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FACTORS FOR STABILIZING THE TIGHTNESS OF COMPRESSED GASES IN THE ENGINE COMBUSTION CHAMBER

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Annotation: *There is information on the average pressure instability in a pair of annular piston and cylinder liner, the effects of partial working leakage from the gap between the engine, and its effect on productivity and the effect on the main engine performance indicators.*

Key words: *engine combustion chamber, air charge, tightness, inertia, compressed gas, hole, accumulations, gills, spark, cracks, edges.*

Introduction. In internal combustion engines, the conversion of thermal energy into mechanical energy is a complex process. Its occurrence in natural conditions is associated with the occurrence of additional losses. The stability of the thermal energy generated in the combustion chamber of the engine also depends on how optimally the work is organized to maintain the tightness of the pressure of the gases formed during the ignition of the pumped fuel mixture. During engine operation, the piston is affected by gas pressure varying in magnitude and direction, inertial forces and lateral pushing forces of the piston cylinder wall. As a result of uneven heating of porcelain in the radial direction and height, additional internal thermal stress occurs.

Due to the uneven distribution of the metal layer on the bottom and inner sides of the porcelain, local stress can also accumulate at the edges where the ring is located.

The piston in the cylinder of the process of compressing the air charge in the combustion chamber at TDC, we can estimate the value of temperature and pressure in the incoming state using the following analytical expressions [1, 2, 3]:

$$T_c = T_a \cdot \varepsilon^{n_1 - 1} ; \quad (1)$$

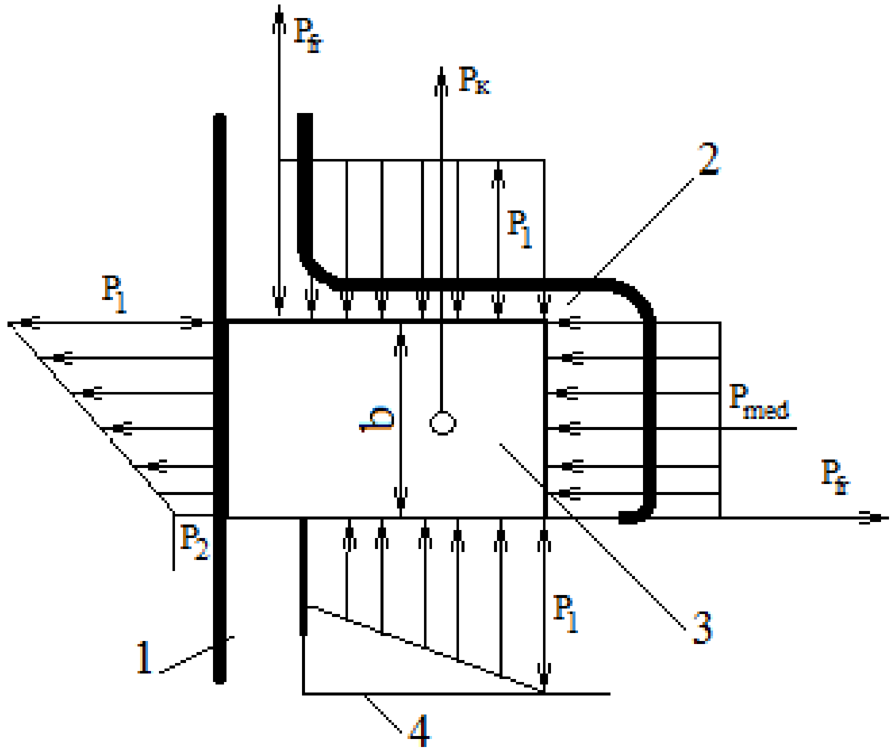
$$P_c = P_a \cdot \varepsilon^{n_1} , \quad (2)$$

where T_a, P_a are the temperature and pressure of the air charge before the fuel enters the cylinder, respectively; e – compression ratio; n1 is an adiabatic number.

According to formulas (1) and (2): within the limits of P_a = 0.9 kg/sec and T_a = 323°K, a change in n_1 can lead to a change in the values of Tc and Pc. As a result of the rapid combustion process, the total time of temperature exchange is short, and it is known that the level of fuel and smoke emissions into the atmosphere in engines is only 1.0-1.5% [1]. But despite this, it is important to stabilize the tightness of compressed gases in the combustion chambers of heat engines, especially around their ring-sleeve pairs.

Pistons of carburetor and diesel engines are made of aluminum alloys with an expansion coefficient of (16-21)10^{-6} 1/deg. equal, and in cylinder liners made of steel or cast iron (11-12) 10^{-6} 1/deg. equal This large difference is due to the temperature gradient between the cracks, while thermal cracks on cast iron surfaces depend on temperature changes. The choice of shape and design parameters of piston rings is made depending on their functions: gas density in the space above the piston; heat is transferred to the walls of the liner and they push the oil away from the walls. Condensation on the piston rings is carried out using labyrinth-type moving elements. Their gas leakage has a narrow value in the range of 0.5-1.0% [1, 2]. The gas pressure in the cylinder after the ring in the first channel when the piston is in the TDC is equal to P. At this time, the pressure in the second channel is P_0~0.65P.

In Fig. 1 schematically shows the forces and pressures acting on the ring.



1-sleeve; 2-ditch; 3-ring; 4-piston.
Figure 1. Impact of forces on the piston ring

In the high-speed mode, when the piston is in the high speed state, the ring overturning state can be caused by inertia P1/s (Fig. 1) and friction forces Rishk [2,3,4]. This can also be caused by deformation of the liner and piston, non-perpendicularity of the planes of the grooves and rings of the cylinder axis. Compression of gases through the groove towards the guide base of the piston occurs due to throttling in the groove and is accompanied by a gradual decrease in pressure in the rear part of the ring as the ring moves away from the base. The pressure in the rear part of the ring when the piston is in position XHN is equal to the pressure inside the cylinder P, and at this moment P_2 ~ 0.65-P. In four-stroke engines, during exhaust and intake, the pressure in the rear part of the ring does not decrease, but residual pressure arises in it. This accumulation of pressure improves the operation of rings that have partially lost their integrity. Due to the fact that in plans without full load the pressure in the cylinder is relatively low, the ability of the rings, partially reduced during operation, to be compressed by gas is reduced. Therefore, rings are considered suitable for use only in cases where they reliably retain their compressive properties according to their gas characteristics. If the engine speed increases, it is recommended to increase the compressibility of the gas by reducing the number of compression rings [1,2,3,4]. In existing carburetor engines at high pressures, it is recommended to reduce the number of compression rings to two, and in diesel engines - to two or three.

Vibrations in the rings occur when the engine speed reaches a certain level and arise mainly as a result of bending of the rings, a decrease in gas pressure in the piston rings in the presence of irregularities in the grooves of the piston rings. sleeve. One way to radically reduce ring vibration is to increase ring rigidity, reduce the size of the piston grooves behind the ring, and reduce ring height.

In cases where the rings vibrate in the radial direction, they begin to lag behind the walls of the bushing. As a result, the tightness of the inner part of the cylinder is not compromised, heat loss worsens, the area of local heating increases, the quality of lubrication deteriorates, the rings begin to sag, and the rubbing surfaces begin to wear out quickly.

The gas pressure in the grooves significantly increases the compression force of the rings on the surface of the bushing: as a result, the oil is squeezed out and friction increases. As the pressure increases between the ring and the bushing surfaces at the rear of the ring, boundary friction arises, under the influence of such conditions the bending process begins to intensify, especially in the upper ring and the belt of the upper part of the ring. sleeve [2,3]. The friction force in the compression rings depends on the average pressure of the gases formed in the piston rings and the height of the ring b (Fig. 1), since the compression force of the ring under the influence of gas is proportional to its inner surface (along the groove), i.e. p(D-2t)b, where t is the radial thickness R of the ring.

Average pressure tends to increase as engine speed increases. Therefore, for all heat engines it is recommended to reduce the number of compression rings and their height in order to reduce mechanical friction losses. [1,5].

When choosing the main design parameters of the rings, it is recommended to pay attention to the following:

1) radial clearance of the cylinder diameter relative to D/t, this value depends on the ring's singleness and its release voltage;

2) ring height b;

3) relative value A_0/t, where the elasticity of the ring, that is, the difference between the shear and crack temperatures in the free state of the ring. Professor B.Ya. Based on the theory proposed by Ginzburg, the average gas pressure force acting on the wall of the piston groove can be determined as follows [4]:

$$P_{med} = 0{,}425E\frac{\frac{A_0}{t}}{(3-\xi)\left(\frac{D}{t}-1\right)^3\frac{D}{t}}\ , \quad (3)$$

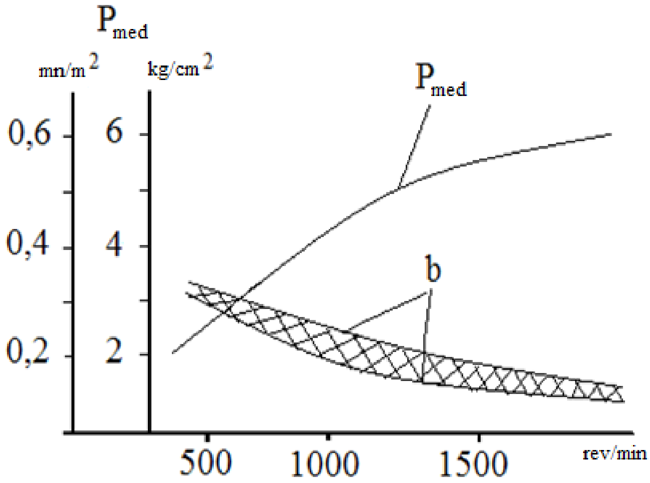
Given the value ξ = 0,196

$$P_{med} = 0{,}425E\frac{\frac{A_0}{t}}{\frac{D}{t}\left(\frac{D}{t}-1\right)^3}\ . \quad (4)$$

here E is the singularity modulus of the ring for alloy cast iron
E ~1.2·105 Mn/m^2 ~ 1.2·105 kg/cm^2; E – coupling coefficient for the shape of the radial pressure curve.

Research has shown that the radial pressure of the ring increases with increasing engine speed of the vibration isolator (Fig. 2).

As the height of the ring increases, due to the increase in the inertial force of the annular mass, the bending of the piston grooves, friction forces and bending of the bushings under the influence of pressure begin to increase. Average radial pressure in compression rings P_{med} = 0.11-0.25 MN/m^2 (1.1-2.5 kg/cm^2), in some cases reaches 0.35 MN/m^2 (3.5 kg/cm^2), oil P_{med} = 0.2-0.4. Mn/m^2 (2 – 4 kg/cm^2) in compression rings. The upper limits of P_{med} apply to engines with small diameter cylinders: P_{med} - the pressure in the first compression ring on the side of the combustion chamber must be high [1, 2, 3].



2 – Figure. Graph Pcp of change in average radial pressure depending on the number of revolutions of the height of the compression rings "b"

The size of the notch of the ring installed on the piston is determined as follows:

$$\Delta_x = \Delta_x^1 + (\alpha_x \cdot \Delta t_x - x_T \Delta t_{r_2}) \quad (5)$$

where αx and αT are the coefficients of linear expansion of the materials of the rings and bushings; Dtx – ring heating temperature, Δtx = 200°C; Δtg – heating temperature of the sleeve; Δtg = 140°C maximum permissible crack in ring locks; for hot engines it is recommended to take Δk = 0.06 - 0.1 mm.

Conclusions:

1. Instability of the average pressure in a pair of piston rings and cylinder liners leads to a decrease in engine power due to partial leakage of the working mixture from the gap between the rings.

2. As a result of the deformation and bending of the liners, the effectiveness of the medium gas pressure sealant begins to decrease, especially when the deformation of the rings matches the deformation of the liner, this is caused by the fact that the rings collide with the sleeve along the surface, but only the top and bottom edges.

3. As the height of the ring increases, the rate of bending of the rings and bushings increases due to an increase in bending friction forces; it is noted that this process is ensured by reducing the number of compression rings.

4. The maximum value of the permissible gap in the ring locks of an engine running on mixed fuels is recommended to be 0.06 - 0.1 mm for hot engines.

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