

## **CHAPTER 3**

### **PUMP AND ITS CLASSIFICATIONS**

#### **3.1 INTRODUCTION**

A pump is a machine used to move liquid through a piping system and to raise the pressure of the liquid (US-DOE, 2006; Ksrassik et al 2011). It is a hydraulic machine which converts mechanical energy into hydraulic energy. Pump can be classified into three major groups according to the method they use to move the fluid: direct lift, displacement and gravity pump.

Pumps operate by some mechanism (typically reciprocating or rotary), and consume energy to perform mechanical work by moving the fluid.

Pump can be classified into two categories:

1. Positive displacement pumps and
2. Non-positive displacement pumps.

#### **3.2 POSITIVE DISPLACEMENT PUMP**

Positive-displacement pump can operate by forcing a fixed volume of fluid from inlet pressure section of the pump into the discharge zone of the pump. It can be classified into two types:

Rotary-type positive displacement pump:

- Internal gear pump
- Screw pump
- Reciprocating-type positive displacement pump:
  - Piston pump
  - Diaphragm Pump

### **3.2.1 Rotary-Type Positive Displacement Pump**

Positive displacement rotary pump can move the fluid by using rotating mechanism that creates a vacuum that captures and draws in the liquid. Rotary positive displacement pump can be classified into two main types:

- Gear pumps - a simple type of rotary pump where the liquid is pushed between two gears.
- Rotary vane pumps - similar to scroll compressors, these pump have a cylindrical rotor encased in a similar shaped housing. As the rotor orbits, the vanes trap fluid between the rotor and the casing, drawing the fluid through the pump.

### **3.2.2 Reciprocating-Type Positive Displacement Pump**

Reciprocating pump move the fluid using one or more oscillating pistons, plungers or membranes (diaphragms), while valves restrict fluid motion to the desired direction.

Pump in this category are simple with one cylinder or more. They can be either single-acting with suction during one direction of the piston

motion and discharge on the other or double-acting with suction and discharge in both directions.

Typical reciprocating pumps are:

- Plunger pumps - a reciprocating plunger pushes the fluid through one or two open valves, closed by suction on the way back.
- Diaphragm pumps - similar to plunger pumps, where the plunger pressurizes hydraulic oil which is used to flex a diaphragm in the pumping cylinder. Diaphragm valves are used to pump hazardous and toxic fluids.
- Piston displacement pumps - usually simple devices for pumping small amounts of liquid or gel manually.

### **3.3 NON - POSITIVE DISPLACEMENT PUMP**

With this pump, the volume of the liquid delivered for each cycle depends on the resistance offered to flow. A pump produces a force on the liquid that is constant for each particular speed of the pump. Resistance in a discharge line produces a force in the opposite direction. When these forces are equal, a liquid is in a state of equilibrium and does not flow.

If the outlet of a non positive-displacement pump is completely closed, the discharge pressure will rise to maximum for a pump operating at a maximum speed. A non-positive displacement pump can be classified as follows:

### **3.3.1 Centrifugal Pump**

A centrifugal pump is a rotodynamic pump that uses a rotating impeller to increase the pressure and flow rate of a fluid (Friedrichs and Kosyn 2000; Gulich 2008). Centrifugal pump are most common type of pump used to move liquids through a piping system. The fluid enters the pump impeller along or near to the rotating axis and it is accelerated by the impeller, flowing radially outward or axially into a diffuser or volute chamber, from where it exits into the downstream piping system. Centrifugal pump are typically used for large discharge through smaller heads.

Centrifugal pump are often associated with the radial-flow type. However, the term "centrifugal pump" can be used to describe all impeller type rotodynamic pumps including the radial, axial and mixed-flow variations.

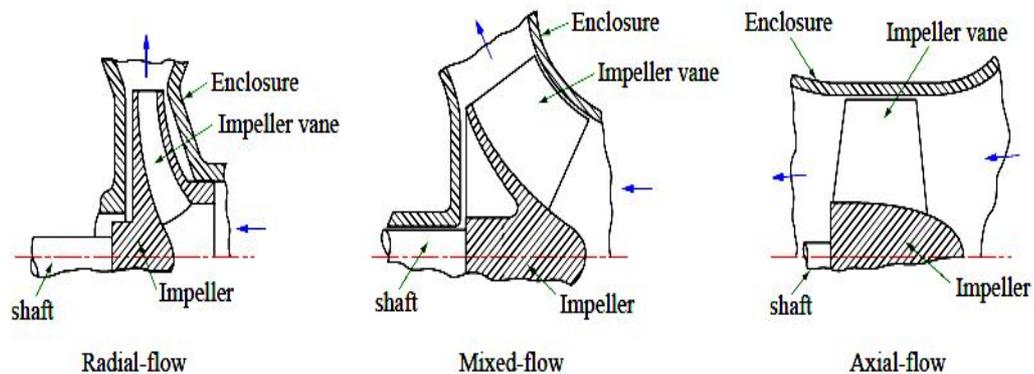
## **3.4 TYPES OF ROTODYNAMIC FLOW PUMP**

Radial, mixed and axial-flow pump belongs to a class of machines known as rotodynamic. As a class, are suitable for most of the liquid pumping applications but notable exceptions include metering, handling of highly viscous liquids and very high pressure or low flow rate requirement. For these applications normally, positive displacement pumps are used.

### **3.4.1 Types of Flow in the Pump**

The categories of pump deal with single and multi-stage versions of radial-flow, mixed-flow and axial-flow pump. These three categories of pumps are identified by the nature of the flow through the impeller as shown

in Figure 3.1. Radial-flow and mixed-flow pumps are commonly known as centrifugal pumps.



**Figure 3.1 Major pump categories**

### 3.4.2 Axial-Flow Pump

Axial-flow pumps differ from radial-flow pumps in that the fluid enters and exits along the same direction parallel to the rotating shaft. The fluid is not accelerated but instead "lifted" by the action of the impeller. Axial-flow pumps operate at lower pressures and higher flow rates than radial-flow pumps.

### 3.4.3 Mixed-Flow Pump

Mixed-flow pumps function as a compromise between radial and axial-flow pumps. The fluid experiences both radial acceleration and lift and exits the impeller somewhere between 0 and 90 degrees from the axial direction. As a consequence, mixed-flow pumps operate at higher pressures than axial-flow pumps while delivering higher discharge than radial-flow pumps.

### 3.4.4 Radial-Flow Pump

The fluid that enters along the axial plane is accelerated by the impeller and exits at right angles to the shaft (radially). Radial-flow pumps operate at higher pressures and lower flow rates than axial and mixed-flow pumps.

**Table 3.1 Characteristics of positive displacement and non-positive displacement pump**

S.No.	Positive- displacement pump	Non positive- displacement pump
1.	For every stroke pumping chamber opens to an outlet port.	It provides a smooth and continuous flow.
2.	Pressure affects the output only to extent that it increases internal leakage.	Pressure can reduce the delivery due to high pressure the liquid simply recirculates inside the pump.
3.	These are self-priming when started properly.	It cannot create a vacuum sufficient for self-priming.

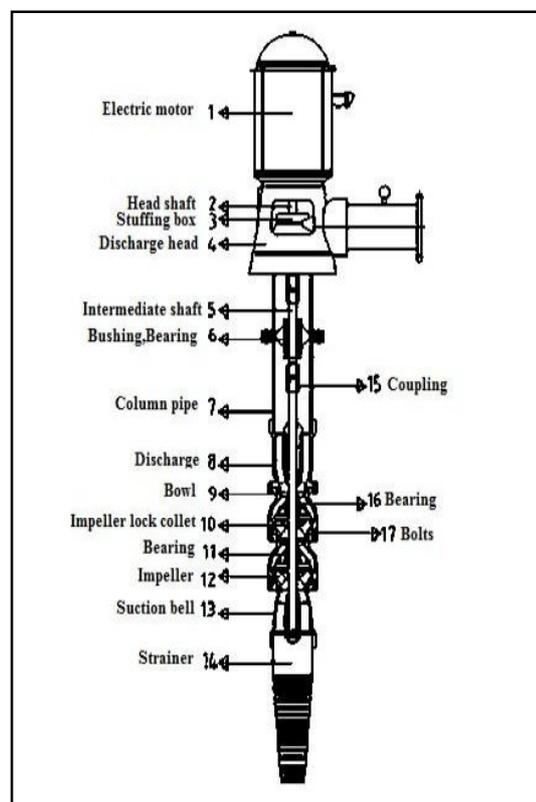
### 3.5 SUBMERSIBLE PUMP

A submersible pump assembly is shown in Figure 3.2 is a device which has a hermetically sealed motor close-coupled to the pump body. The main advantage of this type of pump is that it prevents pump cavitation, a problem associated with a high elevation difference between the pump and the fluid surface. Submersible pumps are more efficient than jet pumps.

### 3.5.1 Working Principle of Submersible Pump

The submersible pump used in ESP installations are multistage centrifugal pump operating in a vertical position. Produced liquids, after being subjected to great centrifugal forces caused by the high rotational speed of the impeller, lose their kinetic energy in the diffuser where a conversion of kinetic to pressure energy takes place. This is the main operational mechanism of radial and mixed flow pumps.

The pump shaft is connected to the gas separator or the protector by a mechanical coupling at the bottom of the pump. The fluid enter the pump through an intake screen and are lifted by the pump stages. Other parts include the radial bearing (bushings) distributed along the length of the shaft providing radial support to the pump shaft running at high rotational speeds.



**Figure 3.2 Submersible pump assembly**

The mixed flow pump are mainly composed of four subassemblies. These subassemblies are the driver, discharge head, column assembly and the pump assembly. The power is transmitted from the electric motor or any other type of driver such as diesel engine to the pump.

There are different types of electric motors used in different applications. If the pump is driven from the top, the discharge head is used and the column pipe and the intermediate shaft are adjusted for the different installations. If the length of the installation is increased, the number of the bearings used to hold the intermediate shaft is also increased.

In the applications where the driver is located on the top of the discharge head, the power is transmitted to the pump by means of several shaft connections. The reason why several shafts are used to transmit the power is the flexibility of the installation. The head shaft going through the discharge head is placed between the intermediate shaft and motor. The stuffing box is placed in the discharge head which is preventing the water coming from the column assembly leak into the motor side. The column assembly is composed of pipes which are connected to each other and the bottom end of the column assembly in the vertical direction is connected to the discharge part of the pump. The intermediate shaft is located in the column assembly and connected to the head shaft and pump shaft by means of coupling connections.

However the intermediate shaft is centered in the column assembly by means of journal bearings. The distance between the bearings are adjusted according to the rotational speed of the pump. The pump shaft holding the impeller is connected to the intermediate shaft. The impellers are locked on the shafts by means of impeller lock collets or key connections.

The bowl are connected to each other by means of bolt and nut. The impeller is located inside the bowl in vertical turbine pump and the bearing inside the bowl is used to align the shaft inside the pump assembly. The manufacturing tolerances are important while producing the bearing inside the bowl from the mechanical efficiency point. Nevertheless, the balance occurring depends upon the manufacturing of the impeller is also checked before the impeller is connected to the pump shaft. At the lower end, the suction intake is located where the journal bearing inside it allows the shaft to be aligned from the bottom end of the pump assembly.