EVALUATION OF THE SURFACE COMPATIBILITY OF PISTON GROUP PARTS WITH DIFFERENT COATINGS USING THE CYCLIC INDENTATION METHOD

R. Huang[1], J. Xu[1], K. Grinkevych[2], G. Tsybanov[3], I. Tkachenko[2]

[1]*Dalian Maritime University(Dalian, China, rxhuang@dlmu.edu.cn)*

[2] *Frantsevich Institute for Problems of Materials Science of NAS of Ukraine (Kyiv, Ukraine,* kevich@ukr.net)

[3] *G. S. Pisarenko Institute for Problems of Strength of NAS of Ukraine (Kyiv, Ukraine, g.v.tsybanov@ipp.kiev.ua)*

The development and use in the engine industry of modern types of materials and coatings requires the establishment of an optimal combination of durability, mechanical strength and wear resistance under dynamic conditions, among other things. In this regard, in this study, experiments were carried out to determine the tribotechnical characteristics of the materials of the piston ring and cylinder liner with different coatings using both the traditional bench tests technique (Fig 1a) and with the imposition of a cyclic load (CL, Fig 1b) [1] . The latter of the techniques makes it possible to bring the conditions of friction in contact closer to operational ones due to the presence of vibrations during engine operation.

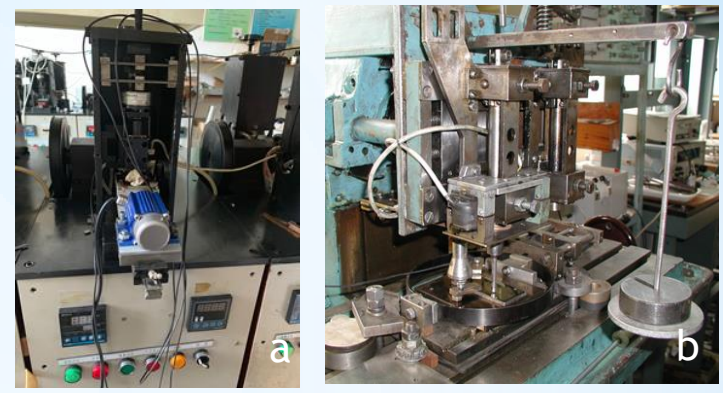


Fig. 1 General view of bench tests unit (a) and CL unit (b)

Under study next surfaces of diesel engine parts was investigated: rings (materials marked as R_A - cast iron with vermicular graphite ChVG30 with $CrAl_2O_3$ coating, R_b - alloy steel 20CrN with CrN coating) and cylinders (C_d – low-alloy cast iron, corrosion-resistant ChNHMD, and C_c - white iron modified with boron). Samples were cut directly from the rings and cylinder liners.

The results of bench tests of pairs R_A/C_c and R_b/C_c in a wide range of temperatures and loads showed an insignificant difference in tribotechnical characteristics. When the ring was in contact with another material of cylinder liner (R_A/C_d) the scuffing was observed there. Wear of liner surface in R_A/C_d contact is about 20 times higher than R_b/C_d.

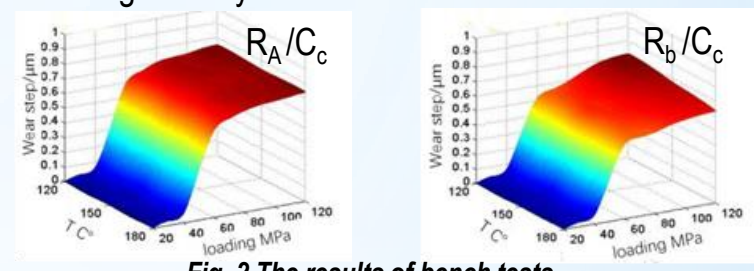
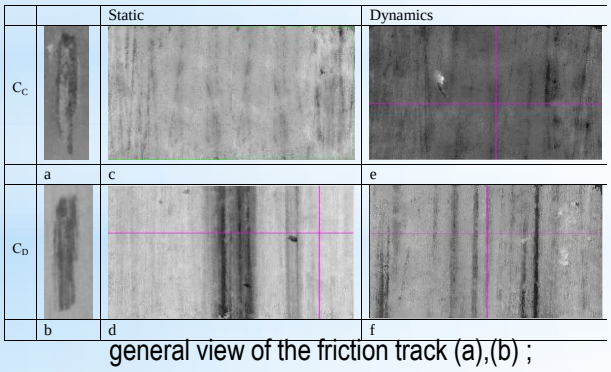


Fig. 2 The results of bench tests

The compatibility of materials of rings and cylinders C_c i C_d (Fig. 3) were checked into account the influent of the dynamic component of the load under both of the plate-cylinder schemes and cylinder-cylinder (like the bench test). One hand the topography of friction tracks confirms the same mechanism of degradation in the bench tests and CL tests

Fig. 3 from ring R_A(IV) , from ring R_A(V), from ring R_b(VI)



general view of the friction track (a),(b) ;

Fig. 4 Optical images (c, d, e, f) of friction tracks on samples of C_c, C_d after tests with indenter IV with R_A.

According to the obtained images of the surfaces (Fig.4) it can be concluded that on the surface of the friction track formed on the sample C_d with coating there is Scuffing, which is characterized by the presence a rough edge and grip, especially in dynamic loading mode. In opposite to the C_d sample, the surface of the uncoated C_c sample is more homogeneous and no scuffing was observed. Obviously, the R_A C_c/C_c and R_A/C_d pairs have different wear mechanisms, which is fully consistent with the results obtained during bench tests of these contact pairs. But due to the form of indenter IV when comparing flat and cylindrical types of samples, the determination of rather small values is a very difficult experimental task.

Other hand the CL test sensibility is higher that under the bench tests. The results obtained prove the possibility using the wear parameters under short term test with cyclic loading. In addition, they can be used to assess the compatibility of friction pairs and calculate the durability according to the criterion of limit wear.

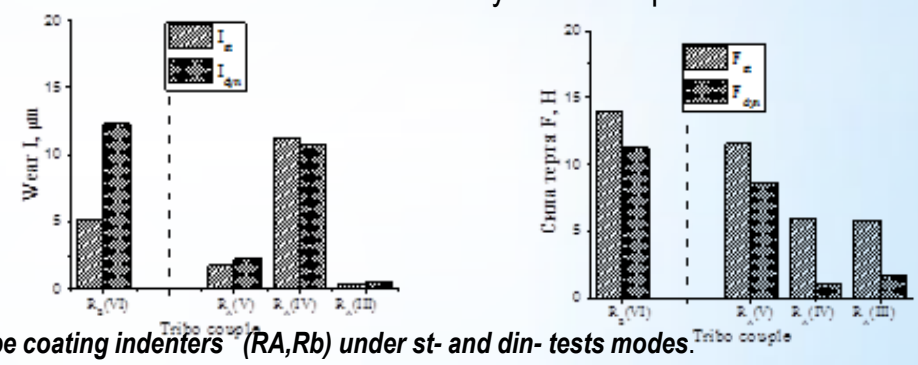


Fig. 4 The wear and friction force of couple the flat sample (Cc) with the cylindrical shape coating indenters (RA,Rb) under st- and din- tests modes.

Summarizing remarks: Phenomenon of mechanically stimulated degradation of materials during friction with forced vibrations of normal load caused by extraneous vibration sources and allows to determine the degradation of the mechanical properties of surfaces, in particular wear of cylinder-piston parts with high sensitivity Experimental evaluations of the degradation of materials using the wear parameters showed that the wear under dynamic loading more 2-3 times intensive than wear at the quasi-static tests. It is shown by analyzing the degree of penetration of the indenter into the studied samples surface layers that the degradation mechanism of tribocouples changes from the smooth surface fatigue wear without coating to the scuffing at the studied combination of coatings.

The loading mode with cycling of the normal load more closely reflects the operational process. In the majority of cases studied, this mode leads to more intense degradation of surfaces in contact with friction which should be taken into account in the evaluation of durability. The obtained results prove the possibility in principle of using the wear parameters under short term test with cyclic loading of ring and cylinder for control of in-service damage of parts like a piston-cylinder group

Acknowledgments This study is partially supported Scientific Program of NASU "Reliability and durability of materials, structures, equipment and buildings Resource 2" (Projects 9.8.2) and budget topic №:1.3.4.1910 of NASU "Development of methods for assessing fatigue damage of metallic materials at the stages of cracks nucleation and growth"