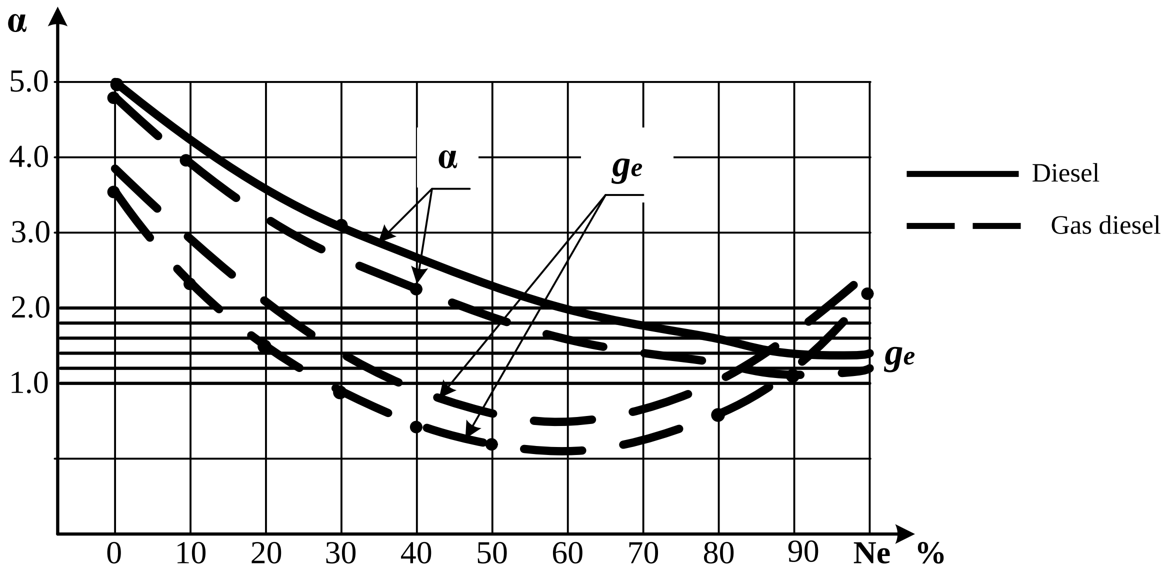

Fig. 1. Variability the parameters of diesel and gas diesel

Also is important influence of both the dosage and theadvance spray timing of the explosive fuel on the performance of the gas diesel.

To evaluate the impact of explosive fuel dosing, let introduce the concept of dynamics factor, which shows the amount of explosive fuel in each working mixture for each mode and it is displayed as:

$$K_i = \frac{G_{di}}{G_{gi}}$$

Where, G_{di} - the amount of explosive fuel, G_{gi} - the amount of gaseous fuel.

3. Conclusion

The poorer the working mixture, the greater the value of K_i, and the advance injection of the explosive fuel is less than that of standard diesel and varies depending on the load, in particular, the advance injection timing decreases as the load increases.

It should be noted that one of the most promising fuels for a diesel engine may be dimethyl ether (DME) (CH3-O-CH3). Its main advantages are smokeless combustion, NOx reduction in emissions and low noise levels. Use of dimethyl ether in the diesel cycle makes it possible to meet the California standard ULEV. DME can be produced directly from synthesis gas produced from natural gas, coal, or biomass. It can also be produced indirectly from methanol via a dehydration reaction

4. References

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