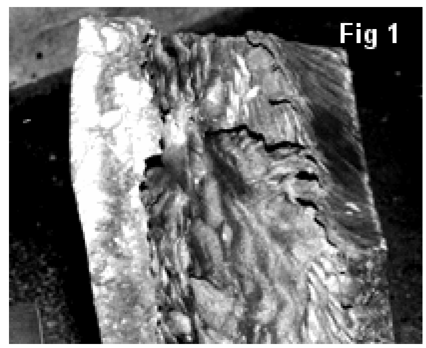
Run Times
LAWRENCE PUMPS INC.
Jan 2007 *vol.4_iss 1*

The extent of erosive wear in a centrifugal pump is dependent on many variables, such as material of construction, slurry characteristics, pump design, and operating conditions. By assuming similar materials of construction and slurry characteristics, we can look at how the latter two elements, pump design and operation, impact wear life and cost when handling abrasive slurries.

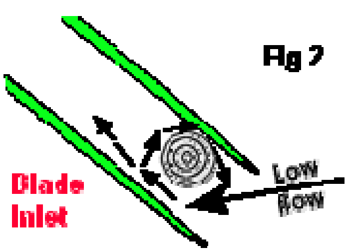
Dale B. Andrews

Erosion occurs when solids impact and scour, or chip away at, the pump internal surfaces. Erosive wear will result in decreased operating performance of a pump, increased electrical and maintenance costs, and may result in the release of hazardous materials to the environment. Other than materials and slurry characteristics, the major factors that directly affect the wear life of centrifugal pump components are the relative velocity of the slurry and the impingement angle of the slurry particles against the exposed surfaces of the pump components.



Relative velocity in a centrifugal pump is the difference in velocity between the fluid and any adjacent pump surface of interest. For a stationary part, such as the pump volute, the relative velocity equals the fluid velocity. For a moving part, such as the impeller, the relative velocity is the difference between the slurry velocity and the impeller surface velocity at any location. Wear in a centrifugal pump will increase as a 2 to4 exponent to the ratio of any increase in fluid relative velocity.

In a well designed pump, operating at its best efficiency point (BEP), wear will usually be dispersed quite evenly over the surface of a component at any given diameter. Severe localized erosion, in comparison to an adjacent surface, is sometimes an indication of off design operation, or a poorly designed feature. As a centrifugal pump flowrate moves away from the pump's best efficiency point, there is an increasing mismatch between the approach angle of the fluid and the impeller inlet vane angle. Deviation between the fluid and vane angles may result in internal recirculation, and possibly cavitation, within the impeller passages (Fig 1). The relative velocity of recirculation is often many times that of design relative velocity, resulting in accelerated wear at



localized areas within the impeller. Typically, one would expect the vanes at the outlet diameter of an impeller to be the first part of an impeller to wear out, as this is where the most work is being applied to the slurry by the impeller vanes. If wear is occurring first at other locations in an impeller, off design operation, or a poorly designed impeller should be a likely suspect. Both of these conditions are usually remediable with a redesigned impeller.

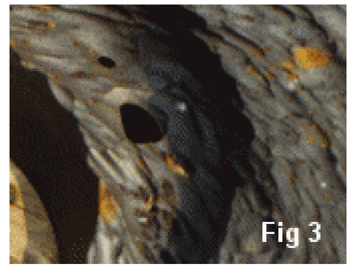


Fig 3

Pumps that use wear rings often experience severe localized wear in the wear ring zone (Fig 3). Much effort and cost has gone into trying to improve wear ring life through the application of surface treatments and hardened materials. Wear rings are used to restrict fluid flow between the high pressure region at the impeller outlet and lower pressure pump inlet. Wear rings perform this function with closely spaced rotating and stationary members that often present a torturous path to fluid flow, resulting in high localized fluid velocity, turbulence and accelerated wear of adjacent surfaces. Pump-out vanes are a more reliable means of leakage management.

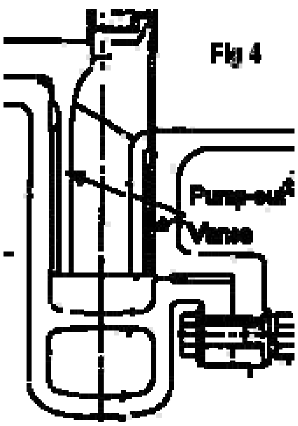


Fig 4

Pump-out vanes are small vanes positioned normal to, and extending radially along an impeller shroud. Like small impeller vanes, the pumping action set up by these vanes restricts recirculation back to the inlet. When new, a pump with wear rings will usually have a higher efficiency than one with pump-out vanes. However, in an erosive environment, that efficiency advantage quickly disappears as the wear rings experience localized erosion, and loss of sealing capability. Pump-out vanes experience much lower relative velocities than wear rings and, as a result, experience less wear. Pumps equipped with them usually operate without significant efficiency loss throughout the wear life of the main impeller vanes.

The cost associated with wear is also related to Specific Speed. In a study published by ASME in 2002, Sellgren, et al, examined the comparative direct costs of slurry pumps of different specific speeds to achieve the same flow and TDH output. Pump specific speeds ranged from 25.8(1330 US) to 37.4(1930 US). For the cases analyzed, it was found that:

- Casing wear rates were inversely related to specific speed
- Impeller and suction liner wear rates were directly related to specific speed

(See Chart 1)

For the pumps used in the analysis the relative cost of the suction liner, impellers, and pressure casings, were 1 : 1.5 : 5 respectively. The cost of parts varied closely with diameter. The projected number of replacements based on wear rate and plotted against specific speed is shown in chart 2. Parts for higher specific speed pumps cost less because they were smaller, but they were also subject to more frequently replacement. The lower specific speed pump pressure cases had the highest projected wear rates, but the number of total parts consumed was projected to be higher for high specific speed

Web http://www.lawrencepumps.com Contact: dandrews@lawrencepumps.com

pumps. As a result, the projected total cost for parts were very similar across the specific speed range, but the high specific speed pumps experienced 3 times the number of instances of parts replacement as the lower specific speed pumps, indicating that the total cost associated with wear is lower for lower specific speeds, particularly when process disruption occurs (Chart 3).

Fig 5

Application of a full casing liner (Fig 5) to protect the pressure shell has added benefit. A casing liner is a less costly part than a pressure casing. With a casing liner, the relative cost of suction liners, impellers, and casing liners is approximately 1 : 1.5 : 2. The lower cost for the casing liners results total part costs that decrease by about 55% over the over the specific speed range. (Chart 4)

In summary, use of properly designed slurry pumps for abrasive applications, running at lower operating speeds, should provide lower life cycle costs if maintenance and operating costs are factored in to the calculation. Use of a volute liner will reduce lifecycle costs independent of personnel and operational cost considerations.

Additional Resources

[Guide to Calculating Life Cycle Cost]
[Life Cycle Cost Calculator]

Charts

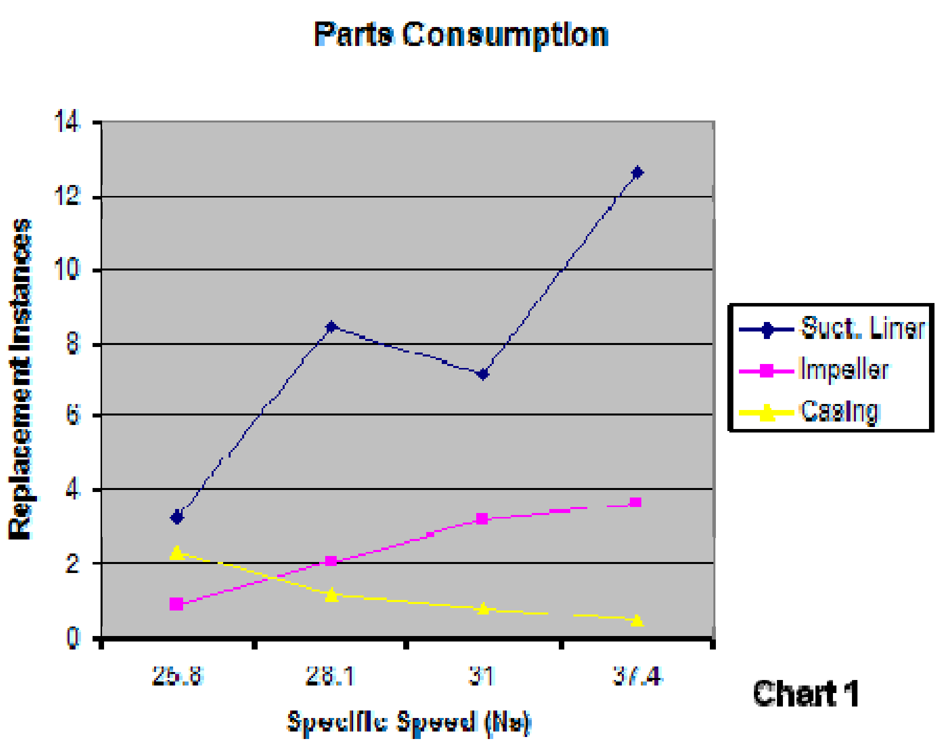


Chart 1

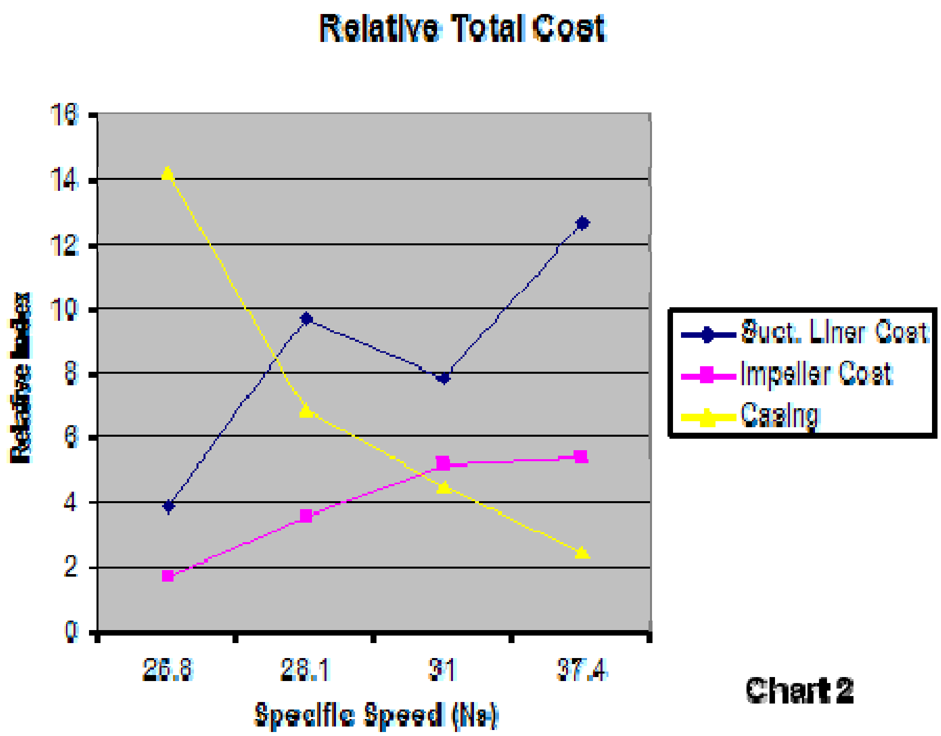


Chart 2

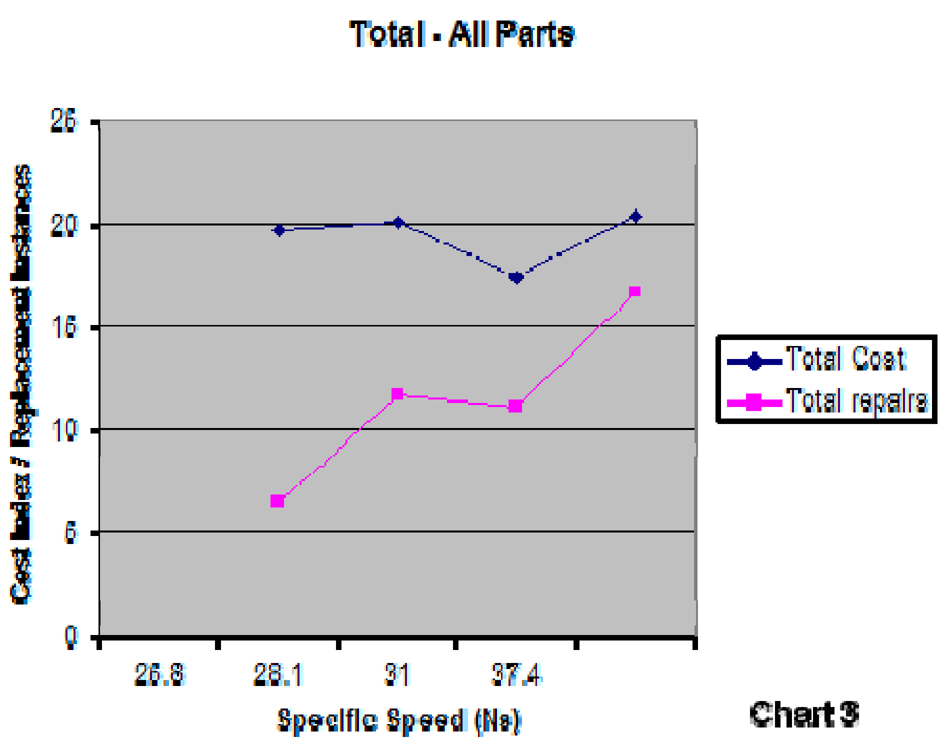


Chart 3

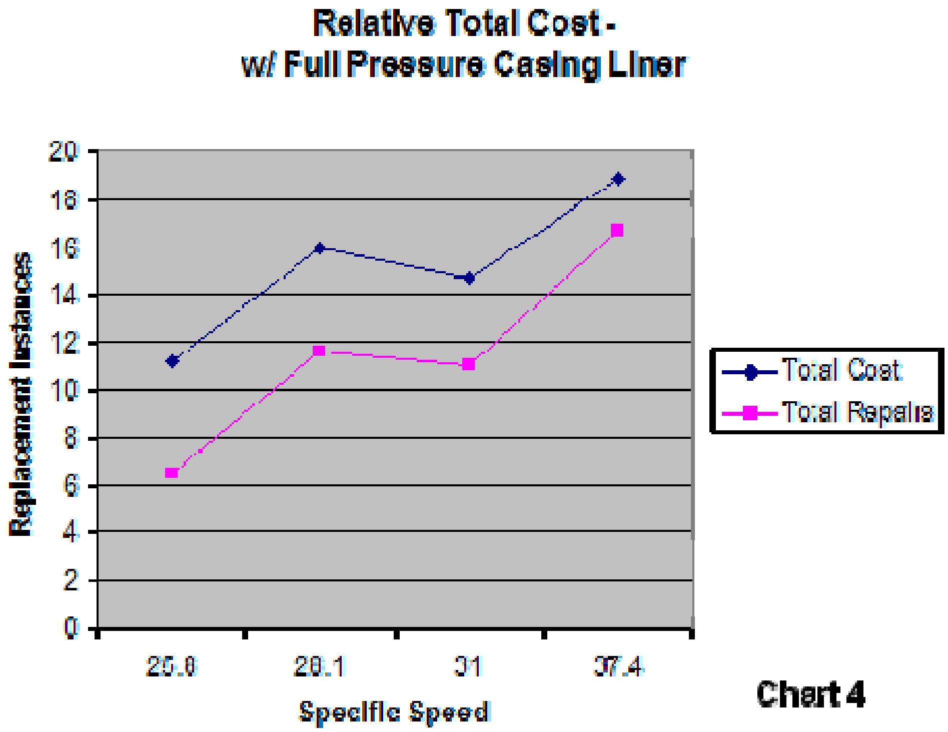

Relative Total Cost -
w/ Full Pressure Casing Liner
Replacement Instances
Specific Speed
Total Cost
Total Repairs

Chart 4