Applied intrinsic safety with centrifugal pumps

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Intrinsic safety is an established term in the context of electrical equipment. It denotes systems which, by design, ensure that even an operating error or a failure of components will not lead to hazardous situations. The significance attached to intrinsic safety as a design element in centrifugal pumps and the effects of using intrinsically safe pumps in practical operation will be described in the following article.

In order to minimise the failure risks in pump applications, pumps are designed redundantly and the key spare parts are kept in store. Operators rely on comprehensive operating instructions and continual employee training to avoid, for example, operator errors. Another cost factor is the increasing use of diagnostic and early-warning systems for fault detection in recent times. Those extra safeguards, however, often lead to problems themselves. Moreover, the average expense from planning and procurement, integration, repair and maintenance to documentation, etc. can amount to up to 10,000 euros per signal.

CHALLENGING OPERATING CONDITIONS AND PHYSICAL PRINCIPLES

Frequently, the pump operation is aggravated by the operating conditions. Examples for rather challenging pumping media are gaseous, corrosive, solid-containing or explosive media as handled in the petrochemical industry and in chemical companies. The centrifugal pump manufacturer Bungartz shows the possibilities of applying physical principles in the design and manufacture of centrifugal pumps for such media and how pumps can render external monitoring systems superfluous.

INTRINSIC SAFETY AS A DESIGN ELEMENT OF PUMP TECHNOLOGY

The intrinsically safe pump technology offered by Bungartz is partially based on the hydrodynamic sealing originally developed by the company. Essentially this sealing consists of a distinctive blading at the rear side of the impeller. Thus, the pumping medium is carried away from the critical shaft gap transition protecting the downstream shaft seal system. Owing to the physical features the pump is perfectly leak-proof and the downstream seal (mechanical, magnetic, lip seal, etc. for the idle state) is relieved (**Figure 1**). These non-contact hydrodynamic shaft seals with seal expeller and centrifugally controlled idle state sealing render the large circulation pumps

Figure 1: The large circulation pumps of the M-UMOR type are legendary. They are particularly suited for solids and are used all over the world, for instance in the pumping of ammonium nitrate.

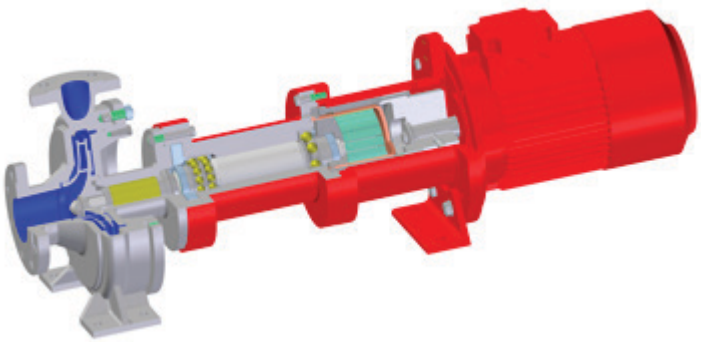

Figure 2: The hermetically sealed chemical pump $MPCH_{DryRun}$ is ATEX-compliant, suitable for molten masses and protected against blockages and operator errors (e.g. insufficient ventilation).

(1,200m³/h) of the M-UMOR type perfectly intrinsically safe. The legendary pumps (one pump has been running since 1948!) are particularly suited for solids and are used all over the world, for instance in the pumping of ammonium nitrate.

The intrinsically safe $MPCH_{DryRun}$, a hermetically sealed chemical pump, also allows use with any liquid. Its design provides that bearing and magnetic drive are not in contact with the pumping medium. Sealing gas flows through the product-free labyrinth area. This area between the rear side of the impeller and the shaft bearing provides a heat barrier with high temperature gradients and thus a low bearing temperature. The grease-lubricated rolling bearings need neither monitoring nor maintenance throughout their minimum service life of 32,000 hours (**Figure 2**). Further advantages are that the system is ATEX-compliant, suitable for molten masses and protected against blockages and operator errors (e.g. insufficient ventilation). There is no need for the usually required signals and controlled systems.

A unique feature of the pump is its self-regulating behaviour owing to a special physics principle: The centrifugal pumps of the V-AN series work without suction capacity. The principle is based on the pressure compensation between pump impeller and feed vessel. This allows the pump to convey depending on the inlet flow rate, which means that it adapts its behaviour in a self-regulating manner to the inflowing feed rate. The V-AN is self-ventilating via a pressure compensation line (**Figure 3**). All pumps of the V-AN series are safe to run dry and intrinsically safe. They work without any mechanical or electrical regulation equipment.

The design advantages thanks to the intelligent application of process physics decisively increase the availability of these special centrifugal pumps. The following examples from a refinery environment provide insight into a conversion to intrinsically safe pumps and describe the preliminary pump selection for a new construction project.

Figure 3: All pumps of the V-AN series are safe to run dry and intrinsically safe. They work without any mechanical or electrical regulation equipment.

Practical example: Conversion of a condensate delivery system

Pump location: refinery

Medium: condensate

Operating data: Q = 42.5 m³/h, minimum feed rate: Q= 0m³

H = 90m liquid column, temperature = 127 °C, (operating temperature: T_{max} 160 °C),

Operating pressure p_{max} = 10 bar (0)

The use of a standard pump with product-lubricated slide bearings and the thus occasionally occurring entrainment of vapour bubbles caused regular standstills with expensive consequential damage. Standard pumps of this type have a significant disadvantage: they are not suitable for dry-running operation. The slide bearings are surrounded by flowing pumping medium or external water. When used to pump condensate in a refinery here, they trigger additional pulsating pressure surges due to the min/max control, which cause malfunctions in the plate heat exchanger. This leads to damage with huge follow-up costs. After numerous failures, the operator finally decided in 2008 to make a conversion. Now, the self-regulating VKS-AN vertical pump provides a hydrodynamic sealing during operation, which works as described above. The use of the back vanes working frictionlessly and being free of wear and tear leads to

sealing with a simple graphite gland packing only being required for the idle state. Neither a sealing system nor other additional equipment is required. The low-pulsation delivery is facilitated by the pump's direct reaction to the volume flow. There is no need for a minimum volume flow. With the grease-lubricated rolling bearings and the self-ventilating effect the pump achieves a high availability. For seven years now the VKS-AN has been operating without any maintenance and in trouble-free condition.

Practical example: Conversion of a refinery waste tank

Pump location: refinery, special feature: use of a slop pump in zone 1 or 0

Medium: viscous refinery waste containing solids, flammable, outgassing

Operating data: – Q = 5m³/h, H = 40m, P (water) = 10kW, speed = 2900 rpm

The refinery waste contains not only solids but also viscous elements of a hazardous, flammable and outgassing nature. The previously used slop pump with product-lubricated slide bearings failed at least once every six months. This led to expensive and time-consuming repair work. Moreover, the safety-relevant location of the former pump rendered its removal and reinstallation extremely laborious and dangerous. Evacuating the environment and working with full protection was mandatory there. The conversion was absolutely necessary. It was made already ten years ago. Since then the intrinsically safe MPATAN slop pump has been working without malfunction and even maintenance-free. Experience shows that under these conditions run times of more than 13 years can be achieved.

Practical example: New construction project with unloading station for tanker trucks

Application area: refinery/tanker truck unloading

Medium: sulphuric acid

Special features of pump use:

Operating data: Q = 30m³/h, Q= 0m³, speed = 2900 rpm

H = 20m liquid column, temperature = 50 °C, density 1.84kg/dm²

Operating pressure p_{max} = 10 bar (0), operating temperature: T_{max} 100 °C)

Pumps for the unloading of tanker trucks are required in the construction project for a new refinery. Pump manufacturer Bungartz is involved in the early planning stage. The self-regulating physical feature of the pumps of the V-AN series facilitate easy unloading from below, complete residual liquid emptying without exerting pressure, utmost safety and even structural simplifications: The construction of a pit or other infrastructure adaptations, which would have been required for standard pumps due to the respective suction head, is unnecessary because of the use of the MPVAN. The result: maximum safety, hermetically sealed against leakage, low operating effort and savings in terms of energy consumption. The trouble-free unloading of tanker trucks for at least 15 years renders the use of the intrinsically safe pump highly economical.

ACHEMA 2015: Hall 8.0, C1

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