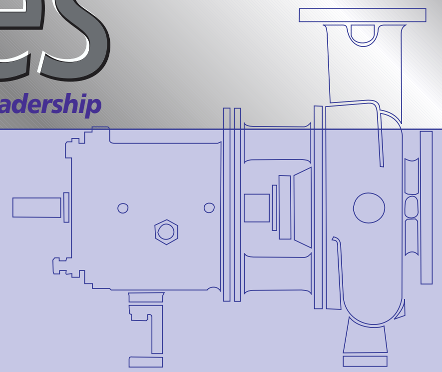
PumpLines
Innovation...Technology...Leadership
SPRING 2003



Team Effort Lowers Pump Life Cycle Costs At Rohm And Haas

The result was cost reductions of 42% and almost a doubling of the previous MTBF.

What does it take to extend the life cycle and lower operating costs for over 100 process pumps?

For the Louisville, Kentucky plant of Rohm and Haas, which manufacturers plastic additives, emulsions, Paraloid coatings and monomers, it took a concerted effort among Rohm and Haas, Goulds Pumps and its distributor, R.A. Mueller of Cincinnati, Ohio. The result was cost reductions of 42% and almost a doubling of the previous mean time between failure (MTBF).

According to Terry Balmer, Reliability Engineer and Rotating Equipment Specialist at the Louisville Plant, "Prior to 1998, our facility had limited mechanical seal usage data, as well as limited pump repair procedures and no standard pump base plate design. We manufactured our own shafts, utilized parts replicators and had few controls in place."

We realized across the company that we needed to reduce the number of seal failures, reduce repair costs and provide increased uptime.

In 1998, after collecting data for one year, Rohm and Haas learned that the average installed cost per seal at its Louisville Plant was $396.00, and MBTF there was 32 months. In the next four-year period, the facility

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Terry Balmer of Rohm and Haas inspects one of over one hundred process pumps involved in the life cycle cost reduction program.

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Goulds Pumps

ITT Industries
Engineered for life

Team Effort...

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reduced the average cost per installed seal to $233.00 and increased the MTBF to 57 months.

Alliances Pay Off
"We realized across the company that we needed to reduce the number of seal failures, reduce repair costs and provide increased uptime," states Balmer. "Alliance partnerships were an important step."

Within the very first year, pump maintenance costs began to decrease and the MTBF started to increase

That's where Goulds alliance experience was so valuable.

Leveraging that expertise, Balmer continues, the Louisville Plant was able to standardize on pumps with solid shafts, labyrinth seals and enlarged seal chambers. The partners also jointly developed an enhanced baseplate design and proper baseplate installation procedures, which included the use of low exothermic epoxy grout.

Balmer also points to the Louisville Plant's comprehensive spare parts strategy — which specifies the use of **only genuine Goulds OEM replacement parts** for all pump repairs — as another significant factor in reducing downtime. In addition, he says, "Mechanics, were trained not only on the new baseplates and their installation, but on proper repair techniques, laser shaft alignment and the importance of the documentation of the repairs they performed."

Immediate Benefits
How long was it before the Louisville Plant began to see improvements?

Balmer admits that in the beginning, there were increases in the costs of repairs, baseplates and their installation. However, he's also quick to explain that within the program's first year, pump maintenance costs began to decrease and the MTBF started to increase. Even the initial skeptics began to revise their thinking.

Now, Balmer, notes, the expectation is to buy better equipment and install it correctly. "Operations Managers, Production Planners and Chemical Operators are confident that once a start button is pressed, equipment will operate at designed rates," he reports.

If Rohm and Haas continues to improve reliability, can it achieve a 7-year MTBF?

"Not impossible," says Balmer. "We hope to continue to improve by updating our information and continuing to partner with our key vendors. We need to address data collection. Better process tracking and more detailed measurements will help make a more informed decision about our next step. For example, if we can we achieve a 7-year MTBF, how much will it cost, and what return on investment can Rohm and Haas expect from it?"

Now the expectation is to buy better equipment and install it correctly.

One thing is certain, though—very certain. The savings realized over the past 4 years make a mighty statement about the rewards of putting alliance partners on your team.

Article by Jane Alexander, Editor
Pumps and Systems Magazine
With **John Beca**
Director - Communications,
ITT Industrial Products Group

New Products

New Pump Smart® Model 200 Version 2.1 Provides Expanded User Benefits

John J. Beca
Director – Communications
ITT Industrial Products Group

PumpSmart Control Solutions has introduced PumpSmart 200 Version 2.1, a major addition to the award winning PumpSmart product line.

The new PS Model 200 V 2.1 provides expanded simplification and functionality as compared to previous PumpSmart models. For example, the number of parameters needed for set up and start have been reduced to only seven (7) for a single pump pressure control application. In addition, the new model allows a user to start up to three (3) fixed speed pumps compared to only one in the earlier PumpSmart 200 model. Like previous PumpSmart offerings, the new PS Model 200 V 2.1 is a microprocessor based, variable speed drive, programmed specifically for centrifugal pumps up to 700 HP.

Accurate control of virtually any process parameter is obtained by the continuous monitoring and reaction to both pump conditions and system demands. The new PS Model 200 V 2.1 will alert the user that a sensor has failed and then automatically change to speed control. The resulting speed is the average speed for the last minute of operation prior to instrument failure. The PS Model 200 V 2.1 offers both fixed and variable dual setpoints. On variable setpoints the user is able to receive a second 4-20m Amp signal and continuously vary the setpoint whenever suction conditions are at a level that would cause cavitation.

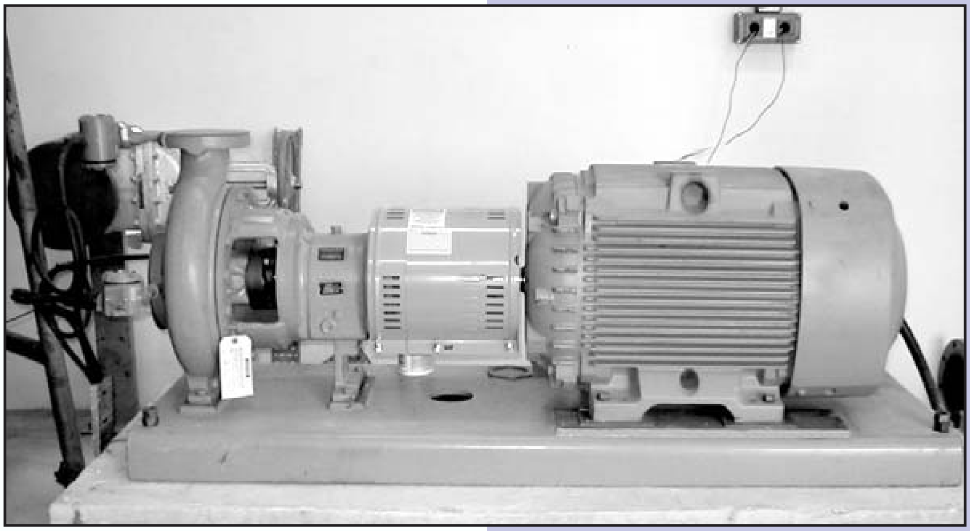
The new PS Model 200 V 2.1 contains a new pump wear monitor which enables it to automatically identify pump performance decreases due to the wearing of hydraulic components. This wear monitor works on any centrifugal pump and does not require performance data to be fed into the drive. The new PS Model 200 V 2.1 provides multi-pump control, controlling up to 4 pumps in coordinated fashion to meet system demand and maximize pump performance and reliability. In addition, the units can alternate lead, and lag, as desired.

As with previous PumpSmart models, energy savings in the 30-70% range are obtained because at lower demands the new PS Model 200 V 2.1 reduces the motor speeds eliminating the extra energy that's used to overcome the pressure drop of control valves. This new model can be applied to any centrifugal pump in a wide range of applications including: cooling water, transfer and loading, paper stock pumps, reboiler and bottom pumps, wastewater, filtration, slurry pumps and boiler feed.

Case Stories

PumpSmart® Fuels Savings for Malaysian Supply Base

Mohamed Nazir
Area Sales Manager
Goulds Pumps, Asia-Pacific



Background:
Customer: Inter Century Sendirian Berhad (ICSB)
Location: Kemaman Supply Base (KSB), Terrengganu, Malaysia

Pumpset includes Goulds Model 3196 size 3x4-13 c/w 75 hp motor and PumpSmart PS300 Installed in June 2002.

Existing installation:
There are two Plenty brand pumps with 50 hp motor each, designed to pump 100 cu.m/hr od diesel against a TDH of 90 metres. These pumps are over 30 years old. The client is the operator of the tank farm. The pumps are to supply the diesel to 8 debunkering units. Each is to supply diesel to patrol boats and cargo boats. It takes about 6 hours to fill one boat. The pumps, when both are operating, can only operate up to 3 debunkering units. Beyond this, the motor trips or there is not enough pressure for the remaining debunkering units.

ICSB
INTER-CENTURY SDN BHD

PUMPSMART PS300

Inter-Century Sdn. Bhd. started using the PS 300 Pump Smart Process Controller since 23rd Jun 2002.

Since then, Pumpsmart have benefited us significantly incomparison to the existing installed conventional pump.

The followings are the improvements that benefited Inter-Century Sdn. Bhd. in our operation at Kemaman Supply Base.

1. Enhance Operation :
   i. Our transfer process pump becomes smoother & faster
   ii. No more cavitations
   iii. The pump is self monitoring
   iv. Our operator just need to open and close valve for pump start up/stop

2. Constant Flow
   Pumpsmart is capable to regulate pressure in the distribution system which allow us to maintain constant flow at all discharge manifolds.

3. Energy Saving
   Power consumption had reduced significantly using pumpsmart. Saving is up to 50% and currently registering savings of RM 10.50 per KWH.

4. Oil Loss
   Since flow is constant the totaliser reading is now very accurate and this eliminate the oil losses recorded at the totaliser

We thank Aliran Luas Sdn Bhd for the innovative introduction of pumpsmart to our organisation

HAMKAMARUL BAHRIN MOHAMAD
Operation Manager

Usually, to avoid long tiring waits, the client encourages crews to leave their vessels overnight. They operate on 3 shifts at times.

The power supply is limited to 100 amperes, beyond which the pumpsets trip. This is the allocation they have been licensed by the Supply base. The client called for a tender site meeting to overhaul the pumpsets with either replacement of parts or new pumps.

Our agent, Ms. Aliran Luas Sdn Bhd attended the meeting with other pump suppliers. Everyone proposed that the pumps be replaced with one single pump with fixed drive of 100 hp. Alternative proposal was to have the existing pump overhauled. We offered the PumpSmart with a 75 hp pump and also added longer payment terms. We even offered to install the pumpset free in return for the differences in the PumpSmart savings.
The client was moved by the confidence we showed. Our agent submitted his offer with no price and indicated "Free supply and installation" with "savings to be returned to agent." No Dollars were seen in the proposal. This made the offer irresistible and the client wanted more details. We did a presentation, after which, they agreed to purchase. They were fully convinced that this should save them operational and maintenance costs.

The pumps were installed. Within 10 days of running, they recorded a savings of RM$118 per day with 8 hours of operations. The pump was giving them ample flow and pressure. The PumpSmart controlled the pressure regardless of the number of debunkering units used. Now they can accommodate 8 vessels at any one time and can pump the vessels full within a remarkabley shorter period of time. They have indicated, on average size vessels, it took about one-fourth of the usual time. They no longer needed a technician to stand-by and they worked days only. No second and third shift work is required. The two old pumps are now put out of action. As soon as client breakseven with the first installation, he will consider buying another set as a standby. The client is very happy with the result and has documented this achievement and presented the results to their parent company for review. Consideration will be given to outfitting all the other pumps installations in Malaysia.

Tech Talk

PumpSmart® PS200 Pump Wear Monitor

Eugene Sabini
Director – Research
ITT Industrial Products Group

The Pump Wear Monitor is a new feature found in the PS200 Rev 2.1. It enables the PS200 to automatically identify pump performance decreases due to wearing of the hydraulic components. This wear monitor works on any centrifugal pump and does not require performance data to be fed into the drive.

Back in early 2001 the Technology Group was challenged to develop a technique to indicate performance degradation due to wear on a PS200 driven pump using only one process variable (Discharge Pressure or Pump Flow) and not have any pre loaded pump performance data. Alarming when hydraulic degradation occurs is an important feature of the PS300 because it tells the user when it is time to rebuild. But the PS300 needs to constantly compare current pump performance to its new performance. This requires the use of four process variables, i.e. four expensive transmitters (Suction Pressure, Discharge Pressure, Temperature and Flow) to measure and calculate the Pumps Total Dynamic Head (TDH).

The simplest way to determine pump wear is to constantly compare what the pump is doing verses what it should be doing. The use of only one Process Variable (PV) Transmitter does not give any information concerning wear, particularly if the goal is to keep that PV constant. As a pump wears the following performance changes occur (see Figure 1):

- Internal leakage gets larger
- Pump flow shifts towards the left.
- Pump losses head
- Power increases

The pump is shown operating against a combination static and friction system. The

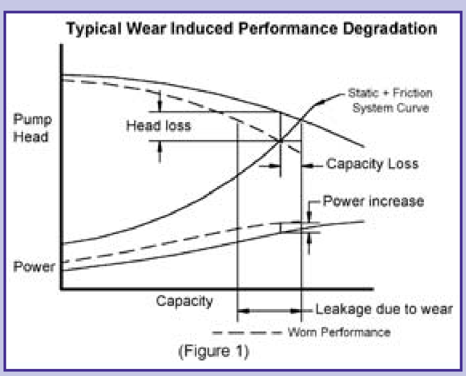


Figure 1.

same performance degradation phenomenon occurs with any type system (all friction through all static) when wear occurs.

When pump performance degrades the only way to maintain the required Process Variable is to increase the pump speed. This increase in speed is accompanied with an even greater increase in the pumps' power requirements. Figure 2 shows how the pump performance changes with changes in speed. The pump performance curve follows the Affinity Laws, which are;

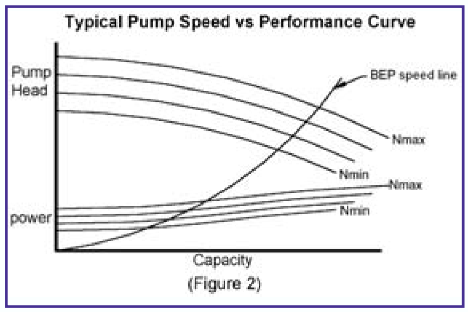


Figure 2.

$$\frac{Q_1}{Q_2} = \left(\frac{N_1}{N_2}\right) \qquad \frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2 \qquad \frac{P_1}{P_2} = \left(\frac{N_1}{N_2}\right)^3$$

Where;

Q = Capacity
H = Pump Head
P = Power
N = Speed

Pump Flow and Discharge Pressure are considered Process Variables but Pump Head is not. To understand why Pump Head is not used as a PV we must consider the function pressure and head provide to the process. Users are interested in controlling a pressure somewhere in the system, at the inlet of a vessel, at the inlet a heat exchanger, in a pipeline etc. The Pump Head is used in the selection process. It enables the user to select the correct pump to provide the required pressure for a given application. Figure 3 shows a typical Discharge Pressure vs. Flow curve. Note that the Discharge Pressure equals the Pump Head plus the Suction Pressure plus the Velocity Head difference. The System Curves can be drawn as an offset to suction pressure assuming that the Velocity Head difference is a small percentage of the Pump Head.

The pump will speed up to maintain a constant Discharge Pressure if any or all of the following are reduced;

- Suction Pressure
- Static Head
- Friction Head

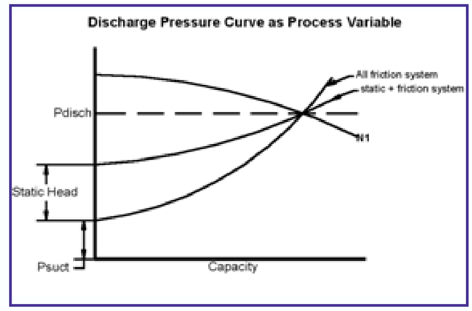


Figure 3.

In each case a speed increase is accompanied by an increase in power. The difficulty occurs when one tries to distinguish between a decrease in Suction Pressure, a decrease in System Head or Performance Degradation due to wear as they all are accompanied by an increase in speed and power. Combined pump wear and decreased system head further complicates the problem.

The Technology Group had to start thinking about pump performance in non-traditional ways to overcome the difficulties in determining when wear actually occurs using one PV. Pump suppliers traditionally think in terms of Head vs. Flow or Power vs. Flow. Now we had to start thinking in terms of Pressure or Flow vs. torque and speed. Figure 4 (Pressure vs. Torque/Speed Curve) was developed to make the transition easier.

The PS200 controller continuously monitors the electrical power (kW, bhp or torque) and the driven speed. This information is available because the PS200 accurately characterizes the motor during the initial motor ID run.

The Pressure - Torque curve now becomes a very powerful analytical tool. For example varying the controller speed by ±3 to 5% one can record two data sets. These sets of data can be used to accurately calculate the slope of the discharge pressure torque line and the intercept which is the suction pressure (patent pending). For a Static and Friction System varying the speed and recording data also gives useful analytical information about the slope of the curve and intercept which provides information about the Static Head plus Suction Pressure of the system. These data sets are also used in algorithms that identity PV change, System Change, Suction Pressure Change or Pump Wear.

This technique enables differentiation between hydraulic performance degradation and a changing system. The technique used to accomplish this by the PS200 rev. 2.1 is:

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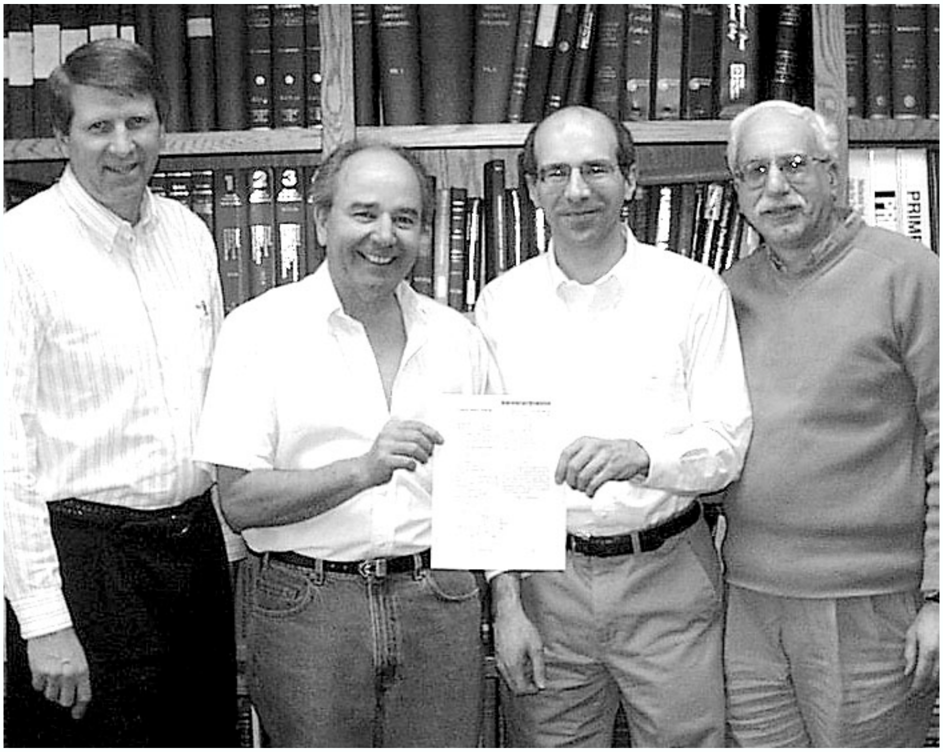
Tech Talk



Co-inventors Jerry Lorenc, Butch Henyan, Ken Hauenstein, and Gene Sabini show off their patent certificate.

Patented Technology: Future Foundation for Control Solutions

Gene Sabini
Director - Research, ITT Industrial Products Group

"Apparatus and Method For Controlling a Pump System," Patent Number US 6,464, 464 B2 was granted on October 15, 2002 to Industrial Products Group co-inventors Eugene Sabini, Jerome Lorenc and Oakley Henyan.

The patent covers all of the control algorithms for flow and pressure as well as all of the fault tolerance features and alarms on the original PumpSmart® device.

1. Loss of performance due to wear
2. Dead head protection/alarm
3. Low Flow protection/alarm
4. Closed Suction Valve protection/alarm
5. Thermal alarm
6. Over pressure alarm
7. Npsh protection/alarm

The highlight of the patent is the control algorithm which eliminates the need for "tuning" and "re-tuning" PID (Proportional, Integral, Differential) circuits found with traditional drives. PID circuits are known to become unstable when system changes occur. We teamed with another colleague on "Method and System for Determining Pump Cavitation And Estimating Degradation in Mechanical Seals," Patent Number US 6,487,903 B2 was granted on December 3, 2002. Co-inventors this time were myself, Jerome Lorenc, Kenneth Hauenstein and Oakley Henyan.
This is a device which indicates when cavitation, due to insufficient NPSHa, occurs. When cavitation occurs in pumps with open seal chambers, the seal chamber evacuates leaving the mechanical seal to run dry. It only takes a few seconds for the seal faces to heat up have damage occur. Repeated exposure to cavitation causes the seals to fail prematurely. The patent proposes a technique to estimate remaining seal life.

The PumpSmart PS300 constantly compares the npsha versus the pumps' npshr and protects against cavitation damage by slowing the pump speed down until the cavitation is eliminated or by alarming. This requires loading in fluid properties and sets of npshr versus capacity tests run at 4 to 5 different speeds. The Cavitation Detector eliminates the need to load or run npshr data as it always detects when cavitation occurs regardless of fluid pumped and pump type. This technology is being incorporated into the PS200 product.

Material Matters

Galvanic or Dissimilar Metals Corrosion *(Part 2)*

Stephen Morrow
Global Manager of Materials Technology
ITT Industrial Products Group

Polarization
The potential produced by a galvanic cell often changes with time, due to the flow of current and corrosion reactions. The extent of corrosion is directly proportional to the current generated. As corrosion proceeds, reaction products and corrosion products accumulate at the cathode and anode respectively. This causes a polarizing effect, which controls the rate at which galvanic corrosion proceeds.

Since electrons flow between dissimilar metals in a galvanic couple, the current flow between anode and cathode causes potential shifts, as the electrical potentials of the metals coupled tend to approach each other. That is, the potential of the anode drifts towards that of the cathode and vice versa. This change or shift in potential is called polarization – anodic polarization (shift is from negative to positive) at the anode and cathodic polarization (shift is from positive to negative) at the cathode. The build-up of a hydrogen layer and increased electrons at the cathode surface is an example of cathodic polarization. The build-up of corrosion products and decrease of electrons at the anode surface is an example of anodic polarization.

To understand this polarization effect it is helpful to think about the negative electrode or anode becoming more positively charged, and shifting towards the positive electrode or cathode as electrons leave the metal. At the same time the positive electrode (cathode) becomes more negatively charged, and shifts towards the negative electrode (anode) as electrons collect or move into the metal. The corrosion current (Icorr) and corrosion potential (Ecorr) is measured where these polarization curves intersect, as illustrated in Figure 4.

The magnitude of the potential shift is dependent on the environment, as well as the material's initial potential. When the potential shift of the anodic metal moves in the direction of the cathode, electron or current density flow is reduced as illustrated in Figure 4, so the galvanic corrosion is not as severe as would otherwise be expected. If the cathodic metal is more easily polarized, its potential shifts more towards the active anodic metal's potential and the corrosion rate/current density

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Material Matters

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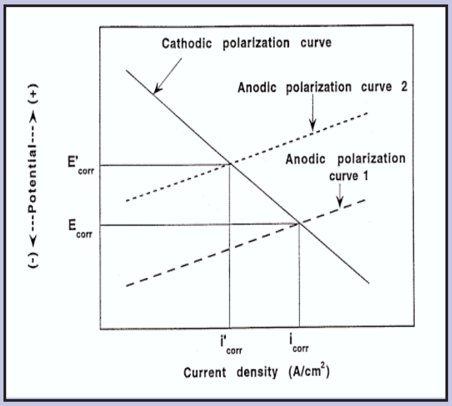


Figure 4. Polarization curves illustrate potential shift of anode in direction of cathode resulting in a reduction of the current density (corrosion rate) from I_{corr} to I'_{corr}.

is also reduced. On the other hand, when the anode potential shift is more easily polarized towards the cathode, with little potential shift or polarization of the cathode, there is an increase in current density and accelerated corrosion occurs.

Surface Area Effects

An important factor in galvanic corrosion is the area effect, or the ratio of the cathodic to anodic surface areas (see Figure 5). Corrosion of the anodic metal is both accelerated and more damaging as the voltage difference increases, and as the cathode area increases relative to the anode area. For any given current in a corrosion cell, the current density (amperes per unit area) is greater coming from a smaller area than a large one. The greater the current density leaving the anodic area, the greater the corrosion rate.

When the anodic current density (corrosion rate) on the active metal is small, the resulting

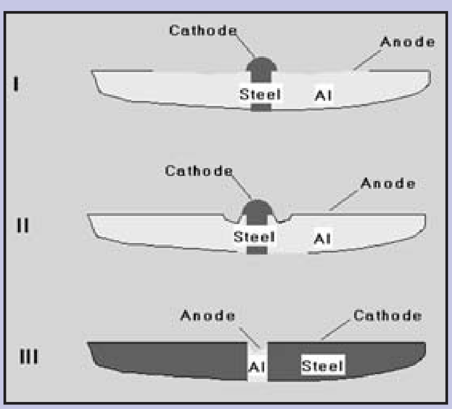


Figure 5. Galvanic Effects related to surface area ratio and electrolyte conductivity.

I large anode-to-cathode ratio in high conductivity electrolyte.

II large anode-to-cathode ratio in low conductivity electrolyte.

III small anode-to-cathode ratio effect – rapid attack of the anode.

slow anodic polarization leads to less galvanic corrosion. A large anode surface will polarize slower than a small anode surface, producing much less galvanic corrosion due to the greatly reduced current density at the anode (See Figure 5 Condition I). The opposite area ratio effect (large cathode surface, small anode surface) produces more pronounced galvanic corrosion. A large cathode surface will polarize slower than a small cathode surface, causing more rapid corrosion of the anode due to an increased current density at the anode (See Figure 5 Condition III).

Unfavorable design ratios consist of small anode-to-large cathode surfaces. This area ratio is undesirable, because the galvanic current becomes highly concentrated onto the small anodic surface area, resulting in accelerated corrosion as illustrated in Figure 5 Condition III. Smaller anodic surfaces suffer deeper and more penetrating corrosion than larger ones. For this reason designs should always avoid creating small anodes connected to large cathodes. The desired arrangement when galvanic couples can not be avoided is the large anode-to-small cathode surface area ratio.

Therefore, barrier coatings applied only to anodic surfaces are undesirable, and present a serious corrosion risk because any coating breaks, defects, or imperfections can expose very small anode areas to much larger cathode areas. This often results in rapid corrosion (high current density) at the small anode sites. For this reason, the practice of applying barrier coatings to anode surfaces alone is not recommended. Galvanic sacrificial coatings (e.g. zinc coating) that provide cathodic protection are preferred.

Coating both anode and cathode surfaces, or only the cathode surface will reduce the rate of corrosion. Limiting the effective cathodic area by coating it reduces corrosion at the anode as well. Barrier coating the cathode alone is better than anode alone, as this reduces the cathodic surface area, and minimizes the corrosion rate controlling cathodic reactions. Increasing the anodic area by leaving it un-coated or by removing an existing barrier coating will also reduce corrosion rates by lowering the current density.

Moreover, in many environments, the oxygen-reduction reaction is of primary importance. In most cases the amount of dissolved oxygen available at the cathode, and the amount of surface area where oxygen-reduction can occur, controls the intensity and rate of corrosion.

The lack of dissolved oxygen in deaerated solutions limits the reduction reactions to metal ion reduction, or the formation of hydrogen gas, which tends to develop a barrier film on the cathode surface. This effectively reduces the cathode surface area and slows the corrosion rate.

Electrolyte Conductivity and Distance Effect

The conductivity of the environment or electrolytic nature is an important consideration. When large surface areas are in contact with high conductivity solutions, such as seawater; the attack on the anodic metal may be spread a great distance from its contact point with the cathodic metal, as shown in Figure 5 Condition I. This is less severe in low conductivity soft waters where the attack is usually restricted to the vicinity of contact, as shown in Figure 5 Condition II.

Galvanic couples of dissimilar metals that are in close physical proximity usually suffer greater galvanic corrosion than those further apart. The intensity of galvanic effects is usually greatest at the point where the anode and cathode are closest, and falls off as separation distance increases. (See Figure 5 Condition I and II). This effect is due to electrolyte resistance, which makes it more difficult for current to flow great distances. The distance effect is dependent upon the electrolyte conductivity and resistance, since current movement is of principal concern in corrosion.

Managing Galvanic Corrosion

Galvanic corrosion can be managed and made to work toward the durability of fluid handling equipment by understanding and utilizing the principles that govern it. Galvanic corrosion is perhaps the only form of corrosion that can be beneficial as well as detrimental. The materials engineer will regularly select galvanic corrosion – that is cathodic protection using galvanic sacrificial anodes, or coatings to reduce corrosion of equipment and structures.[8] Noting the protective function, design engineers often use active materials as cathodically protective pigments (e.g., inorganic zinc primer and paint), that will sacrifice electrons to oxidation, thus protecting steel.

Galvanic corrosion concerns are important when designing products. Under some conditions the cathodic hydrogen-reduction is important as it may be adsorbed into cathode surfaces. When high-strength materials are used such as fasteners or shafting in assemblies, or cathodic protection systems are employed, the amount of hydrogen adsorbed can result in hydrogen embrittlement and cracking failures.

Material Matters

Selecting materials for fasteners, weld filler metals, and critical components such as pump and valve internals can take advantage of the galvanic effect, making these assemblies more durable. In fact pump and valve designs often incorporate dissimilar metals to provide a protective galvanic sacrificial anode effect to critical components such as internals and fasteners in assemblies. Large anodic metals are often furnished as thick-walled components to provide large sacrificial surface areas with low current densities. The general uniform corrosion attack of these surfaces is hardly noticeable, while critical components are significantly protected.

For example, large vertical turbine intake pumps of austenitic stainless steels (SS) perform well in chloride services as long as the pumps are operating and not left idle under stagnating conditions. However, spare pumps are usually made available for standby so they can be put into service promptly if one of those in operation shuts down. During standby periods in chloride media such as seawater, SS is subject to localized corrosion such as pitting, crevice corrosion and microbiological influenced corrosion (MIC). To prevent damage, large vertical pumps used in seawater are often constructed with type 316 SS internals, assembled to massive surface area thick-walled aluminum-bronze or austenitic cast iron (Ni-Resist) columns, casings and suction bells. The bronze and austenitic iron components are more anodic to SS and offer low uniform/general corrosion in seawater.

By design, the more noble austenitic SS internals are cathodically protected from localized corrosion by the galvanic effects provided from contact with more anodic active metals. Alternative designs incorporate attachment of galvanic sacrificial anodes (e.g. aluminum alloys) strategically placed within the pump equipment to provide cathodic protection.

A note of caution: If one reviews the Galvanic Series in Seawater, you will notice that graphite-carbon materials hold an electro-potential position that is as noble as platinum. Graphite-filled bushings, packing, gaskets and other carbon containing materials are very noble non-metallic conductors that can lead to severe galvanic corrosion in contact with metals and alloys of aluminum, copper, stainless steels, and other metals; due to significant potential differences when coupled together. These combinations are not recommended and are best avoided in designs if possible.
Similarly, dual phase alloys such as duplex stainless steels, gray cast iron or high-zinc brass alloys, often have one phase that may be more active than the other and preferentially corrode as the anode. The selective loss of the anodic phase is often referred to as selective leaching or de-alloying. In the case of high-zinc brass alloys, the zinc-rich phase would be more active than the copper-rich matrix phase, often leading to de-zincification in susceptible alloys.

Finally, ions of a more noble metal may sometimes be reduced on the surface of a more active metal (e.g., copper on aluminum or steel, silver or lead on copper, etc.). The resulting metallic deposit provides cathodic sites for galvanic corrosion and pitting of the more active base metal. This is often a concern in boilers and plumbing systems.

Protective Measures

If dissimilar metals are coupled without thought, consequences can be disastrous. As discussed above, galvanic corrosion can be used to our advantage as in cathodic protection by galvanic sacrificial anodes. Bolts, screws, and other fasteners used in assemblies should generally be made of more noble metals less likely to be oxidized, so those critical components are cathodically protected. Sacrificial anodes are commonly used with coatings to control corrosion in fluid handling equipment and on the underwater section of ships, piers, and other marine structures. The same principles can be used to protect steel if the anode metal is applied as a coating. Zinc (galvanizing) and aluminum (aluminizing) coatings are widely used to protect steel in corrosive environments: Examples are galvanized fasteners and automotive body panels, or aluminized automotive exhaust systems.

Under fully immersed conditions, a rough rule of thumb is that zinc coatings one mil (0.001 inch) thick will protect steel for about one year in marine environments.

There are three conditions that must exist for galvanic corrosion to occur. First there must be two electrochemically dissimilar metals or conductive non-metal present. Second, there must be an electrically conductive path between the two materials. And third, there must be an electrolyte providing a conductive path for the metal ions to move between the anode to cathode surfaces. If any one of these conditions does not exist, galvanic corrosion will not occur.

Galvanic Corrosion – Protection Methods

- **Materials selection** - Change materials to avoid dissimilar metal couples that are far apart. Select combinations of metals that will be in electrical contact from groups as close together as possible in the galvanic series to minimize electrical potential differences.
- **Modify the Environment** - Change the environment wherever practical. Add corrosion inhibitors and scavengers to control pH, remove aggressive ions and oxygen, or lower the conductivity of the environment.
- **Protective Coatings** - Barrier films/coatings (e.g. barrier, inhibitive, sacrificial) can be used to isolate the materials from the environment. Apply coatings with caution – Note that it is extremely dangerous to coat only the anodic member of a couple, since this may only reduce its area, resulting in an undesirable area ratio and concentrate accelerated attack at "holidays" or imperfections in the otherwise protective coating. If inert or organic barrier coatings are utilized, both the anode and cathode should be coated. Sacrificial coatings that provide cathodic protection are best if only the anodic metal will be coated.
- **Electrical Isolation** - Electrically insulate dissimilar metals wherever practical. If couples between dissimilar metals are unavoidable, the surfaces should be separated by inert spacers or thick barrier films of nonconductive coatings to break electrical continuity and provide electrical isolation. If complete insulation cannot be achieved, protective coatings at junctions (to increase resistance of the circuit and effect area ratios) will help.
- **Electrochemical Techniques** - Install cathodic protection systems to suppress galvanic corrosion by using galvanic sacrificial anodes or impressed current systems.
- **Design** – Avoid dissimilar metals in contact, unfavorable area ratios, and use more noble metals for critical components. Use designs that avoid crevices such as threaded connections, and provide for drainage. Avoid joining materials that are far apart on the galvanic series by threaded connections, as the threads will generally deteriorate rapidly. Seal and eliminate all crevices if possible, preferably by welding.

REFERENCES

(8) Gregory Kobrin, "Materials Selection." ASM Metals Handbook, Ninth Edition, Volume 13, Corrosion, 1987, ASM International, p 324.

Service Solutions

Refinery Pump Re-Rate Saves Time and Cost

Leonard Cadena, P.E.
Technical Sales Manager, PRO Services
ITT Industrial Products Group

PRO Project Engineers work with Customers and our PRO Service Centers to solve our customers pumping problems by analyzing pumping systems and providing turnkey solutions that make commercial sense.

Problem: A gulf coast refinery was experiencing excessive maintenance costs on three loading pumps due to extreme off Best Efficiency Point (BEP) performance requirements. Vibrations averaged .4 to.5 in/sec at all times. When the pumps were purchased the pumping requirements were thought to be 4800 GPM at 1137 TDH. Now the requirements have been defined as 2200 GPM at 1137 TDH.

Due Diligence: To properly address this pump modification we had to first review the exact requirements of the pumping system as it currently existed. Our objective was to provide the customer with both sound technical and commercial advise. The pump was clearly oversized from a capacity standpoint and needed a larger impeller than the case could currently utilize. The system requirement could not be met by the OEM. The solution options were to purchase a new pump from ITT (as we had the hydraulic fit) or execute a hydraulic re-rate on the existing pump. The customer was concerned with the risks associated with a re-rate when performed improperly. ITT PRO Services was able to provide ample customer references which allowed for a high comfort level on the equipment owners part. The issue lead time and the commercial impact of removing the old base and reinstalling the new and modifying the piping were weighed against the shorter lead time of the re-rate. The re-rate was dependent on the impeller casting availability only. This casting was easily expedited with minimal commercial impact. All other components were readily available.
The re-rate was preferred if it was possible.

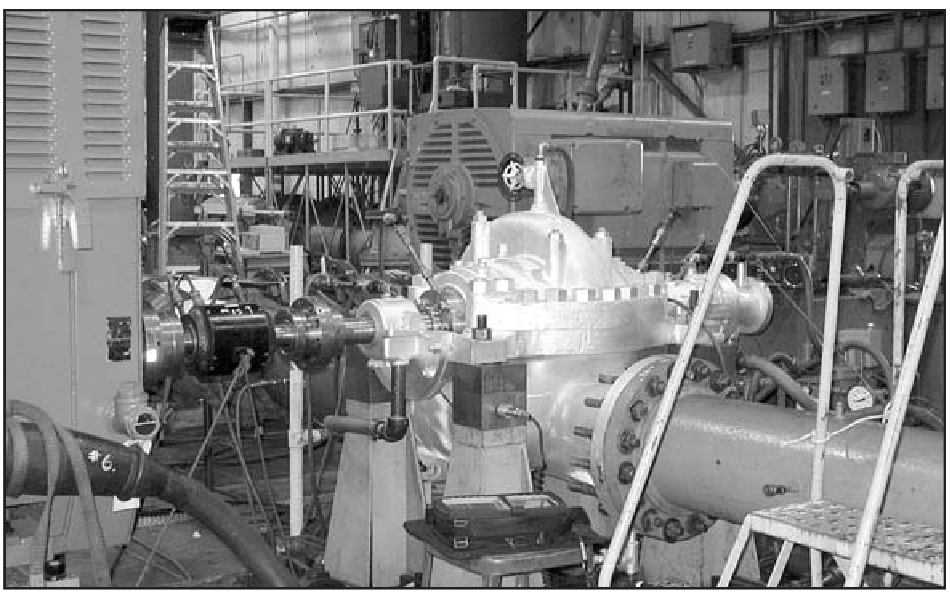
To completely examine the hydraulic issues we went to our family of curves for the API between bearing process pumps and found one that covered this application. We considered complete flow range, head required, and NPSHa. We then had to match the existing volute with our new impeller to guarantee the hydraulic performance of these pumps.

All process pumps have two components that develop the head and maintain the capacity, the impeller and the volute (case). Energy is transferred from the driver through the coupling into the shaft and then into the fluid along the working side of the impeller vanes. This is the end of energy transfer from the driver. While energy is being transferred into the fluid, the impeller is also slowing the product down through a diffusion process (smaller area to larger area as the vanes develop from inlet to exit). This reduction in velocity head increases the pressure head as defined by Bernoulli. When the product is discharged into the volute it also is diffused to complete the head required of the pump. The product capacity is regulated by the impeller eye area and also by the volute opening area at the discharge of the impeller. These two areas are sized to define a certain capacity typically known as the Best Efficiency Point.

Solution: For our re-rate to work we had to take all these issues into account and then mechanically conform the existing pump to their requirements. In this case our impeller was dramatically smaller in capacity than the original with a much smaller area between shrouds and it had to be larger on the diameter to meet the TDH requirements. The volute therefore was required to have a much smaller opening at the openings in the case and have a larger base circle (diameter at the volute tongue openings). This was engineered by receiving the case and completely mapping out the existing hydraulic passages (volutes). The existing volute tongues were then removed and new ones were installed with much reduced areas and larger base circle. Once the hydraulic re-rate was complete we sent the pump to the factory in Seneca Falls to be performance tested. It performed very well hydraulically to our prediction and from a vibration stand point was able to perform within API 610 8th Edition current standards. Once the customer installed it in the field it performed even better.

Commercially this allowed the customer to spend about 35 cents on the dollar versus the total replacement of the pump with a new unit. The 35 cents included the removal of the pump by their personnel, the modification of the pump with new components in our PRO shop, performance testing, reinstallation of the pump by their plant personnel and all software associated with the job. The first pump with performance test was out of service for 28 days. The next pumps without performance tests were out of service for 16 and 18 days. Vibration readings averaged .07 in./sec. after this upgrade.

For more information on this re-rate or to explore a re-rate opportunity on your pump please contact your local PRO Service Center or Service Representative.



PumpSmart® PS200

continued from page 4

1. Benchmark the pump/system. The pump must be known to be in good operating condition, i.e. as new or just rebuilt, not cavitating or dead headed. A series of baseline readings of speed, torque, and pressure or flow is automatically taken once the pump / system has been stabilized and the operating temperature has been reached. The baseline readings are taken at predetermined speed steps from minimum to maximum speed and stored for later analysis. This process takes less than two minutes.

2. Acquire present pump status. At predetermined intervals (user defined - once a day, week, month etc) automatically vary the speed by ±3 to 5 percent and obtain a data set of speed, torque and pressure or flow. The whole procedure takes a few seconds and is not intrusive to the process. Some very complex algorithms are used to detect, on a comparative basis, the amount of torque and speed change required to maintain a particular PV. These algorithms (patent pending) enable differentiation between system changes and the amount of performance degradation.
3. Alarm on a 10% (user definable) or greater performance degradation.

Since we are dealing with one process variable the following assumptions/limitations should be recognized for the proper implementation of the hydraulic degradation algorithms;

- The pump is known to be in good condition when the baseline is obtained.
- The pump baseline is obtained after the pump/system has stabilized and the pumpage temperature has been achieved.
- The Pumpage specific gravity changes cannot exceed ±5% of the specific gravity obtained during baseline operation using flow as the PV. Note: discharge pressure as the PV can tolerate swings in specific gravity.
- The Pumpage viscosity changes cannot exceed ±5% of the viscosity obtained during baseline operation.
- Pump is operated in a non-cavitating mode during operation, baseline gathering or hydraulic performance check.

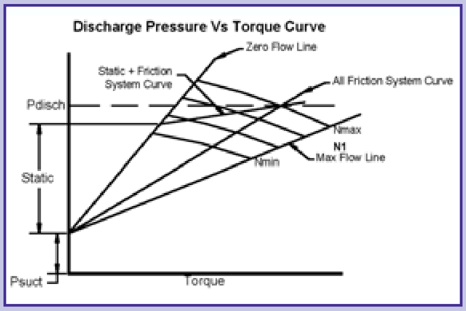


Figure 4.

Send your comments or suggestions to:
John Beca - ITT Industrial Products Group, 240 Fall Street, Seneca Falls, NY 13148 or email: jbeca@fluids.ittind.com
View the latest in pumping technology at: www.gouldspumps.com