The researches of abrasion-resistant characteristics of polymeric material used when repairing of pumping equipment

Anatoliy Ischenko

D.Sc. in engineering, Prof.
Head of "Mechanical Equipment of Ferrous Metallurgy Plants" Department
SHEI "Pryazovskyi State Technical University"

Elena Dashko

Ph.D. student of"Mechanical Equipment of Ferrous Metallurgy Plants" Department
SHEI "Pryazovskyi State Technical University"

Abstract
The results of the study of endurance of polymeric materials, which are used to restore and protect the details of the pumping equipment from an abrasive, corrosion and cavitation effects are given in the article. Proposed fillers are introduced into the polymer and enhance

its wear resistance. The optimal composition of the protective coating of pump housings pumping abrasive fluids is developed.
Keywords: PUMP, POLYMER MATERIAL, ABRASIVE WEAR, PROTECTIVE COATING, FILLER, CORUNDUM

Specifics of metallurgical production and, first of all, extreme operation conditions of the pump equipment during technological processes impose the most strict requirements to reliability of their work. The most considerable negative conditions affecting the pumping equipment wear are the following: pumping of corrosive, viscous, high-temperature, abrasive-carrying media; impact of the elevated vibration and blows; intense dust content with ore and coke dust; high difference of temperatures from -40 °C to +60 °C and more; continuous production cycle.

Hence, housing parts of the pumping equipment, in particular of slurry pumps, need the application of various protective or regenerative coating if they break down by reason of wear to the through-holes. The necessity of protection measures implementation from mentioned wear types is specified by the circumstance that the new equipment cost is high, and therefore, the protection of the pumping equipment is the major problem, which is of great importance for the industry.

There is rather large number of various devices for investigation of resistance wear of protective coating; however, in one case, their use takes a long time for carrying out of tests, in other case, they are too difficult to be made in the conditions of educational laboratory. Therefore, the researches laboratory installation shown in Figure 1 was created for the actual tests of wear resistance of the coverings developed at the Pryazovskyi State Technical University (SHEI “PSTU”).

It allowed carrying out of modeling of medium, which affects the slurry pumps housings during their operation. This process was carried out in the water medium with addition of various materials: granulated slag, corundum of 2mm fraction, high-silica sand. Preliminary experiments allowed establishing that introduction of 2.0 mm fraction corundum into a water medium of volume of approximately 5kg produces maximum effect of metal surfaces wear. At that, 25% of the wearing filler was replaced, i.e. 1.3kg for a new portion, in order to preserve wear conditions after 2 tests cycles (4 hours of work).

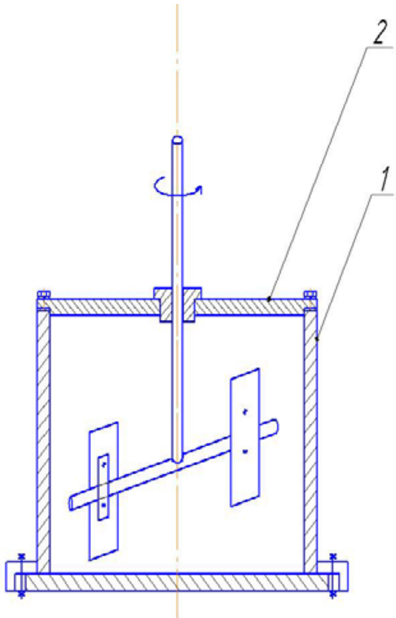

Figure 1. Laboratory installation of abrasive wear investigation

The installation consisted of the housing 1 imitating pump housing with dead-ended cover 2, where the hole was drilled in the center. The mixer was put into the hole. Its shank was fixed in the

chuck of drilling machine with the following technical characteristics:
P_{mot}= 0.25 kW
N_{mot}=1400 r/min
i = 3.14

The installation housing of Ø200 mm in diameter with wall thickness of 10 mm was fixed on a bed of the drilling machine with bolts and pressurized by the rubber seal installed under the cover. The drilling machine design allowed regulating of the mixer rotation speed in steps within 445 – 1400 r/min. The plate under testing with polymeric layer was fixed directly on specially made mixing machine at an angle of 45 ˚ in the plane, which was perpendicular to the rotation axis. Previously, the experiments showed that such position yields the best result of wear intensity.

The domestic material on polyurethane basis DK2 made in accordance with TS U24.3-02070812-002:2014 was tested on wear as polymeric material. These specifications were developed at the “Mechanical equipment of ferrous metallurgy plants” department of SHEI “PSTU” with the following general technical characteristics:
Material density, g/cm^3 1.55
hardening time at t = 20˚C, hrs 24
thermal stability, ˚C -20˚÷ +90˚
production time at t = 0˚C, min 40

The following materials were used as fillers, which had to be conductive to increase in polymeric composition wear resistance; they are high-silica sand, the ceramic powder MF-50, corundum of 2.0 and 0.2 mm fraction, hard alloy powder of up to 0.2 mm fraction. At that, the quantity of polymer and filler was chosen in various ratios in order to find the optimum composition with the resistance to wear. The wear measurements on loss of sample mass were carried out each hour of tests. 4 samples were prepared and used for each percentage ratio of fillers.

The lost mass recalculation of sample in the average volumetric datum of wear presented in Table 3 was carried out; inasmuch as the volume wear is the absolute factor determining true reduction of polymeric coating thickness considering the mixture specific weight.

$$\mathcal{V} = \frac{m}{\rho}, cm^3 \quad (1)$$

Where V - volume value of material wear, cm^3;
m - worn-out material mass, g;
ρ – protective coating density, cm^3/g.
Results of this recalculation are presented in Table 1.

Table 1. Determination results of average value of volume wear experimental values

Composition	Specific weight ρ, g/cm^3	Average volumetric datum of wear Δ_{av}, cm^3 (for 1 hour of work)	Average volumetric datum of wear Σ Δ_{av}, cm^3 (for 2 hours of work)
0% - 0.2 mm fraction 0% - 0.2 mm fraction	**1.5**	0.302	0.633
40% - 0.2 mm fraction 40% - 0.2 mm fraction	**1.637**	0.513	1.112
80% - 0.2 mm fraction 80% - 0.2 mm fraction	**1.697**	0.336	0.772
0% - 0.2 mm fraction 40% - 0.2 mm fraction	**1.596**	0.307	0.733
40% - 0.2 mm fraction 80% - 0.2 mm fraction	**1.679**	0.244	0.475
80% - 0.2 mm fraction	**1.620**	0.54	1.068

0% - 0.2 mm fraction			
0% - 0.2 mm fraction 80% - 0.2 mm fraction	**1.655**	0.245	0.489
40% - 0.2 mm fraction 0% - 0.2 mm fraction	**1.575**	0.372	0.749
80% - 0.2 mm fraction 40% - 0.2 mm fraction	**1.665**	0.589	1.123

First of all, the preliminary analysis of the received results allows stating that the corundum additives of 0.2 mm fraction do not improve the material resistance to wear, and at rather large number of this fraction (to 80%), even deteriorate this indicator in comparison with material, which contains no additives.

According to the obtained data, the dependence of wear (Fig. 2) on the corundum content of 0.2 mm fraction or 2 mm fraction as a part of protective polymeric material without the content considering of both fractions in mixture is developed.

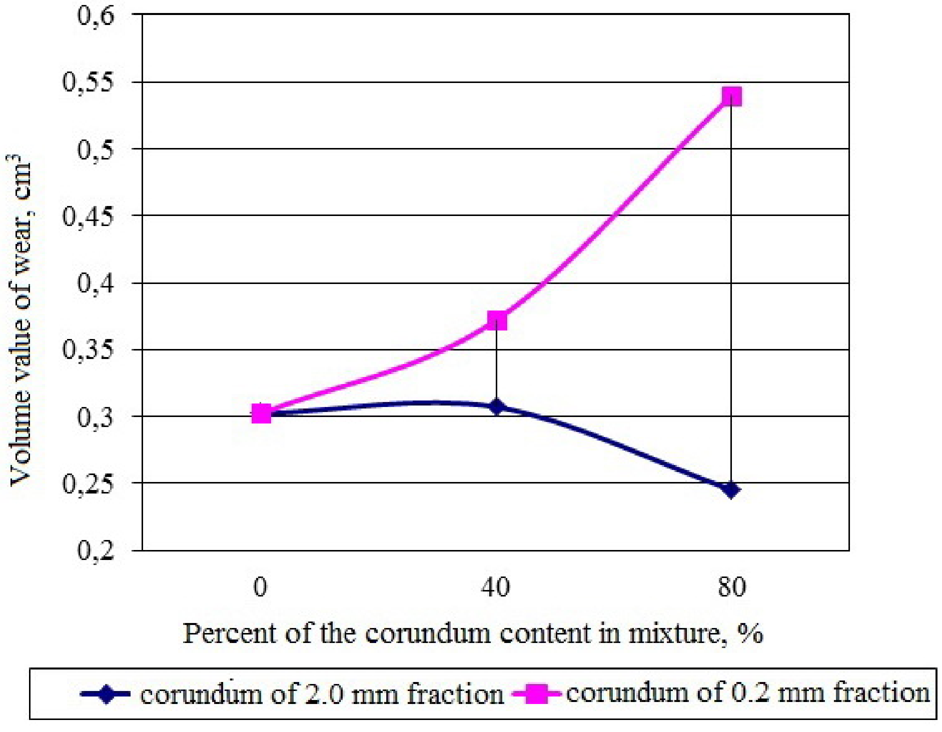

Figure 2. The diagram of dependence of coating volume wear with addition of 0.2 mm fraction only or of 2.0 mm fraction

Transition to the volume wear has even more emphasized the positive effect of corundum large fractions on wear resistance of a coating, and vice versa, the deterioration of its antiwear properties with crushing of small fractions in pure form. This effect of decrease in resistance to wear with introduction of small fractions can be explained by the fact that the material polyurethane basis resists to wear not bad in itself considering its some elasticity, and fine corundum addition makes the mixture more rigid and fine enduring which eventually leads to wear intensification with increase of the corundum content of this fraction.

Another situation is observed under gradual increase of coarse fraction in mixture and content transition to 80% reduces the intensity of wear by almost 20% which is evidence of the fact that corundum “fights” against the wear process as it occupies practically all the surface of protective coating. Apparently, the increase in its contents of more than 80% will have even greater effect on the wear resistance, but there is a problem of protective coating, because the mixture viscosity becomes too high. Due to the stated data, it is interesting to compare the impact of the mixed additives of corundum of different fractions and to estimate the use reasonability of such way of wear resistance increase.

The estimation of impact of various fractions and ratios corundum polymer, which is included into composition, on wear resistance can be carried out by means of the diagram presented in Fig. 3 or in Fig. 4. Apparently from the diagrams, the corundum of 0.2 mm has a negative effect on the intensity of wear and when adding of it to the corundum of 2.0 mm fraction. What is more, the introduction of fine corundum increases the wear intensity steadily at various values of filling by coarse one.

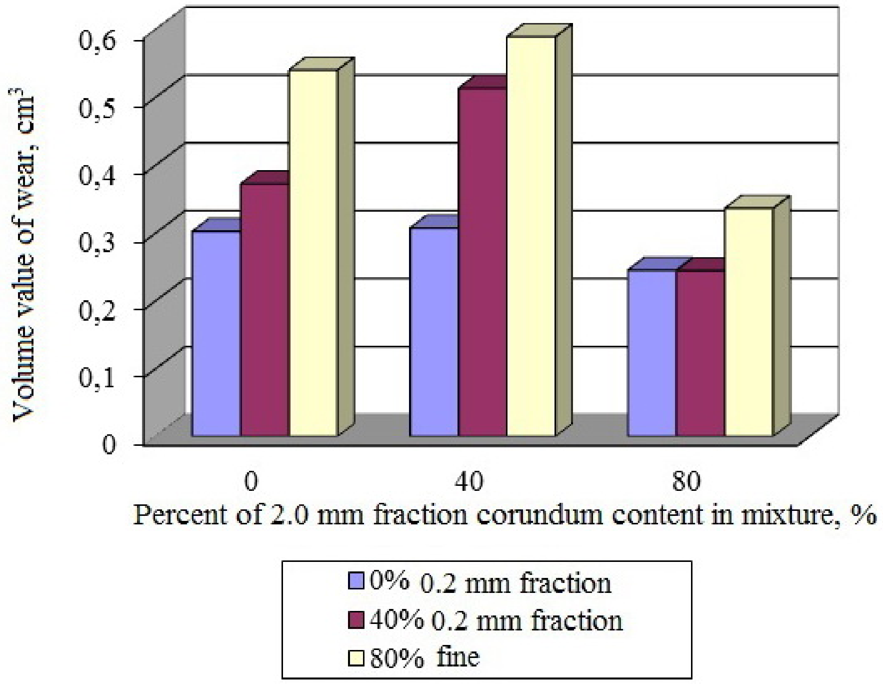

Figure 3. The diagram of corundum components ratio effect on wear intensity in polymer

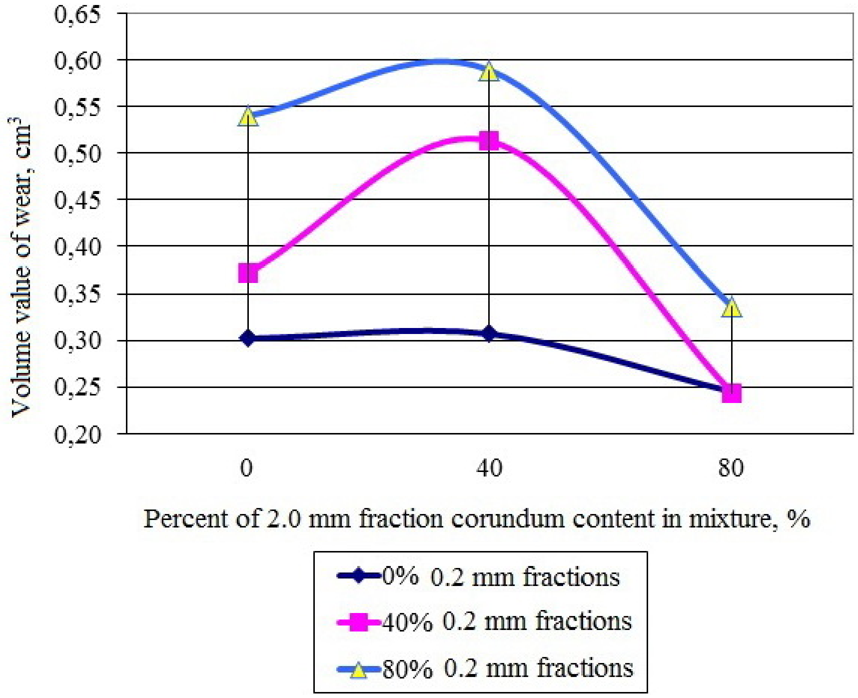

Figure 4. Dependence of wear intensity on a ratio of corundum of various fractions at a part of polymer

Conclusion

The polyurethane basis material developed at the “Mechanical Equipment of Ferrous Metallurgy Plants” department is suggested to use in order to protect the pumps housings subjected to wear. As the result of conducted experiments, the optimum fillers concentration was developed; they allow increasing of bearing capacity of an initial polymeric layer by 19%. Preliminary tests, which were carried out using the vacuum pump at by-product coke plant, showed the reasonability of such covering use for recovery, repairing and protection of an internal surface of the housing from abrasive wear.

References

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