

All about screw pumps engineering essay



**ASSIGN
BUSTER**

Screw pumps are rotary, positive displacement pumps that can have one or more screws to transfer high or low viscosity fluids along an axis. A classic example of screw pumps is the Archimedes screw pump that is still used in irrigation and agricultural applications.

Although progressive cavity pumps can be referred to as a single screw pumps, typically screw pumps have two or more intermeshing screws rotating axially clockwise or counterclockwise. Each screw thread is matched to carry a specific volume of fluid. Like gear pumps, screw pumps may include a stationary screw with a rotating screw or screws. Fluid is transferred through successive contact between the housing and the screw flights from one thread to the next. Geometries can vary. Screw pumps provide a specific volume with each cycle and can be dependable in metering applications.

The geometries of the single or multiple screws and the drive speed will affect the pumping action required. The capacity of screw pumps can be calculated based on the dimensions of the pump, the dimensions of the surface of the screws, and the rotational speed of the rotor since a specific volume is transferred with each revolution. In applications where multiple rotors are used, the load is divided between a number of rotating screws. The casing acts as the stator when two or more rotors are used. Based upon the needs of the application, timed or untimed rotors may be chosen. Untimed rotors are simpler in design.

The combination of factors relating to the drive speed, flow, and the characteristics of the fluid transferred may affect the flow rate and volume

fed through each cavity. In water and wastewater treatment applications, a less viscous solution will require a lower power drive compared to untreated sewage, excess sludge, or concentrated slurries, which may require a higher power motor. The viscosity of the fluid transferred and the lift required may affect the speed and power required. Indicators of pump malfunction include decrease in flow rate or increased noise. The efficiency of screw pumps requires that each rotor turns at a rate that allows each cavity to fill completely in order to work at full capacity.

Theory

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 (Fraser, et. al., 1986.).

History:

The screw pump is the oldest type of pump. The first applications, dating back to the third century B. C., included irrigation and land drainage. The

screw pump is thought to have been first used in Egypt (Ewbank, 1972). After several other types of pumps were invented, the screw pump was not used as much because these other pumps could handle higher head capacities. However, later it was found that these pumps could not handle wastewater like the screw pump could. Because of this, the screw pump became widely used for such an application. The Dutch were the first to design a spiral lift screw in 1955. After this, double screw units were put into operation for flood control in the Netherlands and in municipal sewage installations in Europe. Based on excellent results from the pumps used in Europe, the trend extended to Canada and United States and are currently used today (Cheremisinoff, et. al., 1992) [2].

How a Screw Pump Works:

Screw pumps for power transmission systems are generally used only on submarines. Although low in efficiency and expensive, the screw pump is suitable for high pressures (3000 psi), and delivers fluid with little noise or pressure pulsation. Screw pumps are available in several different designs; however, they all operate in a similar manner. In a fixed-displacement rotary-type screw pump (fig. 1, view A), fluid is propelled axially in a constant, uniform flow through the action of just three moving parts—a power rotor and two idler rotors. The power rotor is the only driven element, extending outside the pump casing for power connections to an electrical motor. The idler rotors are turned by the power rotor through the action of the meshing threads. The fluid pumped between the meshing helical threads of the idler and power rotors provides a protective film to prevent metal-to-metal contact. The idler

rotors perform no work; therefore, they do not need to be connected by gears to transmit power. The enclosures formed by the meshing of the rotors inside the close clearance housing contain the fluid being pumped. As the rotors turn, these enclosures move axially, providing a continuous flow. Effective performance is based on the following factors:

The rolling action obtained with the thread design of the rotors is responsible for the very quiet pump operation. The symmetrical pressure loading around the power rotor eliminates the need for radial bearings because there are no radial loads. The cartridge-type ball bearing in the pump positions the power rotor for proper seal operation. The axial loads on the rotors created by discharge pressure are hydraulically balanced.

The key to screw pump performance is the operation of the idler rotors in their housing bores. The idler rotors generate a hydrodynamic film to support themselves in their bores like journal bearings. Since this film is self-generated, it depends on three operating characteristics of the pump-speed, discharge pressure, and fluid viscosity. The strength of the film is increased by increasing the operating speed, by decreasing pressure, or by increasing the fluid viscosity. This is why screw pump performance capabilities are based on pump speed, discharge pressure, and fluid viscosity.

The supply line is connected at the center of the pump housing in some pumps (fig. 1, view B). Fluid enters into the pump's suction port, which opens into chambers at the ends of the screw assembly. As the screws

turn, the fluid flows between the threads at each end of the assembly. The threads carry the fluid along within the housing toward the center of the pump to the discharge port [1].

Three Basic Types :

Single Screw

The single screw pump is more commonly known as the Archimedean screw. It is quite large; typical dimensions include a diameter of 12 inches or greater, and a length up to about 50 feet. It is normally used as a water-raising pump with the screw arranged at an angle of 30 degrees. It can also be used for handling liquids containing solids in suspension with either vertical lift or horizontal transport. The design of single screw pumps allows very little fracturing of particles and little abrasion damage to the pump. One disadvantage is the considerable bulk necessary to achieve high capacities since rotational speeds are of the order of 30-60 rpm (Warring, 1984) [5].

Intermeshing Screw Pump

The intermeshing screw pump is commonly called a rigid-screw pump. This type of pump is suitable for a wide range of sizes, and can be run at high speeds. The larger screw pumps are used for bulk handling of oils and similar fluids. The basic type is suitable for handling most clean fluids with low flow velocities and at low heads (Warring, 1984)[5].

Eccentric screw pump

The eccentric screw pump is versatile. It is capable of handling a variety of liquids and products with high efficiency. It comprises of a rigid screw form rotor rolling in a resilient internal helical stator of hard or soft rubber with a

moderately eccentric motion. It can handle viscous liquids, slurries, pastes, solids in suspension, and delicate products. This is because of the low flow velocities through the pump (Warring, 1984)[5].

Applications:

There are several applications of the screw pump that include a wide range of markets: utilities fuel oil service, industrial oil burners, lubricating oil service, chemical processes, petroleum and crude oil industries, power hydraulics, and many others (Fraser, et. al., 1986). Listed below are some typical situations where a screw pump is used. The benefits of using a screw pump in each of these situations are discussed (Cheremisinoff, et. al., 1992) [2].

Raw sewage lift stations: Can handle variety of raw sewage influent, are non-clogging, require little attention, are resistant to motor overloads, and are not affected by running dry

Sewage plant lift stations: Used for sewage lifts up to 40 feet and have self-regulating lift capacity (Normal lifts are 30 feet, while high lifts are 40 feet high.)

Return activated sludge: Little floc disintegration, nonturbulent discharge into effluent channel, low horsepower requirements, improved activated sludge treatment.

Stormwater pumping: Are ideal because of large capacity at low heads, no prescreening necessary

Land Drainage: Used for flood control, can pump large volumes of water over levees.

Capacity :

The delivered capacity of any screw pump is the theoretical capacity minus the internal leakage. In order to find the capacity of a screw pump the speed of the pump must be known. The delivered capacity of any rotary screw pump can be increased several different ways. The capacity can be increased by simply increasing the speed, increasing the viscosity, or decreasing the differential pressure. The capacity of the pump depends on several factors (Cheremisinoff, et. al., 1992)[2]:

Diameter of the screw

Speed of the screw

Number of flights mounted on the screw shaft

Flights: Single, double, and triple flights are often used. Flights are also known as helixes. With each increase in flights, there is a 20% increase in capacity. Therefore, a single flight pump has a capacity that is 80% of a double flight pump, which in turn has a capacity that is 80% of a triple flight capacity. The three-flight pump can handle the most capacity in the least amount of space.

Angle of inclination of the screw

The greater the angle of inclination, the lower the output. The output lowers approximately 3% for every degree increase over a 22 inclination.

Level of influent in the influent chamber

Ratio of the diameter of the screw shaft to the outside diameter of the screw flights

Clearance between screw flights and trough

Advantages :

Wide range of flows and pressures

Wide range of liquids and viscosities

Built-in variable capacity

High speed capability allowing freedom of driver selection

Low internal velocities

Self-priming with good suction characteristics

High tolerance for entrained air and other gases

Minimum churning or foaming

Low mechanical vibration, pulsation-free flow, and quiet operation

Rugged, compact design — easy to install and maintain

High tolerance to contamination in comparison with other rotary pumps
(Fraser, et. al., 1986)[4].

Disadvantages :

Relatively high cost because of close tolerances and running clearances

<https://assignbuster.com/all-about-screw-pumps-engineering-essay/>

Performance characteristics sensitive to viscosity change

High pressure capability requires long pumping elements (Fraser, et. al., 1986)[4].

Characteristics and Efficiency of Screw Pumps:

The screw pump has a number of very important advantages compared with centrifugal due to recovery of velocity head at the discharge pumps. In order, however, to appreciate fully pipe are not as great, what the screw pump will do as compared with the centrifugal pump, particularly for low head operation, it is necessary to have a thorough knowledge of the characteristic curves of both types of pumps. The three curves which are reproduced here show an actual comparison between a screw pump and a 36-in. centrifugal pump. A great deal of care has been taken to make this comparison as fair as possible; but owing to the dissimilarity of the characteristics of the two pumps, a perfect comparison is practically impossible. For this reason, wherever it is impossible to make the conditions coincide exactly for the two different pumps, the centrifugal pump has been given every advantage, yet even under rather severe handicaps, the screw still maintains its supremacy under low head conditions.

The combined curve shown in Fig. 3 illustrates that at all heads lower than 12.6 ft. the screw pump is the more efficient of the two pumps. It will be noticed that the 42-in. centrifugal has not been compared with the 42-in. screw pump because the screw pumps are designed for such very low heads that the suction and discharge sizes are made larger than the connections for centrifugal pumps which handle the same capacity. In other words, the <https://assignbuster.com/all-about-screw-pumps-engineering-essay/>

42-in. centrifugal pump would have a capacity so much greater than that of the 42-in. screw that comparison would be impossible. All of the total heads which are shown in the three curves are total dynamic heads, and this includes the velocity head. Therefore, the water delivered from the screw pump is

moving at a lower velocity because of the size of pipe, and hence it is in a more usable form. The entrance losses of the suction pipe and the losses due to recovery of velocity head at the discharge pipe are not as great.

It has often been stated that the speed of a screw pump can be much higher than that of a centrifugal operating under the same conditions. These curves demonstrate this beyond a doubt. It will be noted that the centrifugal pump operates at 224 r. p. m., while the screw pump operates at a speed more than 50 per cent in excess of this, namely, 360 r. p. m. The advantage in the cost and the efficiency of a motor for operating these two pumps is distinctly in favor of the screw pump. Furthermore, the screw pump is a much lighter pump, requiring less expensive foundations, and it is easier to install. The 42-in. screw pump weighs 9, 000 pounds, while the 36-in. centrifugal pump weighs 21, 000 pounds. This shows that the body of the screw pump is much smaller than that of the centrifugal pump in spite of the fact that the pipe sizes are larger than the latter. In addition to this, the arrangement for pumping over levees, or between canals at different levels, is much more simple for the screw pump than for the centrifugal pump. The property through which the canal runs is always long and narrow and the screw pump, together with its prime mover, makes a long narrow installation which lends itself to the shape of the property in which it is to be installed. The

centrifugal pump is usually a more costly pump to produce than the screw pump, and this is especially true of the pump with the characteristics shown in Fig. 2 because of the fact that this 36-in. pump has a Francis runner.

The Francis runner is known for its efficiency at low heads and in this case the curve reaches the unusually high maximum point of 90 per cent. This is partly due to the special design and partly due to the very careful workmanship and careful testing of the unit in question. The screw pump, on the other hand, had a caststeel runner whose surfaces were only partially smooth. No great effort was made to bring up its point of maximum efficiency, and therefore it does not exceed 76 per cent at any point. Yet, even in the face of these handicaps of workmanship and finish on the particular units which were selected for this comparison, the screw pump is shown to be inherently a

more efficient pump at low heads. It does not take a great deal of imagination to see how the screw pump efficiency curve of Fig. 3 would compare with the centrifugal pump efficiency curve had its blades been made of bronze and highly polished so as to reach a maximum point somewhere above 80 per cent. The curves shown in Fig. 3 are out of the ordinary in that they are plotted against the total head rather than against the conventional gallons per minute. This is done because the comparisons are at low heads rather than at a given capacity. By using this method of plotting, it can readily be observed that at low heads the efficiencies of the two pumps can be read directly from the chart. For example, at a head of 6 ft. the efficiency of the screw pump is 57 per cent while that of the centrifugal pump is only 42 per cent. This same information could be taken

from the other curves but it would be inconvenient to do so. To get the efficiency from Fig. 1 it is necessary first to read the capacity. At 6 ft. the capacity is approximately 37, 000 g. p. m. The efficiency is quite indefinite on account of the steepness of the curve; but it is apparent that it checks approximately with the reading given in Fig. 3; namely, 57 per cent. Also in Fig. 2 it is necessary first to read the capacity and then the efficiency, which checks with Fig. 3 and is 42 per cent. In addition to this, Fig. 1 and Fig. 2 would not make a graphical comparison even if plotted on the same sheet. The important point which should be kept in mind is that these curves may not show up the screw pump to advantage when read in their entirety but that at the extreme right where the points of low working heads exist the advantages of the screw pump begin to assert themselves. It is under these conditions that a screw pump should be used. In general, these curves have demonstrated, directly or indirectly, most of the advantages of the screw pump over the centrifugal as follows:

Higher efficiency at low heads, higher speed, lighter

weight, smaller dimensions, lower first cost, lower cost of

installation, cheaper motor, more efficient motor, low head

installation. [6].