As seen in...

POWER Engineering

August 2009 *the magazine of power generation*

Coatings Can Improve Submersible Pump Efficiency

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Metaphorically speaking, pumps are the heart of any system that handles fluids - the second most common piece of machinery used in general industry. Pumps use mechanical forces to move fluids namely gases, liquids, or slurries from one location to another through what is referred to as a hydraulic passage. The hydraulic passage is the trajectory followed by the fluid inside a pump, and it depends on the design of each pump.

There are several types of pumps depending on the method used by the pump for moving the fluid. A common type is the centrifugal, also known as hydrodynamic pump, which increases the momentum of the liquid by the rotation of an impeller, and displaces the fluid axially, radially, or in a combined axial-radial direction.

Centrifugal axial pumps are widely used to move fluids as they are generally simple, low in capital cost, and occupy little space. Submersible or vertical turbine pumps are an example of centrifugal axial pumps. Submersible pumps are heavily used for providing various services such as raw water intake, pumping station, cooling water, commercial/industrial and municipal distribution, and mining among others [1,5].

Submersible pumps intake fluids from the lower end, and move them upwards along the centerline of the pump. The discharge can be made underground or aboveground, and as the impeller is submersed, these pumps can be started without priming [5].

Wire-to-water Efficiency

The efficiency of a pump is a ratio of the energy delivered by the pump to the energy supplied to the pump shaft. It is best represented by the wire-to-water efficiency, which combines the overall efficiency of the pump and the motor.

Wire-to-water efficiency is a measure of the efficiency of the complete facility considering external piping losses, external elevation head, and all internal pump losses. Hence, this efficiency is an index of the effectiveness of the entire system in delivering fluid from its pumping level to its final delivery point, and it is the efficiency most easily determined in the field [2,4].

Despite the fact that all the parts of a pump (impeller and casing primarily) are designed to deliver the head and capacity required by the system in the most effective way, several aspects can affect the efficiency of a pump. These aspects are hydraulic, mechanical, and volumetric losses in the pump [6].

Volumetric loss is due to any leakage of fluid through the pump components. This refers to the leakage of liquid from the discharge side of the pump to the suction side. These losses increase as internal clearance are open up due to wear, cavitation, impingement, or entrainment [3].

Mechanical loss is related to mechanical components, which generate reduction in the power transferred from the motor to the pump. This loss is typical of certain moving components of a pump such as bearings and glands [3].

Hydraulic loss is caused by the frictional forces created between the fluid and the walls of the hydraulic passage, acceleration and hindrance of the fluid, and the change of the fluid flow direction [3]. The smoother the walls of the pump, the less flow fluctuations, and the less energy required for the pump to move the fluid through the hydraulic passage. This is why hydraulic energy losses can be diminished by creating smoother surfaces.

Wire-to-water efficiency (Ew) can be easily determined through the recording of three parameters: system flow rate, pressure at the discharge and system wattage. These variables are mathematically fit into the following equations [3]:

$$E_w=74.57QZ/(3960\ INP) \quad (1)$$

Where,

Ew = Wire-to-water efficiency (%)

Q = Flow rate (gpm)

Z = Net pumping system head (ft)

INP = Electrical power input (kW)

Net pumping system head Z (in feet) is calculated as:

$$Z=2.31P/SG \quad (2)$$

Where,

P = Pressure (psia)

SG = Fluid specific gravity

These equations are combined, resulting in:

$$E_w=0.043QP/(SG \bullet INP) \quad (3)$$

Coatings Improve Efficiency

Coatings are specifically designed for improving the efficiency of fluid handling systems, and protecting metals from the effects of erosion-corrosion. Their unique combination of properties such as hydrophobicity, self-leveling, and hydraulic smoothness makes these coatings ideal candidates for linings the hydraulic passages of pumps.

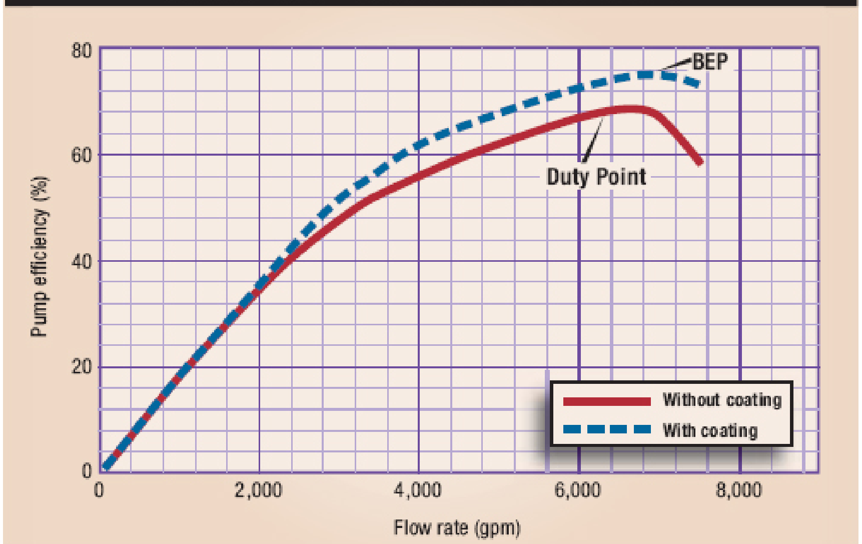
Certain coatings rely upon a surface effect to render the substrate hydraulically smooth, while other superior coatings possess these traits through their entire thickness. The latter is greatly preferred if there is a reasonable expectation of coating wear since the desirable traits will be retained as the coating wears.

Due to the presence of a blend of different amines as part of their composition, these coatings possess a low electronic affinity towards water molecules and result in a smooth glossy finish once applied onto a surface. This fact makes water or any other aqueous polar solutions glide over the coating surface [6].

Efficiency improving coatings self-level once applied onto a surface, which increases the hydraulic smoothness and slipperiness of such a pump passage. In some cases, they can be enriched with a small percentage of Teflon®, which contributes to reducing the frictional forces between the surface and the fluid in motion.

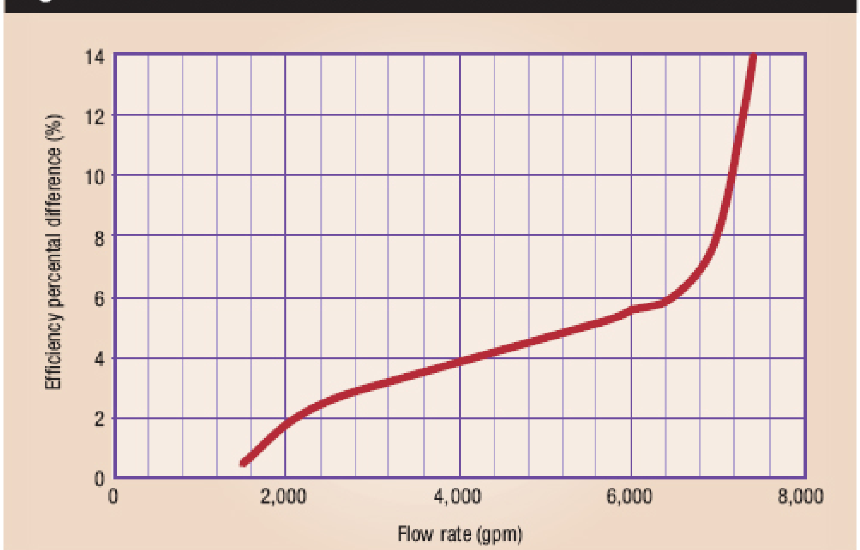
A test was carried out to demonstrate that an improvement in pump efficiency at rated output could be achieved when coating various parts of a submersible pump with efficiency improving coatings.

Figure 1 PUMP EFFICIENCY—FLOW RATE



Pump efficiency evolution as a function of flow rate calculated from data collected in Nov. 2006 and March 2007.

Figure 2 INCREMENTAL CHANGE IN EFFICIENCY MARCH 2007



Pump efficiency incremental change as a function of flow rate calculated from data collected in March 2007.

The pump tested was a single-impeller multi-stage vertical pump, provided by a reputable pump manufacturer. The pump could handle up to 9,000 gpm, with heads up to 500 ft and bowl size of 20".

The submersible pump parts to be coated with the efficiency improving coating were the walls of the discharge head, the enclosing tube, the bowl, the suction bell, and the impeller. All these parts are identified and named in Figure 1.

The baseline data was collected in November 2006. Previously, the pump had been mechanically restored according to Original Equipment Manufacturer (OME) specifications.

All the application work was carried out by an authorized coating applicator. The methodology followed is described as follows:

- All the surfaces to be coated were grit blasted using an angular abrasive to NACE No.2 (Near White Metal), ensuring a minimum 3 mil (75 µm) angular profile.
- All the surfaces were consequently washed down with a recommended cleaner degreaser to remove residual blasting debris and contaminants.
- Masking tape was placed at the outer edges of the areas to be coated to give a neat and clean finish.
- An efficiency improving coating was applied in two coats using stiff short bristled brushes. Each coat was applied at a wet thickness of 10 mils (250 µm) to a maximum wet thickness of 20 mils (500 µm).
- All the coated surfaces were allowed to cure and the coating was inspected for continuity.
- The pump was put back into service.

In March 2007, the pump was run at a constant input while varying the flow rates, with 400 gpm being the incremental rate. The same procedure was carried out in 2006 during baseline data collection. The instrumentation used consisted of an outlet analog manometer to log pressure readings at the discharge of the pump, an annubar to record the flow rate, and a watt transmitter to take readings of the electrical power input. Wire-to-water efficiency was calculated using Equation 3 (See Above).

In Figure 1, wire-to-wire pump efficiency values at various flow rates with and without the efficiency improving coating are shown.

"Without coating" corresponds to the baseline collected in November 2006. The total energy supplied by the pump to the fluid at the discharge of the pump is greater when the inner walls of such a pump have been coated with an efficiency improving coating. The less friction between the inner walls of the pump and the fluid, the less energy is consumed in overcoming these frictional forces. The wire-to-water pump efficiency at BEP was 74.5%, and its corresponding flow rate was 6,500 gpm.

Figure 2 shows an incremental change in the wire-to-water efficiency as a function of the flow rate. These values were obtained based on a comparison between the wire-to-water efficiency calculated for the baseline with no efficiency-improving coating and that obtained after coating the pathways of the pump.

An efficiency improvement over 4% is achieved for flow rate values greater than 4,000 gpm when coating the hydraulic passages of the pump with an efficiency improving coating. For small flow rate values, in this case flow rate under 2,000 gpm, only very slight improvements in efficiency were observed. Over 11% efficiency improvement is observed at 8,000 gpm. The duty point of this pump was determined to be 6,100 gpm. In the vicinity of this point, 5% efficiency improvement was achieved.

More so, these results obtained after applying efficiency improving coatings on the pathway of submersible pumps, can be easily replicated for other types of pumps as well.

References

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