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White Paper

What's a screw pump? Understanding the unique characteristics and operating principles of 1, 2 and 3 screw pumps

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What is a screw pump?

The term ‘screw pump’ is often used generically. However, this generalization can be a pitfall as it fails to recognize the different product or ‘screw’ configurations, as well as the uses, advantages and design considerations for each. The design differences of each screw configuration and pump type make each suitable for different applications and handling fluids with varying characteristics.

Each ‘screw pump’ operates on the same basic principal of a screw turning to isolate a volume of fluid and convey it. However, the mechanical design of each is different. The primary difference in one, two, three or multiple screw pumps is the method in which the rotor or pumping element is supported within the casing. “Screw pump” configurations may include single screw/eccentric screw/ progressive cavity pumps,, external bearing, timed twin screw pumps, internal bearing, product lubricated twin screw pumps, three screw pumps with internal bearings, three screw pumps with external bearings, single suction designs, double suction designs, multiple screw designs similar to a three screw pump with more than two idler rotors or even Archimedes-style flood control pumps.

Single Screw Pumps

A single screw pump -- also known as an eccentric screw, or progressive cavity pump -- contains a single pumping element (screw) that rotates within a stationary, typically elastomeric stator. The individual turns of the screw seal a set volume of fluid by direct contact, with the stator. The stator has a shape that corresponds to the outside surface of the screw. The interference fit between the screw or pumping element and the flexible stator create a unique pump design that can handle a variety of fluid characteristics, including high levels of solids and variable viscosities. However, the interference fit creates a need for lubrication and cooling of the stator material.

The rotor’s drive end is supported by an external bearing, and the pumping element is supported by the stator. When using a single screw pump, chemical and temperature compatibility of the stator with the application parameters must be considered. Also, the flexibility of the stator material limits how much differential pressure can be handled across each turn of screw. Pump rotor/ stator combinations can be staged in order to make a pump capable of high pressure operation. These can be very effective in high pressure applications. In fact, high pressure multi-stage single screw pumps can be greater than 14 feet long. Provided that there is ample physical space available, single screw pumps can be an attractive pumping solution in certain situations.

Two Screw Pumps

Traditionally, the term “two screw pump” has been applied to a screw pump with two shafts. However, a two screw pump can also be considered a four screw pump if it is a double suction design (two opposing sets of screws pumping towards the discharge). For the purpose of this article a two screw pump is considered a double suction external-bearing, timed pumping machine. The pumping element of a two screw pump consists of two intermeshing screws rotating within a stationary bore/housing that is shaped like a figure eight. The rotor and housing/body are metal and the pumping element is supported by bearings at each end of the shaft in this design.

The clearances between the individual areas of the pumping screws are maintained by the timing gears. When a two screw pump is properly timed and assembled there is no metal-to-metal contact within the pump screws. The pumping screws and body/ housing can be made from virtually any machinable alloy. This allows the pump to be applied for the most severe applications in aggressive fluid handling. Hard coatings can also be applied for wear resistance. The individual turns of the screw are sealed by the thin film of fluid that moves through the clearances separating them.

An external bearing design has four shaft penetrations through the pump housings. These penetrations require sealing. Some consider the idea of four mechanical seals a nightmare -- however, this is a feature that makes a two screw pump one of the most robust pump designs, capable of handling a wide range of operating conditions and fluid characteristics.

The four mechanical seals allow the bearings to be completely outside of the pumped fluid. This allows them to have a supply of clean lubricating oil and be independent of the pumped fluid characteristics. The external housings also allows for cooling which means the quality of the lube oil can be maintained in high temperature or horsepower applications.

Three Screw Pumps

A three screw pump operates on the same principle of intermeshing screws as the two screw pump, and can be configured as a double suction pump (technically, a six screw pump). The three screw design utilizes a centrally-located primary screw, or power rotor, which intermeshes with two secondary screws, or idler rotors. The idler rotors are located 180 degrees from each other, are suspended within the pump and do not penetrate the housing. The power rotor penetrates the housing and requires one bearing and one seal; there may be bushings or sleeve bearings that are exposed to the pumped fluid.

During operation of a three screw pump, the rotor turns and allows the pumping element to create a thin film of fluid around it. The force of this fluid film acting on the rotor supports the pumping element within the housing. The method of supporting the rotor limits the possible materials of construction to non-galling combinations and the fluids that can be handled to typically non-aggressive fluids. Screws can be hardened, but stainless steels cannot be used due to the galling characteristics.

Disrupting the fluid film around the rotor can cause the rotor to lose support and potentially contact the rotor housing or the adjacent screws. Disruption of the fluid film can result from solid particles, gas bubbles, low viscosity (slugs of water or solvents) or other variable and/or process upset conditions. If the screws come in contact with one another, they potentially lock together causing the pump to stop moving fluid and potentially damaging the internals.

Three screw pumps are ideal for clean, lubricating fluids. Fluid film thickness and operating clearance is typically smaller than that of a two screw design, giving higher efficiencies and higher pressure capabilities than a two screw pump providing viscosity is adequate and fluid is clean enough to avoid disruptions to the internal fluid film.

In conclusion, using the generic terminology 'screw pump' fails to recognize the key mechanical design and performance differences that each screw pump type offers. However, once they are understand, engineers will find a proven technology suitable for a wide range of applications in multiple industries.

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