# IMPROVEMENT OF TRIBOTECHNICAL CHARACTERISTICS OF PISTON RING SURFACE AT RUNNING IN

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**Summary.** In the article the results of experimental and theoretical researches of the electrochemical - mechanical running in (grinding in) of grinding in surface of piston ring are presented. The ECMR(G) is provided by the improvement of tribotechnical characteristics of the running in surfaces at hydrodynamic friction are shown.

Key words: piston ring, running in, electrochemical - mechanical process

# **INTRODUCTION**

Presently many researchers link the questions of running in with further cognition of processes characteristic for basic units. And because in the engine of loading on the different pair of friction is different, that determination of the mode of running in must be conducted, examining the most loaded pair. Such pair can be units of connecting rod bearing journals - bearing inserts [Baghinov 2009] or is a ring - cylinder liner [Zarenbin 1983].

One of directions in polishing and reduction of time of running in there is a keyin of electric current directly through connections of details, part the layer of electrolyte which is give working motion. This method is used for running in of basic units of engines and is one of perspective directions in research. Essence of the electrochemical - mechanical running in (grinding in) consists of the following: working motion the details of mechanism is given, between details an electrolyte is pumping and an alternaing electric current is going. Due to joint electrochemical - mechanical influence there is rapid adaptation of one surface to other. The most effective factor of ECMR(G) is electrochemical [Alekseev 2000]. That is why, most easy to remove the material from the surface due to anodal dissolution at the hydrodynamic mode of friction. On this basis, for the increase of efficiency of ECMR(G) it is necessary to increase viscidity of electrolytes or rev up sliding, that assuredly to provide the hydrodynamic mode of greasing.

Application of the electrochemical - mechanical running in (grinding in) has a row of substantial advantages before other types of final grinding in. Unlike the abrasive grinding (polishing) in at ECMR(G) formation of abrasive particles is fully eliminated as products of wear and other kinds because affecting material is made imposition of current on an environment and details and takes a place at thin level, as a result products of output are in an environment as atoms, molecules. As well as at the electrochemical polishing, at ECMR(G) there is a removal of internal tensions both in micro- and macrovolume of surface of material. ECMR(G) allows to make the local output of metal, but the passivations phenomena, characteristic for electrochemical process, absent here. In addition, ECMR(G) provides joint running in of details without application of the special instruments unlike abrasive and electrochemical processes. due to it there is rapid structural, micro- and macrogeometrical adaptation of the surfaces under friction. Presently efficiency of ECMR(G) is enhanceable due to additions of olein acid in an electrolyte [Alekseev 2006, 2007]. It enabled considerably to improve tribotechnical characteristics of the runnig in surfaces at the different types of friction. Further researches must be directed on opening of mechanism of forming of running in surfaces of details of basic machines' units on the different types of friction, what is the purpose of this work. A research object is choosen the process of the electrochemical - mechanical running in of grinding in surfaces of piston ring.

### **RESEARCH OBJECT**

Examining factors, influencing on a friction resistance and intensity of output of material it is possible to see at ECMR(G) (Fig.1), that on an intensity of wear influence: form of area of contact, type of friction, properties of the surfaces and factors of external influence. Obviously, that flowing of process of running in of the surfaces depends on initial geometry of surfaces.



Fig.1. Factors, influencing on an intensity of output of material at ECMR(G)

The most surfaces at ECMR(G) pass three basic stages of running in process. Knowing that the Sommerfeld criterion which is evened  $Sm = 10^{-5}$  corresponds transient regime of friction, easily to set the change of types of greasing at running in surfaces. In an initial period of time there is mechanical elimination or driving back of plastic materials, forming of initial area of contact (I stage). With its growth a transition is possible from a semiliquid friction to hydrodynamic (II stage), and at the hydrodynamic regime of friction the spot of contact is finally formed in examined tribosystem (III stage ).

At ECMR(G) tribotechnical characteristics of the runnig in surfaces at the different types of friction are improved. Thus the change of surfaces takes a place on all of three stages of running in, that is impossible at ordinary methods, being based on a mechanical wear or creation on the grinding surfaces of different type of tapes. Surface forming at ECMR(G) takes a place due to electrochemical and mechanical influence (Fig. 2).

Influence of different factors allows to form top surface relief of roughness of surfaces. The mechanical labilizing is instrumental in the etch of tops of ledges, and the presence of superficial tapes and gasification is diminished by embittering of cavities.



After running in

Fig. 2. Processes, influencing on surfaces forming at ECMR(G): 1 – anodal dissolution; 2 – gasification; 3 – electrode wear; 4 – mechanical wear; 5 – forming of superficial tapes

## **RESULTS OF EXPERIMENTAL RESEARCHES**

At providing of the hydrodynamic regime of friction the running in surfaces are fully divided the layer of electrolyte, that eliminates the mechanical factor of wear of the running in surfaces. The output of metal from a surface is carried out due to an anodal dissolution. Therefore for the study of forming of surfaces of piston-rings at ECMR(G) it is enough to set the assured gap between a ring and liner. By basic equalization which describes speed of anodal dissolution there is the following

$$\mathbf{v}_a = \frac{c}{\rho} \cdot \frac{\eta}{a} (U - \varphi_a + \varphi_\kappa) \cdot \chi, \tag{1}$$

where: U - working tension,

- $\varphi_a$  anodal potential at the mechanical labilizing,
- $\varphi_{v}$  cathode potential,
- $\eta$  anodal output on a current at the mechanical labilizing,
- $\chi$  specific conductivity of electrolyte,
- $\rho$  density of material,
- *c* electrochemical equivalent of material of anode (for a chrome C=0.324 g/Ah),
- *a* radial gap in the area of liquid friction.

In equalization (1) permanent sizes are density of material  $\rho$ , anodal output on a current  $\eta$ , specific conductivity of electrolyte  $\chi$ . Taking into account large specific resistance of electrolyte it is possible to consider permanent and the initial set tension. Therefore equalization (1) over can be brought to the next kind for every concrete terms taking into account permanent sizes

$$V_a = \frac{c}{\rho} \cdot \eta_a \frac{(V - \varphi_a + \varphi_k)}{a} \chi = \frac{k}{a}$$
(2)

where: *k*- permanent coefficient for certain conditions ( tension, conductivity, material of anode),

*a* - gap between an anode and cathode.

As be obvious from equalization (2) of variable a size influencing on speed of anodal dissolution is a gap between an anode and cathode.

The necessity of electrochemical treatment of rings frequently arises up in a repair production at presence of production spoilage, at a necessity creation of oilcapacious microrelief, able to retain greasing on smooth rings, with the purpose of increase the quality of surface of porous rings. In all of these cases the task of change of type a surface must be taken to dissolution of tops of roughness with simultaneous prevention of dissolution of cavities. For this purpose an electrolyte must possess low dispersive ability, sufficient specific resistance which allows to conduct a process on small gaps (5-10  $\mu$ m) and effectively brake it on gaps over 30  $\mu$ m.

Let's present the process of electrochemical dissolution of spherical unevenness (Fig. 3) The task of ECMR(G) consists of removing of material from the top of unevenness. Material of detail at foundation of unevenness must not be dissoluted.

As be obvious from a Fig. 3, the least distance from a cast-iron cathode to the chrome-plated anode will be between cast-iron and top of unevenness, this distance is equal  $a_{\min}$ . Maximal distance between an anode and cathode is marked on a scheme  $a_{\max}$ .

If not to take into account, difficult processes of gasification in an electrolyte, surfaces passivation, it is possible to understand that speed of anodal dissolutions on maximal and minimum gaps will be proportional the sizes of gaps.

Taking into account that  $a_{\text{max}}$  equal to the sum  $a_{\text{min}}$  plus the radius of unevenness r, we will write down:

$$a_{\max} = a_{\min} + r \,. \tag{3}$$



Fig. 3. Scheme of electrochemical dissolution of spherical unevenness at ECMR(G)

Knowing equalizations (2) and (3), it is possible to write down speeds of anodal dissolution, which will pass between an anode and cathode in the nearest and most remote points. The value of high and minimum dissolution speed will look like therefore:

$$v_{a\max} = \frac{k}{a_{\min}},$$
(4)

$$v_{a\min} = \frac{k}{a_{\max}} = \frac{k}{a_{\min} + r}$$
(5)

From (4) and (5) evidently, that speeds of maximal and minimum dissolution of surface depend on  $a_{\min}$  and r. In an order to execute the primary terms of dissolution one unevenness with minimum dissolution of basic surface of ring it is necessary to execute a condition at which attitude of high speed of dissolution toward minimum must aspire to endlessness or be maximally large, on this basis, it is possible to write down correlation:

$$\frac{v_{\max}}{v_{\min}} = \frac{r + a_{\min}}{a_{\min}}$$
(6)

If we are using formula (6) on the example of unevenness dissolution with the radius  $r = 20 \ \mu\text{m}$  it is possible to build the graph of theoretical dependence of high speed to minimum  $\frac{v_{\text{max}}}{v_{\text{min}}}$  (Fig. 4). It is possible to draw a conclusion on this graph, that

the best the condition of change the surface (dissolution) of unevenness goes at minimum gaps between an anode and cathode  $a_{\min} \rightarrow 0$ . Herein cases the relation of high and minimum speeds of anodal dissolution will aspire to one. Its meens, that speeds will be compared and on relatively large gap a surface will evenly dissolve, both on a top of unevenness and at its foundation. Therefore at electrochemical dissolution of rings, an electrolyte must possess high specific resistance, and cathode in a process ECMR(G) must move in the direction of anode for the most effective leadthrough of process.



Fig. 4. Theoretical dependence of high speed of dissolution to minimum,  $\frac{v_{\text{max}}}{v_{\text{min}}}$ 

For experimental confirmation of theoretical pre-conditions the special device was collected. Part was fixed in opening of plate. A ring lay down on a laboratory table. A ring is preliminary compressed to the thermal gap in a lock by a plate and screws with nuts. Thus, the permanent radius of curvature of ring was provided. A necessary gap was set by a laboratory table and indicator of sentinel type. A gap between a ring and part changed from 10 to 50  $\mu$ m, with the step of 10  $\mu$ m. Setting of necessary gap was conducted as follows: the ring set in a contact with part was connected in the chain of electric current. Then through the micrometrical head of a laboratory table a ring was taken from part to the moment of disappearance of current in a chain. The moment of tearing away was fixed an ammeter, that was a zero point. After it a necessary us gap, controlled the indicator of sentinel type, was proposed. Every experiment was repeated three times. The experimential time was 10 minutes.

After experiment the wear of standard was determined on the loss of mass by weighing and the roughness of surface was taken off. Weighing was conducted on the analytical scales of WA-31 with exactness of measuring 0,1 mg. A change a roughness was controlled by profilograf-profilometre.

The results of electrochemical output from the surface of piston-ring are presented on Fig. 5. With diminishing of minimum gap between a cast-iron liner and chrome-plated surface of piston-ring an output was notedly increased. On in relation to small gaps (10, 20  $\mu$ m) the dissolution of chrome took a place in 5-6 times more intensive, than on a gap in 50  $\mu$ m.



Fig. 5. Electrochemical output of chrome from the surface of ring at dissolution on different gaps



Fig. 6. Improvement of profile of piston-ring after an ECMR(G) (above is the initial state; down - after an ECMR(G) on the gap of 40  $\mu$ m)

At the ECMR(G) of ring on the gap of 40  $\mu$ m his type is considerably improved (Fig. 6). Two unevenness are visible in the middle part of initial surface profile. Their height makes about 20  $\mu$ m. After experiment they were dissoluted, and character of other surface did not almost change, that talked about high electoralness of ECMR(G) in the applied electrolytes .

## CONCLUSION

1. The process of the electrochemical polishing of rings most effectively will pass at the relation of high speed of dissolution  $v_{max}$  to minimum  $v_{min}$  aspiring to endlessness, a gap between a cathode and taking poison ring must be minimum.

2. With the increase of gap between the details of speed  $v_{max}$  and  $v_{min}$  approached by the value, and their relation aspires to one. Therefore leadthrough of ECMR(G) on the gaps of considerably exceedings the sizes of microroughness not effectively.

3. On in relation to small gaps (10, 20  $\mu$ m) the dissolution of chrome took a place in 5-6 times more intensive, than on a gap in 50  $\mu$ m.

### REFERENCES

- Alekseev V., Zamota T., Ivanov S., 2006. About possibility of the electrochemical mechanical running in (grinding in) of the main conjugations of axial- piston pumps // Collection of scientific works of the Lugansk national agrarian university. Series: Engineerings sciences. – Lugansk: Publ. LNAU. – №64(87), – p. 8 - 11.
- Alekseev V., Zamota T., Izumskiy V., 2000. Research of the electrochemical mechanical running in (grinding in) of surfaces of chromic coverage of piston-ring and cast-iron of liner of cylinders // Collection of scientific works of the Lugansk national agrarian university. Series: Engineerings sciences. – Lugansk: Publ. LNAU, – p. 12 - 16.
- Alekseev V., Zamota T., Parfilko V., Ivanov S., Izumskiy V., 2006. Influence of olein acid on the roughness of contacting surfaces at electrochemical - mechanical running in // Collection of scientific works of the Lugansk national agrarian university. Series: Engineerings sciences. – Lugansk: Publ. LNAU. – №64(87), – p. 12 - 20.
- 4. Baghinov V., Kravchenko A., 2009. Reliability of autotractors. Monograph. Lugansk: Publ. «Knowlidge», 412 p.
- 5. Zarenbin V.G., Kasumov A.K., 1983. Research of the modes of running in of motor-car engines at repairs. M.: Transport, 78 p.
- 6. Patent on an useful model № 24735 «METHOD OF RUNNING IN OF DETAILS»G01M 15/00 /
- 7. Alekseev V., Zamota T., Parfilko V., Ivanov S. / Vol. № 10, от 10.07.2007.

### УЛУЧШЕНИЕ ТРИБОТЕХНИЧЕСКИХ ХАРАКТЕРИСТИК ПОВЕРХНОСТИ ПОРШНЕВОГО КОЛЬЦА ПРИ ДОВОДКЕ

#### Замота Т.Н., Кравченко А.П.

Аннотация. В статье представлены результаты экспериментальных и теоретических исследований электрохимико-механической приработки (доводки) трущейся поверхности поршневого кольца. Показано, что ЭХМП(Д) обеспечивает улучшение триботехнических характеристик прирабатываемых поверхностей при гидродинамическом режиме трения.

Ключевые слова: поршневое кольцо, доводка, электрохимико-механический процесс.