Centrifugal and Positive Displacement Pump Fundamentals

An Online Continuing Education Course for Engineers

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CENTRIFUGAL PUMPS

Introduction

Centrifugal pumps basically consist of a stationary pump casing and an impeller mounted on a rotating shaft. The pump casing provides a pressure boundary for the pump and contains channels to properly direct the suction and discharge flow. The pump casing has suction and discharge penetrations for the main flow path of the pump and normally has small drain and vent fittings to remove gases trapped in the pump casing or to drain the pump casing for maintenance.

Figure 1 is a simplified diagram of a typical centrifugal pump that shows the relative locations of the pump suction, impeller, volute, and discharge. The pump casing guides the liquid from the suction connection to the center, or eye, of the impeller. The vanes of the rotating *impeller* impart a radial and rotary motion to the liquid, forcing it to the outer periphery of the pump casing where it is collected in the outer part of the pump casing called the volute. The *volute* is a region that expands in cross-sectional area as it wraps around the pump casing. The purpose of the volute is to collect the liquid discharged from the periphery of the impeller at high velocity and gradually cause a reduction in fluid velocity by increasing the flow area. This converts the velocity head to static pressure. The fluid is then discharged from the pump through the discharge connection.

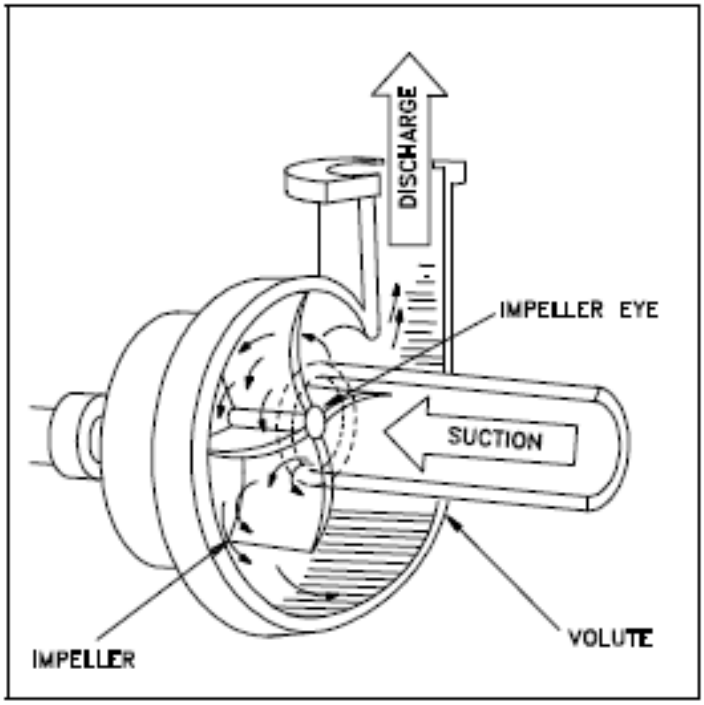


Figure 1 Centrifugal Pump

Centrifugal pumps can also be constructed in a manner that results in two distinct volutes, each receiving the liquid that is discharged from an 180° region of the impeller at any given time. Pumps of this type are called double volute pumps (they may also be referred to a split volute pumps). In some applications the double volute minimizes radial forces imparted to the shaft and bearings due to imbalances in the pressure around the impeller. A comparison of single and double volute centrifugal pumps is shown on Figure 2.

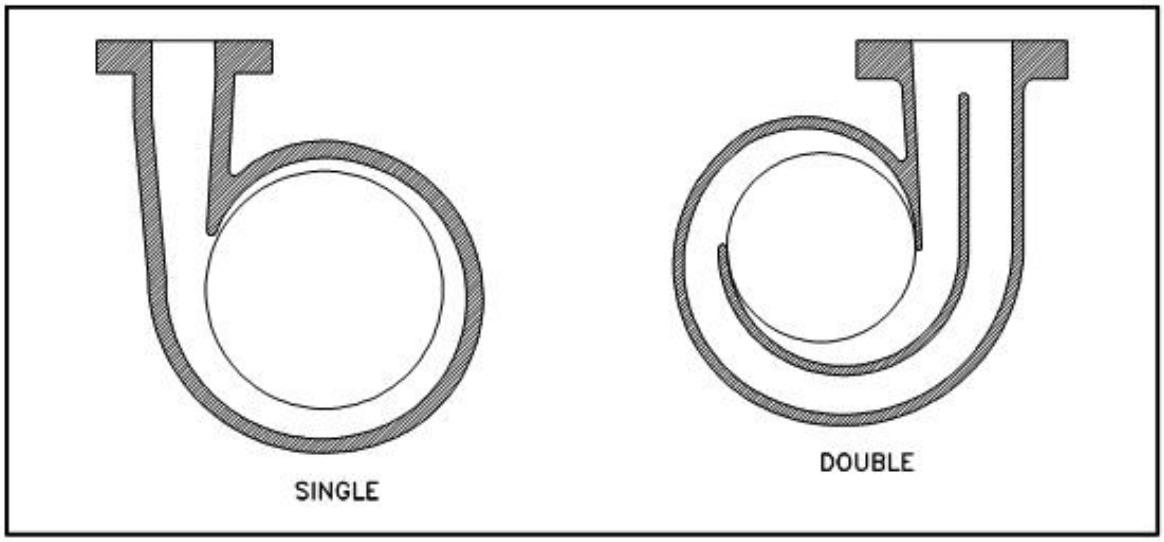


Figure 2 Single and Double Volutes

Diffuser

Some centrifugal pumps contain diffusers. A *diffuser* is a set of stationary vanes that surround the impeller. The purpose of the diffuser is to increase the efficiency of the centrifugal pump by allowing a more gradual expansion and less turbulent area for the liquid to reduce in velocity. The diffuser vanes are designed in a manner that the liquid exiting the impeller will encounter an ever-increasing flow area as it passes through the diffuser. This increase in flow area causes a reduction in flow velocity, converting kinetic energy into flow pressure.

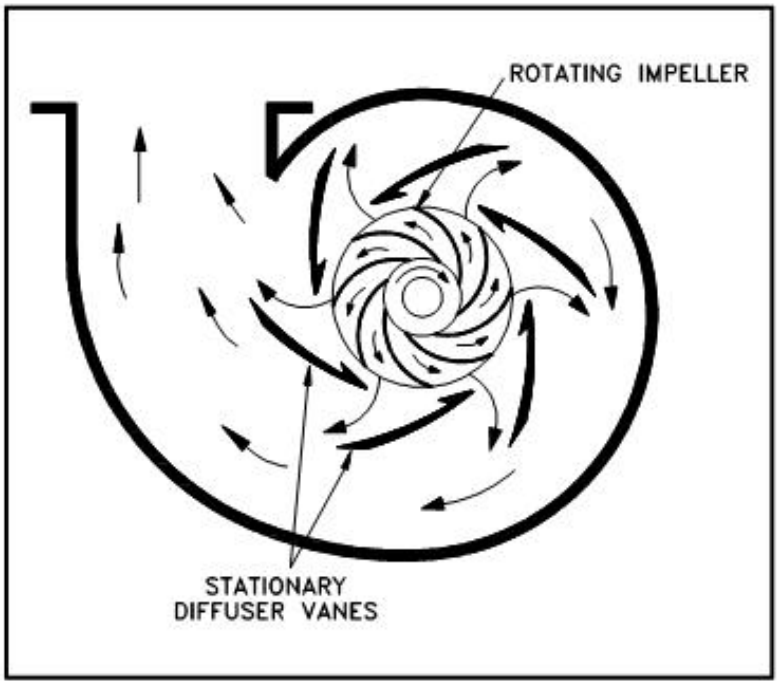


Figure 3 Centrifugal Pump Diffuser

Impeller Classification

Impellers of pumps are classified based on the number of points that the liquid can enter the impeller and also on the amount of webbing between the impeller blades.

Impellers can be either single-suction or double-suction. A single-suction impeller allows liquid to enter the center of the blades from only one direction. A double-suction impeller allows liquid to enter the center of the impeller blades from both sides simultaneously. Figure 4 shows simplified diagrams of single and double-suction impellers.

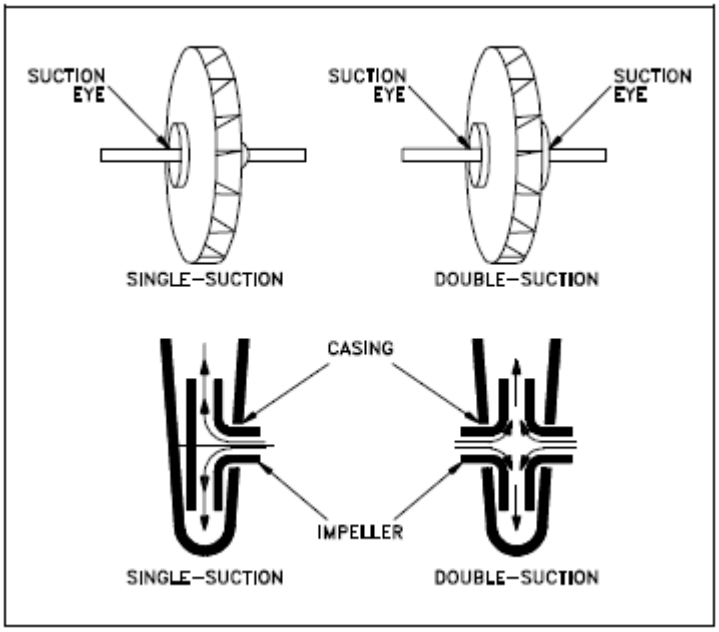


Figure 4 Single-Suction and Double-Suction Impellers

Impellers can be open, semi-open, or enclosed. The open impeller consists only of blades attached to a hub. The semi-open impeller is constructed with a circular plate (the web) attached to one side of the blades. The enclosed impeller has circular plates attached to both sides of the blades. Enclosed impellers are also referred to as shrouded impellers. Figure 5 illustrates examples of open, semi-open, and enclosed impellers.

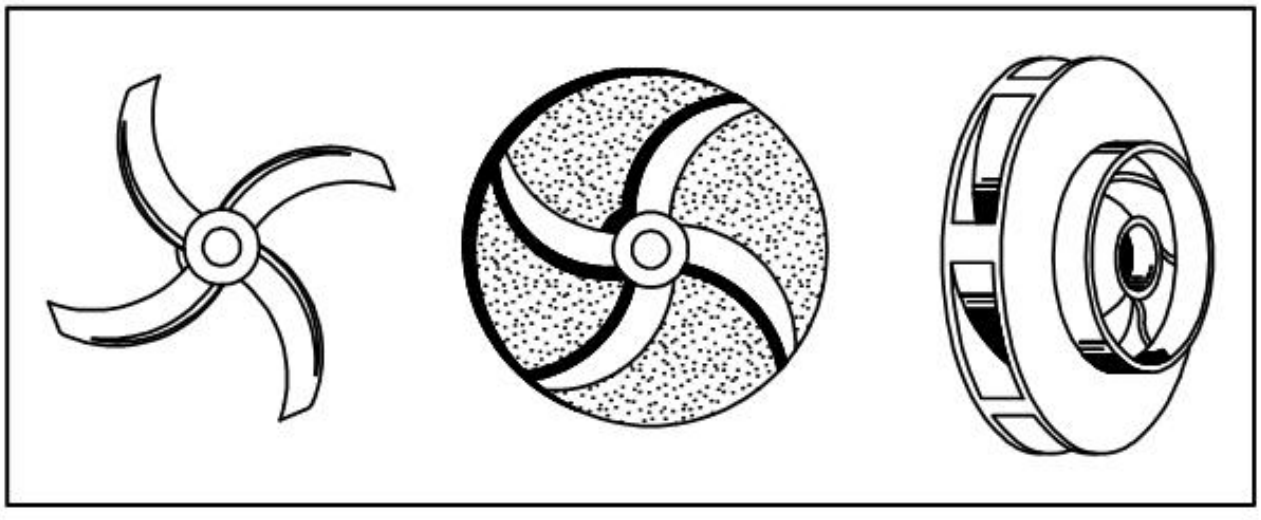


Figure 5 Open, Semi-Open, and Enclosed Impellers

The impeller sometimes contains balancing holes that connect the space around the hub to the suction side of the impeller. The balancing holes have a total cross-sectional area that is considerably greater than the cross-sectional area of the annular space between the wearing ring and the hub. The result is suction pressure on both sides of the impeller hub, which maintains a hydraulic balance of axial thrust.

Centrifugal Pump Classification by Flow

Centrifugal pumps can be classified based on the manner in which fluid flows through the pump. The manner in which fluid flows through the pump is determined by the design of the pump casing and the impeller. The three types of flow through a centrifugal pump are radial flow, axial flow, and mixed flow.

Radial Flow Pumps

In a radial flow pump, the liquid enters at the center of the impeller and is directed out along the impeller blades in a direction at right angles to the pump shaft. The impeller of a typical radial flow pump and the flow through a radial flow pump are shown in Figure 6.

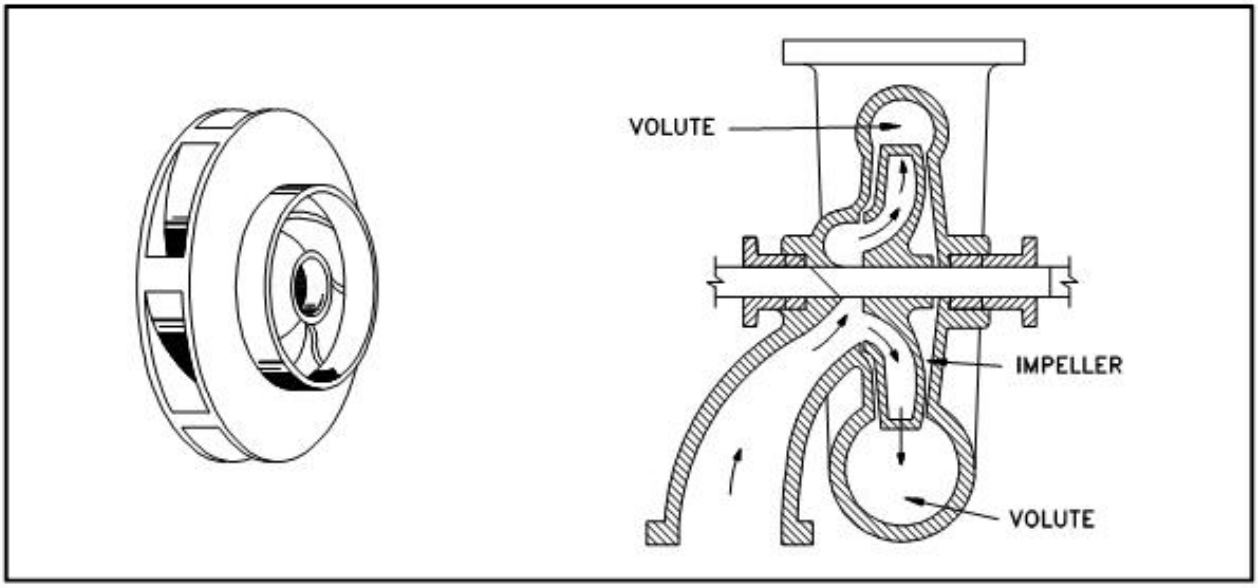
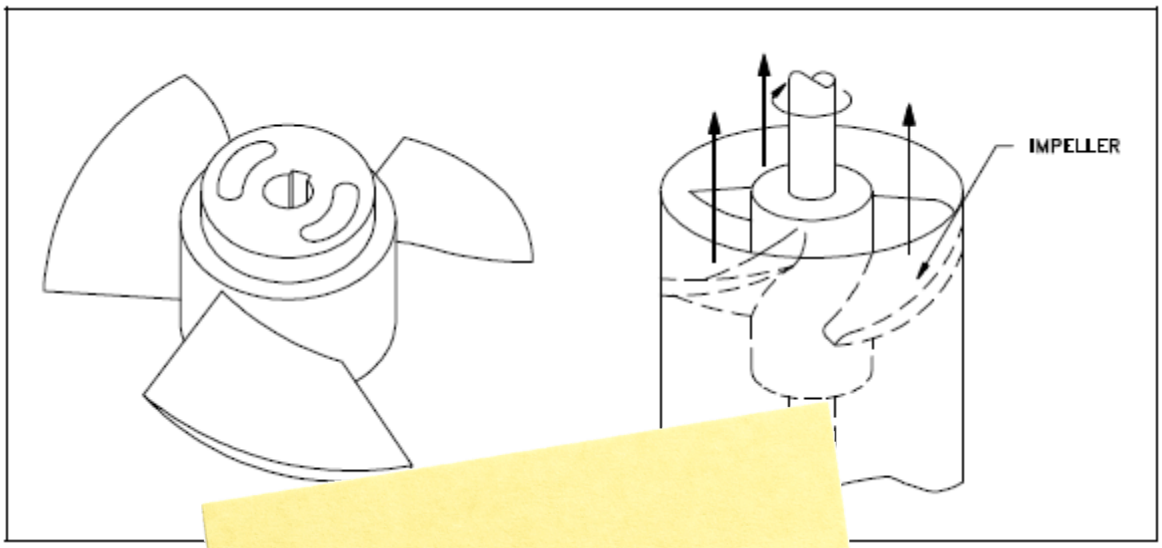


Figure 6 Radial Flow Centrifugal Pump

Axial Flow Pumps

In an axial flow pump, the impeller pushes the liquid in a direction parallel to the pump shaft. Axial flow pumps are sometimes called propeller pumps because they operate essentially the same as the propeller of a boat. The impeller of a typical axial flow pump and the flow through a radial flow pump are shown in Figure 7.



Mixed Flow Pump

Mixed flow pumps l … l axial flow pumps. As liquid flows through t… ades push the liquid out away from the pump s… than 90°. The impeller of a typical mixed flo… mp are shown in Figure 8.

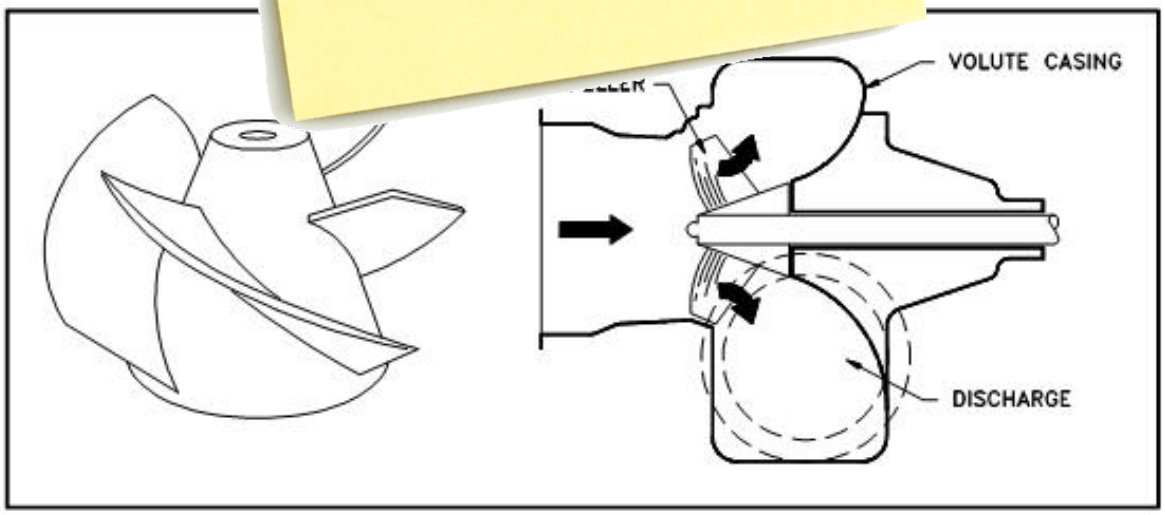


Figure 8 Mixed Flow Centrifugal Pump