The dependence of the temperature cycle in the cylinder of the CI engine when burning methyl hydroxide

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The dependence of the temperature cycle in the cylinder of the CI engine when burning methyl hydroxide

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Abstract. In the course of burning, the processes of gas movement intensively occur in the cylinder, which contribute to heat transfer to the cylinder walls. A diesel engine has different heat dissipation conditions than a gas engine. Due to the higher compression ratio, the temperature of the gases leaving the cylinder is much lower. The temperature of the gases in the cylinder in the course of burning reaches 2000-2300 °C. Using methyl hydroxide and changing the installing angles of advancing fuel injection there is a tendency to change the temperature of the cycle in the cylinder of the diesel engine. Starting from a certain position of the piston in the course of the compression stroke, the air temperature becomes higher than the wall temperatures, and the heat flux changes direction, i.e., heat is transferred from the air to the cylinder walls.

1. Introduction

More heat is diverted from the engine to the cooling system and carried away with the exhaust gases (EG). Heat removal to the cooling system is necessary in order to prevent the piston rings from burning, valve seats burning, piston seizing and jamming, cracking of cylinder heads, the occurrence of detonation, etc. To remove heat to the atmosphere, part of the engine's effective power is spent on the fan drive. With air cooling, the power spent on the fan drive is higher due to the need to overcome the high aerodynamic drag.

To reduce losses, it is important to find out how much heat must be removed to the engine cooling system and how to reduce this amount [1-5].

The burning time in a diesel engine is very short, but in the course of this period the gas pressure increases significantly, and the temperature (T) reaches an average of 2000 °C. In the course of burning, the processes of gas movement intensively occur in the cylinder, which contribute to heat transfer to the cylinder walls. The heat saved in this phase of the work cycle can be converted into useful work in the course of the subsequent expansion course. In the course of burning, about 6% of the thermal energy contained in the fuel is lost due to heat transfer to the walls of the burning chamber and cylinder.

In the course of the expansion course, about 7% of the thermal energy of the fuel is transferred to the walls of the cylinder. When expanding, the piston moves from TDC to BDC and gradually releases a larger surface of the cylinder walls. However, only about 20% of the heat saved even with a long expansion course can be converted into useful work [6-9].

About half of the heat diverted to the cooling system is accounted for by the exhaust stroke. The EG exit the cylinder at high speed and have a high T. Part of their heat is diverted to the cooling system through the exhaust valve and the exhaust channel of the cylinder head. Directly behind the valve, the gas flow changes direction by almost 90°, while vortices arise, which intensifies the heat transfer to the walls of the exhaust channel.

EG must be removed from the cylinder head in the shortest way, since the heat transferred to it noticeably loads the cooling system and for its removal into the ambient air, it is necessary to use part of the effective engine power. In the course of the period of the release of gases, about 15% of the heat contained in the fuel is removed to the cooling system [10-14].

A diesel engine has different heat dissipation conditions than a gas engine. Due to the higher compression ratio, the T of the gases leaving the cylinder is much lower. For this reason, the amount of heat allocated in the course of the course of the exhaust is less and in some cases amounts to about 25% of all the heat transferred to the cooling system.

The T of gases in the course of burning in a diesel engine is higher than that of a gasoline engine. Together with high speeds of gas rotation in the cylinder, these factors increase the amount of heat transferred to the walls of the burning chamber. In the process of burning, this value is about 9%, and in the course of the expansion process - 6%. In the course of the course of the discharge, 9% of the energy contained in the fuel is allocated to the cooling system [15-19].

The T of the gases in the cylinder in the course of burning reaches 2000-2300 °C. If the heat transferred to the walls of the burning chamber and cylinder were not removed, then their T would exceed the permissible values for the materials from which these parts are made. Much depends on the gas velocity near the wall. It is practically impossible to determine this speed in the burning chamber, since it varies throughout the entire working cycle. Similarly, it is difficult to determine the T difference between the cylinder wall and air. At the inlet and at the beginning of compression, the air is colder than the walls of the cylinder and the burning chamber, and therefore heat is transferred from the wall to the air. Starting from a certain position of the piston in the course of the compression stroke, the air T becomes higher than the wall T, and the heat flux changes direction, i.e., heat is transferred from the air to the cylinder walls. The calculation of heat transfer under such conditions is a task of great complexity [20-26].

Sudden changes in the T of the gases in the burning chamber also affect the T of the walls, which fluctuates in the course of one cycle on the surface of the walls and at a depth of less than 1.5-2 mm, and is set deeper at a certain average value. When calculating heat transfer, it is this average T value that must be taken for the outer surface of the cylinder wall, with which heat is transferred to the coolant [27].

The surface of the burning chamber includes not only forcedly cooled parts, but also the piston bottom, valve plates. Heat transfer to the walls of the burning chamber is inhibited by a layer of soot, and into the walls of the cylinder by an oil film. The valve heads must be flat so that a minimum area is exposed to hot gases. When opening, the inlet valve is cooled by the flow of the incoming charge, while the exhaust valve in the course of operation is very heated by the EG. The valve stem is protected from the effects of hot gases by a long guide extending almost to its plate [28].

2. Experimental part

Figure 1 shows the effect of the use of methyl hydroxide on the maximum averaged cycle T in a diesel cylinder 2H 10.5 / 12.0 when working with fuel injection angle (FIA) at various installing angle advances fuel injection at a nominal operating mode at $n = 1800$ min^{-1} [29].

As can be seen from the graphs, with an increase in the installing of methyl hydroxide, the value of the maximum averaged T increases in the entire range of changes in the installing of diesel fuel (DF). With a change in the installing DF, the value of the maximum averaged T changes over complex dependencies.

With the installing of the DF $\Theta_{df} = 26^o$, the value of the maximum averaged T of the cycle increases from $T_{max} = 1980$ K at $\Theta_m = 22^o$ to $T_{max} = 2050$ K at $\Theta_m = 34^o$. The growth is 3.53%. With an increase in the installing to $\Theta_{df} = 30^o$, the value of the maximum averaged T of the cycle changes from $T_{max} = 1960$ K at $\Theta_m = 22^o$ to $T_{max} = 2050$ K at $\Theta_m = 34^o$. The increase is 4.6%. With a change in the installing of DF to $\Theta_{df} = 34^o$, the value of the maximum averaged cycle T changes from 1930 K to 2050 K with a change in the installing of methyl hydroxide from $\Theta_m = 22^o$ to $\Theta_m = 38^o$, respectively. The increase is 6.2% [30-35].

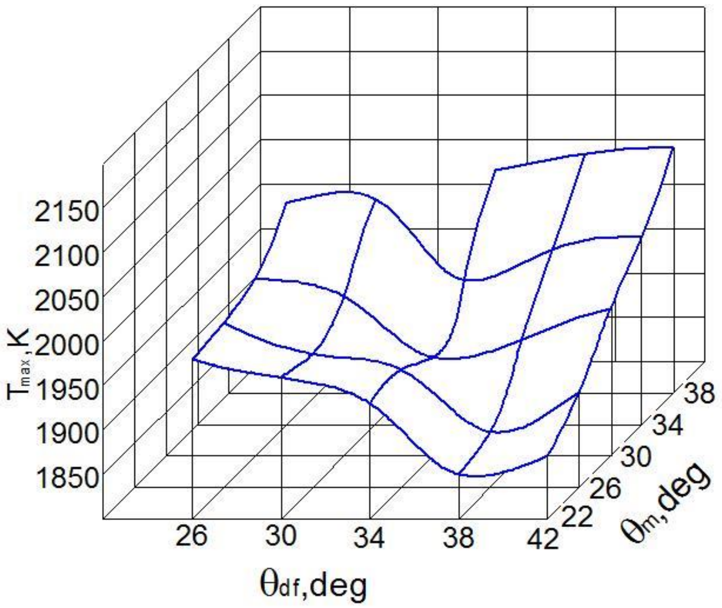

Figure 1. The effect of the use of methyl hydroxide on the maximum averaged cycle T in a diesel cylinder when working with FIA for: at n = 1800 min^{-1} and p_e = 0.585 MPa, q_{cdf} = 6.6 mg/cycle.

With an increase in the installing DF to $\Theta_{df} = 38^o$, the value of the maximum averaged cycle T changes from T_{max} = 1850 K at $\Theta_m = 22^o$ to T_{max} = 2070 K at $\Theta_m = 38^o$. The change is 11.9%. When installing the of DF $\Theta_{df} = 42^o$, the value of the maximum averaged T increases from T_{max} = 1870 K at $\Theta_m = 22^o$ to T_{max} = 2080 K at $\Theta_m = 38^o$. The growth is 11.2% [36-41].

With the installing of of methyl hydroxide $\Theta_m = 22^o$, the value of the maximum averaged cycle T decreases from T_{max} = 1980 K at $\Theta_{df} = 26^o$ to T_{max} = 1870 K at $\Theta_{df} = 42^o$. The decrease is 5.5%. With an increase in the methyl hydroxide installing to $\Theta_m = 26^o$, the value of the maximum averaged T changes from T_{max} = 1985 K at $\Theta_{df} = 26^o$ to T_{max} = 1910 K at $\Theta_{df} = 42^o$. The decrease is equal to 3.7%.

With a change in the installing of methyl hydroxide to $\Theta_m = 30^o$, the value of the maximum averaged T of the cycle changes from 2000 K to 1970 K with a change in the setting of methyl hydroxide from $\Theta_{df} = 26^o$ to $\Theta_{df} = 42^o$, respectively. The decrease is 1.5%.

With an increase in the installed methyl hydroxide to $\Theta_m = 34^o$, the value of the maximum averaged cycle T changes from T_{max} = 2050 K at $\Theta_{df} = 26^o$ to T_{max} = 2010 K MPa at $\Theta_{df} = 42^o$. The change is 1.9%. With the installing of methyl hydroxide $\Theta_m = 38^o$, the value of the maximum averaged cycle T increases from T_{max} = 2050 K at $\Theta_{df} = 34^o$ to T_{max} = 2080 K at $\Theta_{df} = 42^o$. The growth is 1.4% [42-46].

Figure 2 shows the effect of the use of methyl hydroxide on the maximum averaged cycle T in a diesel cylinder when working with FIA at various installing of drives at maximum torque mode at n = 1400 min^{-1}.

As can be seen from the graphs, with an increase in the installing of methyl hydroxide, the value of the maximum averaged T of the cycle increases in the entire range of changes in the installing of AAFI of DF. When changing the installing angles of injection of DF, the value of the maximum averaged T changes in complex relationships [47-52].

With the installing of the DF $\Theta_{df} = 26^o$, the value of the maximum averaged T increases from T_{max} = 1870 K at $\Theta_m = 22^o$ to T_{max} = 1940 K at $\Theta_m = 34^o$. The growth is 3.7%. With an increase in the installing AAFI to $\Theta_{df} = 30^o$, the value of the maximum averaged T changes from T_{max} = 1840 K at $\Theta_m = 22^o$ to T_{max} = 1980 K at $\Theta_M = 34^o$. The increase is 7.6%. When the installing DF is changed to $\Theta_{df} = 34^o$, the value of the maximum averaged cycle T changes from 1810 K to 2000 K when the installing methyl hydroxide changes from $\Theta_m = 22^o$ to $\Theta_m = 38^o$, respectively. The increase is 10.5% [53].

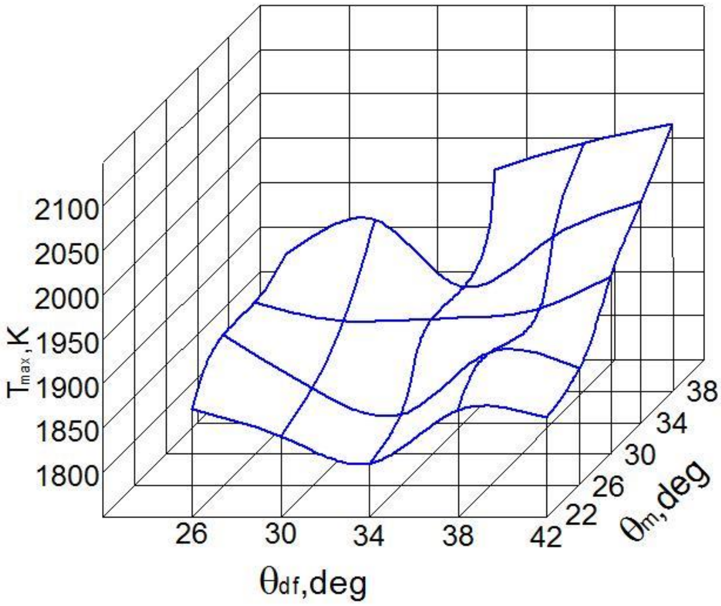

Figure 2. The effect of the use of methyl hydroxide on the maximum averaged cycle T in a diesel cylinder when working with FIA for: at n = 1400 min^{-1} and p_e = 0.594 MPa, q_{cdf} = 6.0 mg/cycle.

With an increase in the installing DF to Θ_{df} = 38º, the value of the maximum averaged cycle T changes from T_{max} = 1870 K at Θ_m = 22º to T_{max} = 2030 K at Θ_m = 38º. The change is 8.6%. With the installing of the DF Θ_{df} = 42º, the value of the maximum averaged T of the cycle increases from T_{max} = 1860 K at Θ_m = 22º to T_{max} = 2050 K at Θ_m = 38º. The growth is 10.2% [54-58].

With the installing of methyl hydroxide Θ_m = 22º, the value of the maximum averaged cycle T decreases from T_{max} = 1870 K at Θ_{df} = 26º to T_{max} = 1860 K at Θdf = 42º. The decrease is 10 K. With an increase in the installed of methyl hydroxide to Θ_m = 26º, the value of the maximum averaged T changes from T_{max} = 1920 K at Θ_{df} = 26º to T_{max} = 1880 K at Θ_{df} = 42º. The decrease is 2.0%.

With a change in the installing of methyl hydroxide to Θ_m = 30º, the value of the maximum averaged T changes from 1920 K to 1950 K with a change in the installing of methyl hydroxide from Θ_{df} = 26º to Θ_{df} = 42º, respectively. The growth is 1.5% [59, 60].

With an increase in the installed methyl hydroxide to Θ_m = 34º, the value of the maximum averaged T changes from T_{max} = 1940 K at Θ_{df} = 26º to T_{max} = 2000 K MPa at Θ_{df} = 42º. The change is 3.0%. With the installing of methyl hydroxide Θ_m = 38º, the value of the maximum averaged T increases from T_{max} = 2000 K at Θ_{df} = 34º to T_{max} = 2050 K at Θ_{df} = 42º. The growth is 2.5% [61-65].

3. Conclusion

Based on laboratory and bench tests and theoretical studies of the influence of methyl hydroxide on the maximum average cycle T in a diesel cylinder, as well as when working on DF at various set fuel injection angles, the T of the gases in the cylinder in the course of burning reaches 2000-2300 °C. Changes in the T of the gases in the burning chamber also affect the T of the walls, which on the wall surface and depth fluctuates less in the course of one cycle.

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