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Comparison of some laboratory wear tests and field wear in slurry pumps

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ABSTRACT

A number of different laboratory wear tests have been undertaken to measure the wear resistance of a natural rubber and a eutectic and hypereutectic white iron under abrasion and erosion conditions. Laboratory work included two different slurry jet erosion tests, a Coriolis test and an ASTM dry sand rubber wheel test.

The laboratory results were compared with wear of the same materials in a centrifugal slurry pump application in a mineral processing plant. The pump application has been monitored for over 2 years and over 40 parts run to destruction. Analysis of the wear data shows a factor of almost 3 difference in wear rate between the rubber and the best white iron. Coefficient of variance of the data was in line with typical wear results from the field.

The laboratory wear tests were conducted with a silica sand slurry and average particle size range of 300–500 μm to match the field conditions. The Coriolis and one of the jet erosion tests showed order of magnitude similarity with the field test results for the metals, but the other tests gave very different trends. The jet and Coriolis erosion tests on the rubber showed a much lower wear rate than seen in the field, while the DSRW test found that the eutectic white iron wear rate was lower than that of the hypereutectic iron (all opposite of the field test).

Explanation for the different wear rates between the laboratory and field tests was postulated to be non-representative wear mechanisms. This is compounded by the lack of understanding of specific wear conditions in the pump (local velocity, concentration, particle size, size distribution and particle shape) as well as microstructure of the samples.

1. Introduction

The wear of centrifugal slurry pumps in mill circuit applications in mineral processing plant is generally quite severe. Typical life of pumps is in the range 1500–4000 h and material wear rates can be over 2 mm/day. Part section thickness in large pumps of over 100 mm is not uncommon. A typical Warman® MC mill circuit slurry pump application is shown in Fig. 1.

The mill circuit pump shown above has a number of key internal parts subject to wear. These include the rotating impeller that imparts energy to the fluid, the casing liner, the frame liner (or back liner) and the throatbush or inlet side-liner. The impeller and throatbush orientation is shown in Fig. 2.

Walker [1] shows that the throatbush in a mill circuit slurry pump often wears faster than the other components due to a combination of the sharp particle shape, the coarse particle size distribution and the high velocity recirculating flow. Given both the aggressive nature of the mill circuit duty and the preferential wear of the throatbush, it is this part that is used to compare the 3 different materials in the current study.

The type of wear that occurs on the throatbush is not well understood. It is hypothesised to be a combination of 2 or 3 body abrasion and mostly erosion. During operation with the above pump, the throatbush is adjusted regularly (often weekly) up to touch with the rotating impeller causing both metal–metal contact and wedging of any particles in the gap. There is however only a relatively short touching period and as both parts subsequently wear there is increased flow in the gap and erosion wear. As the gap increases there is less abrasion wear and more erosion wear. This cycle repeats with 8–10 adjustments not uncommon over the life of the part.

The objective of the current research is to compare the wear life seen in the field application of the throatbush material with that of similar material in laboratory simulated wear tests. The laboratory tests included two tests in Australia (using the author's erosion jet tester and a commercial dry sand rubber wheel (DSRW) abrasion test at a technical institute) and two tests (slurry jet erosion (SJE) and Coriolis erosion) undertaken at research establishments in Canada.

2. Field wear data

2.1. Wear rate measurement method

In the current work, the wear rate in mm/day is used as the base measure for comparison. This assumes a relatively constant

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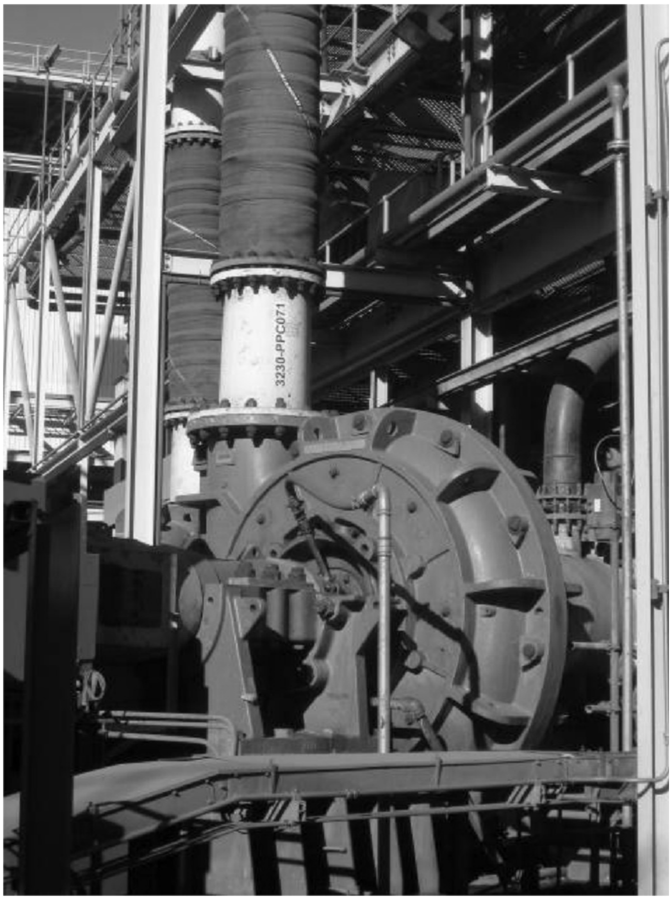

Fig. 1. Warman® MC mill circuit (cyclone feed) slurry pump.

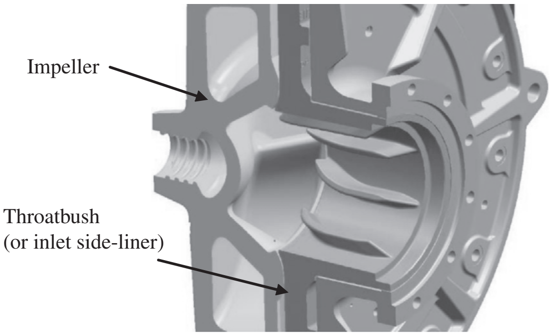

Fig. 2. Sectional view showing relationship between impeller and throatbush.

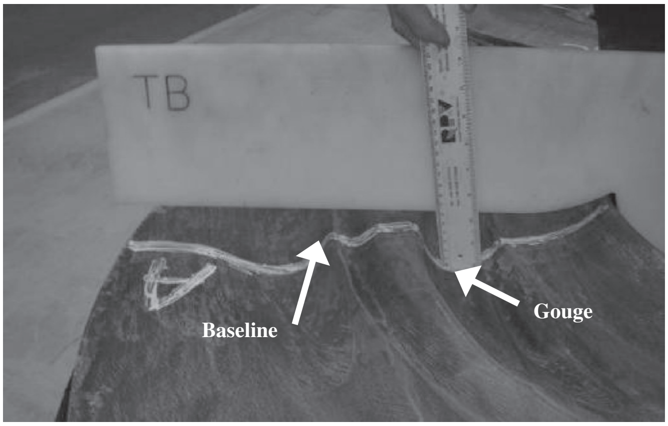

Fig. 3. Part wear measurement using a template.

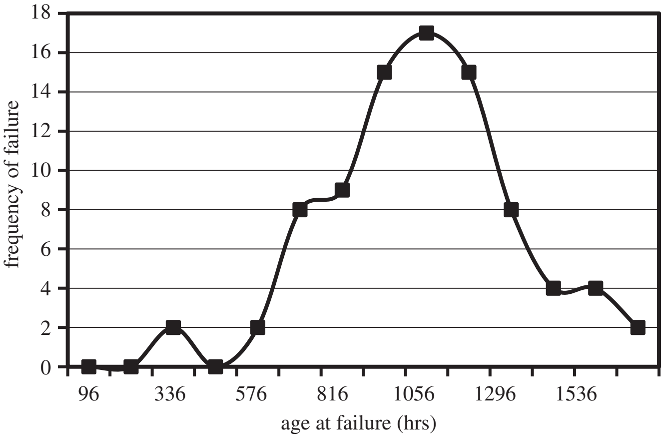

Fig. 4. Wear life distribution at functional failure [2].

mass flow rate through the pump for all data points. Wear depth on the throatbush was measured using a simple template as shown in Fig. 3.

A point to note in Fig. 3 is that the wear is not uniform, but rather there is a "baseline wear" which is the overall surface wear and a "gouging wear" that occurs locally and is generally much deeper. The gouging wear is used in the current work as in most mill circuit pump applications it is this wear that is life limiting for the part.

In examining data from different pump applications (including some mill circuit), Walker [2] found significant variability in measured wear life, with the coefficient of variance—COV (standard deviation/mean) on the order of 0.2–0.3. A typical wear life distribution curve is shown in Fig. 4.

Given this sort of variability, it is essential that there is sufficient data to be able to statistically determine a wear rate, mean and standard deviation so as to meaningfully compare the different material performance. In field slurry applications (operating plants) this is generally far easier said than done, as many variables are not controllable and equipment often starts and stops to meet production or other equipment maintenance requirements.

The current application is almost unique in the authors' 35 years experience. With co-operative plant personnel, a very consistent duty and multiple operating pumps on the same slurry it has been possible to accumulate a significant data set over a 2 year period.

2.2. Slurry particle size distribution

The slurry particle size analysis is shown in Fig. 5. As illustrated in Walker [3], mill circuit applications have a d50 particle size typically250–500 μm and a d85 size of 600–3000 μm. The current application has a relatively coarse large fraction (d85 of 3000 μm), but is otherwise reasonably typical with a d50 of 300 μm.

2.3. Velocity and contact conditions

As mentioned in the introduction, an exact determination of the flow in the gap between the impeller and throatbush (and which is the primary influence on the wear of the throatbush) is difficult to determine. Further, the gap is changing all the time at a rate of up to 2 mm/day. To give some perspective to the likely particle velocity seen in the gap a number of assumptions can be made. Given that a typical gap for the application is around 6 mm,