

Sulphur pump challenges

Elemental (pure) sulphur is a valuable by-product recovered during the refinement of oil and gas and is sold on to be used in the manufacture of numerous products including fertilisers, chemicals, pharmaceuticals, asphalt and concrete.

Sulphur is extracted and transported around processing plants in liquid form. It melts at approximately 118C and caramelises due to the formation of polymers at approximately 156C, and so only remains in its liquid state suitable for pumping within a narrow temperature band, ideally at 138C. Additionally, sulphur is a poor conductor of heat and is twice the density of water, all of which creates unique challenges for sulphur pumps.

To date, many sulphur pumps used during sulphur extraction in oil & gas production and petroleum refining industries have been simple fully jacketed adaptations of API 610 VS4 vertical pumps. These have proven very expensive to manufacture with long delivery times and have brought with them maintenance and reliability issues for operators.

The Amaranth approach

In 2013, Amaranth decided to draw on its extensive expertise in designing bespoke pumping solutions for the oil and gas industry and apply this knowledge to produce a VS4 vertical pump that was fully compliant with API 610 11th : 2010 edition and ISO 13709 : 2010 and which could meet the challenges of reliably and cost-effectively pumping molten sulphur.

Amaranth first undertook a detailed study of existing sulphur pumps, which are usually simple adaptations of existing pump designs, and how they were used and maintained to determine where issues occurred. Users reported high incidents of bearing failures, shaft problems and having to run significantly shorter maintenance periods to try and minimize failures, all of which resulted in increased downtime for the plants.

To deliver a robust, reliable and easily maintainable sulphur pump, Amaranth embarked on an 18 month design and test process using advanced computer techniques including 3D modelling, FEA & CFD with the objectives of designing a pump with the following key benefits:

- New arrangement for the shaft bearings and lubrication film to reduce the previous bearing and shaft issues operators had reported.
- Steam jacket with optimised connectors between the column and pipework sections to maintain the temperature of the molten sulphur and hence its viscosity, reducing the solidification of the sulphur around the pump particularly when it's lifted for maintenance.
- New design of impeller optimised for best efficiency for molten sulphur.
- Utilising proven modular column design to enable the rapid production of bespoke pump lengths and greatly simplify maintenance and removal of the pump.
- Improved access so that regular maintenance can be completed quickly and with less disruption to the associated pipework and plant.
- A design life of 30 years including 3 years uninterrupted operation.

Steam jacketing

To provide a stable heating regime for the molten sulphur the steam jacket extends over as much of the shaft support column and discharge pipework as possible without compromising assembly and serviceability. A major design criteria was the ease of strip down during planned maintenance and the steam jacket ensures that sulphur does not solidify during the removal of the pump. Tube compression fittings assist this by allowing quick removal and replacement.

The steam jacket, in accordance with API 610, is designed to allow mechanical cleaning, flushing and draining of the entire passageway and the jacketing is designed to ensure that no leakage is possible into any casing joints.

Alignment

Accurate alignment is crucial for reliability in vertical pumps. The pump has a discharge connection capable of accepting two API 610 nozzle loads applied in accordance with the standard and heavy duty mounting flanges, lantern concentricity and flanged and minimised number of shaft connections for low vibration. Finite element analysis was also used to reduce resonance and vibration found in some manufacturer's designs of this type of pump.

The number of spigot joints are minimised to ensure concentricity and alignment and a unique line bearing design ensures maximum load capability and reliable operation, which along with self-adjusting pipework further reduces stresses.

Bearing lubrication and support

The pump uses a patented flood type line shaft bearing lubrication which can be either process or external fluid. This is fed into the pump shaft support above the uppermost line bearing and fluid cascades down the column through all the line bearings rather than projecting abrasive products directly at the shaft. The use of anti-vortex pins and the bearing housing design within the shaft columns ensures that the lubricating film coverage is stable above the line bearings, providing a uniform supply to the bearings.

Additionally, if process fluid is used for lubrication then this is first fed through a unique Amarith vortex device that removes greater than 90% of particulate within the process fluid prior to it arriving at the bearing.

The line bearing design has been optimised to minimise heat increase across the bearing, which if not controlled would push the molten sulphur closer to the point of caramelisation. Line bearing drains are also designed to avoid hold-up of molten sulphur in areas of potential heat generation such as close running parts.

The bottom line bearing is lubricated using a pressure feed from the delivery pipework ensuring that a lubricating film is always present even with higher hydraulic loads and no flat surfaces are present ensuring drainage of internal surfaces when the pump is removed for maintenance.

Impeller

Due to the high specific gravity of molten sulphur pump efficiency is very important. Amarith has made significant investments in the development of design and production processes to deliver the most advanced and efficient bespoke centrifugal pumps on shorter lead times at a commercially acceptable cost. The sulphur pump impeller draws in this work with a bespoke but a cost-effective design optimised for BEP, efficiency and lowest running costs.

Great care was also taken in the design of the impeller suction side wear ring which is spiral grooved to ensure molten sulphur passing through this close clearance part has minimal heat build-up to aid drainage of the casing impeller area when the pump is removed for maintenance.

Temperature control

Due to the heat associated with the process of pumping molten sulphur it is important for the overall reliability that a controlled lower temperature is maintained elsewhere in the pump.

The pump has an increased height between the mechanical seal and thrust bearing to allow greater air flow, which aligned with the heat sink design enables an acceptable stable temperature to be maintained at the thrust bearing. In addition, a fan is installed above the thrust bearing to optimise its running temperature in high ambient temperatures.

Modular design

The unique modular design can be configured to handle numerous variants, quickly delivering a design for almost any depth required. A range of standardised modules, consisting of assemblies and sub-assemblies, which have already checked against mating parts for clashes using computer-aided design tools, ensures that any variant assembled from the modules fits together perfectly. This innovative method of vertical pump design significantly reduces the engineering time compared to the traditional approach of designing pumps for each application's unique length and working parameters.

As standard, the pump can accommodate sump depths from 0.65m up to 6.0m as standard, although bespoke designs of up to 10m have been supplied. Various support plates and flanges are also available.

Materials

A full range of standard material options are available, from carbon steel and stainless steel, to super duplex, to match the process fluid. NACE compliant and other materials are also available.

Seals and components

The pumps can be fitted with a variety of proprietary components to cater for site preferences, for example single and double cartridge seals (including gas running), motors (IEC & NEMA), couplings and fixed or variable speed driver from all the major manufacturers. Double mechanical seal arrangements can be fitted with a seal support system.

ATEX

Fully compliant with ATEX EC-Directive 94/9/EC

Summary

Following three years and an investment of over £1M, Amarith launched its new range of API 610 11th edition VS4 Sulphur Vertical Pump giving oil & gas operators, for the first time, a cost-effective, efficient and reliable pump for the transportation of molten sulphur from point of extraction to ongoing processing.

Full technical details of the Amarith API 610 11th edition VS4 Sulphur Vertical Pump can be found [here](#).