**Protecting pump integrity in the mining sector**

**Protecting the integrity of centrifugal process pumps used in critical applications in mining is key to minimising downtime and ensuring the safety of workers. Jacques Visser of Morgan Advanced Materials examines the various technologies available for ensuring pump safety and how the use of modern materials and designs are bringing new dimensions of performance to these applications.**

**Centrifugal pumps are widely utilised in most types of mining, primarily for the removal of slurry, but also for other tasks such as water removal. Their effective and continued operation is key, as any interruption can result in the undesired build-up of liquids in working areas, with the potential to compromise both process efficiency and the safety of operatives.**

**However, the uniquely demanding conditions under which these pumps operate mean they can be subject to the build-up of pressure when, for example, suction or delivery valves become closed or operate incorrectly, or lines become blocked due to the presence of solids such as sand, grit or small pieces of rock.**

**In these instances, the rapid increase in pressure can lead to the failure of a pump and, even worse, a pump explosion with the potential for severe injury or even death to operatives working nearby.**

**And while the cost of a specialist replacement pump may be significant, to say nothing of the cost of downtime while this critical component is sourced and installed, even these costs pale into insignificance when compared with the financial and reputational damage resulting from a workplace fatality.**

**Even this may not be the end of the matter, with companies facing heavy fines and individual directors even subject to imprisonment if investigations reveal that safety measures required by local or international law were in any way neglected. BS2915:1990 is the key regulation in the UK but there are many local regulations too.**

**The risk is illustrated by several well-documented cases, such as an incident in Virginia, USA, in 2002, when a fine coal transfer pump which had been left standing for two days was started without gland service water and quickly overheated. The pump was stopped by an operator, but the gland service water then entered the red hot all-metal casing, rapidly creating a build-up of steam which caused the pump to explode and the operative to lose his life.**

**To combat this risk and to help maximise pump life, a variety of technologies have been developed over the years designed to shut off operation before pressure within the pump reaches a level where it is prone to fail.**

**Among them is the use of current detection equipment, whose success is based on the premise that current drops when pump valves are closed. However, research on motors between 2kW and 110kW in duty has shown that there is frequently no relationship between the current change and the size of the pump, or the speed or duty of the motor, making this type of technology of questionable value in many applications.**

**Another alternative is the use of pressure sensing equipment, although once again a question arises as to the relationship between pressure at immediate delivery before and after valve closures or the occurrence of blockages. Furthermore, any rise in pressure is only likely to be detectable at the point when the fluid starts to boil, which is by definition too close to the point at which the pump may explode. Meanwhile, any probes used with this equipment are likely to have their effectiveness hampered by the presence of chemicals and slurries, while these systems are in the main considered an expensive option.**

**The same issue also has the potential to cause issues with temperature monitoring equipment. While generally a more reliable option than pressure sensing as the temperature increases immediately when valves are closed, this option is again expensive as probes or thermocouples not only have to be hard-wired to the breaker but are also subject to the effects of slurry build-up, again impacting on their performance and ability to provide the rapid, reliable data needed to trigger a shutdown.**

**Strain gauges are a further option for specifiers and system designers, but again are not always found to be reliable, while fusible plugs are reliant on the same technology as temperature and**

pressure sensing and so do not overcome the issues associated with these technologies. Meanwhile, pressure relief valves again add to cost while their presence may compromise the leak-tightness of the whole system and they may not react quickly enough to relieve a rapid pressure build-up. And while most pumps are fitted as a matter of course with safety valves, these components require regular testing and maintenance to ensure they will come into action at the desired pressure. Indeed, the issue of maintenance is a key one given that many mines operate a continuous shift pattern, meaning that downtime for routine maintenance to pumps and associated components has to be minimised.

Concerns over the effectiveness and cost of these technologies, as well as the need for a truly maintenance-free solution, led to the development of the first bursting discs or rupture discs. A rupture disc is a sacrificial part containing a domed membrane which fails instantly – within milliseconds - at a pre-determined pressure and cannot reseal itself. This is ideal in scenarios where pressure may be subject to rapid build-up and other forms of pressure relief may either be unable to respond quickly enough.

Many of the early discs were made from foil, in many ways an ideal material but one which is relatively delicate and can therefore be susceptible to damage such as bending and scratching, which is most likely to occur when the disc is inserted into its holder. In these instances, the performance of the disc may be compromised, with the most likely scenario being that it will 'burst' at too low a pressure, resulting in unnecessary downtime and the cost of a replacement. This cost is by no means insignificant – around £400 per unit is not untypical, depending on the application – while ancillary items such as the specialist holder raise purchase costs further, meaning that foil discs represent an expensive option given their relative fragility.

The issues with foil discs drove leading materials companies to seek a more cost-effective and practical solution using a more robust material which did not require a specialist holder, and which was less prone to damage during the installation process and so to premature failure resulting from accidental alterations to the disc's shape or surface profile.

The solution came in the late 1980s in the form of the first graphite discs. These were (and still are) designed to fit between the bolts within the standard  ANSI flanges found on most pumps, eliminating the need for a separate holder and easing installation. Furthermore, with graphite being

**a harder and tougher material, the discs can withstand a certain amount of scratching with no compromise to their burst pressure, and can operate at a broad range of temperatures between -50ºC and 250ºC. The use of a PTFE material bonded to the disc optimises resistance to any alkalis present and ensures their presence does not impact on the disc's service life or performance.**

**The flexibility and versatility of graphite is a material enables the production of discs to very precise customer parameters – indeed, there are very few, if any, 'standard' products on the market. Rather than relying on calculations using pump casing pressures, burst pressure is typically calculated by taking the working pressure and adding 75 per cent, meaning a pump with a working pressure of 1 bar will require a disc with a burst pressure of 1.75 bar. Physical destructive testing of sample discs from individual batches before they leave the facility guarantees that the discs will operate to the agreed customer parameters, with test certificates provided to ensure that local and international safety regulations are satisfied.**

**The sophistication of modern manufacturing techniques even allows the production of discs which can cope with negative or vacuum pressure. For these applications, for example where the system is subject to hydraulic back pressure, discs can be manufactured with a vacuum bar inside the orifice, meaning they will still operate effectively in the presence of any vacuum 'pull'. Discs can be manufactured in diameters of between 0.5" and 16" in a variety of thicknesses to suit virtually any application. If fitted correctly, graphite rupture discs have an almost unlimited service life, require no interim maintenance, and can typically be changed within a matter of minutes. While they are frequently used in conjunction with a safety valve, a rupture disc on its own is more than capable of ensuring that pre-determined pressure within a pump cannot be exceeded.**

**The latest development has seen the introduction of 'centreline' discs to completely negate the issue of scratch damage. The versatility and cost-effectiveness of graphite discs has seen them tested against other methods specified by many of the leading international mining companies as the preferred system for protecting pumps from excess pressure build-up.**

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