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Why Rotary Positive Displacement Screw Pumps Are an Efficient Pumping Solution Over Time

By Mike Moore

Transporting crude oil has always presented unique fluid-handling challenges. For example, pipelines often traverse remote territory in harsh environments, which is why they require pumping solutions capable of performing reliably over many years with minimal maintenance. Variations in temperature and crude oil grades, as well as contaminants such as sand or water, can increase the range of viscosities a pipeline must be able to accommodate. Additionally, the demand for increased energy efficiency and greater environmental responsibility affects all industries, particularly oil & gas.

For years, rotary pumps have been the standard in delivering high-efficiency, low-maintenance fluid handling solutions for critical applications. However, there's often been a perception that screw pumps are expensive, which prevents many crude oil transport companies from taking full advantage of the built-in benefits for energy savings and reduced environmental impact they offer.

The fact is positive displacement screw pumps deliver tremendous cost advantages. Consider the example of a typical 250,000-barrel-per-day crude oil pumping station in Canada using three rotary positive displacement screw pumps operating in parallel with one standby pump. Next, compare its cost performance to the traditional centrifugal pump solution of two pumps operating in parallel with one standby pump.

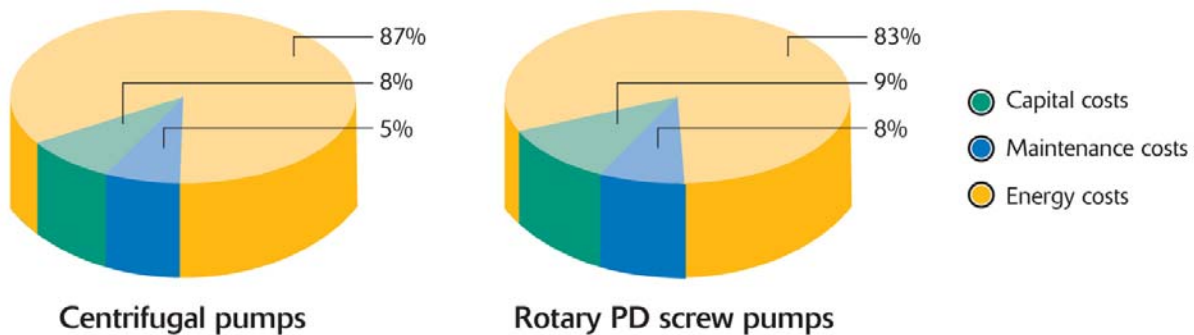
Over a five-year period of using the positive displacement alternative, combined capital and maintenance costs account for less than 17 percent of the total cost of ownership, and efficiency is 27 percent higher than the centrifugal solution. Also, the positive displacement alternative reduced energy costs by 29 percent.

Centrifugal and Rotary Positive Displacement Screw Pump Costs Over 5 Years

	Centrifugal Pumps	Rotary Positive Displacement Screw Pumps
Capital costs	\$2,263,313	\$1,917,764
Maintenance costs	\$1,439,200	\$1,738,745
Energy costs	\$24,854,086	\$17,585,577
TOTAL COST OF OWNING AND OPERATING	\$28,556,599	\$21,242,086

Based on a 250,000-barrel-per-day crude oil pumping station in Canada handling a product viscosity of 350 cSt.

Capital, Maintenance and Energy Costs for Centrifugal and Rotary Positive Displacement Screw Pumps



Based on a 250,000-barrel-per-day crude oil pumping station over five years in Canada.

Despite the clear-cut cost advantages, rotary positive displacement screw pumps are still often misunderstood. Whereas they may come in a variety of designs and operating ranges, they all work on the same basic principle: a rotating cavity or chamber within a close fitting housing is filled with process fluid, the cavity or chamber closes due to the rotary action of the pump shaft(s), the fluid is transported to the discharge and displaced, this action being accomplished without the need for inlet or outlet check valves. In addition, the delivered capacity is nearly constant throughout the discharge pressure range due to the close internal pump clearances. This stable hydraulic performance characteristic allows for a high degree of system control if the shape of the system head curve should increase or decrease. By contrast, a centrifugal pump is a fluid-handling machine that is at the mercy of the system head curve unless its duty point is externally manipulated.

The hydraulic principle behind screw pump operation delivers both high volumetric and high overall operating efficiencies in addition to offering long mean time between repairs and ease-of-

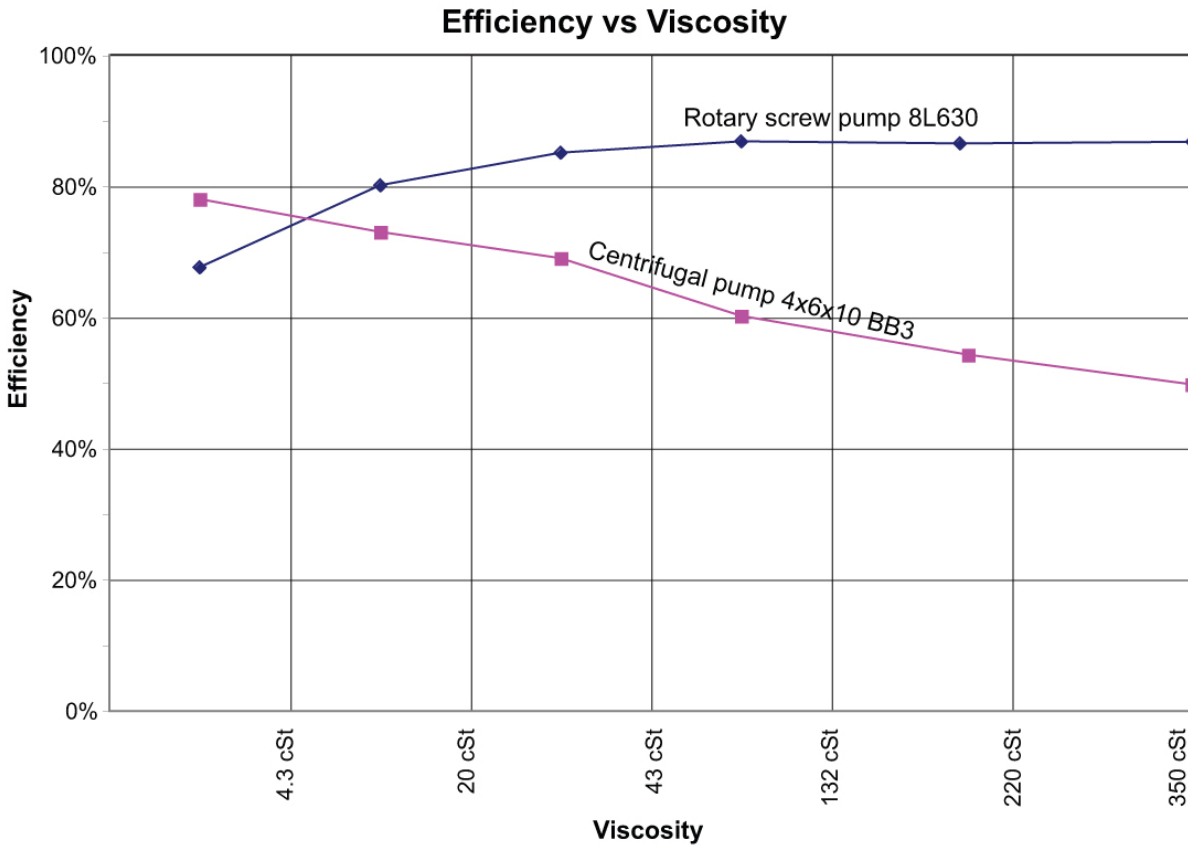
maintenance features for field servicing, which combine to maximize operational uptime. Other value-added advantages of these pumps include:

- Constant flow, even in the presence of varying system back pressures due to changes in viscosity.
- Non-pulsating flow, without the need for pulsation dampeners, which eliminate stresses imposed on the pipeline system reducing the risk of pipeline failures.
- Low noise and vibration levels, minimizing foundation requirements.

How else do rotary positive displacement screw pumps compare to centrifugal units? Positive displacement pumps create flow, whereas centrifugal pumps create pressure. Oil pipelines normally require a constant flow at various pressures, and the required boost pressure will vary with changes in viscosity. In the event of an unplanned shutdown the product within the pipeline has the potential to cool, thereby allowing the crude viscosity to increase to a point where a centrifugal pump might not be able to produce sufficient discharge pressure to initiate, and ultimately clear, the pipeline.

So, when should you use a rotary positive displacement screw pump instead of a centrifugal? The choice isn't always obvious, and you should start with an examination of your needs and the differences between the two technologies. When it comes to flow rate versus pressure, the centrifugal pump often has varying flow; the positive displacement pump, on the other hand, usually delivers a constant flow in spite of the pressure. Then take a look at the difference viscosity has on pumping capacity. The flow of a centrifugal pump is reduced as viscosity increases, while the positive displacement pump's flow increases.

Efficiency of Rotary Positive Displacement Screw Pumps Used for High-Viscosity Crude Oil



Centrifugal and rotary positive displacement screw pumps are both options for transporting crude oil. However, a rotary screw pump handles high-viscosity crude oil more efficiently, which reduces energy costs.

Then there are the questions of mechanical efficiency. Each type of pump performs dramatically differently when measuring efficiency versus pressure. Pressure changes have little effect on a rotary positive displacement screw pump's performance, but a significant one when a centrifugal pump is used.

When mechanical efficiency is applied to viscosity, the results are equally clear. Due to the de-rating affect on the capacity, total developed head and efficiency, the overall efficiency of a

centrifugal pump declines as viscosity goes up. By comparison, the overall efficiency of a rotary positive displacement screw pump typically improves when handling more viscous fluids due to the increased volumetric efficiency, a key variable when calculating the mechanical efficiency of a piece of rotating equipment.

Looking at one more point of comparison, centrifugal pumps are designed to operate at their Best Efficiency Point (BEP). If you move too far from this fundamental design point, you run the risk of reducing pump life. But positive displacement pumps are volumetric machines whose performance is not governed by the BEP requirement of kinetic pumps.

Some organizations around the world are already reaping the rewards of their move to rotary positive displacement screw pumps for transporting crude oil. A French oil company building a pipeline in Africa to transport viscous crude oil 90 miles from the production field to a refinery had originally considered installing piston pumps. After estimating the total cost of equipment purchase, maintenance and energy use over time, the company determined it would be 50 percent less expensive to buy six rotary positive displacement screw pumps.

Another company, which is retrofitting an existing 375-mile pipeline to transport 60,000 barrels per day of viscous crude oil in the Western United States, came to a similar conclusion. It bought 20 three-screw rotary positive displacement pumps and projects saving up to \$17.3 million in operating costs over five years compared to other pumping options.

In conclusion, displacement screw pumps are an important option for transporting a wide range of fluids, including high-viscosity crude oil. They deliver reliability and performance, meaning companies can count on longer periods between repairs. When they do need service, the pumps' straightforward design keeps down time minimal.

Perhaps the most important point for positive displacement pumps in today's global economic climate is their cost-saving advantages. They simply outperform centrifugal pumps when it comes to total cost of ownership, and that added success rate lets crude oil transport organizations combat the industry's ever higher energy costs.