Explaining COR Pump Technology – Part 1

Pumps are generally divided into two categories: hydrostatic and hydrodynamic. Hydro dynamical pumps operate on a hydrodynamic physical process in which there are pressure and energy changes in the proportional square of the speed of the rotor. Hydrostatic pumps (commonly referred to as positive displacement pumps or PD pumps) increase and decrease volume of the pump chamber during operating cycle. In order to increase efficiency, some hydrostatic pumps have adopted COR Pump Technology.

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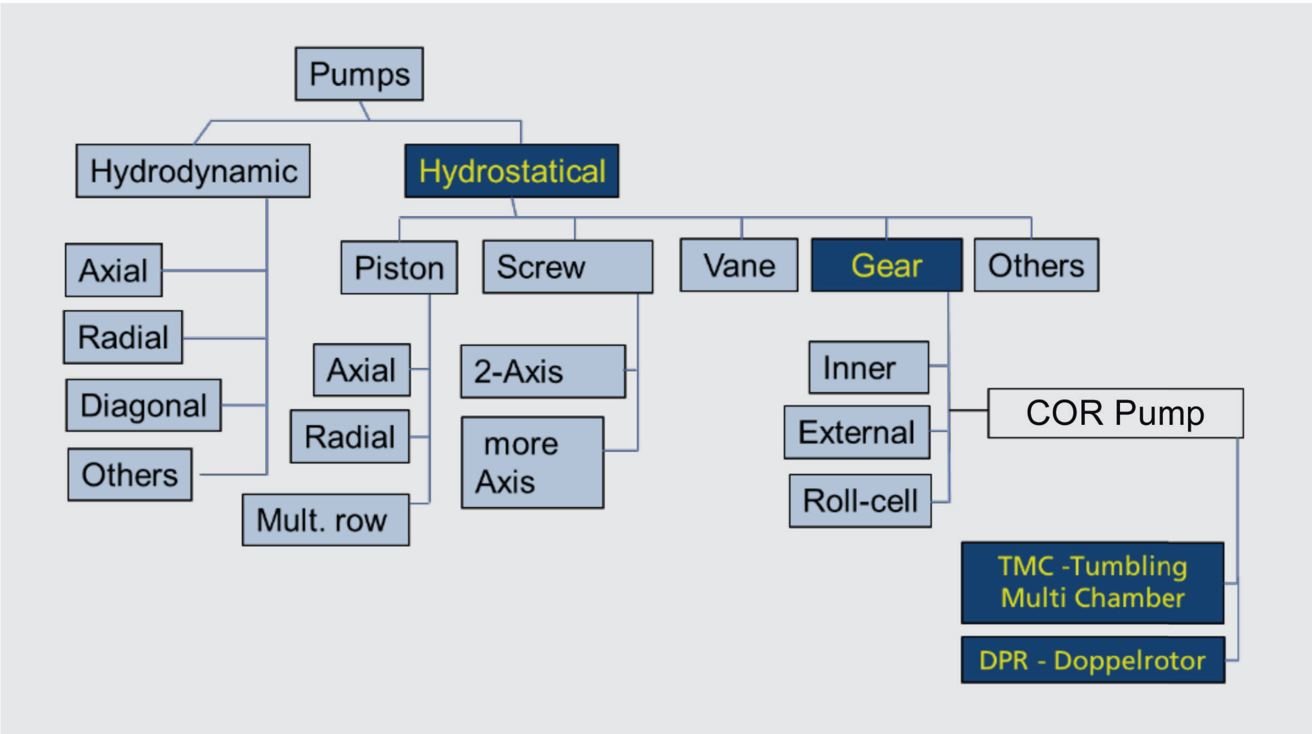

Figure 1: Pump Technology Classification.

Target properties of hydrostatic pumps are:

- Stable efficiency in wide working area (over different flow or pressure) with low noise emissions,
- high reliability at high mechanical and/or thermal loads,
- small size and weight, low price, easy assembly and servicing,
- possibility of integration with control devices (pressure, flow, temperature sensors),
- possibility of operating over wide viscosity range of liquids, and
- low pulsation of pressure and flow.

Hydrostatic pumps are classified into two groups: pumps with a translatory motion of displacement element, such as a piston, and pumps with a rotating element, or runner.

COR Pump Technology

New developments in high dimensionally and thermally stable polymer resins and molding tooling techniques have expanded the range of applications in which polymer materials may be used. One example of an automotive component now amenable to be made from high dimensionally and thermally stable polymer material is the COR pump technology. Such approach allows the most demanding components to be moulded with reasonable accuracy.

The COR technology consists of two pumping principles: DoppelRotor (COR-DRP) and Tumbling multi chamber (COR-TMC). The COR pump system consists of four pieces, two of which are rotating. It requires no valves and most of the torque is converted into useful work, as only one of the two rotating pieces is driven. The fluid is transferred through the center of the pump, with the help of moving cavities and centrifugal force, to the outlet on the periphery.

Figure 2: COR pump technology.

The operating principle of a COR pump is based on the formation of the separate chambers, enclosed by two toothed topographies. When rotated, the chambers open (grow) and close (shrink) simultaneously to control the fluid displacement precisely. Connection of the pulsating chambers with the suitable control openings, which operate as a valve plat, results in the displacement effect. The pump housing serves as a separating element between the pressure side and the suction side.

The COR technology is therefore derived from two pumping principles: DoppelRotor (COR-DRP) and Tumbling multi chamber (COR-TMC). COR-DRP is analogous to a gerotor pump (generated rotor), as the fluid between the teeth is displaced by two rotating parts with a different number of teeth. COR-TMC is analogous to an axial piston pump. The valve plate between the shaft and pump runner of TMC pump has similar functions as a swash and valve plates of the axial piston pump.

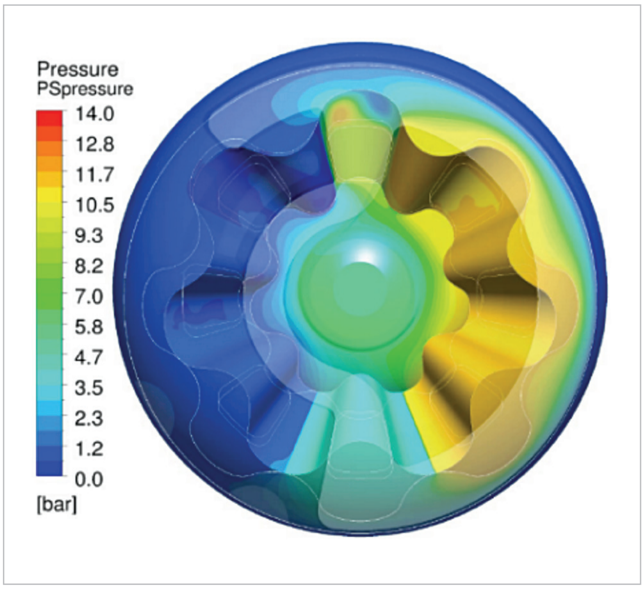

Figure 3: Pressure distribution (suction/pressure).

The COR pump consists of a pump stator with a 3D inner gear shape. It has n teeth and a pump rotor with n+1 teeth, which fits on the stator shape under a certain angle. The gear teeth are arranged axially and the shape of the teeth enables simultaneous engagement, which ensures sealing between individual gaps.

COR pump advantages over other types of pumps are:

- Economically interested production price (all pumping parts are produced with injection molding of dimensionally stable polymer material with high mechanical & thermal performance),
- robustness against particle contamination corrosion resistance,
- good hydraulic characteristics,
- small dimensions,
- high working pressure and
- bi-directional (backward) rotation.

The motion of the pump rotor is determined by the rotation of the e-motor rotor. Sliding movement occurs on inclined flat surfaces between the pump rotor and the shaft. The pump rotor rotates with 1/8 of the angular speed of the shaft and makes a change angle around the apparent point above the upper plane on the pump rotor. Composed motion causes the change of volume of the chamber between the stator's gear and the rotor gears. As a consequence, there is a vacuum (under pressure) on one side, and overpressure on the opposite side that causes suction and displacement of the medium.

Performance Parameters of COR Pump

The possible sources of performance loss in a COR pump are divided into two categories: mechanical-hydraulic and volumetric. Mechanical-hydraulic losses arise due to friction in the gaps, friction caused by turbulent liquid flows and friction from the difference in pressure in the system. Volumetric losses and compression losses arise due to internal leakage, and loss of compressibility of the pumping fluid.

The purpose of hydraulic pumps is to convert mechanical energy into hydraulic. Hydraulic power is defined as the product of pressure difference (output-input) and the flow of liquid. Overall efficiency is defined with the conversion of mechanical work into hydraulic power.

$$Pmeh(t) = M \ x \ \omega \ \mid \ P_{hidr} = \Delta p \ x \ Q \ \mid \ \eta_{m,h} = \frac{P_{hidraulical}}{P_{mechanical}}$$

In the assembly, when the electric motor is part of the pump, the total efficiency of the system is defined as the ratio between hydraulic power on input and electrical power given from the e-motor. Electric power is equal to the product of the DC current and the electrical voltage UDC. Total efficiency of the pump is given as a combination of electrical current and voltage, pressure difference and liquid flow. The total efficiency of the pump can also be defined as a product of volumetric efficiency, mechanical hydraulic efficiency and efficiency of the e-motor.

$$\eta_{pump} = \frac{P_{hidraulical}}{P_{electrical}} \quad \Big| \quad \eta_{pump} = \frac{\Delta p \ x \ Q}{I_{DC}} \ x \ U_{DC} \quad \Big| \quad \eta_{pump} = \eta_{vol} \ x \ \eta_{m,h} \ x \ \eta_{EM}$$

Leakages within the pump unit relate to the size of the gaps between pump elements, pressure difference (input vs. output), rotation speed, volumetric displacement and viscosity of the fluid. Volumetric efficiency is defined as the ratio between real output flow and theoretical volumetric flow, defined by pump ideal geometry. In positive displacement pumps, the flow of liquid is linearly correlated to rotation speed.

The internal leakage is one of the most significant of pump efficiency losses, through which the geometry is strongly influenced by the manufacturing process. It appears between the 3D shapes of pump parts and in the air gap in journal bearing of e-motor.

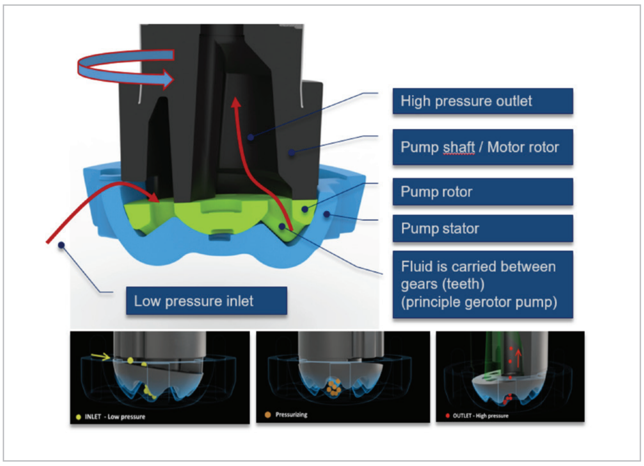

Figure 4: Basic components and engagement of fluid within COR pump.

Be sure to read Part 2 of this article in the August 2020 issue of Pump Engineer magazine.

About the Authors

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