Types of Pumps

An Online Continuing Education Course for Engineers

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Types of Pumps

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Introduction

Engineers are expected to select a pump type that is appropriate for the application and design conditions. There is no “best” pump type to select by default. A suitable pump type should be selected based on the specifics of the application.

Fortunately, there are many different types of pumps being manufactured. Being aware of the different pump types is a good first step in evaluating and selecting a pump type.

There are different ways of grouping or classifying pumps. The course starts by explaining these different approaches. Next, the classification approaches from standard organizations are covered.

This course presents a detailed classification of pumps in accordance with the widely accepted pump standards. For each pump type, major features are listed, pump operation is explained, and common applications are covered. Figures are provided for most pump types to aid in understanding the classification and pump operation.

Ways of Classifying Pumps

Pumps are mechanical devices that move fluids. There is a consensus on grouping pumps into these divisions:

Rotodynamic Pumps
Positive Displacement Pumps:

- Reciprocating Pumps
- Rotary Pumps

Rotodynamic pumps (also called dynamic pumps) utilize a spinning impeller to add velocity and pressure to a liquid. Positive displacement (PD) pumps move set volumes of liquid, with pressure increased as the liquid is forced through the discharge.

Further subdivision of rotodynamic pumps varies greatly depending on the source and approach. Historically, rotodynamic pumps were grouped as follows:

Rotodynamic Pumps:

- Centrifugal Pumps
- Submersible Pumps
- Vertical Pumps
- Other Pumps

Over time, pumps developed into more varied configurations that were optimized for specific applications. The lines blurred between the historic groupings. Engineers began to group pumps according to the impeller configuration (axial flow, mixed flow, and radial flow), as shown in Figure 1 and Table 1. A pump with a radial flow impeller is considered a centrifugal pump, although different sources have different definitions for the term centrifugal pump.

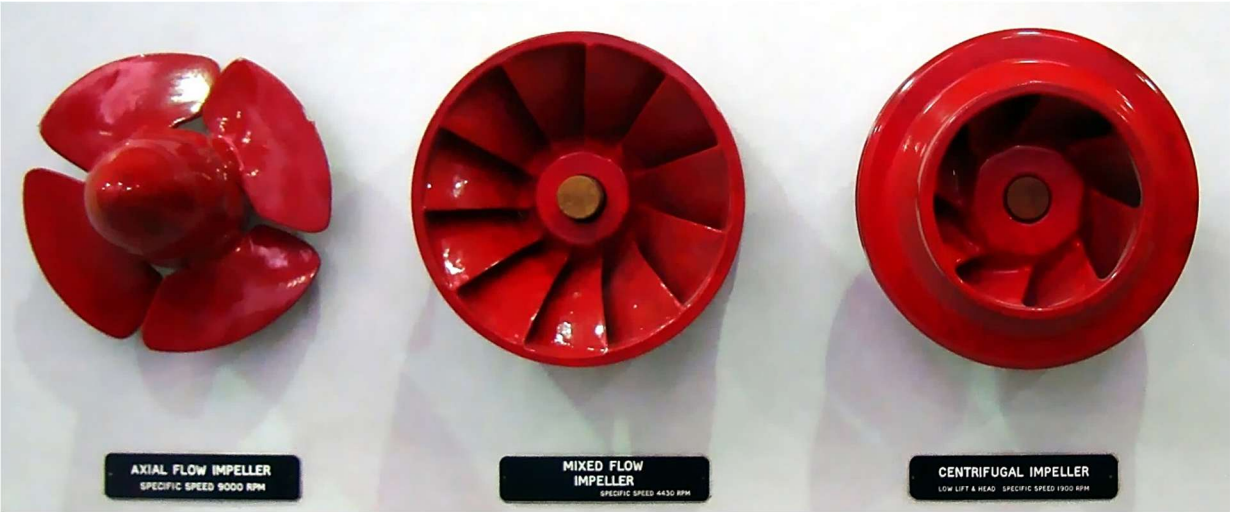
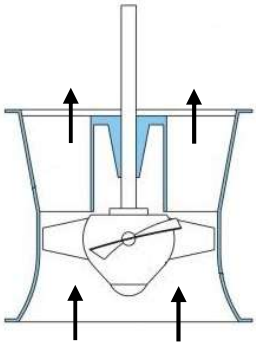
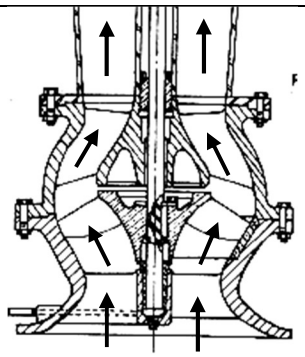
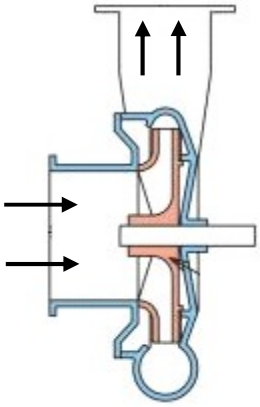


Figure 1: Example impellers for the three main impeller types for rotodynamic pumps.
Source: commons.wikimedia.org/wiki/File:Pump_Impellers-1.jpg CC BY-SA 3.0

Table 1: Comparison of Rotodynamic Pump Impeller Types

Impeller Type	Section View	Flow Change	Best Performance
Axial Flow		0º	High Flow Rate Low Pressure
Mixed Flow		40º to 60º	Medium Flow Rate Medium Pressure

			
Radial Flow (Centrifugal)		90º	Low Flow Rate High Pressure
Sources: commons.wikimedia.org/wiki/File:Axial_flow_pump-diagram.jpg (modified) by Jonasz, CC BY-SA 3.0 *commons.wikimedia.org/wiki/File:Centrifugal_pump-tech_diagram (modified) by Jonasz, CC BY-SA 3.0*			

Although the impeller classification is popular, many unique impeller configurations have been developed that don't fit neatly into the three groups in Table 1. Also, there are pump models that offer a variety of different impellers without a significant change to the physical pump configuration.

Other ways rotodynamic pumps are classified include the following:

- By the number of impellers (single stage, multistage)
- By suction type (single suction, double suction)
- By casing form (horizontal split case, vertical joint, radial split, axial split, in-line)
- By the number of pump casings (single casing, double casing)
- By discharge type (volute, guided vane, diffusers)
- By coupling type (flexible, rigid, other)
- By the position of the pump shaft (horizontal, vertical)

- By impeller bearing support (cantilever/overhung, between bearings, vertically suspended)
- By wet or dry application (submersible, wet pit, dry pit)
- By working pressure (low pressure, medium pressure, high pressure)

Standards organizations have promoted a classification system that incorporates many of the methods above, as explained in the next section.

Pump Standards Overview

In 1974, the American National Standards Institute (ANSI) and American Society of Mechanical Engineers (ASME) developed the pump standard ANSI/ASME B73.1 to provide dimensional interchangeability for common centrifugal pumps. The standards specify inlet and outlet locations, flange sizes, and base dimensions. Although originally developed for chemical and industrial process applications, ANSI standards are commonly specified for numerous locations, as they allow an easy pump exchange, such as switching to a different pump manufacturer without piping or structural changes.

In 1983, the Hydraulic Institute (HI) updated the pump standards into a multi-volume set, with pump classifications for rotary, reciprocating, and centrifugal pumps. The standard on centrifugal pumps (changed to rotodynamic pumps in 2019) included grouping pumps according to these elements:

Impeller bearing support type (overhung, between bearings, vertically suspended):
- Overhung pumps:
  - Coupling type and shaft position
- Between bearing pumps:
  - Number of impellers and casing form
- Vertically suspended pumps:
  - Number of casings and discharge type

The above classification allowed for the development of detailed pump standards for each type of pump. The standards have quality requirements and acceptance criteria for various pump designs and installation arrangements. The standards promote reliability and safety. The pump classifications allow for tighter standards.

In 1985, the American Petroleum Institute (API) updated API 610 entitled “Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries” to match the classifications in the HI Standards. API standards have strict requirements for robust pump construction, high-quality internal components, test protocols, high-pressure applications, and high-temperature applications.

In the early 2000s, HI Standards were approved by ANSI, giving them further influence.

In 2019, ANSI/HI Standards were revised by using the term “rotodynamic” pumps instead of centrifugal pumps. The definition of centrifugal pumps was clarified as a pump having a radial flow impeller. The HI Standards become more inclusive of all impeller types and pump types.

Most pump manufacturers have agreed to follow HI, API, and/or ASME pump standards. Some regulations require following these standards.

Pump Standards Numbers

HI Standards are the most commonly accepted guidelines and specifications for the design of pumping systems. Engineers involved in the design of pumping systems should be familiar with the standards. Key standards for positive displacement pumps are listed in Table 2.

Table 2: Key ANSI/HI Standards for PD Pumps	
Standard No.	Standard Title
3.1 - 3.5	Rotary Pumps for Nomenclature, Definitions, Application, and Operation
3.6	Rotary Pump Tests
4.1 - 4.6	Sealless Magnetically Driven Rotary Pumps for Nomenclature, Definitions, Application, Operation, and Test
6.1 - 6.5	Reciprocating Pumps
6.6	Reciprocating Tests
8.1 - 8.5	Direct-acting Pumps
7.1 - 7.5	Controlled-Volume Metering Pumps
7.6	Controlled-Volume Metering Pumps for Tests
9.6.9	Rotary Pumps - Guidelines for Condition Monitoring
10.1 - 10.5	Air-Operated Pumps

Rotodynamic (formerly centrifugal) pumps are covered by the relevant HI Standards listed in Table 3.

Table 3: Key ANSI/HI Standards for Dynamic (formerly Centrifugal) Pumps	
Standard No.	Standard Title
9.6.1	Rotodynamic Pumps Guideline for NPSH Margin
9.6.3	Rotodynamic Pumps – Guideline for Operating Region
9.6.5	Rotodynamic Pumps Guideline for Condition Monitoring
9.8	Rotodynamic Pumps for Pump Intake Design
14.1 & 2	Rotodynamic P ns
14.3	
14.4	aintenance
14.6	eptance Tests

API standards for pumps are c

Standard No.	Standard Title
610	Centrifugal Pumps for Petroleum, Petrochemical, and Natural Gas Industries
674	Reciprocating Positive Displacement Pumps
675	Metering Pumps
676	Rotary Positive Displacement Pumps
685	Sealless Pumps