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Mechanical Seal Development on Cryogenic Liquefied Gas pumps.

Introduction-

A gases manufacturing company has a large number of liquefied gas pumps in service.

The pumps are used both in fixed locations for tanker loading, product transfer, vapouriser feed pumps or attached to road tankers for product offloading duties.

This company has an enviable track record of reliability with its large production units but the track record with the small liquefied gas pumps was terrible.

Machinery details-

The majority of the pumps are simple single stage centrifugal devices with a simple single mechanical seal.

The pumps are usually close coupled to the motor, often the pump shaft forms a simple extension to the actual motor shaft.

The mechanical shaft seals are a simple single bellows seal, with usually a carbon stationary face with a tungsten carbide rotary.

Due to the low temperature of operation the pumps are usually made from a combination of bronze and stainless steel.

The majority of the pumps are in the size range 30kW or smaller.

Initial investigation-

The client company has an enviable record of reliability and technical improvement on its gas production and liquefaction facilities and has extensive resources in house devoted to the maintenance and development of its machines.

However, the emphasis over the years has been almost entirely on its considerable fleet of large machines.

Of course, this makes a good deal of sense but as the company has grown over many years, there is a large collection of small liquefied gas pumps.

Each facility and depot may only have between three and six pumps, but over the UK and Europe (and indeed the rest of the world) there are many hundreds of the pumps operating.

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Taken on a case by case basis, each pump on its own probably is not that much of a problem to deal with, however, when typical life times between maintenance (Mean Time Between Failure, MTBF) can be as short as four to six weeks, taken over the company a significant cost is incurred annually and resources are allocated that could be better utilised elsewhere.

The fundamental problem with pumping a liquefied gaseous product in a mechanically sealed pump is one of lubrication.

The mechanical seal faces need to be lubricated in order to avoid excessive and destructive wear. In a simple single mechanical seal this lubricant is usually the product. In these simple pumps, indeed the pumped liquefied gas is the lubricant between the faces of the seal.

The problem arises with this arrangement due to the tendency of the liquefied gas to boil off between the faces causing the seal to run dry. Traditionally in mechanical seals this dry running means rapid failure of the non lubricated seal faces.

A second problem with the use of mechanical seals on liquefied gas pumps is the tendency for the pumps to be cooled down rapidly without properly drying them beforehand.

This leads to condensation forming across the seal which then freezes.

The ice causes two problems.

Firstly it causes the seal faces to stick together and on start up tears pieces of the carbon face away.

Secondly, the ice crystals between the seal faces if not cleared away by defrosting before start up, cause scoring of the carbon seat. In either case the result is a liquefied gas leak, loss of product, freezing of the motor bearings and an early overhaul of the pump.

This can be particularly hazardous if the product is liquid Oxygen and it enters the bearings of the motor.

In such circumstances it is not that unusual for explosions to occur blowing the pump and motor apart.

At this company there were several different arrangements designed to keep the motor bearings warm to prevent the grease from freezing due to cold “creep” along the shaft.

There was also a programme to fit “soft start” controls to the motors so that the pumps would ramp up gradually when started and hopefully give the mechanical seal a chance to establish a fluid film between the faces before excessive wear could occur.

Further investigation-

Having a close working relationship with a leading mechanical seal manufacturer, I was aware that a lot of work had been done applying mechanical seal technology to gas applications.

Initial discussions between myself and the mechanical seal manufacturers seemed to indicate that the application of the gas seal technology to the liquefied gas pumps would be perfect.

A survey was undertaken in order to decide what sizes of seal would be required to cover the majority of the applications. It was decided that just three different seal sizes would cover most of the range of pumps.

It was decided to trial some seals on pumps at plants fairly local to the company's main UK engineering workshop.

In addition to the fitting of the new gas seals the following was carried out-

A full overhaul specification was written with step by step instructions and tolerances in order to return the pumps to at least as good condition when new.

The pump shaft and impeller were balanced as a unit to $G=2.5$ as a minimum.

A detailed installation instruction was written so that it could be ensured that no pump was installed in a way that lead to pipe strain or twisting of the motor which could pull the components out of alignment internally.

A directive was written to ensure that each pump was dried and cooled properly before putting into service.

Having laid down the ground work for this project, the first seal was installed in a pump and put into service.

After running trouble free for nine months the next few pumps were overhauled and retro fitted.

There were no technical failures during the early phase of implementation.

The only seal failures were scoring caused by ice crystals in the seal due to a lack of sufficient drying out before start up.

Following the successful trials the seal types became a world standard for this company and were specified on all new equipment bought.

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It is not unusual for one of these mechanical seals to be reused when a pump is overhauled.

Because the seals run on a gas film rather than a liquid film, there is no contact at all when operating between the seal faces. So no wear takes place.

The actual cost of the seals is 150% higher than the original mechanical seals that were previously used, accounted for by the considerably more complex and advanced construction of the seals.

Despite this higher initial cost, the increased reliability of the pumps and the reduced product losses from leaking seals makes the use of these seals in all liquefied gas duties a no contest decision for the budget conscious maintenance engineer.

Conclusion-

For a company with a generally excellent record of machinery reliability, this project was perhaps the last major opportunity presently existing to make a step change in the standards of machinery maintenance.

The company was very focused on the efficiency and reliability of its large machines and while there is nothing wrong in principle with that, the amount of money and resources consumed by the many small liquefied gas pumps was out of control.

In fact it is not an exaggeration to say that more money and resources would be allocated to keeping small pumps going than to a machine a hundred or even 1000 times larger on the same site. It was odd that no one gave a moments thought about the pumps but were continually vigilant about the condition of their other machines.

It was only when a person with a different view of the situation came along that something was actually done to bring the standard of the liquefied gas pumps up to the standard of the rest of the machines operated by the company.

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About the author-

Stephen H Shakeshaft is a Mechanical Engineer based in the United Kingdom. He is the Principal Consultant and Director of Stephen H Shakeshaft Consulting Ltd., an engineering consultancy specialising in optimisation of existing assets and engineering design of new build projects.

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Stephen has over 30 years experience of working at the “sharp end” as well as the “back room” of manufacturing industries with clients in the chemical, utility, metals, industrial gases and pharmaceutical businesses.

Stephen is a registered professional engineer in the UK and is a corporate member of both the Institution of Mechanical Engineers and the Institution of Engineering and Technology.

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The consultancy welcomes contact from all who are interested in plant and machinery maintenance, systems and development.