Mechanical Seal Coolers: A Basic Accessory Gets a Facelift

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Mechanical seal coolers often are considered a basic accessory, with little effort placed on selecting the optimal one. A seal cooler directly affects performance of a mechanical seal and extends its mean time between failures (MTBF). The heat removal and thermosiphoning capabilities of the cooler, its hydraulic characteristicstics, as well as its ability to remove trapped air (ventability) influence mechanical seal performance. Industry has long considered the single coiled tube heat exchanger, known as "coil in a can", the standard for mechanical seal cooling. Recent comparative testing concluded that helically coiled heat exchangers are superior in terms of heat rejection, pressure drop, thermosiphoning capability and venting of trapped air. This article introduces helically coiled mechanical seal coolers and acquaints the reader with the construction features and material options for this type of device. An analysis of the comparative testing is also presented.

Helically Coiled Seal Cooler

Helically coiled heat exchangers offer certain advantages: compact size, higher film coefficient (the rate at which heat is transferred through a wall from one fluid to another) and more effective use of available pressure drop. These combined features result in more efficient and less expensive designs.

True counter-current flow fully uses the available LMTD (Logarithmic Mean Temperature Difference). Helical geometry enables the handling of high temperatures and extreme temperature differences without high-induced stresses, High operating pressure capability and an ability to fully clean the service fluid flow area add to the exchanger's advantages. Gas bubbles are a frequent cause of seal cooler performance problems. As the seal fluid within a pump is heated, soluble gas comes out of solution and forms bubbles in the liquid flow. A single-tubed seal cooler in this situation will encounter performance problems, especially with an API Plan 23 arrangement. A multi-tubed seal cooler can handle such two-phase flow without problem. A single-tubed unit must have sufficient upstream pressure to force the bubble from the seal cooler. This often is difficult with Plan 23 configurations. A multi-tubed unit, which has several parallel flow paths, performs problem-free. Furthermore, a multi-tubed unit may be oriented so that venting of the gas is possible. Although various configurations are available, the basic and most common design consists of a series of stacked, helically coiled tubes. The tube ends are connected to manifolds that act as fluid entry and exit locations. The tube bundle is constructed of a number of tubes stacked on top of each other, and the entire bundle is placed inside a casing

Once positioned in the casing, the assembly forms a helical flow path for both the casing and the tubeside fluids. Mechanical seal coolers are usually

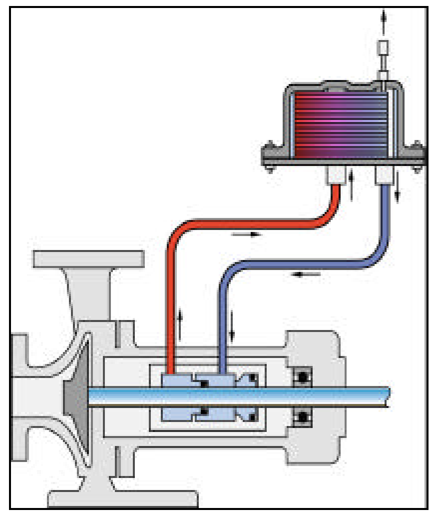

Figure 1. A typical seal cooling arrangement

oriented with the seal fluid on the tubeside and cooling water on the casing side.

Stainless steel is the standard material of construction for both tubes and manifolds. A variety of tubing material may be used, the only limitation is that it is cold worked and either welded or brazed. Other frequently used materials include copper, titanium, Alloy 20, Alloy 825, Alloy 400 and Admiralty. The casing material is usually made of cast iron or cast steel. Other materials are available as well, such as stainless steel and other corrosion resistant metals.

Comparative Performance

A seal cooler comparative test stand was built to evaluate various units under identical operating conditions. The stand enabled the testing of three different units at the same time. Complete valving and instrumentation made accurate control and analysis of test results possible. An initial test pertained to an API seal flush plan 23 arrangement.

Photo 1. Helically coiled seal cooler

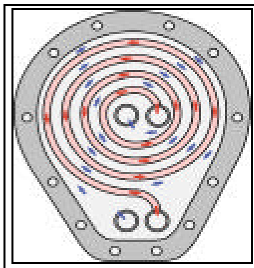

Figure 2. The flow path in a helically coiled seal cooler

Plan 23 requires that the seal fluid be cooled by recirculation. This process is accomplished by a pumping cooler ring within a pump. Pressure drop across the seal cooler must be kept to a minimum to maximize the recirculation flowrate. This particular test analyzed heat rejection capability as a function of pressure drop across each seal cooler. Cooling water inlet temperature and flowrate were a constant for each design. Results of the test are shown in Figure 3.

As indicated, a helically coiled design provides improved heat rejection at equal pressure drop across the seal cooler. Improved heat rejection results in a lower temperature return seal fluid, and thus improved seal life.

Another test was conducted that compared heat rejection as a function of seal fluid flowrate. Cooling water inlet temperature and flowrate were a constant for each type of seal cooler. Again, a helically coiled seal cooler convincingly out-performed single-tubed units. This was true even when the single-tubed units had much more surface area. The results are shown in Figure 4.

API 682 Requirements

New guidelines established by API Standard 682**,** Shaft Sealing Systems for Centrifugal and Rotary Pumps, affect the requirements for mechanical seal coolers. The cooler should provide complete drainability on both the cooling water and process side and, in the event the pumping ring is lost, it must maintain cooling through the thermosiphoning process. Regarding thermosiphoning, the cooler must be capable of cooling hot seal fluid without the aid of forced circulation provided by a pumping ring. The cooler must be able to provide the natural circulation that is produced by the thermosiphoning effect, which occurs because the density of the seal fluid changes as it is cooled.

Single-tubed units are incapable of providing thermosiphon natural re-circulation and, depending on orientation, they may not provide drainability. Multi-tubed seal coolers, however, are completely drainable, offer ventability and will supply thermosiphon recirculation if mounted properly. Figure 5 illustrates thermosiphon cooling in a 2.5 ft^2 helically coiled. seal cooler.

API 682 further requires, unless otherwise specified, that tubes shall be 3/4” in diameter with walls at least .095” thick. Helically coiled seal coolers do not comply with this requirement but, if just consideration is given to the issue, a user may conclude that this particular requirement doesn’t need to be strictly followed.

Here’s why: At a seal water flowrate of 5 gpm, a 3/4” tube with a 0.095” thick wall will produce a tube velocity of 6.5 ft./sec. A helically coiled seal cooler with 2.5 ft^2 of surface, which is comprised of eight (8) 1/4” tubes with 0.035” wall thickness, produces a 7.9 ft./sec. tube velocity. First, this greater velocity and smaller hydraulic diameter substantially improve heat transfer. For a well-optimized seal cooler, the seal fluid heat transfer

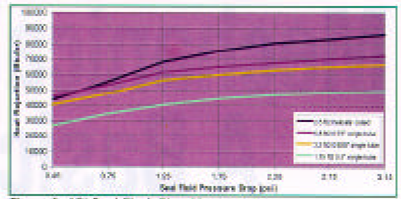

Figure 3. API Seal Flush Plan 23 comparison

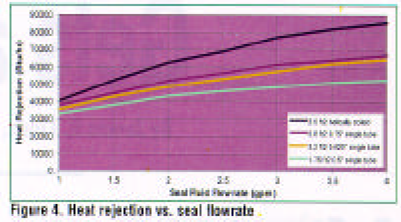

Figure 4. Heat rejection vs. seal flowrate

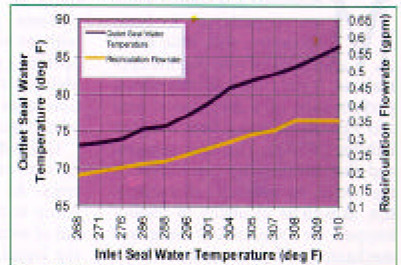

Figure 5. Thermosiphon performance

coefficient is proportional to $(\text{tube velocity})^{0.8}$ and $(\text{hydraulic diameter})^{-0.2}$

Second, many studies on fouling have documented the positive effect velocity has on the rate at which a heat exchanger fouls. Fouling is kept to a minimum by maintaining high shear rates in a heat exchanger. Shear rate is proportional to $(\text{tube velocity})^2$. Again, a higher velocity will improve performance.

Conclusion

The characteristics and capabilities of a mechanical seal cooler heavily influence mechanical seal performance. Multi-tubed helically coiled seal coolers have demonstrat-ed superior performance to single-tubed units. The main criteria for establishing an effective seal cooler is the heat rejected as a function of pressure drop across the seal cooler. Performance tests have concluded that the helically coiled heat exchanger is superior in this regard. Bear in mind, helically coiled seal coolers are completely drainable and provide thermosiphoning cooling in the event there is a loss of forced circulation.