

Impeller – Types of Impellers

Types of Impellers in Centrifugal Pumps

Impeller design is the **most significant factor** for determining performance of a centrifugal pump. A properly designed impeller **optimizes flow** while **minimizing turbulence** and **maximizing efficiency**.

The impeller of a centrifugal pump can be **of three basic types**:

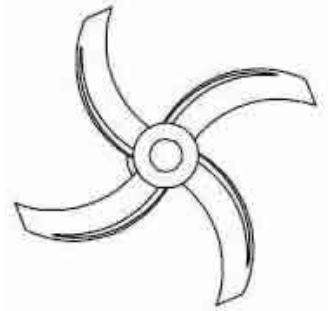
- **Open impeller.** Open impellers have the vanes free on both sides. Open impellers are structurally weak. They are typically used in small-diameter, inexpensive pumps and pumps handling suspended solids.
- **Semi-open impeller.** The vanes are free on one side and enclosed on the other. The shroud adds mechanical strength. They also offer higher efficiencies than open impellers. They can be used in medium-diameter pumps and with liquids containing small amounts of suspended solids. Because of minimization of recirculation and other losses, it is very important that a small clearance exists between the impeller vanes and the casing.
- **Closed impeller.** The vanes are located between the two discs, all in a single casting. They are used in large pumps with high efficiencies and low required **Net Positive Suction Head**. The centrifugal pumps with closed impeller are the most widely used pumps handling clear liquids. They rely on close-clearance wear rings on the impeller and on the pump casing. The closed impeller is a more complicated and expensive design not only because of the impeller, but the additional wear rings are needed.

The impeller blades can be:

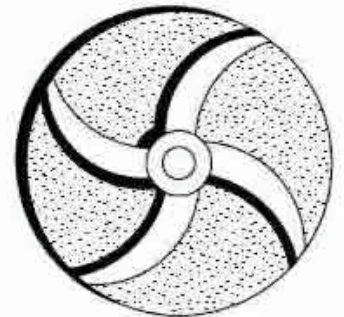
- **Backward-curved** blade design (preferred design due to negative slope of performance curve)
- **Radial** blade design
- **Forward-curved** blade design (due to positive slope conditions this design can cause pump surge)

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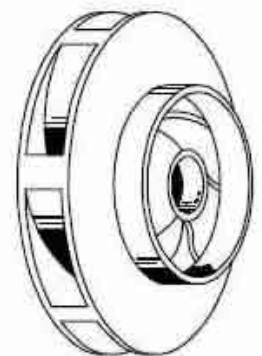
- **Single-suction.** A single-suction impeller allows liquid to enter the center of the blades from only one direction.
- **Double-suction.** A double-suction impeller allows liquid to enter the center of the impeller blades from both sides simultaneously. This reduces forces exerted on the shaft.



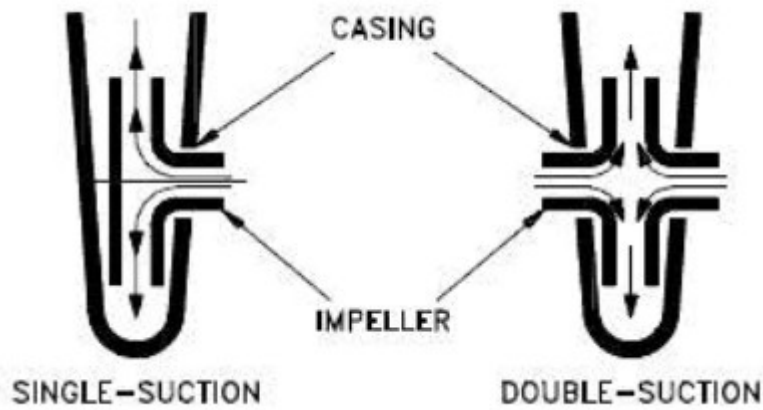
open impeller



semi-open impeller



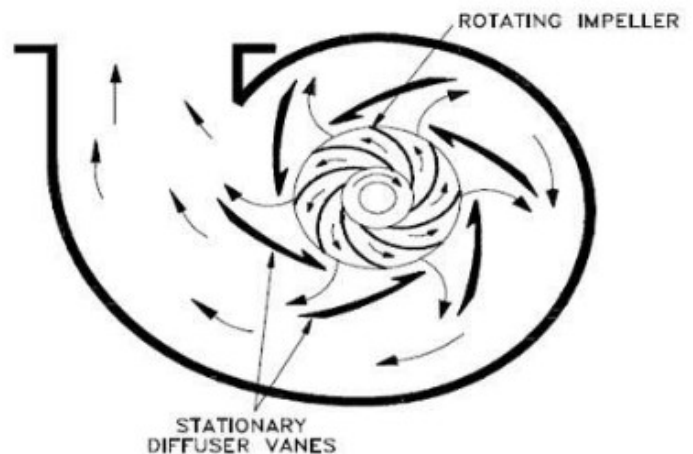
closed impeller



The output pressure slightly changes according to the design used. The blades may be open or closed. Also the **diffuser** may be fitted with fixed vanes to help guide the flow toward the exit. The energy transferred to the liquid corresponds to the velocity at the edge of the impeller. The faster the impeller revolves or the bigger the impeller is, the higher will the velocity head be.

In general, **centrifugal pumps** can be classified based on the manner in which fluid flows through the pump. It is not classification based on the impeller alone, but it is based on the design of **pump casing** and the **impeller**. The three types of flow through a centrifugal pump are:

- **radial flow**
- **mixed flow** (part radial, part axial)
- **axial flow** (propeller type)



GODWIN HL SERIES

[OUR PRODUCTS](#) > [PUMPS](#) > [DIESEL PUMPS](#) > GODWIN HL SERIES

Medium volume, high head, solids-handling

Godwin's HL series Dri-Prime pumps offer higher discharge head capabilities, to 600 feet or 260 psi with single stage impeller design. The pumps will handle raw sewage, sludges, and liquids with solids up to 3 in diameter, and offer automatic priming to 28 feet. Like the CD series Dri-Prime pumps, HL series pumps are available with:

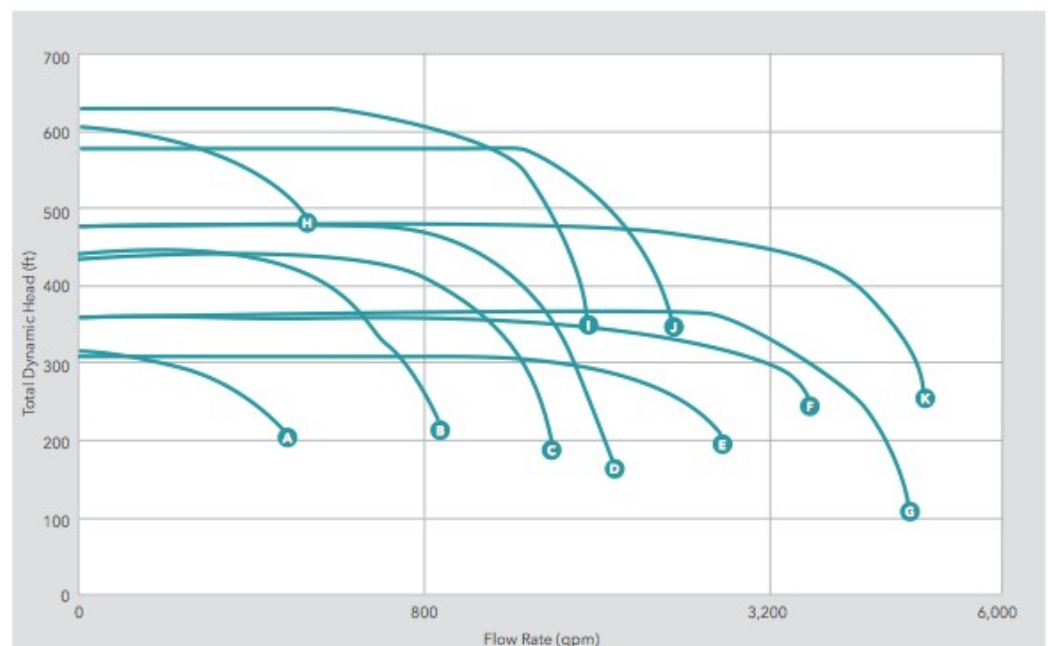
- A variety of diesel or gaseous engines or electric motors
- Dry- running oil bath seal arrangements with abrasion resistant silicon carbide interfaces
- Cast chromium steel impeller for longer life
- CD4MCu stainless steel pumpend construction for high and low pH applications (316 stainless steel available in the HL80M model only)
- Highway trailer or skid mount, both incorporating integral overnight running fuel tanks

THE HL SERIES AT A GLANCE:

- Flow: 107 to 1,200 m³/h
- Solids handling: 65 mm
- Head: 100 to 160 meters
- Extreme high head pumps: four models with heads up to 193 meters with a single-stage impeller

Performance curves

- A HL80M
- B HL100M
- C HL125M
- D HL150M
- E HL200M
- F HL225M
- G HL250M
- H HL110M
- I HL130M
- J HL160M
- K HL260M



Composite curves for comparison purposes only. Consult engineering data for exact flow and head capabilities.

GODWIN CD SERIES

[OUR PRODUCTS](#) > [PUMPS](#) > [DIESEL PUMPS](#) > [GODWIN CD SERIES](#)

High volume, medium head, large solids-handling

Godwin Pumps' CD series Dri-Prime pumps will handle raw sewage, sludges, and liquids with solids up to 5" in diameter. The pumps offer automatic priming to 28 feet, utilizing the Dri-Prime automatic priming system with no moving parts and simple maintenance. Available with a variety of diesel or gas engines or electric motors, and a cast chromium steel impeller for longer life, CD series Dri-Prime pumps are ideal for construction sites and general dewatering. Possible builds include:

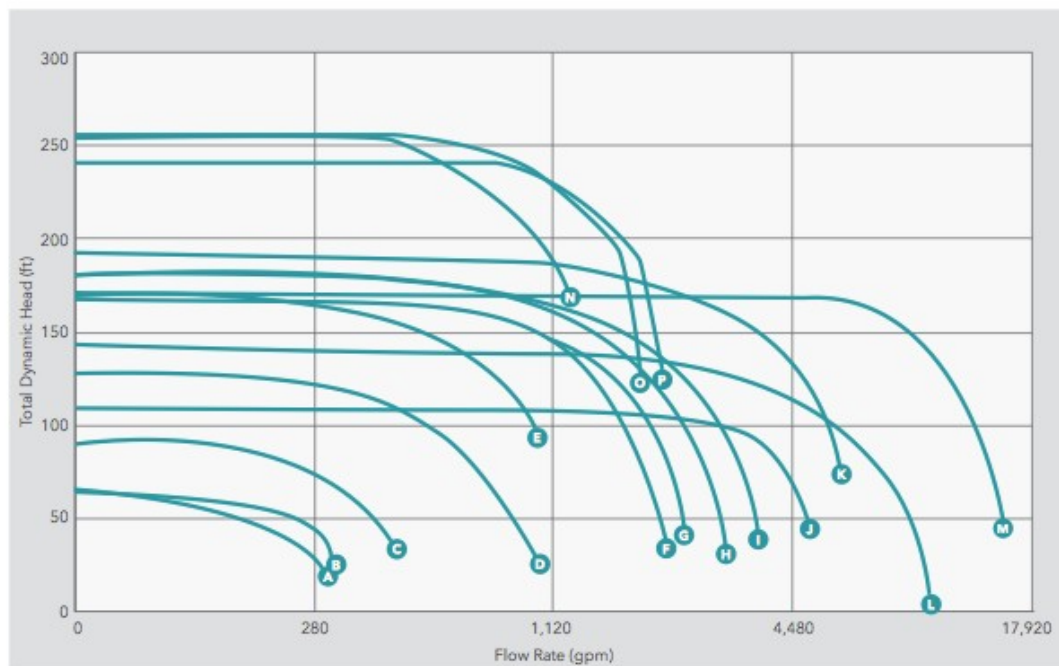
- 316 or CD4MCu stainless steel pumpend construction for high and low pH applications
- Highway trailer or skid mount, both incorporating integral overnight running fuel tanks
- Sound attenuated enclosures for any model

THE CD SERIES AT A GLANCE:

- Flow: 80 to 3,500 m³/h
- Solids handling: 125 mm
- Head: 32 to 60 meters
- Elevated head pumps: three models with heads up to 85 meters

Performance curves

- A CD75MA5
- B CD80D
- C CD80M
- D CD100M
- E CD103M
- F CD150M
- G CD200M
- H CD225M
- I CD250M
- J DPC300
- K CD300M
- L CD400M
- M CD500M
- N CD140M
- O CD160M
- P CD180M



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The impeller is placed within the volute. However, as you may have noticed in the image above, the impeller is not typically centered in the volute.

Instead, the impeller is positioned so that the outer diameter of the impeller is closest to the volute at the point just past the discharge. This point where the impeller is closest to the volute is called the cutwater.

Beginning from the cutwater, as we move around the impeller, the distance between the volute and impeller gradually increases until we reach the discharge point. This steady expansion of the area around the impeller means that pressure will build moving from the smallest clearance to the greatest and the increasing pressure will push the liquid out of the discharge point.

Three formulas or rules to explain shaft deflection

THREE FORMULAS OR RULES TO EXPLAIN SHAFT DEFLECTION T013

In my seminars I talk about the three magic formulas or rules you need to know if you want to understand how centrifugal pumps function. Here are the formulas I show:

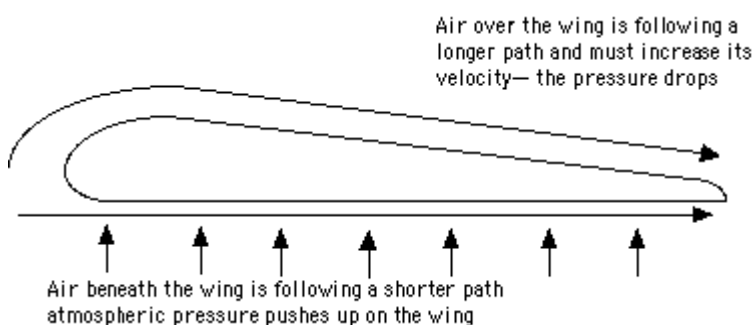
- Velocity plus head must remain a constant. As the velocity of a liquid increases, the pressure (ninety degrees to the flow) will decrease and as the velocity of a liquid decreases, the pressure (ninety degrees to the flow) will increase.
- Velocity times area must remain a constant if liquid is to flow.
- Pressure acting on an area creates a force.

Let's will look at each of these formulas in detail:

Formula #1. Velocity + head = a constant.

This formula explains how airplanes fly. It all started when the Wright brothers discovered the correct wing shape for an aircraft.

Please take a look at the following diagram. You will note that the air is flowing under the wing at some velocity. The air going over the top of the wing has a longer path to travel so its velocity must increase if it is to join with the air coming underneath the wing.



The air underneath the wing is at atmospheric pressure, but since the velocity is greater on the top of the wing the pressure falls to some value below atmospheric pressure. This causes atmospheric pressure to push on the bottom of the wing, lifting the wing, the airplane, and all the people inside, up into the air. It will continue to do so as long as the wing is moving forward and the configuration of the wing does not change.

Gravity offsets this lifting force and the aircraft flies between these two forces. This same principle explains how an automobile carburetor works, why the shower curtain comes into the bath tub when you take a shower, and how a sailboat can sail faster than the wind.

Let's skip to formula #3 to learn why the wing lifted into the air.

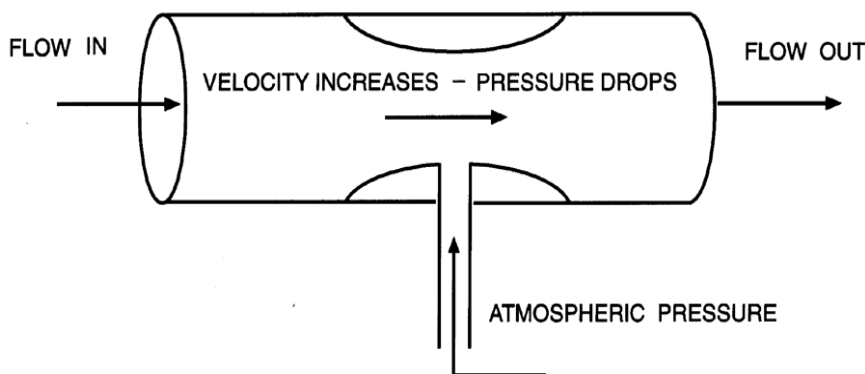
Formula #3: pressure x area = force.

PRESSURE x AREA = FORCE $\frac{\text{pounds}}{\text{inch}^2} \times \text{inch}^2 = \text{pounds}$ $\frac{\text{kilograms}}{\text{centimeter}^2} \times \text{centimeters}^2 = \text{kilograms}$	Pressure is measure in pounds per square inch (kilograms per square centimeter) Area is measured in square inches (square centimeters) The units for force then become pounds (kilograms)
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It is important for us to know the forces being generated because force over distance in a given time period is a measure of work, energy expended, or heat depending upon which units we use.

Formula #2: velocity x area = a constant

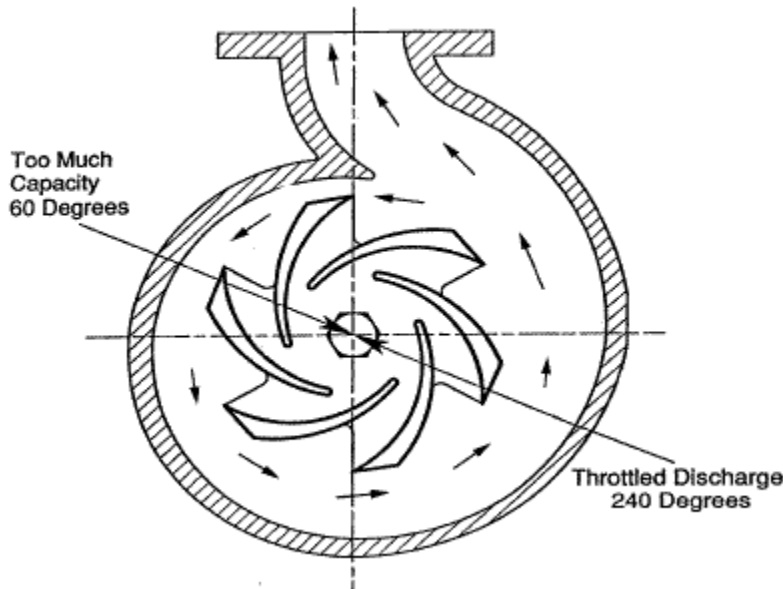
This formula explains the action of a venturi and explains what happens when the traveling liquid encounters different diameter passages in the pump and pumping system.



As the area inside a venturi goes down the velocity of the fluid goes up. This increase in velocity causes the pressure to decrease (formula #1) allowing atmospheric pressure to push a fluid into the venturi.

We use the venturi principle to push paint to a spray gun, remove air from a condenser, add chemical to a boiler etc. It is the same principle we use to get fuel to the carburetor of older automobiles.

Now we will look at the cross section of a centrifugal pump and these three formulas will explain why mechanical seals have so much trouble with shaft deflection.



This illustration describes a volute pump because the impeller is not in the center of the casing. You will note that there is less clearance between the impeller and the cut-water than there is between the impeller and the rest of the casing.

You will also note that this volute area is increasing as you move from the cutwater, around the casing to the discharge nozzle.

Circular pumps have an equal area around the impeller. They are used to pump greater quantities of liquid without having to create a high head. The volute design is the most popular design because it does produce a head.

When we removed the packing from a centrifugal pump we lost a big part of the shaft support system. It therefore becomes very important that we keep the forces equal around the impeller to prevent shaft displacement. If the force increases on one side of the impeller it will deflect the attached shaft and interfere with the performance of the mechanical seal.

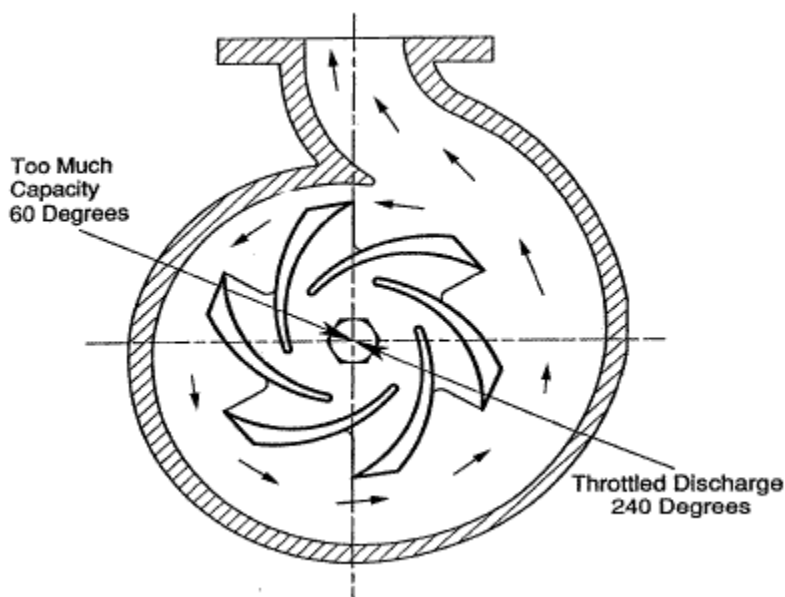
Since the impeller is symmetrical in shape (the area is the same all around the impeller) It is important that we do not let the pressure vary around the impeller or the resultant forces will not be equal (formula #3). To keep the pressure equal around the impeller, you have to keep the velocity of the liquid constant around the impeller (formula #1).

The pump could be operating at one of three points on the pump curve:

- On the right hand side of the curve where you will get a high capacity and a low head
- On the left hand side of the curve where you will get high head and low capacity
- At the best efficiency point (BEP) where the head and capacity are exactly right for that pump.

Assuming you are on the right hand side of the curve (high capacity side) the liquid velocity will increase as it approaches the discharge because there is not enough head on the system. As the liquid velocity increases the pressure will decrease (rule #1) and the shaft will deflect radially at 60° from the cutwater because pressure times area will create a force.

If you are on the left-hand side of the curve (high head) the liquid will not be able to flow out the discharge so a portion of it will recirculate by the cutwater. As the velocity of the liquid increases (rule #2) the pressure will decrease (rule #1) and the shaft will deflect radially at 240° from the cutwater because pressure times area will create a force.



Between these two extremes there is a point where there will be no radial shaft deflection caused by the wrong capacity. This is called the best efficiency point (BEP) of the pump. Look at the diagram again and note those deflections:

In another section of this CD I talk about methods of stabilizing the shaft for these “off design” operations, but the fact remains that shaft deflection continues to be a major source of mechanical seal problems and will continue to be so until the pump manufacturer accepts the responsibility of building a sensible pump.

Your solutions to this deflection problem are limited because changing the shaft material will not help. You can:

- Decrease the length of the shaft.
- Increase the diameter of the shaft.
- Convert to a double volute design.
- Support the shaft in the stuffing box with some type of support bushing.
- Put in the correct size pump and operate at the best efficiency point (BEP)
- In some limited cases a variable speed driver would help.

If you would like to calculate the actual forces involved, please see: [Shaft Bending](#)

PREVIOUS ARTICLE

NEXT ARTICLE

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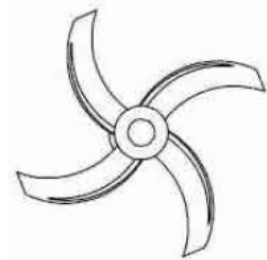
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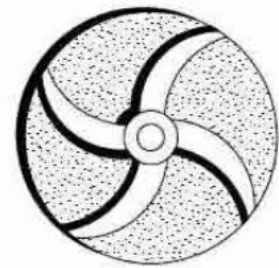
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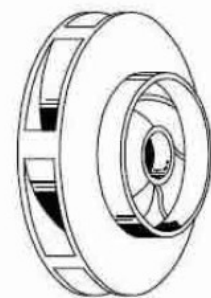
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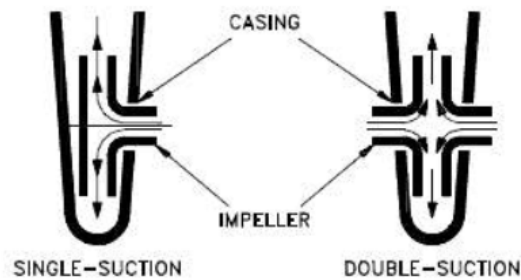


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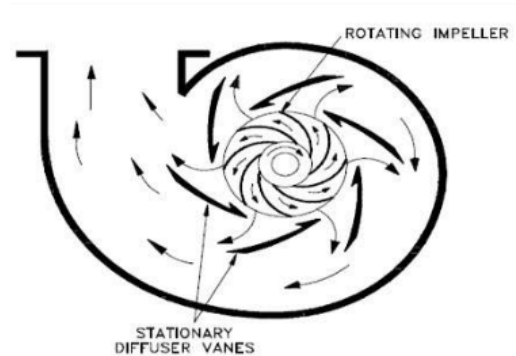
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