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White Paper

Two-screw pumps provide the right stuff for chemical processing needs

By Rob Jordan

Two-screw positive displacement pumps provide performance solutions for many chemical batch processing applications that cannot be achieved through the use of more common centrifugal pump technology. Frequently, two-screw pumps are a "last resort" because they can be a higher investment cost than centrifugal technology and are less known – but these factors should not be an engineer's only criteria for evaluation. Two-screw pumps should be considered in any application where the process may involve variations in flow, temperature, pressure, liquid characteristics or viscosity. Two-screw performance excels in chemical process and transfer applications that experience one or more of these variations, as well as an operating conditions that may be difficult or push the limits of other more common pump designs.

Two-screw designs in chemical processing applications are capable of flow rates up to 5,000 gallons per minute, differential pressures that exceed 1,000 psid, product temperatures up to 750° F and product viscosities in excess of 1,000,000 cP, making them a very robust piece of machinery. They are capable of handling a variety of process conditions that exist in the chemical manufacturing and processing industry.

In batch process applications, flexibility drives return on investment. When evaluating total cost of ownership during start-up, operation, maintenance and shut down, a two-screw pump may well prove to be the most economical solution.

Understanding the Benefits of Two-Screw Technology

Two-screw pumps are capable of handling multiple liquids or products over extended viscosity ranges during batch processing. They can also contend with a wide range of liquid characteristics -- such as lubricating, non-lubricating, corrosive, and abrasive liquids -- in addition to liquids containing entrained gases. It is important to note this capability. A centrifugal pump's impeller creates an area of low pressure at the impeller's eye. When pumping a fluid containing entrained gas, the gas will separate and collect at the eye. The phenomenon known as vapor locking happens when gases collect at the eye and restricts liquid flow through the impeller. The only way to correct vapor locking is to remove the gas. This involves stopping the pump, removing the air from the system and repriming the pump. Rotary displacement pumps, which includes one, two and three screw pumps, are volumetric machines and not limited in this aspect. Entrained gas entering the pumping cavity is displaced with the fluid discharged from the pump as the fluid is isolated from suction.

A second benefit offered by twin screw pumps is energy efficiency. Two-screw and other rotary positive displacement pump efficiency increases as the viscosity increases. This is due to the internal clearances becoming more effective in sealing the pumping cavity. Due to their design, centrifugal pumps will experience a loss of capacity and efficiency as viscosity increases. Internal losses in a centrifugal pump will increase as the viscosity increases, resulting in reduced capacity, head development and efficiency. Centrifugal pump capacity will also vary as the system pressure changes, resulting in the need for additional controls such as control valves and variable speed drives or larger pump sizes and drivers.

Two-screw pumps offer an extremely low net positive suction head (NPSH) requirement. This allows for pumping under a wide range of difficult suction conditions, liquids and operating scenarios. A two-screw pump offers users low NPSHR because the suction design has low resistance to flow of the liquid entering the pumping chambers; with higher resistance to flow you generate a larger pressures loss and increase the likelihood of cavitation. Specific design features of a two screw pump that reduce a liquids resistance to flow are: 1) divided flow paths that split the incoming fluid to opposing ends of the case; 2) large cross sectional area of the suction passageway;

3) lower axial speeds within the pumping chamber which are a function of the pump rotational speed and selected screw pitches.

A typical batch process may involve a change in the characteristics of the product and components of the pumped material as the batch process progresses. Each type of product requires a unique range of pressures and temperatures during batch processing to initiate the appropriate chemical reactions. The reactions typically require a pump that can circulate the product from the reactor vessel through a heat exchanger, and then back to the vessel. As such, the pump must be able to handle the full range of product viscosities as it changes from the reactant's characteristics to the final product and be capable of emptying the reactor after each batch.

Low NPSHR and run-dry capabilities become important at this stage because any product left in the reactor is not available for further use. Pumping out the reactor with a very low liquid level and emptying it with gas slugs, plus the ability for the pump to run dry can increase plant profitability. A two-screw pump's properly-designed mechanical seal support and internal clearances maintained by rigid timing gears allow it to handle this process requirement. This makes the two-screw pump capable of pumping the low viscosity fluids involved in solvent or caustic cleaning cycles in addition to the higher viscosity final products created in the reactor, making it a unique piece of pumping machinery.

Additional Design Considerations

Two-screw pump designs offer optional jacketing for the pump body and stuffing box housings adding additional operational flexibility during start up, shut down, cleaning cycles and upset conditions. Screw profiles and pitches design options deliver application specific energy efficiency operating requirements, delivering application-specific efficiency not attainable in other pumping technologies. Stuffing boxes are offered that meet industry standards, providing the design engineer with multiple options. Many models include a rotor design that offers a back pull-out feature to aid inspection and maintenance. This eliminates the need to disturb piping or the driver.

Special hard coatings such as ceramic, chrome, nickel and cobalt based materials can also be used to add wear resistance to critical pumping surfaces such as the body bore and screws. The pump's casing can be manufactured from any machinable alloy, depending on the application's need for corrosion protection. Pumps have been manufactured using materials including cast iron, ductile iron, white iron, Ni-resist, steel, low-temp steel, stainless steel, duplex stainless steel and Hastelloy®.

Robust Capability

Understanding the requirements of each application is the key in sizing and designing these heavy duty robust pumps. The design concept must include conditions experienced during start-up, operation, maintenance and shut down. System designers should work together with the pump manufacturer to fully understand the process so that maximum benefits are achieved. Each application is unique, which may alter the design of the two-screw pump to allow for such options as special clearances, special coatings, flange ratings, mechanical seal arrangements, suction and discharge nozzle locations, instrumentation and other components that may be necessary to a production facility and proprietary process.

Because two-screw pumps can be manufactured in high temperature, corrosion resistant and abrasion resistant designs, these pumps should be a "first choice" in batch processing applications. Specific chemical processing applications that can benefit from the use of two-screw pumps include the manufacture of polymer adhesives, polymer sealing solutions, polymer cements, structural foams and pelletized polymers that are used to create products such as carpet threads, carpet backing, pen grips, knobs, packaging, personal care products, interior and exterior automotive components and thousands of other commercial and industrial products.

These are not "off the shelf" solutions – but then, how many "off the shelf" chemical batch processing applications are there?

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