



SCREW PUMP

(FM Project Report)

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INTRODUCTION:

As complexity grows in processes and the transfer of fluids in pipelines and plants, screw pump technology has attracted increased interest from engineers and operators in the industry. The emphasis to increase energy efficiency while improving flexibility and driving down operating costs is leading the way. Increasing demands for high-performance screw pumps in oil and gas as well as other applications require a deep understanding of the fluid flow field inside the machine. Important effects on the performance such as dynamic losses, the influence of the leakage gaps, and the presence and extent of cavitation are difficult to observe by experiments. However, it is possible to study such effects using well-validated computational fluid dynamics models.

Screw Pump:

A screw pump is a positive displacement machine and is one of the technologies considered by oil and gas operators to be used for multiphase applications. In turbomachines, the transfer of energy between the rotor and the fluid does not – in theory – result in lateral forces on the rotor. In positive displacement machines, on the other hand, the transfer of energy between the moving and stationary components usually results in unbalanced pressure fields and forces. As a positive displacement pump, a twin-screw pump enjoys many advantages, including a stable transmission medium, low-pressure pulsation, low noise, long life, and reliable operation ^[1]. They can be used on the surface or the seabed in multiphase pipelines to central processing plants.

From a vibration and dynamics point of view, screw pumps fall into a unique category. On the one hand, unlike piston pumps (a typical positive displacement pump), the prime mover is a rotor, not a crankshaft. On the other hand, unlike centrifugal pumps (a typical roto-dynamic pump), the transfer of energy between the rotor and the fluid is not achieved by imparting kinetic energy on the fluid from the rotor, it is achieved by trapping a volume of fluid and pushing it against the back pressure ^[2].

Screw pumps are split into two parts: Single rotor and multiple rotor types. The single-rotor thread meshes with the internal housing threads in the single-rotor type. Multiple rotor types are split into two parts as well: Single-end and double-end. In both cases, only one rotor is driven. While a gear is used to rotate the other rotor in double-end screw pumps, the single-end screw pump configuration enables the other rotor to rotate with the motion of the driven rotor. Even though all rotary pumps move the

fluid circumferentially, the flow pattern of screw pumps is axial. This makes the screw pumps unique and gives numerous advantages as follows ^[3]:

- It can work in a wide range of different conditions such as flow type, pressures, liquid type, and viscosity.
- Since the inertia of rotating parts is lower, it can work at high speeds.
- The axial flow pattern results in low internal velocity.
- It can work in multiphase operations.
- Since the mechanical vibration is so low, it can work silently.
- The installation and maintenance of the pump are relatively easy.
- The pump can tolerate solid particles in the pump.

Parameters:

Some important parameters govern the performance of a screw pump. They can be counted as follows ^[4]:

1. Inlet Condition: Since a screw pump is not able to pull or lift the fluid, there must be a force to enter the fluid into the pump. Generally, atmospheric pressure is used for this operation.
2. Fluids and Vapor Pressure: The vapor or dissolved air pressure may cause cavitation and this suffers efficiency. Also, it may cause noisy operations.
3. Viscosity: The fluid's viscosity has a direct relation with the filling cavity rate. Since fluids with higher viscosity need more time to fill the rotor cavity, the pump's speed should be lower in this situation.
4. Outlet Conditions: Outlet conditions such as pipe size are crucial to outlet pressure. For example, with a good selection of pipe size, the operation of the pump may be more efficient.

Twin-Screw Pump:

The twin-screw pump, which is the subject of interest, is in the double-end screw pump family, are positive displacement machine. It is configured with two opposed screws which have the same size as a common driving rotor. The screws are connected by a gear that conveys the fluid trapped in the screw chambers axially from suction to discharge and forces it out against the back pressure. The pump has a common inlet and a common outlet. All axial loads on the screws are balanced. Double-end screw pumps are capable of working in a wide range of pressure applications with large volumetric flow rates. Furthermore, the viscous and the multiphase flow can be handled with the same

system. Fluid is moved by the series of C-shaped cavities which are generated by the rotating screws. Therefore, the pump geometry and pump speed are the only governing parameters to define the theoretical volumetric flow rate of the pump ^[5].

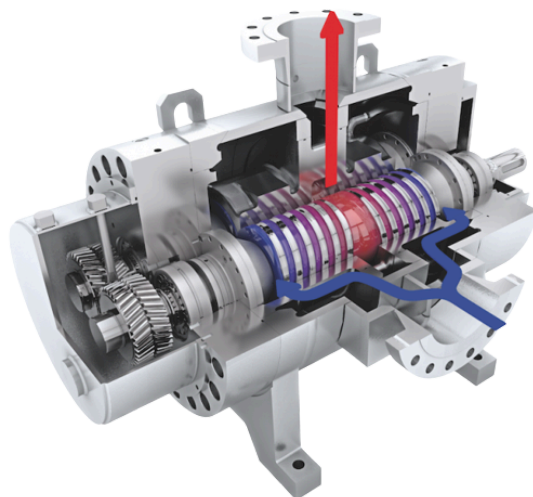


Figure 1 Screw Pump

The operating principle of the twin-screw pump is different from centrifugal pumps. As a positive displacement machine, the screw pump pressure head is achieved by trapping the fluid in a chamber and conveying it by the rotation of the screws to the discharge side where it is pushed out against the back pressure. Unlike centrifugal pumps, the pressure head is dependent on the pump back pressure while the rotational speed affects the flow rate only ^[8].

Most twin screw pumps are self-priming and can work with low suction pressure. They are also gas tolerant and able to handle free and entrained gases without vapor locking. Low internal fluid velocity and the gentle meshing of the rotors also contribute to low shear rates, which is especially important for shear-sensitive, non-Newtonian fluids as well as different kinds of emulsions. The operational flexibility of these pumps is manifested by their ability to work over a large viscosity range, from light hydrocarbons to residues and emulsions. The screws are normally case-hardened for improved wear resistance, and customized coatings are occasionally used to protect rotor bores, the rotor liner, and the pump casing ^[9].

CONSTRUCTION:

The screw pump is constructed from the following components:

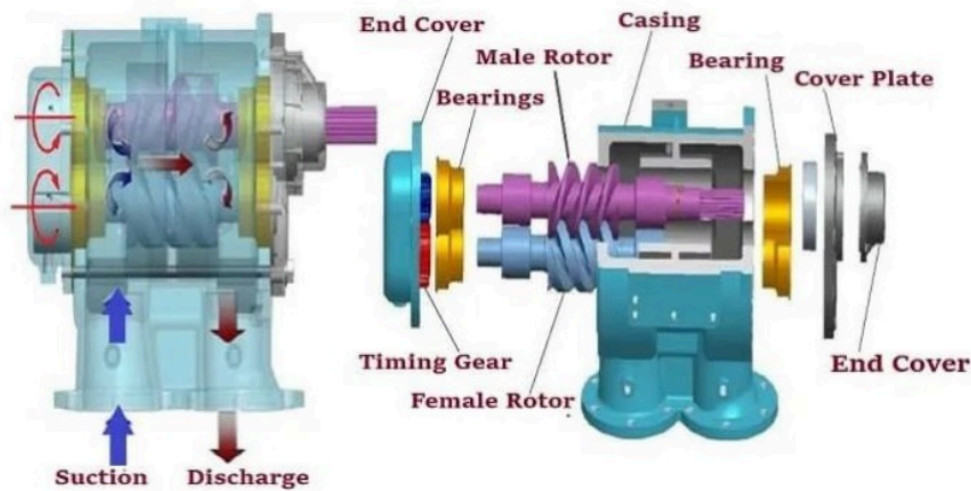


Figure 2 Construction of screw gauge

- **Driver screw:** The main rotating rotor for pumping is the driven screw rotor connected to the motor shaft.
- **Driven screw:** The driven screw is meshed with the driver screw and rotates due to the primary rotation of the driver screw.
- **Timing gear:** These gears have such an arrangement that they restrict the male and female rotors to have metal to metal contact.
- **Inlet and outlet ports:** Passages for the input and output of the fluid for the pump.
- **Pressure Relief Valve:** Used to relieve the build up pressure inside the pump.
- **Bearings:** Used to sustain heavy loads as well as radial and axial stresses so that they don't impact the pump.
- **Driving shaft:** The drive shaft links the driver shaft to the motor.

WORKING OF SCREW PUMP:

A screw pump is a positive displacement pump, and it works on the principle of displacing a fluid from one end to the other by suction and axial displacement. When the pump is started by the prime mover, the driver screw rotates due to the linkage to the rotating shaft connected with the main driving shaft of the motor. The driven screw relates to the driver screw and has a good fit with it which creates suction for the fluid. The fluid enters through the inlet ports and is carried linearly through the helical recesses of the meshed screw rotors. The meshing is necessary to avoid the movement of fluid through the casing. The volume of fluid moves forward uniformly with the rotation of screw along the axis and its pressure is increased. The fluid comes from both the ends towards the center of the pump where the discharge port is located.

APPLICATIONS:

- Utilized in industries for pumping oil to huge equipment.
- Screw pumps are more efficient for pumping heavier oils. They can pump liquids with higher viscosity and higher flow rates.
- They can pump both liquid and gases at the same time.
- Oil, Gas and mining fields utilize screw pumps.
- Ceramics, paint, food, chemicals, and paper industries all use these pumps.

ADVANTAGES:

Screw pumps have many advantages such as:

- Can be used for all type of fluids.
- Easy maintenance.
- Provide a steady, non-pulsating flow of liquid.
- Higher volumetric efficiency
- Compared to centrifugal pumps these pumps can be employed for pumping fluids with high viscosity.

- Smaller size and relatively quiet operation
- Self-Priming ability

LIMITATIONS:

Following the advantages, we now look at some limitations of screw pumps such as:

- a gas ballast needed to pump light gasses.
- worse ultimate pressure and lower pumping speed for light gasses (Helium and Hydrogen) if without gas ballast
- cannot be scaled down to small pumping speeds below 50 m³/h; below approx. 100 m³/h multistage roots or scroll pumps are used.

CAD MODELLING:

Screw Pump:

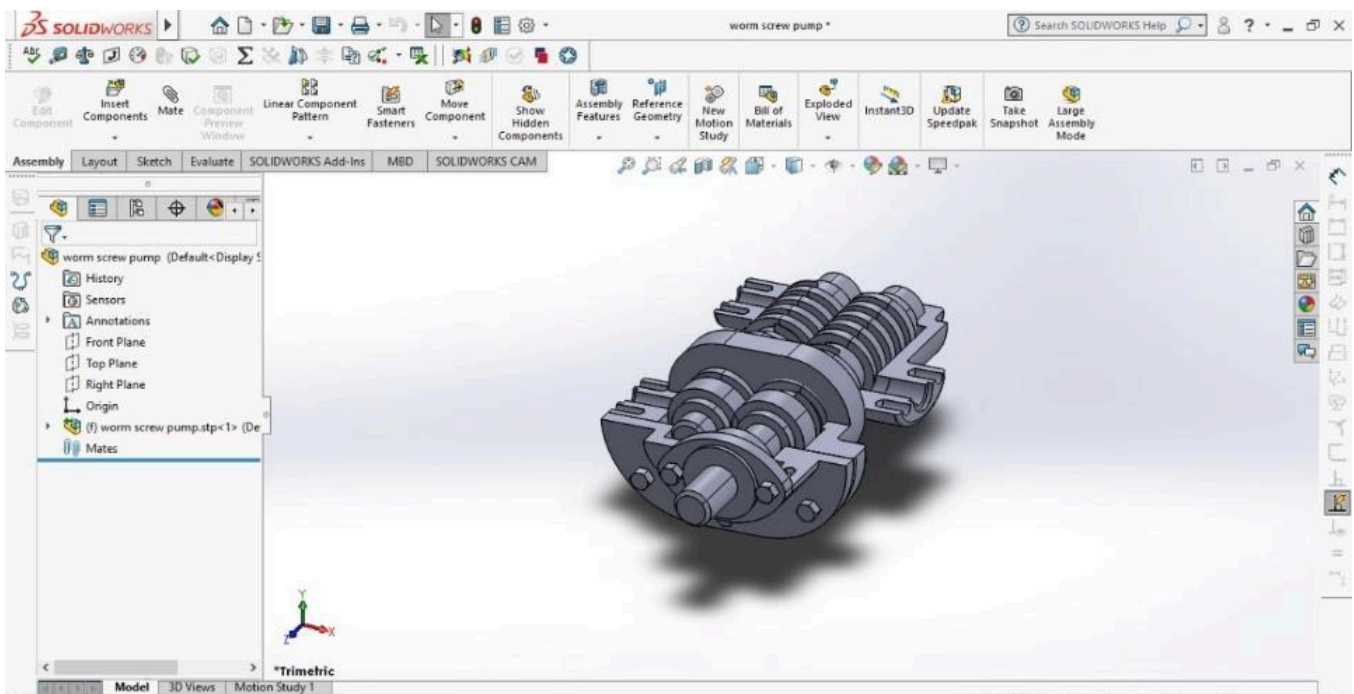


Figure 3 CAD model of a screw pump

Assembly:

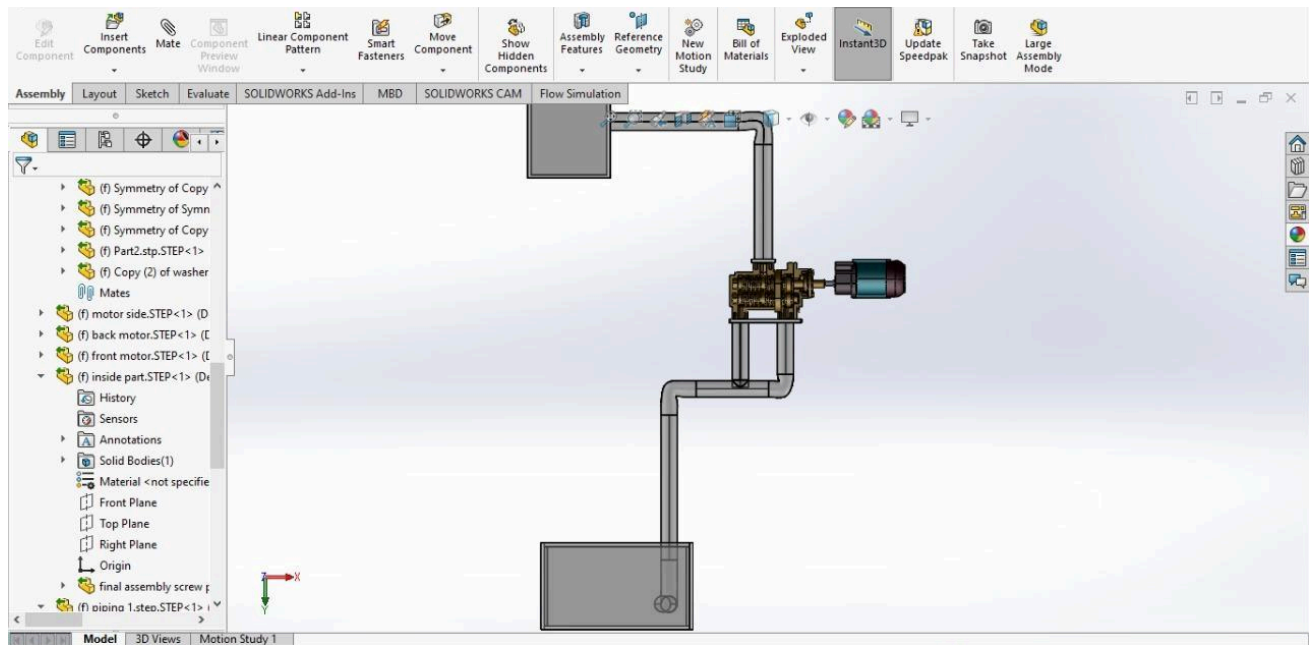


Figure 4 View of screw pump assembly

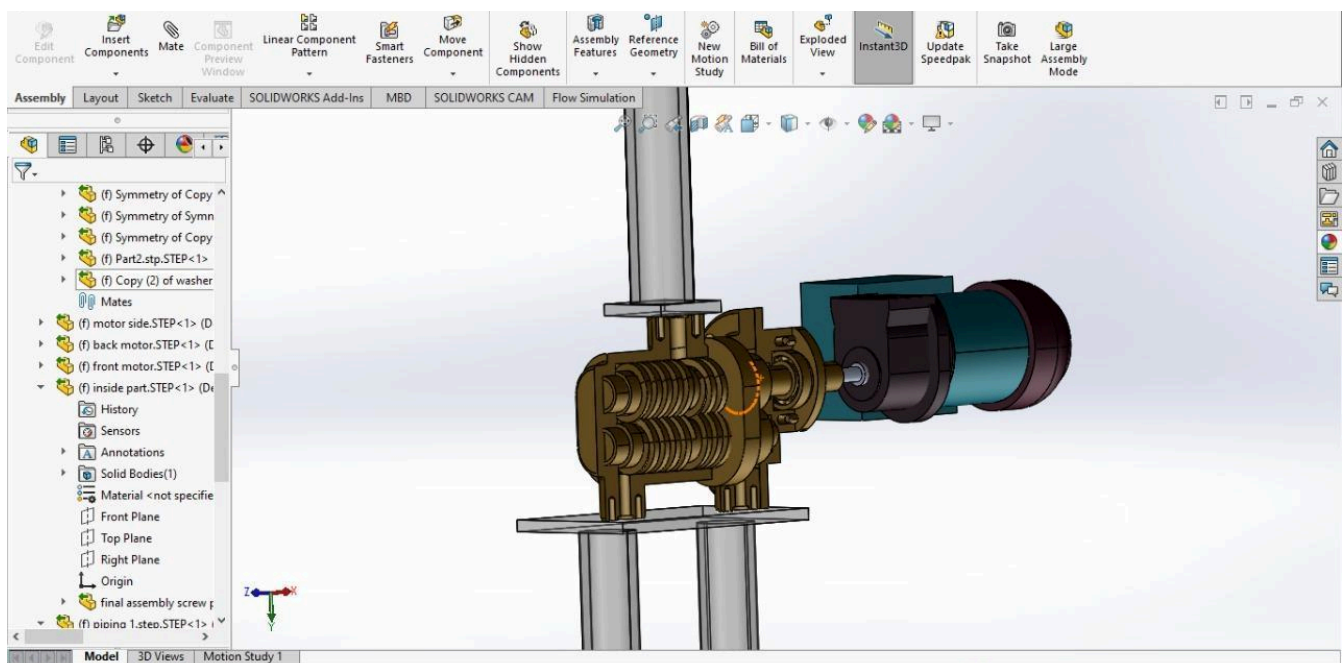


Figure 5 Screw pump with motor

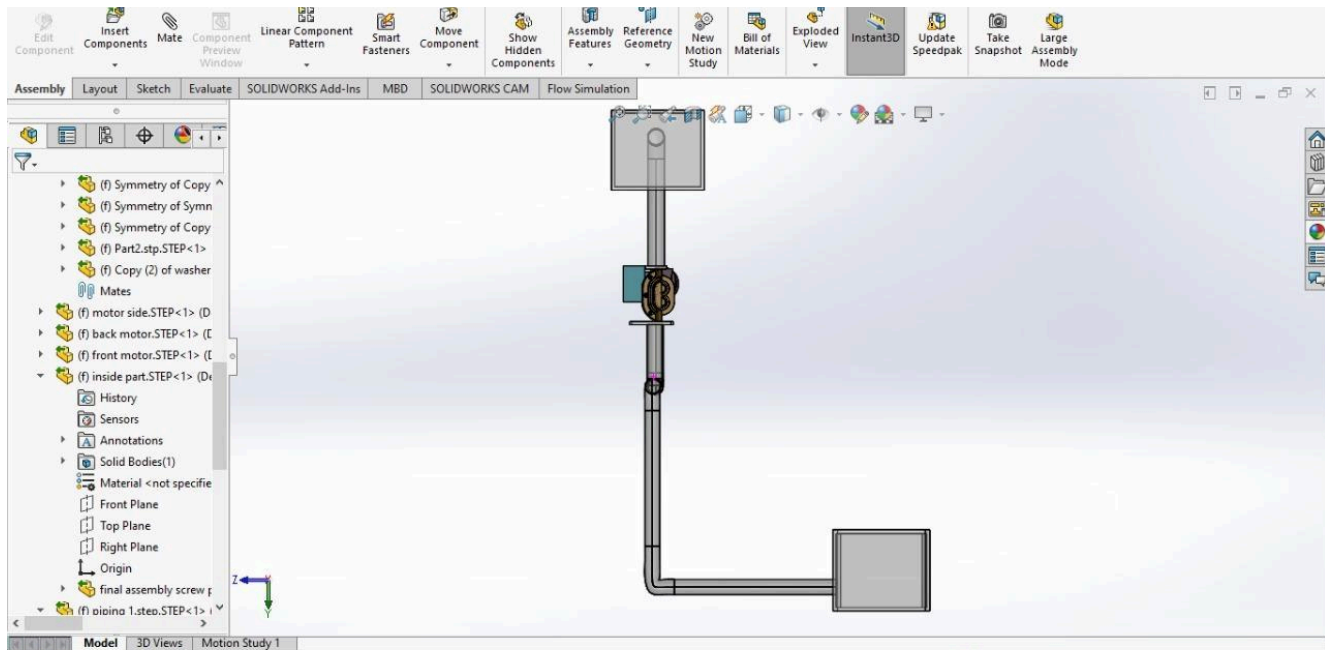


Figure 6 Side view of assembly

FUTURE RECOMMENDATIONS:

Torque of pump

Because there is a pressure difference between the suction end and the discharge end of the screw pump, the liquid in the screw-bushing pair will exert a force on the screw. At the same time, there is interference between stator and rotor, which will cause friction torque between stator and rotor, and affect the output. The torque of screw pump in no-load operation is generally very small, but the torque required when the screw pump is stationary for a long time is very large, which is 20-30 times of the torque in no-load operation and 2-3 times of the torque in full-load operation. The starting torque is related to the length of sealing line of screw pump, the interference between stator and rotor, the hardness and working pressure of rubber, the length of static time and the roughness of friction surface. The more the number of stages, the greater the roughness, the higher the rubber hardness, and the larger the interference between rotors and the higher the working pressure of the pump, the greater the starting torque of the pump. From the use point of view, the pump should be started after a long time of rest as much as possible; From the point of view of design and manufacture, the hardness and interference of rubber should be appropriately reduced, and coating materials with smaller friction coefficient of rotor and stator rubber should be selected. At the same time, it is very important to reduce the roughness of rotor and stator surfaces.

Influence of rotor speed

The rotational speed of the rotor determines the displacement of the screw pump. The higher the rotational speed of the rotor is, the greater the displacement will be. However, the higher the rotating speed, the greater the centrifugal force of the sucker rod, the more serious the bending vibration of the sucker rod, and the greater the friction between the sucker rod coupling and the inner wall of the tubing. At the same time, the lifting height will also decrease due to the increase of the loss along the way and the acceleration of the stator rubber wear. Therefore, the rotating speed of the rotor should not be too high, but should generally be less than 500r/min. At present, the rotating speed of the screw pump in the actual operation of our oilfield is generally below 160r/min.

Influence of viscosity

Because the screw pump is used to lift crude oil in practical application, and often because of lifting heavy oil, the working characteristics of the pump in the process of lifting will be very different from those when lifting clear water. On the one hand, the increase of viscosity reduces the leakage, which is beneficial to improve the volumetric efficiency and system efficiency of the pump; On the other hand, the increase of viscosity will increase the flow resistance, decrease the filling degree and lifting height of the pump, and decrease the volumetric efficiency and system efficiency of the pump. At the same time, the increased friction of the pump will increase the resistance torque. Therefore, in practical application, we should pay full attention to the influence of viscosity.

CONCLUSION:

In this project report we conclude that screw pumps are a unique type of rotary positive displacement pump in which the flow through the pumping elements is truly axial. The liquid is carried between the screw threads on one or more rotors. The liquid is then displaced axially as the screws rotate and mesh. In other types of rotary pumps, the liquid is forced to travel circumferentially, however the screw pump has an axial flow pattern and low internal velocities. It provides a number of advantages in many applications where liquid agitation or churning is objectionable. Screw pumps are classified as two different types: the single rotor and the multiple rotor. The multiple rotor is further divided into timed and untimed categories. Timed rotors rely on outside means for phasing the mesh of the threads and for supporting the forces acting on the rotors. Untimed rotors rely on precision and accuracy of the screw forms for proper mesh and transmission of rotation.