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Utilisation of best available techniques: Coating of pumps to achieve optimum performance

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Pumps are the primary drivers of a modern pulp and paper mill's circulatory system, providing process chemicals and stock to various parts of the mill as well as transporting waste streams away. It is critical that these pumps operate reliably and efficiently in order to meet production goals and ensure safe operation of the process.

While pump operational reliability is critical, pulp and paper production is also a huge consumer of electrical energy and pumps consume nearly a third of the plants overall electrical power demand, as seen in Figure 1. Since electrical energy is an operational cost to be managed, it has become a critical interest to many mills to control their energy usage in order to achieve and maintain operational cost goals. More and more mills are therefore becoming interested and focused on managing and improving the Kwh of electricity expended per M^3 of process flow through their pump systems. If a mill can improve the efficient usage of the energy consumed, they are best optimising their energy consumption and flow capacities.

Pumps operate under fluctuating conditions including, but not limited to pressures, temperatures, corrosion, abrasion and cavitation. The effects on the wet end components of a pump's critical tolerances, and the resulting impact on performance, are well understood.

- Insufficient discharge pressure can result in re-circulation, leading to accelerated abrasive conditions if particulates are in suspension
- Higher than expected temperatures can accelerate corrosive conditions of a media affecting a pump's metallurgical condition
- Increasing amounts of solids in suspension can accelerate erosive wear of critical tolerances, reducing discharge pressures and increasing wear at wear ring seats, cutwaters and volutes faces. (see Figure 2)
- Cavitation can impact impellor vanes accelerating metal loss and weakening of the vanes themselve (see Figure 3)
- Corrosion on internals due to media changes or metallurgical deficiencies can lead to scale deposits and or pitting with resultant increased surface roughness increasing pipe frictional forces and hydraulic drag. (see Fig. 4)

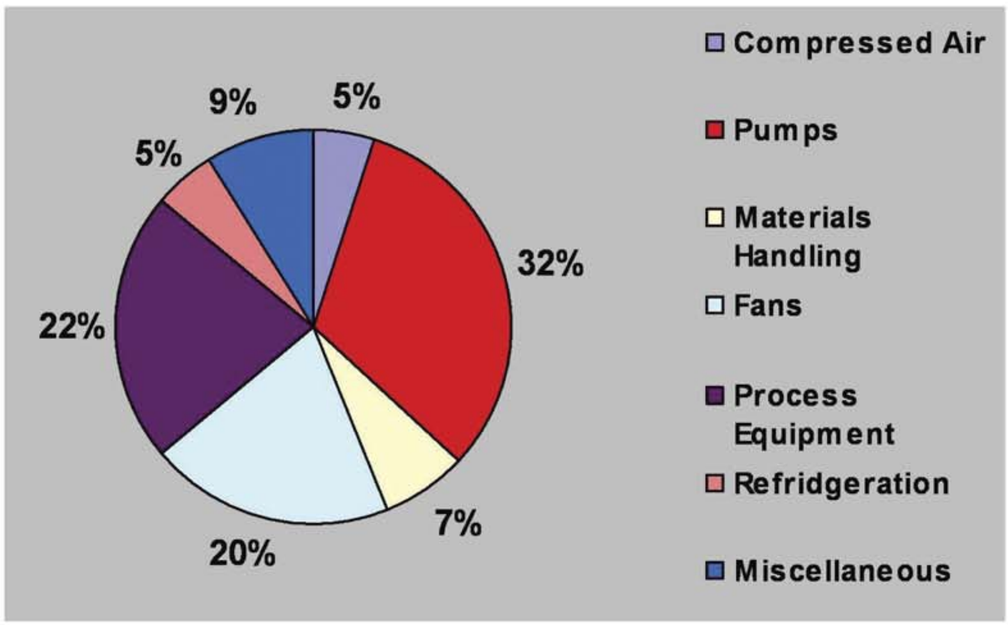

Figure 1 *US DOE 2002*

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Corrosion and erosion are the primary causes of metal loss in pumps unless abrasion or cavitation is present as well. Corrosion is primarily an electrochemical reaction occurring between the metal and the environment which causes the anodic metallic ions to go into solution. As this occurs, the metallic surface oxidises and rust scale forms. This scale is easily washed away in flow conditions as the passivated rust layers are weakly bound to the surface. Once the passivated layers are removed, the exposed metallic surface begins the corrosion process again and the cycle repeats itself over and over.

In order to prevent this, a film or barrier may be applied which dielectrically insulates the metal surface, which contains anodic and cathodic regions, from the corrosive media. This film or barrier must be able to withstand not just the corrosive conditions but also mechanical forces associated with high pressure flow, sometimes containing suspended particles. Often, these flows may be at elevated temperatures as well which presents a thermal stress element to an otherwise isothermal condition.

SOLUTIONS

The use of coatings to maintain a new pump as well as improve an 'in service' centrifugal pump's performance and energy efficiency has been well known by pump designers and coatings manufacturers for many years. In 1948, A. J. Stepanoff discussed in his book 'Centrifugal and Axial Flow Pumps' the use and benefits derived from porcelain enameling a pump's wet-end. The premise behind this thought was that smooth, hydraulically efficient films present less frictional drag. If these coatings also can resist the effect of corrosion/erosion, chemical attack and abrasion then not only is the flow through the hydraulic passage more efficient but the dimensional tolerances are able to be maintained for an extended period, resulting in longer life and reliable operation of the pump.

In order to determine how effectively a coating system can impact a pump's performance, one must first establish a performance reference point.

This involves measuring flow and energy consumption over several duty points to establish a pump curve. Ultra-sonic devices are capable of accurately measuring pump flow rates. Pressure gauges at suction and discharge can establish inlet and discharge pressures. By using amp meters, one can measure the energy demand. Once these steps are taken, the energy per unit flow can be established at a given discharge pressure.

If the pump is impacted by corrosion involving scale buildup, reducing tolerances or increasing frictional drag,

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Figure 2 *Abraded Throat Bushing*

Figure 3 *Cavitated Impellor*

Figure 4 *Corroded Pump*

Figure 5 *Stock Pump*

a coating process can reduce corrosion scale build-up and reduce frictional drag. If erosion or abrasion accelerated by corrosive chemical exposures has opened up critical tolerances in the wet end of the pump then a resurfacing grade coating, utilising abrasion-resistant reinforcements such as Al^2O^3 or SiC may be chosen which can then be applied to restore these tolerances back to design specifications and provide extended wear resistance. There are specific considerations which need to be factored into any coating material's selection, such as but not limited to, adhesion of coating, resistance to chemical /corrosive attack, resistance to erosive/abrasive wear, and resistance to operating thermal stresses.

In addition, any coating process requires care in surface preparation to best ensure the desired performance of the coating itself. This typically will involve decontamination of the surface to remove impurities which might impair adhesion; surface cleaning to remove scale, corrosion deposits; and grit blasting to increase the available surface area for maximisation of the applied coatings adhesion.

Application may require multiple steps to rebuild or fare smooth worn surfaces and to achieve the required total dry film thickness.

These steps need to be taken in a controlled environment and should only be undertaken by personnel experienced in the application of industrial maintenance coating who have been qualified by the manufacturer.

Finally, inspection and re-assembly of the pump components needs to be done with care to ensure that tolerance fits and clearances are maintained.

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EXAMPLES

In one example at a paper mill where pump efficiency and reliability were a concern, a pump (Fig. 5) was identified for maintenance based on noted reduction of flow over a period of months.

After the pump was disassembled, it was decontaminated by steam cleaning, abrasive grit blasted to Sa2.5 cleanliness with a 75 micron minimum angular pattern. The sections where erosive wear had damaged the pump were then rebuilt to original tolerances based on the original equipment manufacturer's prints using an advanced reinforced ceramic reinforced composite coating with some areas receiving as much as 6mm of coating to rebuild back to original dimensions.

Following this stage, all exposed surfaces where corrosion could damage the wetted surfaces or scale could reform were coated with two coats of a low coefficient of friction polymer composite coating. The coating was reinforced with ceramic particles for increased resistance to erosive and abrasive flow.

After repairs were completed, all areas were inspected for any discontinuities and the pump was re-assembled and performance measurements were taken to re-establish performance, energy consumption per unit flow and efficiency curves. Charts 1 to 3 illustrate before and after measurements.

- Flow volumes increased 59%
- Average overall efficiency increased 22%
- Energy expended per unit flow decreased 25%

This example shows how protective coatings can positively impact reliability and performance by:

- significantly reducing the surface roughness over the base metal component.
- decreasing the surface energy resulting in less 'wetting' of the pump's internal surfaces and subsequently reducing overall friction.
- eliminating the erosion/corrosion

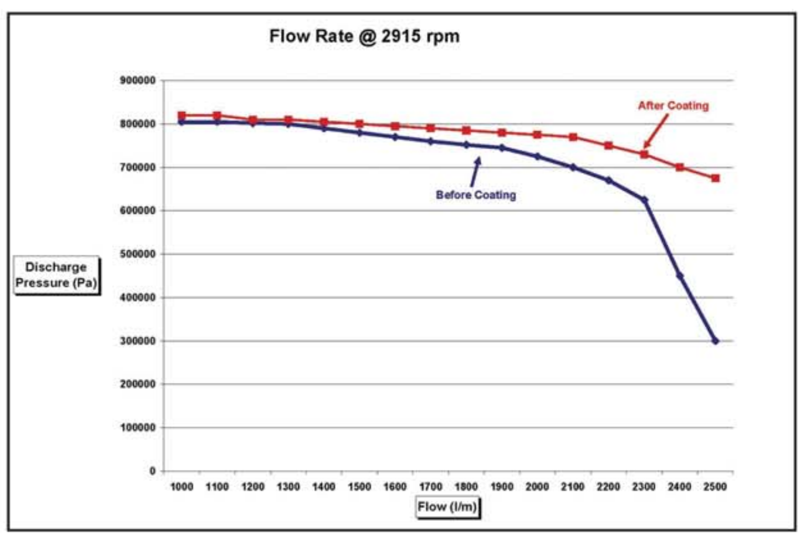

Chart 1

process resulting in smoother flow passages and less friction.
- increasing resistance to the effects of abrasion in applications with solids or slurries resulting in less wear and loss of tolerances.

In practice, protective coatings may be used to either protect new pump components from damage or upgrade and return worn 'in service' pump components to new or near new conditions at a fraction of the cost of spare parts, or whole replacement costs. In the process of upgrading the wet end components with protective coatings not only can performance be improved but, in some instances, energy efficiency can be impacted, leading to reduced operational costs associated with electrical energy demand. In order to determine if a coating is an appropriate option to use to improve performance, reliability and possible energy efficiency one may wish to consider the following factors:
- Will the coating resist the internal 'wet end' conditions of the pump during operation (temperature, pressure, suspended solids, chemical corrosivity, etc)?
- Can the coating be applied to all the critical surfaces to prevent erosion, corrosion, abrasion or chemical attack?
- Does the existing pump have sufficient clearances to allow the coating to be applied to the manufacturer's recommended dry film thickness?
- What would be the potential impact to my process if an applied coating were to come loose from the metal and enter my process flow?

Consultation with a qualified supplier of protective coatings can answer many of the questions and yield remarkable results with a potential for significant impact on performance, reliability and energy efficiency.

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Chart 2: *Efficiency before and after coating*

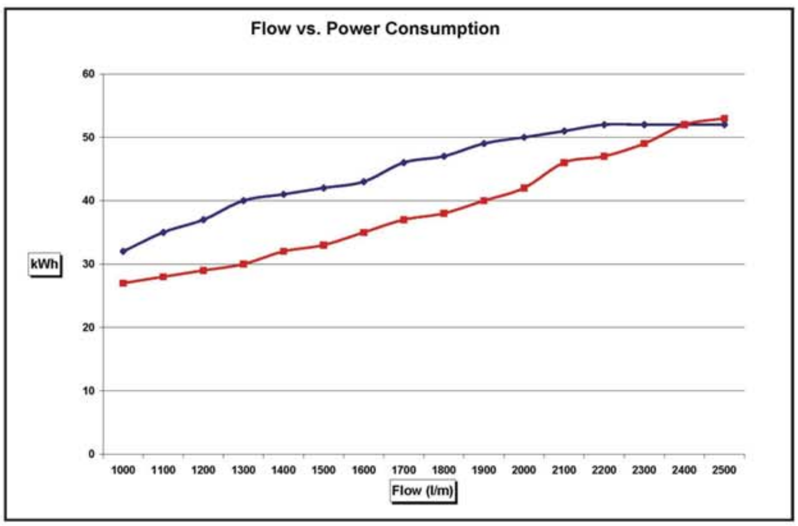

Chart 3: *Flow vs. power consumption*

24 Hour Period	Flow (M3/hr)	Energy (kWh)	Max Efficiency (%)	Min Efficiency (%)	Energy (kWh/M3)
Before Coat 2/11/2001	2059	997	52	38	0,48
After Coat 4/27/2002	3283	1185	62	49	0,36

Chart 4: *Summary*