# III. Machine Building

## Feasible Ways To Improve The Durability Of The Pumps' Parts Operating With Hydroabrasive Mixtures

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**Keywords:** pump, water jet mixture, wear resistance, abrasive, pumping equipment, lifetime.

**ABSTRACT.** The analysis of insufficient wear resistance of the pumps' parts, which operate with hydroabrasive mixtures, is provided. The ways to improve the wear resistance of the pumps' wet ends by the usage of the stamped units instead of the molded and carbon fiber composite materials are observed.

**Introduction.** The problem of pumping equipment lifetime, primarily pulp pumps, for the mining industry remains complex issue. Pulp pumps operate with medium and high abrasive materials and mounted in technological lines of crushing after the mills first and second grinding steps, exposed by high-pressure transportation of concentrates and tailings of concentrating mill, etc [1].

Analysis of the reasons for the insufficient wear resistance of the pumps parts for hydroabrasive mixes and the methods used to improve it to develop new design and technological solutions in this area.

Present engineering companies offer a wide range of pumping equipment, including [1]:

• pumps GrA, GrU, GrT, produced by Bobruisk Machine-Building Plant (Russia), which used for pumping abrasive slurries with density up to 1600 kg/m$^3$, temperature up to 70 ° C, solids inclusion's size of up to 25 mm and a volume concentration of 30 %;

• pumps WARMAN, produced by Weir Group. The range of operating conditions of these pumps is quiet wide. For example, model AH is used to dedicate for severe conditions of operation and has the dimensions of the suction and discharge ports 20 and 18 inches, respectively;

• pumps produced by Metso Minerals: from a large variety of slurry pumps Metso Minerals pumps X used in severe conditions of operation and pumps H and M for medium and light severe conditions of operation;

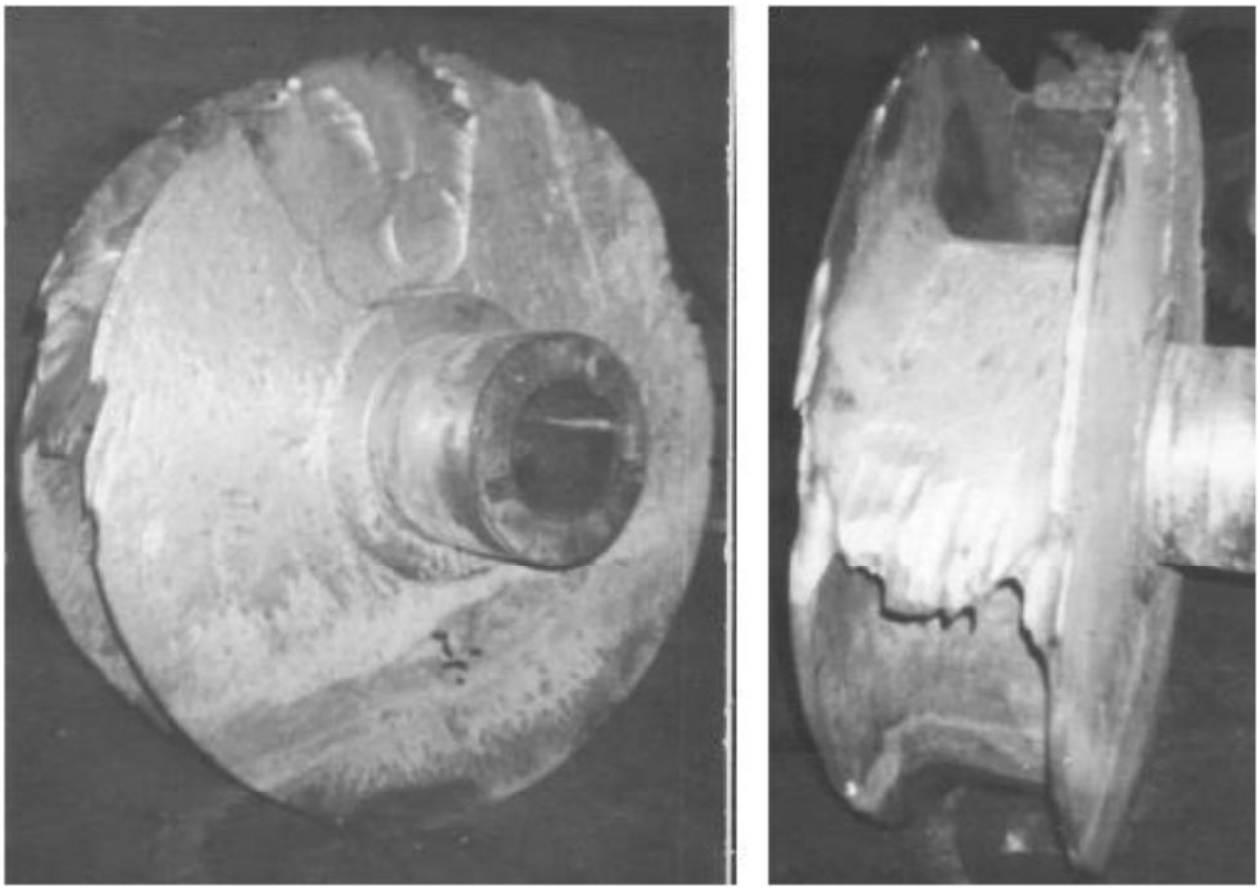
• pumps produced by American company Krebs; which distinctive feature is a new patented design suction part of the pump, significantly declines the internal recycling within the flow of the pump;

• pumps produced by company GIW has a wide range of applications and marked LCC, LCV, LSA, LSR, MEGA, WBC.

In addition, there are some pumps produced by other campaigns, such as Habermann, Zulser, Ahlstrom, Flygt, Ritz, Damen Dredging, Flowserve [1].

Despite the fact that the developers and manufacturers of pumps constantly working on improving the durability of the pumps, the problem does not become less relevant.

On the fig. 1 the worn wheel is depicted. The productivity of the wheel is 5000 $m^3$/h (outer wheel diameter 1260 mm).



*(a)* (b)

Fig. 1. The worn pump wheel. a) dimensional view; b) the view from flow channel

The wheel has been working for 3 months at one of the Ukrainian mining and processing plant. The extreme worn appeared in the area of outer diameter. The chemical composition of the wheel's material is the following: carbon (> 3%), chromium (> 33%) and nickel (> 3%).

On the fig. 2 the picture of the worn pump wheel WARMAN with productivity 4000 $m^3$/h with significant abrasive wear is provided.

As noted in [2, 3], the main factors determining the loss of performance are:

1. Hydroabrasive wear of the flowing pumps parts, which makes the volume losses and increase vibration, which leads to rotor imbalance and performance reduction.
2. Corrosion wears on pump components due to water influence.
3. Cavitation wear leads to steep increase of vibration and the destruction of the flowing pumps parts.
4. The main measures to increase the wear resistance of the flowing pumps parts, which using known developers, are shown in Table 1.

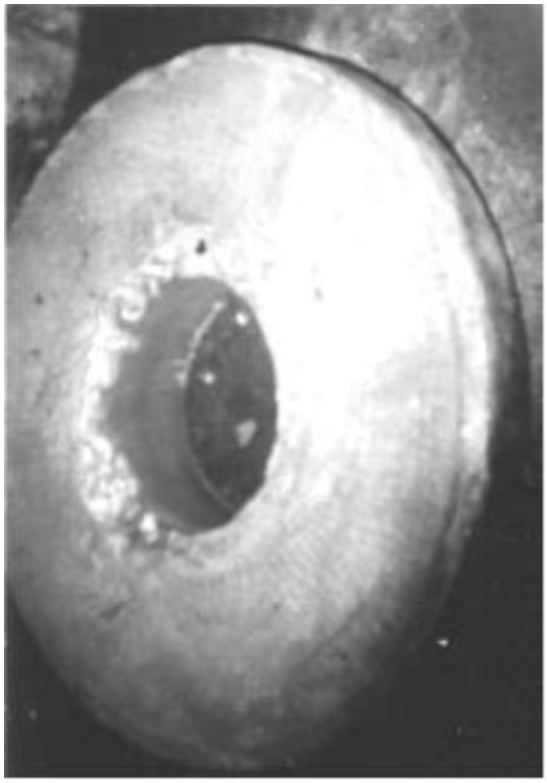


Fig. 2. The worn wheel disk of the WARMAN pump

The WARMAN research in the field of ensuring wear resistance are most indicative [2]. Noted, that various materials applied by production of pumps behave at abrasive wear differently. Wear resistance of white cast iron depends on two main components of their structure: carbide and matrix. Usually the matrix (as a rule, martensite with austenite inclusions) collapses with greater speed, than carbides.

Process of wear begins with emergence of microsinks between carbide and a matrix. Formation of sinks is a result of separation of a matrix from carbide, which occurs at the time of blow of a particle. As particles continue to influence a surface, microsinks extend and unite. Less strong matrix collapses the first. Later the combination of the unprotected and not fastened with a matrix carbides and existence of microcracks leads to gradual removal (washout) of carbides. Process of wear of rubber is usually followed by lengthening of material in a point of contact with a particle with the subsequent stretching and deformation of other material in a ledge.

Consecutive collisions of particles with a surface of ceramics lead to emergence of cracks and their distribution in the course of work. Parts of ceramics are broken, fatigue deformation collects in process of deepening of cracks. The gradual destruction happens. At the moments of powerful collisions there can be deep cracks and occur a material break. The mechanism of removal the particles of material from ceramics depends on its composition and an internal microstructure and is specific to different types of ceramics.

Wear of surfaces can be uniform (with smooth or rough polishing), quasiuniform (a wavy surface) or local (local flutes or dot erosion) [2].

WARMAN makes experiments at the special stand for detection of influence of geometry of parts on wear in various details of the pump. The main direction of this experimental work is development of mathematical methods of forecasting of specific types of wear.

*Table 1. The main measures to increase the wear resistance of the flowing pumps parts, which using their developers*

| Trade-mark or pump brand | Design and technological solutions |
|---|---|
| GrA, GraU, GrT<br>by Bobruisk Machine-Building Plant | The running pumps parts can be made of super-hard alloys, the abrasive material on the organic binder, rubber and polyurethane [1]. |
| Metso Minerals | The types of XR, XM, HR, HM, MR and MM have a rubber lining and a metal inner surface of the case.<br>Standard wear parts are made of natural rubber (Elastaslayd et al.) or carbide (Metahrom, Metahard, Metalsayz et al.), as well as synthetic rubbers [1]. |
| Krebs | New patented design of the suction area of the pump greatly decreases the internal recycling within the flow of the pump.<br>The pump mill Max by Krebs has a cast metal case and a metal impeller, the pump Max has a rubber lined case and a metal impeller [1]. A metal details are made of high-chromium alloys, which received the name Krebs alloy, a rubber details are made of natural rubber. |
| LCC-M<br>by GIW | The pumps LCC-M have monohull design and high strength material Gasite used for wear parts. The pumps LCC-R have a rubber lining and force-pipe sizes up to 12 inches, flow rates up to 2260 m3 / h and heads up to 45 m of water column. Impellers can be manufacturing of polyurethane [1]. |
| Habermann | The pumps NP and NPK are intended for pumping abrasive slurries and sand particles, KB и KBP are intended for pumping large, including gravel particles over 100 millimeters.<br>Material HBN450VG is used for production metal components of these pumps and has 650 units Brielle hardness [1]. |
| WARMAN | The worn-out parts made from solid high-chromium alloys (for example, Hyperchrome® A61 and Ultrachrome® AS1) так and from various cast elastomers.<br>Along with improvements of a hydraulic design work on improvement of properties of materials of the worn-out details is continued. The pumps with a metal internal surface and natural rubber lining was gained the greatest distribution, but examples of use of polyurethane, synthetic rubber and ceramics are known. Material of the metal worn-out details usually consists of an alloy of iron and carbon with the high content of chrome (ranging from 23 to 30%) and various alloying additives. Vacuum casting is used for production of similar materials. As a result the declared hardness sizes reach 750 Brinell and more. Natural rubber lining is less strong, but is more elastic [1, 2]. |

**Summary.** The companies making the pump equipment offer the modern enterprises rather wide choice of pumps with various technical characteristics and wear resistance of details.

But it is impossible to claim that all reserves of increase of wear resistance of flowing part of slurry pumps are used. It is possible to refer replacement of cast designs of bladed wheels of pumps by combined designs consisting, for example, of stamped elements, of details of the alloyed rolled metal with a high superficial hardness.

The use of composite materials on a basis carbon - carbon components which are widely applied in designs of flowing part snuffled the solid propellant rocket engines which are exposed to intensive erosive influence is perspective [5].

The offered directions of increase of wear resistance of flowing part of pumps will demand certainly carrying out research and developmental works.

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