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Maintaining the health of your pump
Centrifugal pumps: Tracking down cavitation and other problems

On a major part of the pump breakdowns in the Chemical Process Industry, the causes are NPSH problems, gas admixtures in the transported fluids, dry running or operating a pump outside the permitted range. Faulty operation and faulty set-up rank amongst the most common causes of damage in pumps, accounting for 90 to 95 per cent of all damage. Problems are most easily avoided if you know how they come about. PROCESS has been looking for the tell-tale signs.

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When it starts to rattle as if sand was trickling onto a tin roof, then the pump operator needs to be at maximum concentration: It is the sound of cavitation! And cavitation is always a sign that the pump is “suffering”. Liquids being expelled and abrasive media are similarly bad news for a centrifugal pump. This article looks at how the problems can be counteracted.

Cavitation

What exactly happens during cavitation? According to Bernoulli, the static pressure in a medium is lower the higher the velocity. If the static pressure falls below the vaporization pressure of a liquid, then bubbles of steam or gas form — which then condense in areas of higher pressure, with very high pressure and temperature peaks.

On a centrifugal pump, the suction-side pump inlet is the Achilles heel, as Rheinhütte describe: The bubbles of steam arising there are carried along by the flow and then come together again inside the pump, creating a hammer-like effect. The resulting micro-liquid jet is directed at great speed and at high pressure (up to 20,000 bar) against the surrounding surfaces — with very unfortunate consequences:

destruction of the pump components (especially impellers) due to the bubble implosion;

change in the characteristic line of the pump and thus of the operating point (even to the extent of complete interruption of the feed flow);

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This is how the Sero multi-function pump works
Advantages of the Edur pumps
KSB is knowing about casting
Lined pumps from Richter Chemie-Technik
BASF markets technical know-how
Rheinhütte have materials ready for aggressive media
All about pumps: Sulzer Technical Review

strong increase in vibrations (structure-borne noise) and noises.

The effect and consequences of cavitation depend to a large extent on the pump itself (pump geometry), and also on the characteristics of the fluid (temperature, steam pressure) and on the suction-side plant conditions. In special cases, Rheinhütte suggest installing an inducer in front of the impeller. In principle, the inducer works during operation like a fore-pump and increases the pressure (NPSH, Net Positive Suction Head) on the impeller inlet. It is mounted on the pump shaft directly in front of the impeller.

KSB points out that coatings which are later applied can fail very rapidly due to flaking where there is high cavitation intensity. Paintable and sprayable coating using an epoxy resin base, with finer strengthening particles and coating thicknesses of less than one millimeter, exhibit needle-like erosion marks after just a few hours. The consequence of further cavitation stress is that large areas of the coating elements flake off from the base material. Where there are thicker, smear-applied layers with larger reinforcing particles, small flakes rapidly breach off from the surface. The experts at KSB therefore recommend a regular check on the coating, in order to avoid damage to the base material through timely repair to the coating.

To predict cavitation on pumps, Sulzer Pumps uses the simplified version of a cavity-boundary area-tracing method, developed in the Laboratory for Hydraulic Machines at the Swiss Technical University (ETH) in Lausanne. This makes it possible to predict the impairment to the feed level from the developing cavitation.

Furthermore, the method is helping the pump constructor to improve the suction capacity of the impellers through accurate prediction of the effects of changes in the geometry.

Degassing liquids

If condensates, liquefied gases, hydrocarbons, aerosols or refrigerants are being conveyed at near to boiling point, these media place special demands on the pump due to the high proportion of gas they contain. The Sero SRZS multi-function pump offers a raft of advantages in this compared with “normal” centrifugal pumps. Its good suction capacity, combined with a lack of sensitivity to cavitation, make the pump ideally suited to the conveying of gas-containing fluids.

The multi-function pump is largely non-sensitive to inclusions of steam or gas in the conveying medium, and can at the same time achieve a considerable pressure head. Gas bubbles are directed with the conveying materials through the pump, and the proportion of gas can be up to 50 per cent. Fluid/gas mixes are conveyed problem-free without external aids. Where the proportion of gas is, for example, ten percent, this has practically no effect on the characteristic line, with this also being assisted by the significantly steeper Q/H characteristic curve compared to a radial centrifugal pump.

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Edur multi-phase pumps are similarly equipped for safe conveying of gas in the conveying material. The manufacturer's experience is that centrifugal pumps operating under real operating conditions frequently have to convey non-dissolved gases or vapors with the conveying medium. The causes can be plant-conditioned. However, process-conditioned requirements also need to be taken into account: In many technical process applications, one often finds several phases of different media present simultaneously which need to be controlled. Typically, liquids need to be enriched with gases, liquid/gas mixes conveyed, or even gassing liquids need to be transported safely. The company information from Edur is that its pumps achieve a good level of mixing of the two phases, with separate feed of liquids and gases, and a high level of dispersion.

Abrasive media

If abrasive media require conveying, then the different types of pump construction come up against their limits more or less quickly. Centrifugal pumps are well-suited to transporting solids if the medium is present as a suspension, as outlined by Professor Helmut Jaberg from the Technical University (TU) Graz/Austria: “Provided the suspension arrives at the suction fitting of the pump, it will be pumped,” said Jaberg.

Of course, the manufacturer has to take precautions against abrasive wear in the flow-carrying components, for example by using ductile metals with a high hardness, using cast mineral composite or by applying rubberized surfaces to metallic substrates. Generally, Jaberg recommends:

large, well-rinsed axial face seals;

dual-wall finish;

adjustable and replaceable wearing walls and opening;

pressure-relieved housing;

use of shaft protection sleeves;

thick profiles on the impeller inlet.

Pump management

In addition to faulty configuration of the pump, not operating the pump in accordance with the configuration or incorrect operation rank high up on the list of causes of pump problems. This, in turn, is often related to the problem of in-house pump expertise being lost by the operator — for example, due to outsourcing of maintenance works to outside agencies. In this area, BASF in Ludwigshafen/Germany has its own approach: “Do the important things yourself” is the order of the day there.

In the group's Ludwigshafen plant alone there are around 50,000 pumps installed, including around 35,000 process pumps. Of these, around 10,000 are considered to be special design pumps, specifically configured for the specific use. “In most cases, these pumps are working in the primary process flows, and so require demand attention for us,” says Heinz

Hefele, Head of the Specialist Technical Center for 'Rotating Equipment' at BASF. He heads up around 350 specialists who are engaged in designing and maintaining turbines, compressors and pumps, along with machines used in process engineering such as mixers, kneaders and centrifuges. Maintenance of all electrical machinery and actuating drives are part of the group's area of responsibilities.

If the problem relates to the specification and/or configuration of pumps, then employees at the Rotating Equipment group are regularly called on to give advice — not necessarily for every simple standard pump, but always for special design pumps. The BASF specialists place great value on achieving a favorable rating for the pump in terms of the lifecycle costs assessment. For if there is a need to assess technically comparable alternatives for ensuring the availability of a pump system (and, with that, possibly of a production plant), then a detailed LCC assessment is the right tool: "Anyone who takes a consistent view of the cost-of-ownership factor in choosing the type of pump design can avoid costs which amount to considerable sums," says Hefele, drawing on his own wealth of experience.

Rotating Equipment today maintains around 5,000 pumps a year under its own operations. For this, it carries out practically all servicing work for process pumps in the plant. As part of his pump management, Hefele is looking to lower maintenance costs further over the long term. A key component in pump management at BASF is that, for years, an expert database has been built up and is constantly being added to, where details derived from experiences relating to pump damage, causes of failures and repair and maintenance measures have been recorded. That pays off in real money.n