ЭФФЕКТИВНОСТЬ МАСЛЯНОГО ОХЛАЖДЕНИЯ ПОРШНЕЙ В ДВИГАТЕЛЯХ ВНУТРЕННЕГО СГОРАНИЯ

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Аннотация. *В статье рассматривается разнообразие методов охлаждения поршней маслом, применяемых в транспортных средствах, включая создание рёбер на нижней части днища поршня, способы разбрызгивания масла для охлаждения, а также реализация вторичного охлаждения за счёт многократного удара масла о горячую поверхность поршня.*

Ключевые слова: *транспорт, поршень, кольцо, канавка, двигатель, тепло, материал, деформация, температура, частота вращения, охлаждение, коленчатый вал.*

EFFICIENCY OF OIL COOLING METHODS FOR PISTONS IN INTERNAL COMBUSTION ENGINES

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Annotation. *The article discusses the variety of piston oil cooling methods used in vehicles, including the formation of ribs on the lower part of the piston crown, splash lubrication techniques for cooling, and secondary cooling achieved by repeated oil impact on the hot surface of the piston.*

Keywords: *transport, piston, ring, groove, engine, heat, material, deformation, temperature, rotational speed, cooling, crankshaft.*

Introduction. One of the methods used to increase engine power is by raising the crankshaft’s rotational speed. However, this inevitably increases the thermal and mechanical loads on the piston group. Therefore, oil cooling—

considered a relatively effective method—is used, particularly to reduce the piston's temperature.

According to Professor B.Ya.Ginsburg's analysis, for engines with a cylinder diameter where the power exceeds 3.67 kW per centimeter, it is recommended to cool the piston with oil to ensure the reliable and long-term operation of the piston rings. This method not only lowers the temperature of the piston crown and the zone where the first ring is located but also reduces the temperature of the entire piston. Aside from requiring slight structural modifications to some parts of the piston or engine, this is one of the methods that ensures reliable piston operation.

Main Processes. There are various methods of oil cooling, with the main ones including:

- oil spray cooling;
- oil splash cooling;
- combined oil spray and splash cooling;
- oil flow cooling.

For tractor engines, the most appropriate method—requiring no significant structural modifications—is piston cooling by oil spray. In this method, oil is primarily sprayed toward the inner part of the piston, specifically the underside of the piston crown.

Oil can be sprayed onto the piston crown using two different methods:

from the upper end of the connecting rod (Figure 1);

from a fixed nozzle mounted inside the crankcase (Figure 2).

In both cases, compared to other oil cooling methods, only minimal structural changes are required.

According to researcher E.A. Pakhomov, when the piston of the D-37E engine is cooled by oil spray, the temperature drops by 36 to 53°C at the crown and by 20 to 28°C at the skirt.

It should be noted that, in order to improve the effectiveness of oil cooling, it is advisable to create ribs on the underside of the piston crown. This, firstly, increases the heat transfer surface, and secondly, enhances the strength of the piston crown. In this case, the value of q_n=¿*6,6* can be increased up to. apid cooling occurs on the surface where the sprayed oil meets the piston ($\alpha_м \geq 2000\ kkal/m^2.hours\ °C$), while cooling on the other surface is slower ($\alpha_м \geq 400...600 kkal/m^2.hour\ °C$).

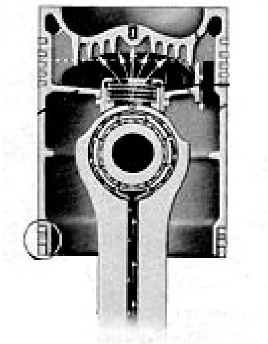

***Figure** 1. Piston cooling with oil sprayed from the connecting rod head*

***Figure 2.** Piston cooling by oil sprayed from stationary nozzles.*

When the engine's crankshaft rotational speed increases, the continuity of the oil flow from the upper end of the connecting rod, as described in the method, is disrupted, causing the oil to be supplied in pulses. The reason for this is the inertial forces acting on the oil flowing through the channel inside the connecting rod. If the pressure from the oil flowing upward is less than the pressure from the inertial forces acting in the opposite direction, the oil will not exit the connecting rod head. In the opposite case, the oil will be ejected. This phenomenon was thoroughly studied by Professor B.Ya. Ginsburg, who provided recommendations for practical application. To prevent this occurrence, an automatically operating valve is installed at the lower end of the connecting rod.

In general, this method is considered effective and is applied in agricultural tractors.

The second variant of this method involves spraying oil from a fixed nozzle installed on the side of the crankcase. The advantage of this method is that oil is continuously sprayed in a specified amount. However, the disadvantage is that before the oil reaches the top, 20 to 40% of the sprayed oil does not come into contact with the designated piston surface and is wasted. In this method, an increase in oil consumption for burning is observed. This happens because the amount of oil sprayed onto the cylinder walls increases, and the oil scraper ring is unable to remove it all, causing some of the oil to enter the combustion chamber and burn.

Oil Splash Cooling. In this method, a special chamber is provided inside the piston for the oil. The oil accumulated in this chamber, due to the piston's reciprocating motion, repeatedly strikes the cooling surface, absorbing more heat and continuously releasing it into the oil flow. Therefore, it is crucial to correctly determine the duration of the oil's stay in the chamber. If the oil remains too long, it will not absorb heat from the hot surface, and instead of cooling, it will become hot itself and cause overheating.

Oil Splash Cooling can be organized in two ways:

- Splashing in an open chamber (Figure 3).
- Splashing in a closed chamber (Figure 4).

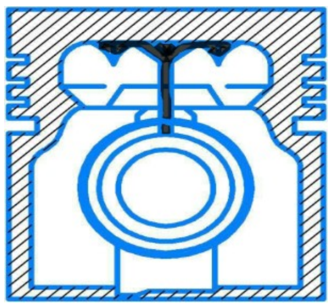

Figure 3. Cooling the piston by splashing oil in an open volume.

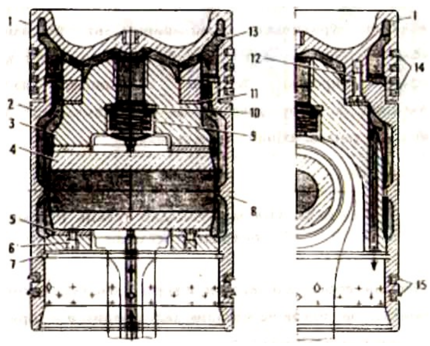

Figure 4. Cooling the piston by splashing oil in a closed volume..

The effectiveness of splash cooling depends on the crankshaft's rotational speed, the viscosity of the oil, and the degree to which the chamber is filled with oil. The results of the research show that when the chamber is filled with oil up to 50%, the heat transfer coefficient is the highest. However, when the chamber is filled to 5% or 90%, the heat transfer coefficient decreases by 1.55 times and 2 to 3 times, respectively.

In this method, the thermal stress indicator, denoted by $q_n=10$ does not exceed the specified limit. When cooled using this method, the temperature in the area where the first piston ring is located decreases by 25 to 30°C.

Oil flow cooling methods are not used for agricultural engine pistons. They are primarily used in high-power, low-speed engine pistons. For this purpose, special spiral channels are created within the piston body to allow the flow of oil (Figure 5).

Figure 5. Cooling the piston with oil in the channels made in the body.

Since this method is not used in agricultural tractor engines, I have decided to limit the discussion to the brief explanation above.

In general, cooling with oil is considered the most effective method for reducing thermal stress on the piston. Choosing one or another of these methods, based on factors such as engine power, function, crankshaft rotation frequency, and piston construction, yields the best results.

References:

1. Qodirov S. M. Ichki yonuv dvigatellari //Darslik. Toshkent. – 2006.
2. Молдаванов В. П., Пикман А. Р., Авербух В. Х. Производство поршневых колец двигателей внутреннего сгорания //М.: Машиностроение. – 1980.
3. Гинцбург Б. Я. и др. Профилирование юбок поршней //Москва.«Машиностроение. – 1973.
4. Fayziyev, M. M., Miryunusov, M. M., Orifjonov, M. M., & Bozorov, B. I. (2007). Ichki yonuv dvigatellari. *T.:«Turon-iqbol*, *608*.
5. Xudoyberdiev T. S., Xudoyorov A. N. Ichki yonuv dvigatellarining porsheni va porshen halqalari //Toshkent.«O ‘zbekiston. – 2007.

6. Vlaswinkel M., Antunes D., Willems F. Automated and Risk-Aware Engine Control Calibration Using Constrained Bayesian Optimization //arXiv preprint arXiv:2503.20493. – 2025.