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Last month's issue of *Run Times* discussed the Partial Emissions pump, a specialty centrifugal pump design for low flow – high head applications. This month, in the last of a four-part series on impeller designs, we will discuss two other low-flow high-head centrifugal pump designs; the Regenerative Turbine Pump and the Pitot Tube pump. Like the partial emission pump, these pumps demonstrate higher efficiencies than standard centrifugal pumps operating under similar conditions. However, the operating characteristics and trade-offs of these designs vary greatly, and making the right choice is critical for a successful installation.

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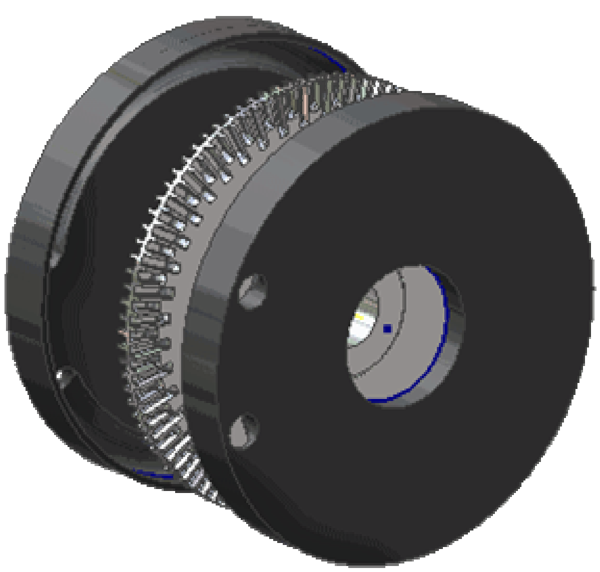
Regenerative Turbine Pumps.

The regenerative turbine pump is characterized by a unique impeller design. The impeller shroud has a large number of blades machined into its periphery. Generally, a blade row exists on each side of the shroud to minimize axial thrust. In a traditional centrifugal pump, fluid enters the impeller adjacent to the shaft centerline and then is accelerated outward, exiting the impeller at its outside diameter. A regenerative turbine pump differs in that the fluid enters near the impeller outside diameter, is accelerated through approximately 330 degrees of rotation and exits the pump discharge at, or near, the same radius as the inlet. A sector of about 30 degrees separates the inlet from the outlet. In this sector, the casing walls parallel to the impeller shroud are positioned in very close proximity to the rotating impeller to minimize leakage between the high pressure exit and the impeller inlet.



The regenerative turbine pump can achieve more head at a given impeller diameter and speed than any other centrifugal pump type. The pump design community still harbors much disagreement regarding a strict definition of the fluid mechanics involved. Most agree that the pump's head generation capability is related to the regenerative aspect of the pump whereby fluid entering an impeller blade is accelerated not only tangentially in the direction of rotation, but also radially outward into the casing channel by centrifugal force. As the fluid strikes the casing wall it is redirected back onto an adjacent blade where additional energy is imparted. This process repeats itself multiple times during a single rotation of the impeller.

Advantages and disadvantages of a regenerative turbine pump

- The primary advantage of a regenerative turbine pump is high head at a low flow in a small space. A 4 inch (10 cm) diameter impeller operating at 3500 rpm generates a shut-off head of about 500 ft (150M).

- Another advantage of the regenerative turbine pump is a very steeply rising head curve between minimum and maximum flow. This provides for very accurate flow control and very stable parallel operation.

- The most significant disadvantage of a regenerative turbine pump is its intolerance to solids in the flow stream. Blade wall thickness is often less than 0.06 in (1.5mm) and axial clearance is usually under 0.005 in. (0.13mm). Solids will quickly wear the thin walls and open the clearances. A very small increase in clearance will destroy the performance of the pump.

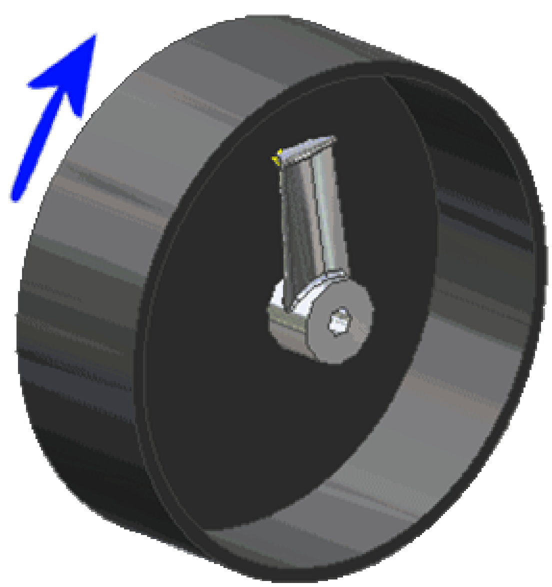
- Small clearances make the unit especially susceptible to damage from improper assembly or installation.

- NPSH characteristics of a regenerative turbine impeller are poor, with suction specific speeds often below 5000 (80 SI units).

- Regenerative turbine pumps have fixed diameter impellers with no practical provision for impeller trim. Unless there is a provision for variable speed operation, a change in performance requirements necessitates the replacement of major wet end components.

Pitot Tube Pumps

The pitot tube pump has no impeller. In a pitot tube pump, the casing rotates. This, in turn, causes the body of fluid within the casing to accelerate to almost the same speed. The tangential velocity of the fluid in the casing is proportional to its radius from the axis of rotation.



The pitot tube pump uses one or more stationary nozzles orientated tangentially with the rotating fluid at nearly the maximum radius of the casing to take advantage of the high fluid velocity. Fluid enters the pitot tube nozzle at near its maximum velocity. The pitot tube nozzle converts the velocity head of fluid[1] into pressure.

Advantages and disadvantages of a pitot tube pump

- A pitot tube pump has a very steep performance curve making it well suited for accurate flow control and stable parallel operation.

- A pitot tube pump generates no axial thrust, as the shaft is not exposed to fluid pressure and pressure is equal at all points within the casing. There are no radial hydraulic forces affecting bearings or seals, again because pressure at all points within the casing is equal. For the most part, this is a good thing. However, on units with larger diameter shafts, too light a thrust load can create a risk of bearing skids. A skid occurs when the bearing rolling element starts to slide instead of roll within the bearing race, resulting premature bearing failure.

- NPSH Available is not an issue. If fluid can get into the casing, the pump can pump it.

- From a hydraulic standpoint, the most significant drawback of a pitot tube pump is also an intolerance to solids. Because the pitot tube nozzle is stationary, a very high relative velocity exists between it and the rotating fluid, making it very prone to wear. In addition, solids with a higher density than the fluid will tend to centrifuge outward and accumulate on the walls of the rotating casing until the build-up interferes with pump operation.

- The mass associated with the rotating fluid filled casing necessitates a relatively heavy shaft and bearing arrangement. As bearings go up in size, heat generation in the bearings also increases, while conversely, bearing speed limits go down. Mechanical reliability can become an issue when operating at higher speeds.

- For safety reasons, a pitot tube pump requires a secondary stationary enclosure to house the rotating casing. This casing within a casing adds cost and size to the unit.

In Closing

Each of these pump styles offers a unique set of advantages and disadvantages that are largely dependent on the application requirements; a statement that could be used for any centrifugal pump. However, low flow high head pump designs, are especially unforgiving to misapplication. For applications that involving more than just ultra-clean liquids with plenty of NPSH available, making the proper choice from these very different designs can make a substantial difference in the total ownership cost over the product's life cycle.

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[1] Velcity head is the kinetic energy associated with the mass of fluid traveling at a given velocity. It is calculated as $V^2/2g$ where V is the fluid velocity and g is the acceleration due to gravity.