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## Operating & design

# Three-screw pumps aid power plant

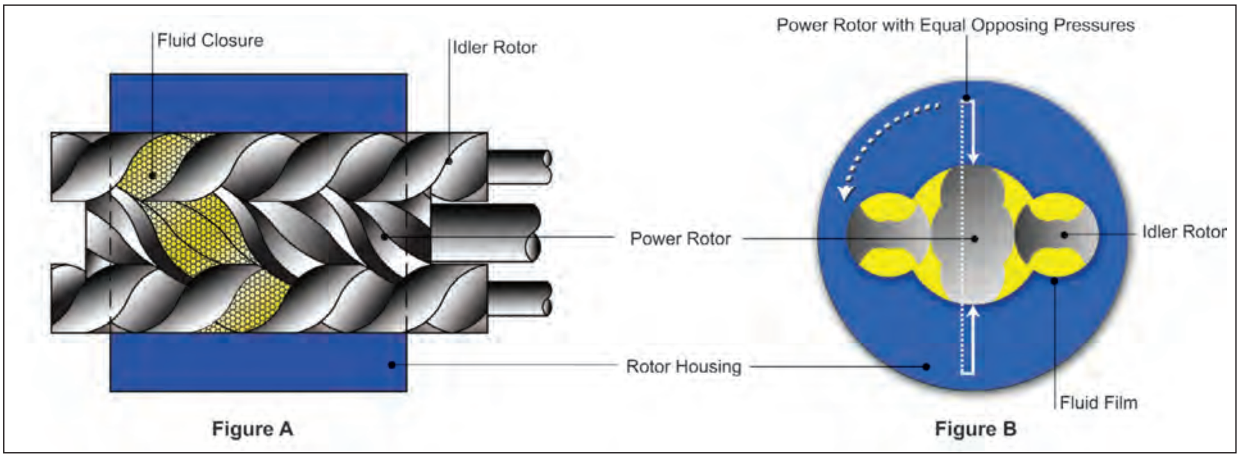
Three-screw pumps can increase reliability, which means increased uptime, longer maintenance intervals, and longevity. This means savings for machinery lubrication, crude oil transport, hydraulic power transfer, fuel oil transport and machine coolant applications.

The modern-day three-screw pump design was invented in 1923 by Carl Montelius who, along with Swedish financier Bengt Ingestrom, founded Imo AB (today a part of CIRCOR). The pump oper-ates on the same principle of intermeshing screws as the two-screw pump, but the three-screw design uses a centrally located primary drive screw, or power rotor, which intermeshes with two secondary sealing screws, or idler rotors.

The intermeshing of the threads of these rotors, along with the close fit of the surrounding housing, creates a moving labyrinth seal, which captures the fluid and transports it axially. The enclosed area containing the fluid is referred to as a fluid closure (see Figure A). The pumping element does not pre-compress the fluid, but rather transports it from the suction side of the pump to the discharge port in a smooth, continuous manner. It is the fluid closure concept that provides the three-screw pump with its positive displacement capability.

Symmetrical pressure loading on the power rotor with such small forces eliminates the need for bearings to absorb radial forces. The idler rotors generate a hydrodynamic film providing radial support similar to journal bearings (See Figure B). Axial loads on the power rotor and idler rotors, created by differential pressure, balance them hydraulically with such small forces that they can be handled by a single ball bearing. This dramatically increases the life of the pump and simplifies the service.

Three-screw pumps come in many configurations and sizes, enabling them to serve as a replacement when other




*It is the fluid closure concept that provides the three-screw pump with its positive displacement capability.*

*The three-screw pump uses a centrally located primary drive screw, or power rotor.*

pumps are not performing. They can be easily retrofitted into existing systems.

## Three-screw pump design

Three screw pumps are ideal for clean, lubricating fluids. Fluid film thickness/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 that the viscosity is adequate and the fluid is clean enough to avoid disruptions to the internal fluid film.

The simple design of a three-screw pump: just three rotating parts and one shaft seal, offers advantages for a variety of industries and applications. Some of the primary advantages to three-screw pumps include:

- Pulse-free flow with extremely low vibration and noise levels. The pumping element geometry eliminates the requirement for pulsation dampeners often found in systems employing other pumping technologies. Pulsation-free flow allows output condition management that's critical to a variety of applications, such as precision hydraulic controls and fuel metering for gas turbine atomization.
- Low noise. The rotor profile in the screw pump provides a smooth and continuous output flow that greatly reduces pressure pulsations. The result is lowered airborne, fluid-borne and structure-borne noise, typically less than 75 db(A).
- Higher-pressure boost capabilities, even when handling low-viscosity fluids as low as one centistoke. This advantage is due to the smaller operating clearances than are found with two-screw designs.
- Highly energy efficient design. Tight internal clearances, coupled with a design that allows for minimal input power in relation to output power, results in high energy efficiency.
- Long service life due to non-contacting pumping elements by means of hydrostatic and hydrodynamic fluid films, axially balanced rotors, and top-notch metallurgy.
- Excellent suction lift compared to other pump designs with similar output flows. This is due to the small peripheral diameter of the rotors and low axial velocity of the fluid. The three-screw pump has an inherent advantage in negative suction pressure applications, allowing the pumping of higher viscosity fluids at much higher speeds than other pumping technologies.
- Low horsepower consumption while operating on high viscosity fluids. This is due to the small peripheral diameters of the rotors and low fluid axial velocities reducing fluid shearing within the pump.

*The simple design of the three screw pump (just three rotating parts and one shaft seal) offers advantages for a variety of industries and applications.*

## Maintenance Tips

Because wear is a natural occurrence with rotating equipment, to ensure maximum equipment life, plant personnel should attend to the following:

a. Filters and strainers: Periodically check for cleanliness and clean or replace as necessary to protect equipment from damage due to pressure drops across clogged or dirty elements.
b. Foundation and hold-down bolts: Check for tightness at least every six months.
c. Alignment of pump and driver: Check and correct, if necessary, every six months, or more often if your system experiences an unusual amount of vibration or large variations in operating temperatures.
d. Bearings: Lubricate as specified in instruction manual. Check often for noise and/or abnormal vibrations and rough operation; if noted, stop operation and replace bearings.
e. Packing: Repack when all packing gland travel is exhausted or damaged.
f. Shaft seals: Recognize that a small amount of seal leakage (about 10 drops per hour per seal) is normal and necessary, visually check equipment for signs of damage or leakage from shaft seals, gaskets and O-rings and be sure all connections are tight. If the 10 drops per hour per seal is exceeded, shut down equipment and repair or replace with a seal compatible to the pump's operating conditions, as shaft seals have a finite life.

*Example of a three screw pump, used by industry for pumping lubricating liquids that do not contain abrasive components such as heavy and diesel oil, circulation or lubricating and hydraulic oils.*

## Case study

The Three Gorges Dam is a hydroelectric river dam spanning the Yangtze River in Yichang, Hubei province, China. It is the largest hydroelectric power station in the world, with a total generating capacity of more than 22,400 MW. The project is comprised of 32 power generator units (14 on the left bank, 12 on the right bank, and six underground).

The pumps for the governing system at the hydropower plant operate continuously, requiring them to possess the utmost in quality and durability to withstand the enormous wear and tear they are subjected to, as well as to perform safely. The dam's unique circumstances, however, presented some additional challenges, especially variations in outlet pressure. While it is relatively simple to design components to operate under steady pressure, frequent pressure variations can damage the pump's housing as well as the rotating and bearing parts of the pump. The original pumps used for this application failed to meet these unique demands, and did break the housings. The China Three Gorges Project Corporation needed a better solution.

As the authorized CIRCOR distributor for the Three Gorges Dam project, Wuhan KLF Pump Co. recom-mended a retrofi t package of 78 Allweiler SN and SM three-screw pumps based on their proven safety, compliance with quality standards and available local tech-nical support from a full-service manufac-turing and service center in Wuxi. Three-screw pumps are a technology well suited to powering hydraulic machinery because they move liquid continuously, and virtually without pulsation, turbulence, crushing, or loss of lubrication.

Ordinarily, there are compatibility hurdles to be overcome in replacing pumps within an existing setup, but once having a firm grasp on the precise operating conditions presented, the team could determine the most reliable pump setup, including engineering a custom-designed baseplate. Designed in collaboration with the Changjiang Water Resources Commission, the malfunctioning pumps on the hydropower plant's left bank were replaced with 16 units of SM pumps.

Subsequently, another 47 units were installed in the new-build right bank portion of the plant. In addition to the governor pumps, low-pressure pumps were also installed for the lube oil system at the plant, a total of 14 units of SN pumps.

One of the unique applications at the dam is pumping hydraulic oil to open and close the heavy floodgates and regulate the water inlet. The SM governor pumps (lube oil feed/boost pump) were selected due to their heavy-duty design. They are used in the hydraulic system for opening and closing the water turbine's inlet blade. The SN lube oil circulation pump and the lube oil drain pump were configured to cool the water turbine bearing.

To this day, the Allweiler three-screw pumps continue their smooth operation. Wuhan KLF's service team has always offered support to address small issues as they arise.

## Conclusion

Three-screw pumps can optimize performance and efficiency in a broad spectrum of applications while delivering benefits across a very long lifecycle. With an inherent advantage in negative suction pressure applications, higher viscosity fluids can be pumped at much higher speeds than with other pumping technologies. The pumps' simple design provides significant maintenance advantages that further enhance their value in critical applications. ●

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