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Research Article

THE DEPENDENCE OF THE WEAR OF ENGINE PARTS ON THE EVAPORATION TEMPERATURE OF GASOLINE

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ABSTRACT

The article analyzes the dependence of the wear of engine parts on the evaporation temperature of gasoline. The main reason for the rapid wear of engine parts when using fuels with poor volatility is the washing off of oil from rubbing parts. To ensure optimal engine operation conditions in hot climatic conditions, we suggest that the start temperature of the distillation of gasoline boil not lower than 40°C ÷ 43°C, and the distillation temperature of 10% gasoline should not be lower than 70°C, and the boiling point of 90% for summer gasoline should not exceed 180°C, and the temperature end of distillation - 195°C.

KEYWORDS

Volatility of gasoline, wear of engine parts, completeness of combustion, piston rings, starting qualities of gasoline, distillation temperature.

INTRODUCTION

To assess the volatility, fractional distillation is performed and the temperature at which 10, 50 and 90% of the fuel evaporate by volume is determined (t10%, t50%, t90%). The volatility of gasoline affects the

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ease of starting the engine, the duration of warm-up and the stability of the engine. The volatility of gasoline should ensure the optimal composition of the fuel-air mixture at all engine operating modes.

RESEARCH ANALYSIS

It is known that only that fuel that is in a gaseous state burns in engines. Therefore, for complete combustion, it is necessary that the entire liquid phase of the fuel passes into the vapor phase, and thorough mixing of the fuel vapors with air occurs to form a combustible mixture.

By the value of the temperature at which 10% of the fuel evaporates (t10%), the starting qualities of the fuel and the engine are determined. The use of very light gasolines causes other operational difficulties, such as the formation of steam locks in the fuel system, especially during the summer period. From the point of view of starting properties of gasolines, it is desirable to have a higher content, and from the point of view of the formation of vapor plugs, preferably a lower content of low-boiling fractions. Their optimal content depends on the climatic conditions of vehicle operation.

The dependence of the limiting air temperature (t^1_a) at which the engine can be started and the air temperature (t^2_a) at which the engine stops due to the formation of steam locks on the boiling point ($t_{b.p.}$)of gasoline can be determined by the following formula:

$$t^1_a = 0{,}67\, t_{b.p.} - 49; \quad t^2_a = 1{,}85\, t_{b.p.} - 29$$

In hot weather, the main problem is the formation of vapor locks as a result of the vaporization of gasoline in the fuel pump and in the fuel supply lines, which limits the supply of fuel to the engine. This leads to a depletion of the mixture and a deterioration in throttle response, or, in extreme conditions, to a stop of the engine.

For example, if the beginning of boiling of gasoline in the summer for the southern regions of the country at + 40°C ÷ + 50°C is 35°C, then steam locks form in the power system, which can lead to disruption of the fuel pump:

$$t^2_a = 1{,}85\, t_{b.p.} - 29 = 1{,}85 \cdot 35 - 29 = 35{,}75°C;$$

$$t^2_a = 1{,}85\, t_{b.p.} - 29 = 1{,}85 \cdot 40 - 29 = 45°C;$$

$$t^2_a = 1{,}85\, t_{b.p.} - 29 = 1{,}85 \cdot 43 - 29 \approx 50°C.$$

So, the result obtained shows that for an air temperature of 45°C in summer, the boiling point ($t_{b.p.}$) of gasoline should not be less than 40°C, and for an air temperature of 50°C, the boiling point ($t_{b.p.}$) of gasoline should not be lower than 43°C.

The distillation temperature of 50°C of gasoline ($t_{50\%}$) has a particularly strong effect on the duration of heating. The lower this temperature, the easier and more complete the evaporation of gasoline at low temperatures and the faster the engine warms up (Table 1).

Table 1
Influence of the distillation temperature of 50°C gasoline ($t_{50\%}$) for the duration of engine warm-up

Air temperature, °C	Warm-up duration, min, at $t_{50\%}$ gasoline		
15	4-5	6-7	8-9
25	2-3	4-5	6-7
–10	7-8	10-11	13-14
–15	9-10	12-13	15-17

For a stable, without interruptions, the transition of the engine from low speeds to the maximum, the distillation temperature of 50% of gasoline should be: - for summer gasoline - no higher than 115°C, for winter gasoline - no higher than 100°C. As can be seen from the table, with an increase in the distillation temperature of 50°C of gasoline, the duration of engine warm-up increases.

DISCUSSION

The lower $t_{50\%}$, the more homogeneous the hydrocarbon composition of the fuel, the more steeply the acceleration curve rises in its middle part, the gasoline evaporates faster in the intake manifold, the filling of the cylinders with the combustible mixture improves, as a result the engine warms up faster, its power increases and its throttle response improves. It has been experimentally proven that the quality of the fuel slightly deteriorates with a change in distillation temperatures $t_{10\%}$ and $t_{90\%}$ of the fuel volume, but sharply decreases with an increase in $t_{50\%}$.

The complete evaporation of gasoline in the engine is determined by temperatures of 90% and the temperature of the end of boiling.

At high values of these temperatures, part of the gasoline does not have time to evaporate and enters the engine cylinders as a combustible mixture in liquid form. Non-evaporated gasoline does not burn, and flushes the oil from the cylinder walls, getting into the crankcase, reduces the viscosity of the engine oil, which leads to increased wear of engine parts.

The combustion rate of such a mixture is reduced, the mixture burns out during the expansion process, which leads to a decrease in the power and economy of the engine. Fuel consumption increases (Fig. 1).

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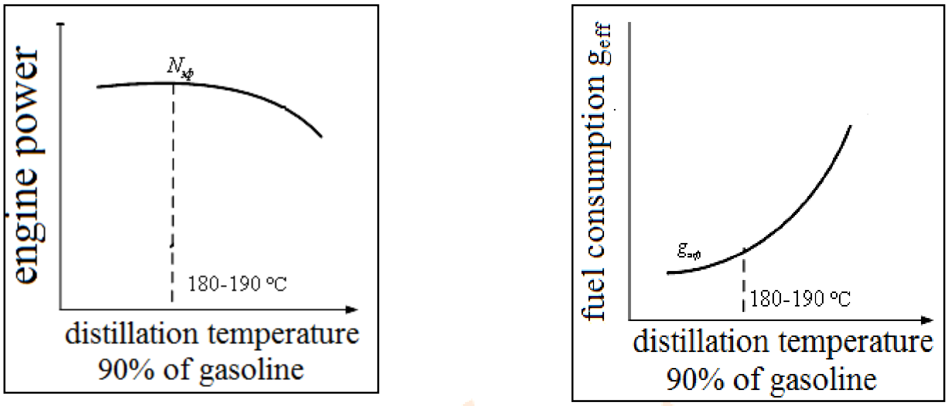

Fig. 1. Influence of distillation end temperature on engine power N_{ef} and fuel consumption g_{ef}

It has been experimentally proven that the quality of the fuel slightly deteriorates with a change in distillation temperatures $t_{10\%}$ and $t_{90\%}$ of the fuel volume, but sharply decreases with an increase in $t_{50\%}$.

A further decrease in $t_{50\%}$ does not lead to a significant improvement in the quick warm-up of the engine and its throttle response.

At high boiling point temperatures, heavy gasoline fractions do not completely evaporate in the combustion chamber, and the non-evaporated part flows through the piston ring locks into the engine crankcase. In this case, the oil is washed off the cylinder walls, and the crankcase oil dilutes and the wear of engine parts increases (Fig. 2).

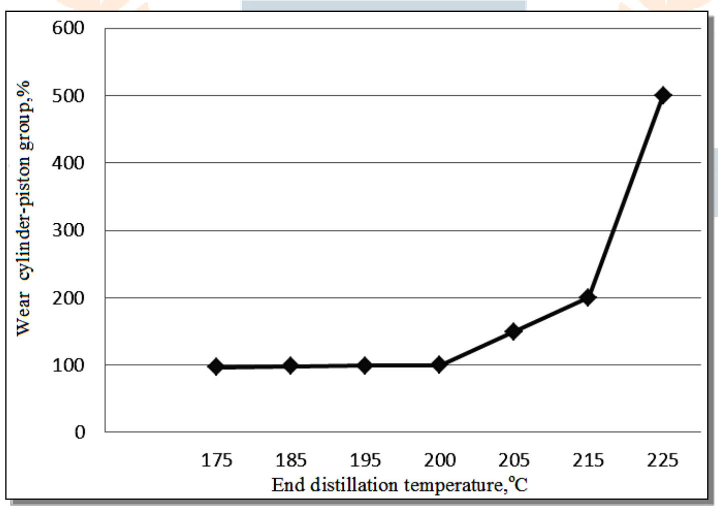

Fig. 2. Effect of distillation end temperature on wear cylinder-piston group

It can be seen from the figure that an increase in the end point of boiling of gasoline leads to an increase in the wear of the cylinder-piston group of the engine and, accordingly, to an increase in fuel consumption.

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CONCLUSIONS

The study shows that in order to ensure optimal operating conditions of the engine, the distillation temperature of the end of the boiling point of gasoline should be:

- Boil-off 90% for summer gasoline - not higher than 180°C, and the temperature of the end of distillation - 195°C
- Boil-off 90% for winter - not higher than 160°C, and the temperature of the end of distillation - 185°C.

The use of fuel with a high end boiling point not only leads to an increase in the wear of the parts of the cylinder-piston group of the engine, but also to the amount of carbon deposits in the combustion chamber and to a decrease in engine power.

Thus, in hot climates where winter grades of automobile fuels are not produced, it is desirable to limit the boiling point of gasoline to 195°C, while maintaining $t_{10\%}$ and $t_{50\%}$with in 70°C and и 105°C.

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