Rotary Pumps on Pipeline Services

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Make CIRCOR Your Pipeline Partner

Pipelines are used to transport a broad range of liquids, including crude oils, fuel oils and refined products such as gasoline, as well as water and specialty chemicals. Lines range from as short as several dozen feet to hundreds or even thousands of miles long. They can cross state or country boundaries. But wherever they are located, pipelines present some of the toughest transport challenges found anywhere. That's why CIRCOR can be your ideal pipeline partner. We understand the demands of moving oils from the field to the refinery. And we stand ready with a portfolio of proven pumping technologies, including rotary pumps, which best meet some of the unique requirements of pipeline applications for moving liquids with heavier viscosity.

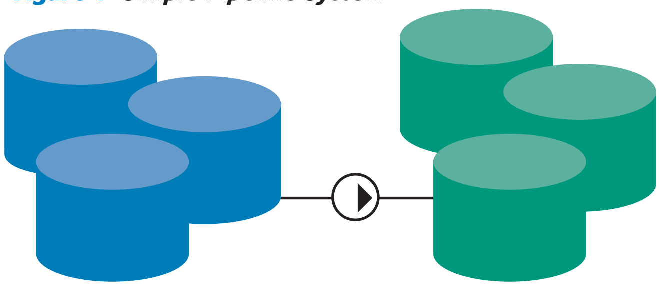
This article provides some insight into how rotary pumps can be applied to these applications. It looks at pumping system designs, flow control on variable-flow systems and serial pump operation on multistation pipelines – all key components in assuring reliable pump operation.

Types of Pipeline Services

Pipeline services include loading/unloading, local transport and long-distance transport. Examples of load/unload include pumping a relatively short distance from or to rail cars, tank trucks, barges or tanker ships. These services are typically intermittent. Differential pump pressures are usually low, less than 125 pounds per square inch differential (psid). The combination of low power and intermittent use makes pump operating efficiencies less important than in other services.

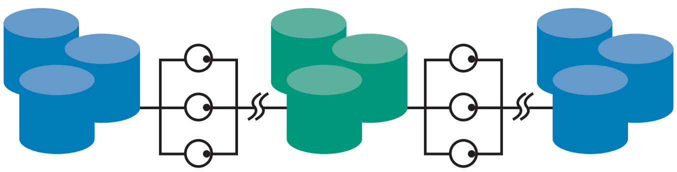
Local transport is defined as a single pumping station installation with line lengths less than 50 miles. Design operating pressures can reach 1,450 pounds per square inch gauge (psig) or more. These pipelines can be intermittent- or continuous-duty services and can range from modest power levels to hundreds of horsepower.

Figure 1 ***Simple Pipeline System***



Long-distance transport is usually more than 50 miles and includes multiple pumping stations along the length of the pipeline. These pipelines normally operate around the clock, at partial or full capacity. Controls and instrumentation tend to be more sophisticated and automated. Long-distance pipelines frequently operate at variable station flow rates, depending on product demand at the end terminal. Pumping stations normally have three or more pumps, with one in standby mode (three half-capacity pumps). If pipeline capacity is to be increased over time, more pumps may be added to each station.

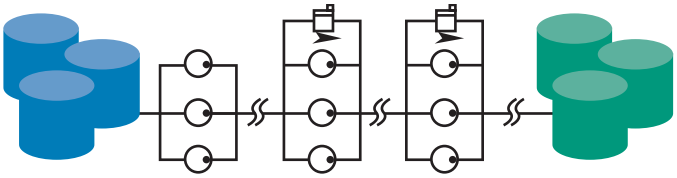
Figure 2 ***Multistation Tank System***



Pumping Stations

Pumping stations for liquid pipelines can be as simple as a single pump located adjacent to a supply tank, pumping liquid down the pipeline to a receiving tank (Figure 1). The supply and receiving tank-level switches can control the pumping cycle by starting or stopping the pump at appropriate minimum and maximum tank-liquid levels. Longer pipelines needing intermediate pumping stations can be handled in one of two basic arrangements. The first is to use storage tanks at each station (Figure 2). The upstream station pumps to the downstream station's tanks. The downstream station's pumps take suction from these tanks and send the liquid further downstream. The alternate arrangement is a "tight" system, leaving the pumping stations in series, with each station's pumps taking suction from the pipeline (Figure 3). This has the advantage of eliminating the need for storage tanks, but requires control over each pumping station, so that exactly the same flow rate moves through each station.

Figure 3 ***Multistation Tight System***



Why Apply Rotary Pumps?

Most pipeline pumps are centrifugal units. When the product being transported is a low-viscosity liquid, centrifugal pumps are cost-effective, reliable and efficient; however, as liquid viscosity increases, the frictional losses within a centrifugal pump quickly reduce pumping efficiency dramatically. For this reason rotary positive displacement pumps are often used, when products such as heavy crude oil, bunker fuels (No. 6 fuel oil), low-sulfur fuels, asphalt or Orimulsion® manufactured boiler-fuel emulsion (30 percent water and 70 percent bitumen) need to be transported.

Rotary positive displacement (PD) pumps can offer tremendous cost savings, when compared to traditional centrifugal pumps. In the example below, a typical 250,000 barrels per day (BPD) crude oil pumping station in western Canada that uses three rotary PD screw pumps operating in parallel with one standby pump can actually reduce energy costs by 29 percent over a five-year period, versus the traditional approach of two centrifugal pumps with a standby pump (Table 1).

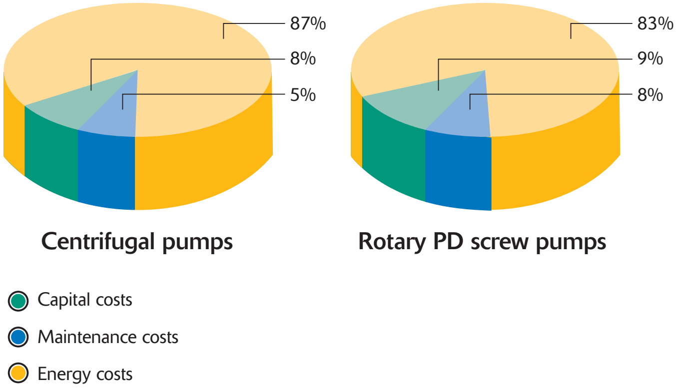
	Traditional Centrifugal Pumps Brand X *10 x 12 x 17 BB3, four stage*	Rotary PD Screw Pumps CIRCOR *8L-912Y*
Capital costs	$ 2,263,313	$ 1,917,764
Maintenance costs	1,439,200	1,738,745
Energy costs	24,854,086	17,585,577
Total cost of ownership	**$28,556,599**	**$21,242,086**

Table 1 – Cost of Ownership Comparison

Observations

- Over a five-year period, the combined capital and maintenance costs of rotary PD pumps account for less than 17% of the total cost of ownership (Figure 4).
- When comparing the two pumping solutions, the combined capital and maintenance costs differ by less than 1.5%.
- The overall efficiency of the CIRCOR solution is 27% higher than the traditional centrifugal technology.
- A 29% reduction in energy costs can be achieved by utilizing the CIRCOR solution.

Figure 4 ***Contribution to Total Cost of Ownership***



While there are many types of rotary pumps, the most common for pipeline services are two- and three-screw pumps, gear pumps (internal and external) and vane pumps for low-pressure services. Two- and three-screw pumps are used for higher-pressure services, especially at medium to high flow rates. Table 2 shows the approximate maximum flow and pressure capability for each type, not necessarily achievable concurrently.

Type	Maximum gpm	Maximum psid
Gear	1,500	250
Vane	1,000	250
2-screw	5,500	1,500
3-screw	3,400	2,000

Table 2 – Rotary Pump Flow and Pressure Ranges

Specified Operating Requirements

Obviously pump and driver specifications will be needed, to acquire equipment that will perform to your specific requirements. When it comes to rotary pumps, the following must be defined:

1. Number of pumping stations
2. Number of pumps per station
3. Possible range of:
   – Pump inlet pressures
   – Pump discharge pressures
   – Liquid temperature
   – Liquid viscosity
   – Per-pump flow rate
   – Particulate content
   – Upset conditions
   – Static conditions
4. Driver requirements
5. Pump instrumentation
6. Pump leak detection

Particulate Content

Particulate content can range from unknown to specific weight percentages of sediment, sand, etc. For liquids containing abrasives, pump life is inversely proportional to somewhere between the square and cube of pump speed. Operating larger pumps at lower speeds will increase initial cost, but can save on maintenance costs over many years. Another proven technique to extend pump life in abrasive environments is to select pumps with effectively more stages than needed for pressure capability. For example, every wrap in a screw pump acts as a pressure stage, similar to a multistage centrifugal pump. More stages reduce both the pressure rise per stage and the slip flow (volumetric inefficiency), spreading out the wear. The result is extended pump service life and, frequently, higher average efficiency over time.

Leak Detection

Product leak detection could be a critical element in both pumping station safety and environmental contamination. Unless there are attendants on-site at all times, to monitor possible product leakage from any source, automatic alarm or shutdown should be considered. Rotary pumps commonly use mechanical seals, to contain product within the pump casing. A mechanical seal will wear and can fail catastrophically. And product under pressure can leak large volumes in short time periods. Many pumps used for pipeline services can be equipped with various seal leak-detection schemes, to alert/alarm or shut down in the event of excessive seal leakage.

Driver Selection

Driver selection depends on available power sources. In remote areas, diesel engines are usually chosen. They provide some range of speed and, therefore, flow control of the pumps. The most common drives are fixed-speed electric motors. They can improve station efficiency, by avoiding the necessity of drawing power to pump flow to be bypassed around the station (wasted energy). Spacer couplings are highly recommended between the pump and its drive. They allow access to pump shaft-end seal and bearing, as well as motor shaft-end bearing.

Assessing Conditions

Upset and static conditions need to be assessed during pipeline design. Most rotary high-pressure pumps cannot tolerate anything close to discharge pressure at their inlet (suction) port. If an upstream pumping station in a tight system is started and the downstream station is not started in close synchronization, the downstream station may see excessive pressure on its inlet side. A low-pressure set inlet-side relief valve may be necessary, together with an overspill tank and appropriate instrumentation.

Pump Heating and/or Cooling

If the product is so viscous that heating it before pumping is necessary, then it is prudent (and sometimes essential) to provide a means of preheating the pumps, so that they are not faced with sudden introduction of hot liquids. Depending on available utilities, pumps can be jacketed for use of heating media, such as steam or hot oil. Heat-tracing with electric thermal wire is another option. The outside of the pump needs to be insulated, to contain the heat. Heating and insulation systems must take into account pump maintainability, if the heating or insulating system must first be removed to service the pump. Be sure to avoid applying heat to timing-gear cases or pump bearings. In some instances these pump components may actually need cooling, to operate for extended periods.

Pump Protection

Like most pumps, rotary pumps are vulnerable to premature wear or failure from too little or too much inlet pressure, too high a discharge pressure, excessive inlet temperature, dry-running and ingestion of foreign material (weld rod, wire pieces from cleaning brushes, etc.).

In addition, if the liquid is inherently "dirty," like many crude oils and bunker fuels, then pump wear will be a normal part of operating pipeline pumps. Systems need to be instrumented to at least alarm, if any of these parameters approach a limiting value. If pumps are unattended most of the time, then automatic shutdown is the only protection from catastrophic pump failure. Use of inlet strainers is highly desirable, provided that they are instrumented to detect excessive pressure drop and cleaned when needed.

As with any positive displacement pump, a pressure-relief device is essential to safe operation. The "shutoff head" of a positive displacement pump can be enormous – far above the pressure rating of any system component. A relief valve is normally installed at each pump discharge, with the valve outlet connected back to the supply tank or the pump inlet piping, as far from the pump as practical.

System Considerations

When starting a rotary pipeline pump with the pipeline already full, the system must provide for the time required to accelerate the liquid from zero velocity to final velocity. There may be 50 miles of product that need to get to 10 feet per second (ft/sec). This is normally accomplished with an electrically operated valve around each pump that bypasses discharge flow either back to the supply tank or back to pump suction. The valve is open on pump startup and closes gradually, as the flow velocity in the pipeline builds.

If bypassing back to the pump inlet piping, move as far away from the pumps as practical. This will maximize the mass of liquid available to absorb the driver power draw not yet going down the pipeline, while the bypass is not fully closed.

Maintenance

Maintenance for rotary pumps is not much different from any other pump. Ideally the installation has provided both space to access the pump for service and some shelter from the elements. Since rotary pumps have relatively close internal running clearances, be especially careful to achieve and maintain good pump-to-motor-shaft alignment. Avoid pipe strain at all costs, for the same reason. If pumping station downtime is a serious matter, then have an installed standby pump ready to take over, as well as critical spare parts. If a pump "goes down," identify the cause before starting another one.

Many pipeline pumps have service parts that need to be removed from both ends of the pump. Spacer couplings go a long way in easing the drive-end service. Avoidance of walls or objects close to the pump end opposite the driver is usually necessary, to avoid the need to disconnect piping and remove pumps to a bench area.

Some pumps are better maintained on a bench in a maintenance area in which there is adequate space to perform the work, where components can be easily assessed for their condition and new parts can be installed correctly.

Another CIRCOR Advantage

Rotary positive displacement pumps can play key roles in reliable, efficient and effective transport of liquids over short or very long distances. They are an optimum choice for applications in which efficiency is a strong driver of pump selection and operation.

In fact, rotary pumps have an extensive history of successful applications to pipeline transport. And CIRCOR matches that tradition, with an array of time-tested rotary products. Plus, we use our deep pipeline application experience and expertise to develop and deliver reliable pumping solutions that optimize uptime and efficiency – and provide pipeline operators with unmatched peace of mind.

About CIRCOR Corporation

CIRCOR is a global leader in critical fluid-handling solutions, including the manufacture of positive displacement industrial pumps and valves used in global oil & gas, power generation, marine, Naval and a variety of other industrial applications. Key product brands include Allweiler, Fairmount Automation, Houttuin, Imo, LSC, Portland Valve, Tushaco, Warren and Zenith. Additional information about CIRCOR's products, businesses and practices is available at www.circorpt.com.

About CIRCOR Oil & Gas Solutions

CIRCOR has served virtually every oil company throughout the world over the past 90 years, bringing particular critical expertise to crude oil transport in production facility, pipeline, tank farm and refinery applications and surrounding customers with design, engineering, manufacture, installation, testing and technical support services. The CIRCOR portfolio of pumping technologies delivers not only unsurpassed reliability, but operational and energy efficiencies, environmental responsibility and cost savings over the life cycle of the pump.

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