

The Magazine For Pump Users Worldwide

April 2006

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Turn of the Screw

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A non-timed twin screw pump for railcar unloading service at an asphalt terminal.

Three screw pumps and non-timed twin screw pumps have replaced traditional centrifugal and timed twin screw pumps in refinery asphalt services. Here's why.

Pumping asphalt from its origin at the refinery to a terminal has been attempted by several different technologies over the years. Throughout its transition from refinery to terminal, asphalt experiences several temperature changes that present an insurmountable challenge for most pumping technologies.

Beginning at the refinery, asphalt is typically hot (above 350-deg F) and pumped with centrifugal pumps or timed twin screw pumps. The asphalt is then stored in heated tanks until it is loaded into railcars, barges or trucks.

Once the asphalt is allowed to cool slightly, centrifugal pumps become very inefficient and unreliable due to the increased viscosity. Many of the timed twin screw pumps utilized were first installed 25+ years ago. They have prod-

uct-lubricated timing gears and bearings and up to four mechanical seals. Since the gears and bearings are lubricated by asphalt, these components tend to wear relatively quickly and lead to other more expensive repairs, such as new mechanical seals and rotor sets.

The evolution of three screw pumps over the last 20 years has enabled them to replace traditional centrifugal and timed twin screw pumps in refinery asphalt services.

Three screw pumps have one power rotor and two driven rotors. The rotors are gas nitrided (hardened to approximately 62-Rc) and torque is transmitted from the power rotor to the driven rotors via a rolling contact. The pumped product creates a liquid film that prevents metal-to-metal contact of the rotors.



This three screw asphalt transfer/loading pump replaced a timed screw pump at a refinery.

The rotors run in a liner that acts as a journal bearing that provides support for the rotors throughout the entire length of the pumping chamber. During operation, a liquid film supports the rotors and prevents contact between the rotors and the liner.

Three screw pumps do not require product-lubricated timing gears, as torque transmission is achieved through rolling contact of the rotors. This simplified torque transmission system eliminates a significant maintenance item on timed twin screw pumps with product lubricated timing gears.

Hydraulically-balanced three screw pumps do not require thrust bearings or thrust plates, meaning only one bearing is required for positioning of the rotor set. Bearings are typically re-greasable and should never rely on the pumped product for lubrication.

Since three screw pumps have only one shaft penetration, they require only one mechanical seal. The mechanical seal is normally a bellows type with a steam quench to prevent the faces from cementing together during down periods.

By design, three screw pumps are relatively simple machines with only a few rotating elements: rotor set, bearing and mechanical seal. This proven technology – when compared to a timed twin screw pump (product lubricated) that has a rotor set, multiple bearings and seals and timing gears – offers a significantly lower installed cost, as well as a lower overall cost of ownership.

Three screw pumps are positive displacement machines (conforming to API 676) that are not

affected by viscosity swings. These same viscosity swings normally force centrifugal pumps to operate at some point on the curve other than their best efficiency point, thus lowering the overall reliability of centrifugal pumps in asphalt service.

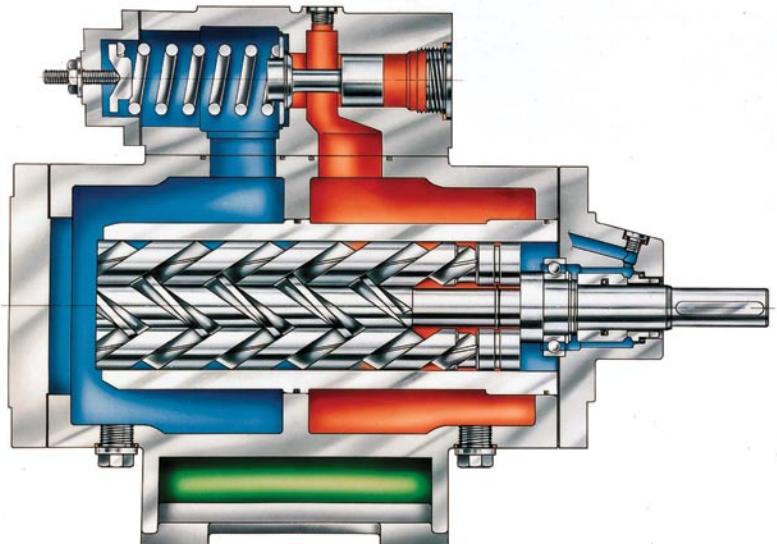
Since all of the rotating elements of a three screw pump are normally contained in a cartridge, the casings are normally fabricated of welded steel, which can accommodate a built-in heating jacket. The flexibility of fabricating the casings allows operators to replace misapplied asphalt pumps with a drop-in replacement that does not require any pipe or baseplate modifications.

At the asphalt receiving end, terminals have traditionally used gear pumps to unload, transfer and load asphalt. The relatively inexpensive upfront cost and years of experience repairing gear pumps allowed terminal operators to overlook their potential problems.

Since asphalt is routinely delivered at temperatures well below 270-deg F, terminals had to first heat railcars or barges before pumping with a gear pump. That is because the NPSHa is too low for a gear pump to actually pump the highly viscous product without cavitating. As with any positive displacement pump, lowering the speed improves the NPSHr. However, gear pumps already operate at low speeds via a gear box and typically the speed cannot be lowered enough to compensate for the low NPSHa.

Another potential operational problem encountered with gear pumps occurs when asphalt solidifies in the discharge pipe. Standard practice dictates heating the discharge pipe until the slug is liquefied. If the slug is not liquefied and the gear pump is turned on, there is a great possibility the gear teeth will break or the shaft will machine out the non-drive end of the pump through the wear plate.

Since gear pumps are unbalanced machines, they require a thrust or wear plate and the seals are typically subjected to discharge pressure, which leads to premature wear of the pack



A cross-sectional drawing of a three screw pump.



Thriving Under Harsh Conditions

ing. These maintenance costs are in addition to the amount of extra time, energy and money required to heat the asphalt above 270-deg F.

Alternatively, terminal operators have begun utilizing non-timed twin screw pumps over the last ten years. These pumps have one power rotor and one driven rotor. Torque is transmitted from the power to the driven rotor via a rolling contact (the same principle as the three screw pump). The rotors are supported on each end by product-lubricated bushings, and hydraulic balancing of the rotors is maintained by the flow of product



A cutaway model of a non-timed twin screw pump.

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through the bushing/rotor annulus.

Since screw pumps can operate at synchronous motor speeds, they can also be driven with a VFD. This enables the pump to operate at lower speeds and lower NPSHa. This means non-timed twin screw pumps can typically begin pumping asphalt at 220-deg F, thus saving tremendous amounts of time and money.

Screw pumps with built-in integral relief valves and hand wheels are a great tool for pushing solidified asphalt out of a discharge pipe. In this scenario, the hand-wheel is turned to open the relief valve allowing asphalt to internally by-pass some of the liquid while the pump discharge fluid pushes the slug out of the pipe. This method of removing solid asphalt slugs is much safer and efficient than torching the discharge pipe.

Non-timed twin screw pumps are also very simple machines, with only a few rotating elements: rotor set and bearing. The seal (typically packing) is only subjected to suction pressure and the casings can be supplied with built in heating jackets and relief valves.

Asphalt is only one of many viscous products well-suited for screw pumps. In refineries and terminals, screw pumps are a great selection for vacuum tower bottoms, heavy oils, residuals, flare knock-out, pitch, tar, emulsions, hot oils and olefin applications.

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