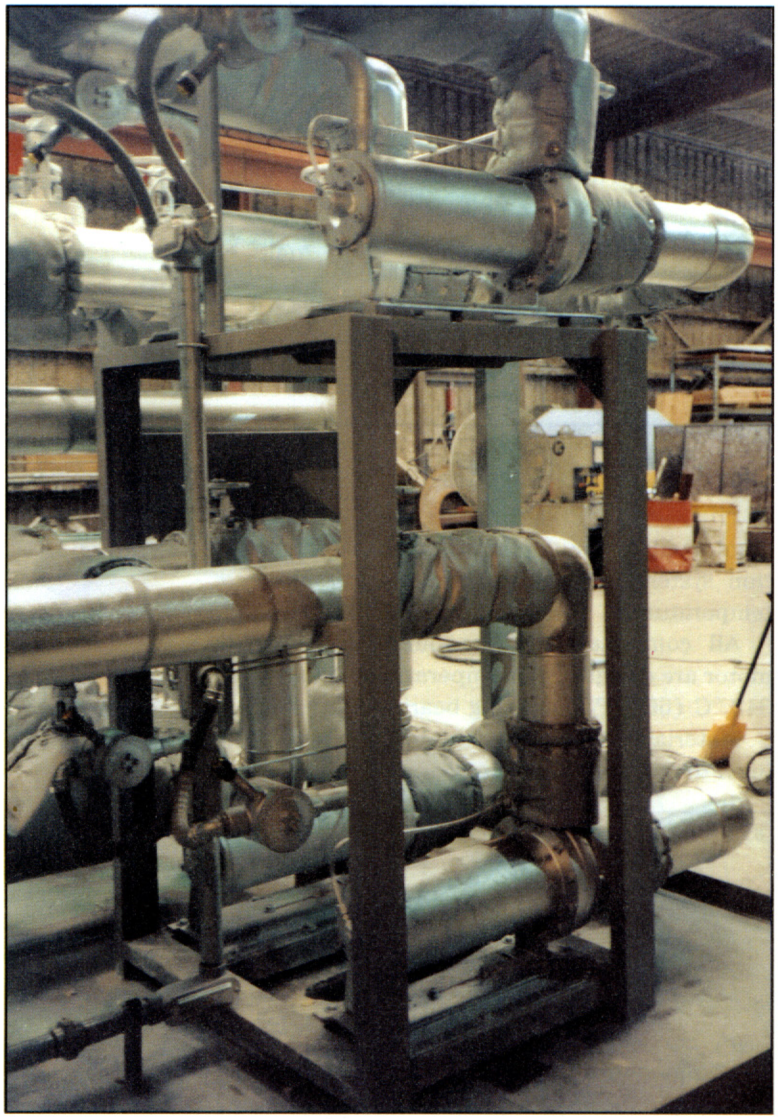
High temperature canned motor pumps

The logical simplicity of the canned motor pump has found many uses in clean, low temperature duties where containment and reliability are of of importance. High temperatures have proved a stumbling block for the wider application of these pumps, as the ancillary cooling water systems have compromised the simplicity and reliability of the pump design. Stephen A Jaskiewicz and Joseph A Cleary, of Crane Co., Chempump Division, describe their solution to these problems.



Four Crane Co., Chempump Division, canned motor pumps in a high temperature application. Photo courtesy of Texas Systems and Controls, Houston, TX, USA.

Canned motor pumps have been in use for over forty years. One of the most common and successful applications is pumping heat transfer fluids in excess of 200 °C (400 °F).

The use of a canned motor for high temperature service eliminates the need for centerline mounting, expansion joints and alignment which are required for conventional pumps (including magnetically driven units) and also offers the added safety of true secondary containment.

A canned motor pump has only one moving part, the rotor/impeller assembly. This assembly normally rotates on sleeve bearings, one forward and one aft of the armature. The bearings are typically aligned by a close tolerance fit between the bearing housings and the stator assembly. Because the alignment of the bearings does not depend on any components attached to the piping, they are not subjected to the stress that is inherent in high temperature applications. A canned motor pump requires only two bearings unlike conventional or magnetic driven units which require a minimum of four.

Double containment can be offered by employing a leakproof electrical feed-through for the motor lead wires. If the stator cavity is filled with a dielectric heat transfer oil, to improve motor performance, an expansion tank to contain any releases, or an inline relief valve, to allow for piping any releases to a safe area, can be installed.

In the design of a canned motor pump, a fluid (usually the process fluid) must flow between the stator and rotor to remove motor heat and to lubricate the bearings. Because most motor windings are constructed of materials that are limited to temperatures below 232 °C (450 °C), the process fluid temperatures are generally limited to 177 °C (350 °C).

With these temperature restrictions taken into consideration, how can a canned motor pump be used for high temperature fluid applications?

Cooling water systems

The most popular design has been to isolate the fluid in the motor section of the unit, circulate and cool the captive fluid by the use of a liquid-cooled heat exchanger and confine the high temperature process fluid to the pump casing/impeller section.

The flow path of this type of pump is illustrated in figure 1.

This design is actually two pumps in one. The main pump performs the function of supplying the needs of the system while a secondary pump circulates fluid to cool the motor and lubricate the bearings. The motor section is separated from the pump by a thermal barrier that minimizes the transfer of heat to the motor windings. The fluid is restricted to the motor section by a series of pressure ports, from the discharge of the pump, thus maintaining this area at a pressure somewhat greater than suction pressure.

The process fluid enters the motor cavity through the shaft clearance hole upon introduction of the fluid into the pump. The motor section must then be vented to ensure that all the vapour and trapped air is removed from the rotor cavity and the tubing of the heat exchanger.

Once the motor section is vented, the pump can be energized. During operation of the pump, the auxiliary impeller in the rotor cavity circulates the fluid in the motor section through a heat exchanger which is normally water cooled. This fluid is then returned to the rotor cavity and is continually recirculated to maintain the motor below the temperature limits of the winding. This design is so effective that the pump casing can be at temperatures up to 540 °C (1000 °F) while the motor section is maintained below the limits of the motor insulation 177 °C (350 °F). This design has been utilized for many years on thousands of applications. The main concern in using this pump centres around the requirement for cooling water.

Non-water-cooled systems

Cooling water systems are expensive to maintain and the water often fouls or corrodes the heat exchanger. Also, pump performance and life is dependent on a constant supply of cooling water.

The cooling water problems have been eliminated by the development of motor insulation systems capable of operating at elevated temperatures.

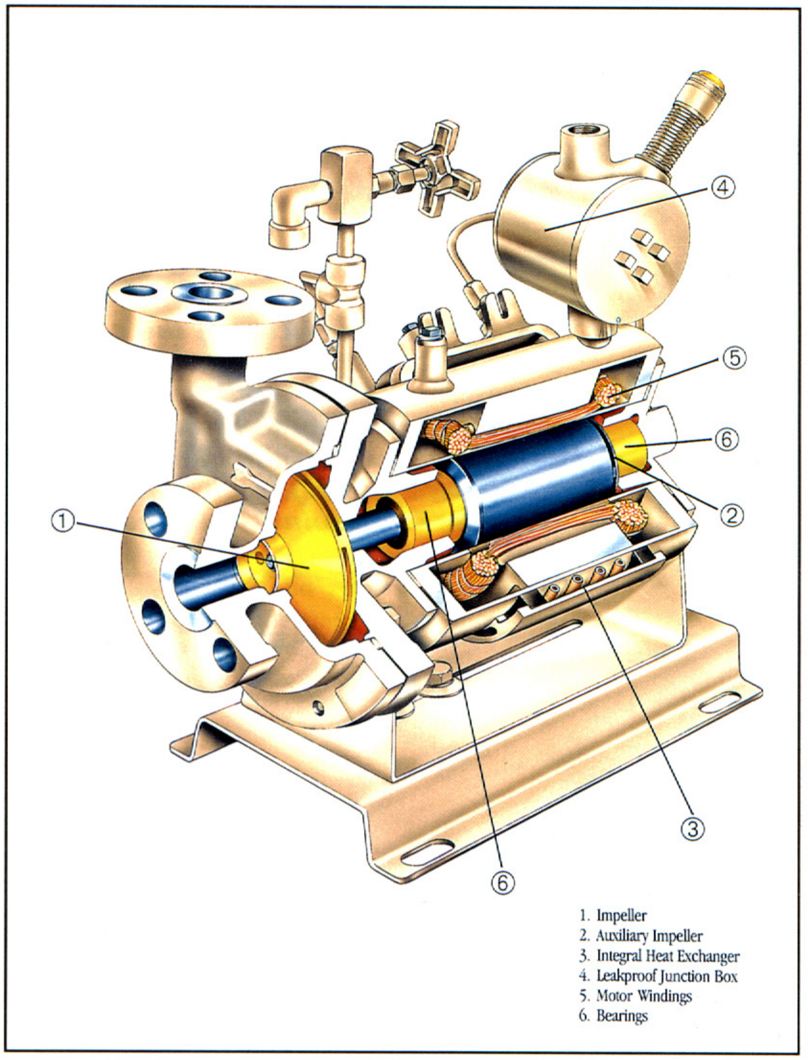


Figure 1

All components of the pump and canned motor are designed for temperatures in excess of 343 °C (650 °F) including bearing materials.

Materials were selected and tolerances developed to compensate for the expansion that takes

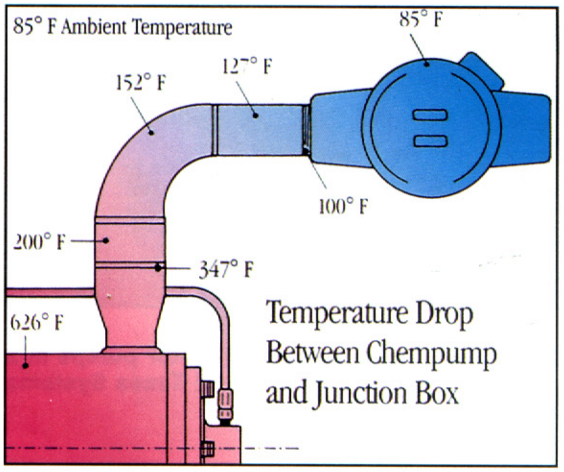


Figure 2

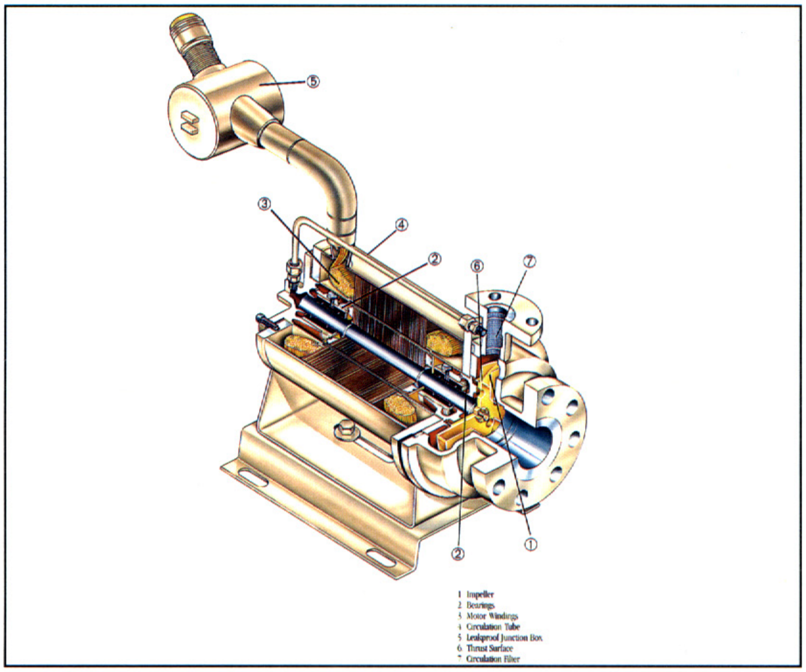
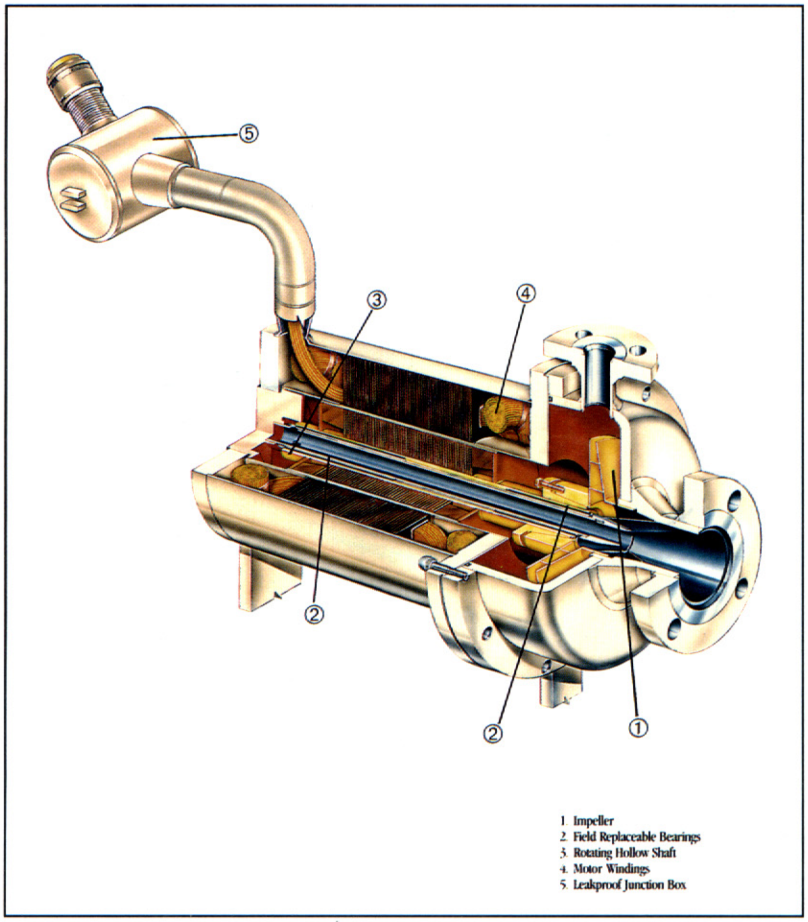


Figure 3

place as a pump is heated from ambient temperatures.

The electrical connection box is mounted away from the hot pump surface so that standard wiring can be used to connect power to the pumps. Figure 2 demonstrates the heat reduction achieved by mounting the electrical box a short distance from the stator assembly.

Figure 4



The insulation system was tested in a circulation loop at temperatures over 343 °C (650 °F). The heat transfer oil used was commercially available and selected for its low toxicity levels and effect on the environment. Tests were conducted for 1 year in the laboratory at the above temperatures at all operating conditions while a series of insulation systems and materials were subjected to endurance runs at elevated temperatures.

During laboratory testing, temperature measurements were taken at critical areas of the pump and motor, especially inside the motor winding area. At the same time, electrical test data and hydraulic performance data were recorded. Upon completion of this testing, user sites were selected for actual field testing. The test units, with the cooperation of interested customers, were inspected on a quarterly basis to determine bearing performance, motor insulation resistance and mechanical and chemical effects. At the conclusion of the successful testing the product was released to the market.

Two different high temperature canned motor pumps were developed, one internally circulated, the other externally circulated. Because cooling water is not necessary, the design is much simpler and fewer parts are necessary. Each design offers distinct advantages depending on the specific application.

An externally circulated design of this type of pump is illustrated in figure 3.

Regardless of the temperature, a portion of the process fluid is still required to lubricate the bearings. For externally lubricated pumps, this recirculation fluid is taken off the pump discharge. This recirculation fluid can be filtered by a self cleaning screen located in the discharge flange. The fluid is directed to the rear of the pump where it lubricates the rear bearing, passes through the rotor cavity, lubricates the front bearing and returns to the eye of the impeller through the shaft clearance hole.

An added advantage of this single pass design is that venting of the rotor cavity is not necessary.

Internal circulation

The internally circulated design is shown in Figure 4. Internally circulated pumps make use of a hollow shaft to return the lubricating fluid to the pump suction. With this flow pattern the process fluid is confined inside the pump assembly. This design does not require venting either.

An excellent application for an internally circulated pump is molten solids. Because the fluid is contained internally, the pump assembly can be heat traced and the process fluid can be handled without concern for solidification.

High-temperature non-water-cooled canned pumps have motor insulation that can withstand temperatures to 540 °C (1000 °F). Since process temperatures are above temperatures normally encountered by "standard motors", the power rating must be established as a function of pumping temperature. Chart 1 demonstrates the increase in rated horsepower as the ambient (process fluid) temperature is decreased. This graph also illustrates the effect of insulating the pump assembly on the performance of the motor.

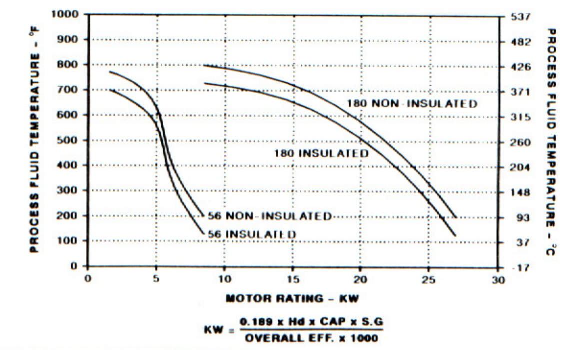


Chart 1

Conclusion

In conclusion, canned motor pumps offer many advantages over other types of pumps because of economical installation and leak-free service. An additional benefit is true secondary containment which eliminates hazards to personnel, loss of expensive fluids, and conformance to local and national regulations concerning emission control.

Over forty years of successful performance has proven the integrity and reliability of canned motor pumps. The addition of the non-water-cooled motor insulation to the available water-cooled designs adds a new dimension to the viability of canned motor pumps. ■