Fluid Machinery

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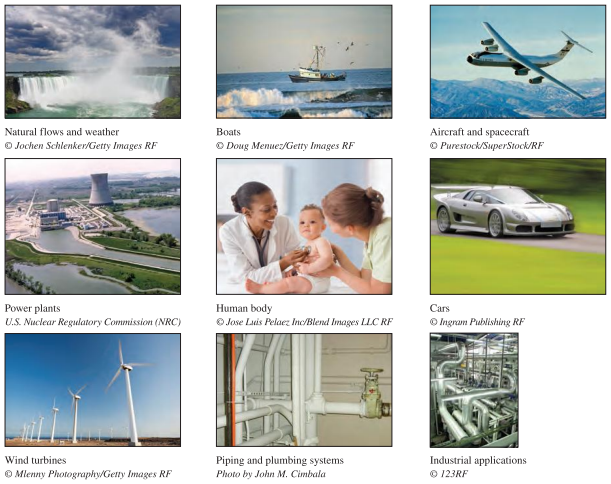
ME 101 : Introduction to Mechanical Engineering
`http://zahurul.buet.ac.bd/ME101/`

Applications of Fluid Mechanics



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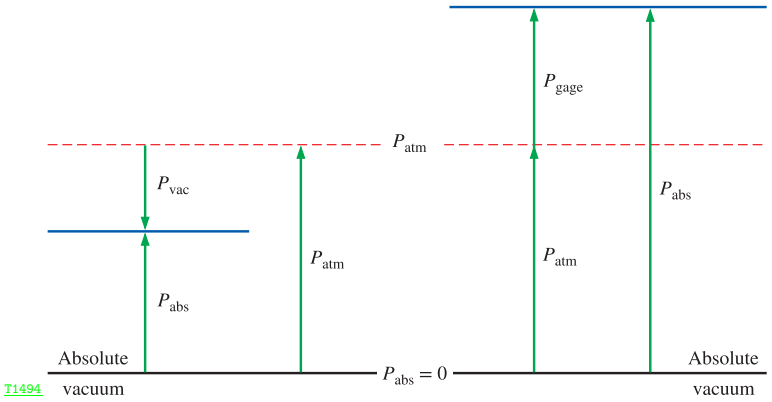
T1493

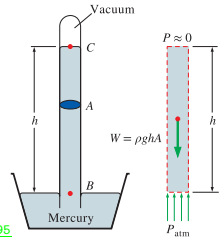
Atmospheric Pressure & Gauge Pressure



T1494

Barometer & Manometer

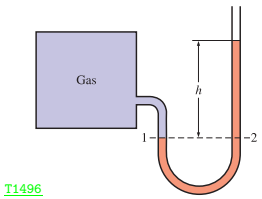
Barometer



T1495

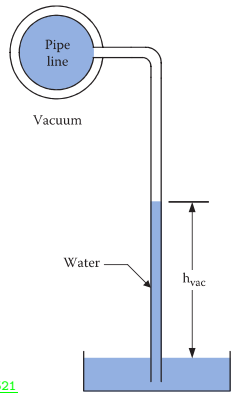
$P_{atm} = \rho g h$

Manometer



T1496

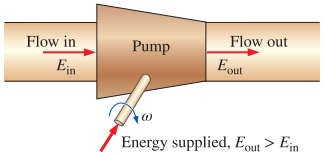
$P_2 = P_1 = P_{atm} + \rho g h$



T1521

$P = P_{atm} - \rho g h$

Classification of Turbomachinery



T1497

(a) A pump supplies energy to a fluid, (b) a turbine extracts energy from a fluid.

1. The purpose of a **pump** is to add energy to a fluid, resulting in an increase in fluid pressure, not necessarily an increase of fluid speed across the pump.
2. The purpose of a **turbine** is to extract energy from a fluid, resulting in a decrease of fluid pressure, not necessarily a decrease of fluid speed across the turbine.

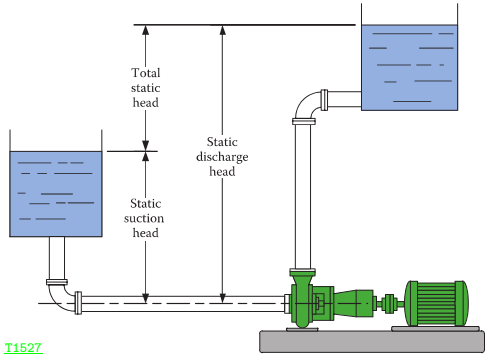
In general, fluid machines that move **liquids** are called **pumps**, but there are several other names for machines that move gases:

- A **fan** is a gas pump with relatively low pressure rise and high flow rate. Examples include ceiling fans, house fans, and propellers.
- A **blower** is a gas pump with relatively moderate to high pressure rise and moderate to high flow rate. Examples include centrifugal blowers and squirrel cage blowers in automotive ventilation systems, furnaces, and leaf blowers.
- A **compressor** is a gas pump designed to deliver a very high pressure rise, typically at low to moderate flow rates. Examples include air compressors that run pneumatic tools and inflate tires at automotive service stations, and refrigerant compressors used in heat pumps, refrigerators, and air conditioners.

T1498

	Fan	Blower	Compressor
ΔP	Low	Medium	High
$\dot{V}$	High	Medium	Low

Pump Head & Efficiency



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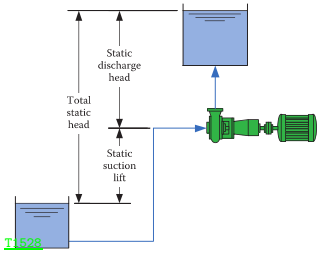
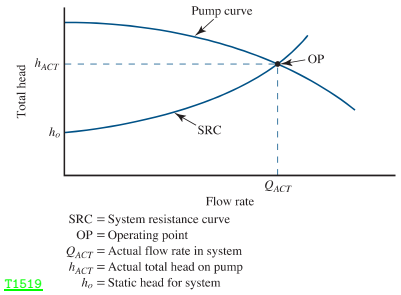


T1528

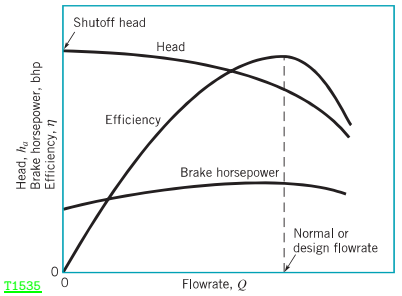
- Volume flow rate, $\dot{V} = \frac{\dot{m}}{\rho}$
- Water horsepower, $W_{whp} = \dot{m}gH$; $H \equiv$ Total static head
- Shaft horsepower, $W_{shaft} = \omega T_{shaft}$
- Pump efficiency, $\eta_{pump} = \frac{W_{whp}}{W_{shaft}}$

Pump Operating Points & Performance



SRC = System resistance curve
OP = Operating point
Q_{ACT} = Actual flow rate in system
h_{ACT} = Actual total head on pump
h_o = Static head for system

T1519



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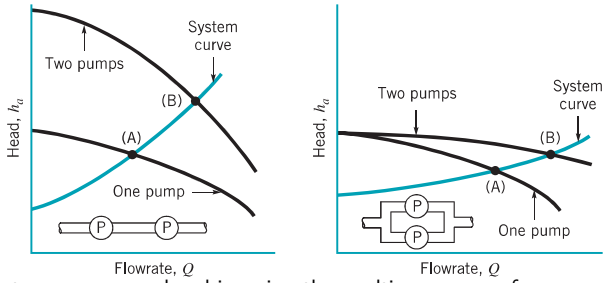
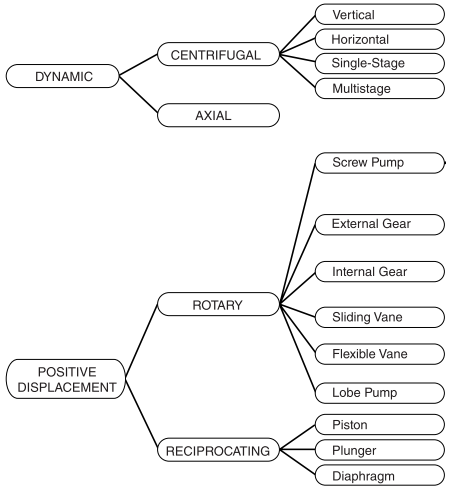
Parallel & Series Pump Operation



T1857

- When two pumps are placed in series, the resulting pump performance curve is obtained by adding heads at the same flowrate. For two identical pumps in series, both the actual head gained by the fluid and the flowrate are increased, but neither will be doubled if the system curve remains the same.
- For two identical pumps in parallel, the combined performance curve is obtained by adding flowrates at the same head. The flowrate for the system will not be doubled with the addition of two pumps in parallel if the same system curve applies. However, a significant increase in flowrate can be obtained.

Pump Classification

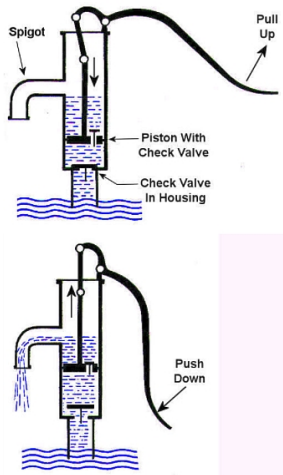


T1506

- **Positive displacement** - class of equipment such as pumps and compressors that move specific amounts of fluid from one place to another; can be rotary or reciprocating.
- **Dynamic** - class of equipment such as pumps and compressors that convert kinetic energy to pressure; can be axial or centrifugal.
- **Reciprocating pump** - a positive displacement pump that uses a plunger, piston, or diaphragm moving in a back-and-forth motion to physically displace a specific amount of fluid in a chamber.
- **Rotary pump** - a positive displacement pump that uses rotating elements to move fluids.
- **Centrifugal pump** - a dynamic pump that accelerates fluid in a circular motion.
- **Axial pump** - a dynamic pump that accelerates fluid in a straight line.

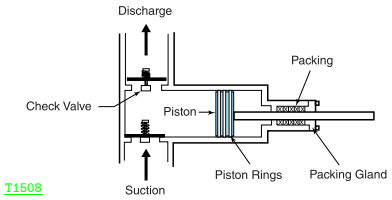
Positive Displacement Hand Pump

T1515



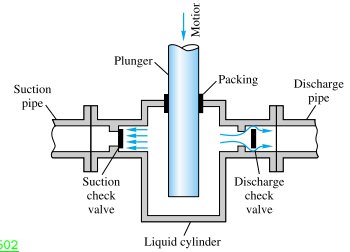
T1516

Positive Displacement Reciprocating Pump



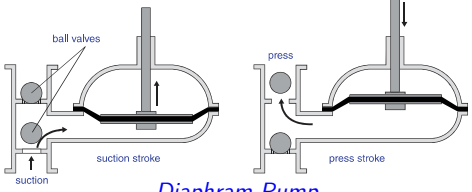
T1508

Reciprocating piston pump



T1502

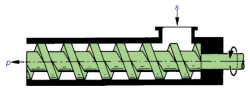
Plunger pump



T1523

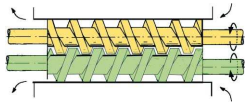
Diaphram Pump

Screw Pump



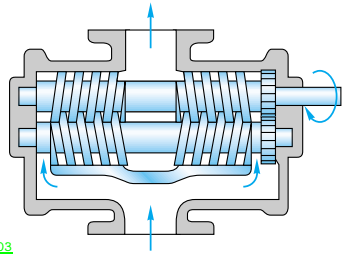
T1524

One-shaft screw pump



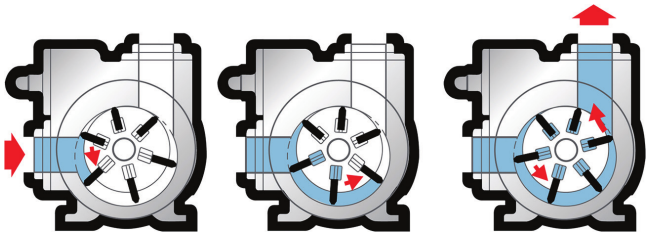
T1525

Two-axis screw pump



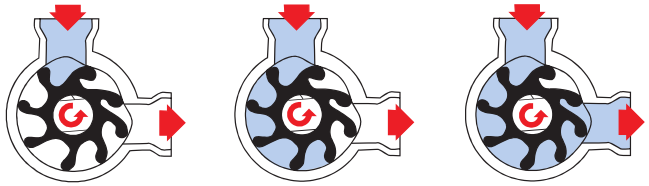
T1503

T1526



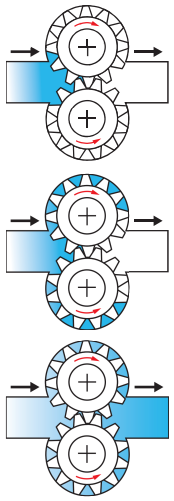
T1520

Sliding vane pump



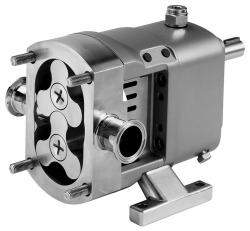
T1522

Flexible impeller pump



T1518

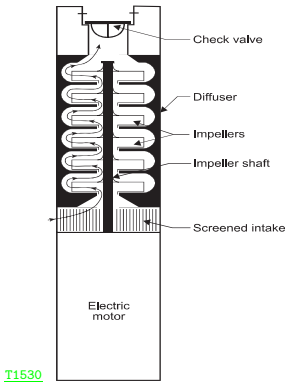
Gear pump



T1529

Lobe pump

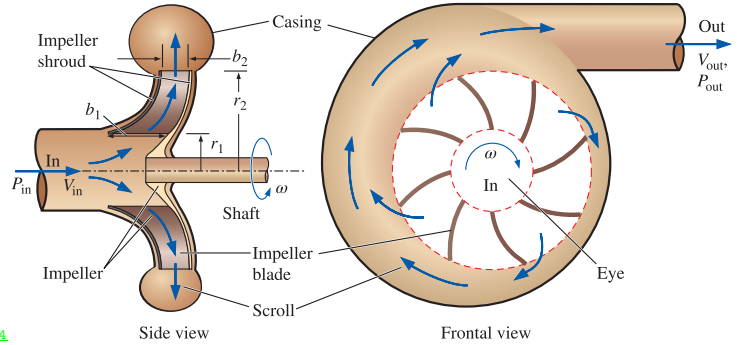
Submersible pump



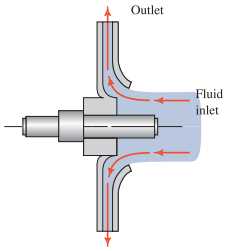
T1530

T1531

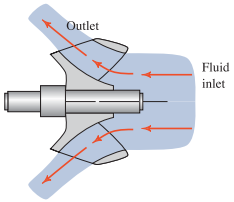
Centrifugal Pump



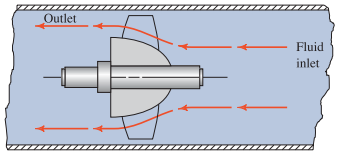
T1504



(a) Radial flow impeller



(b) Mixed flow impeller

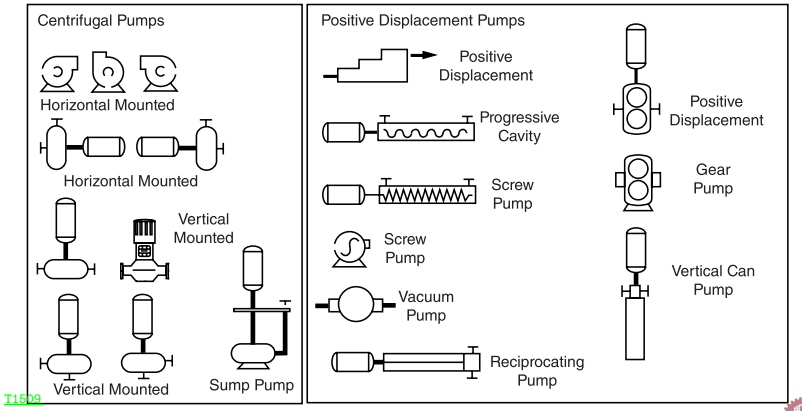


(c) Axial flow impeller (propeller)

T1506 Open impeller Closed impeller

T1505

Pump Symbols



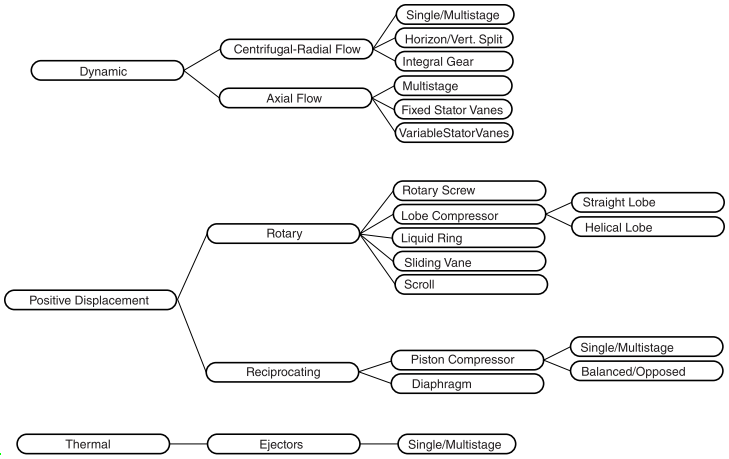
T1509

Compression

The principles of compression are:

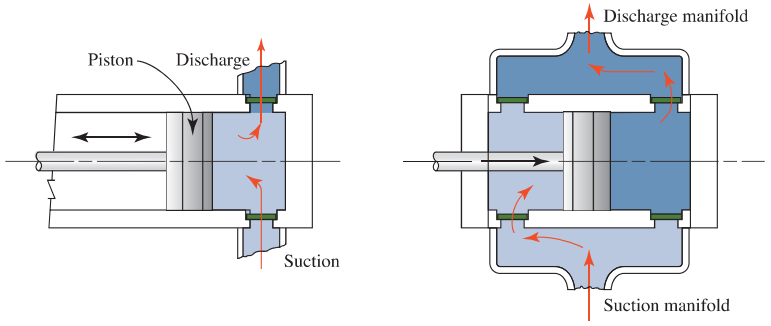
- Gases and vapors are compressible.
- Compression decreases volume.
- Compression moves gas molecules close together.
- Compressed gases will resume their original shape when released.
- Compressed gases produce heat because of molecular friction.
- The smaller the volume, the higher the pressure.
- Gas volume varies with temperature and pressure.
- Liquids and solids are not compressible (except under tremendous pressures).

Compressor Classification



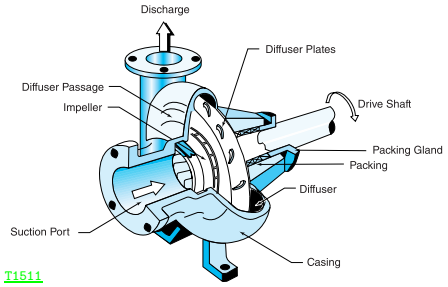
T1510

Reciprocating Compressor

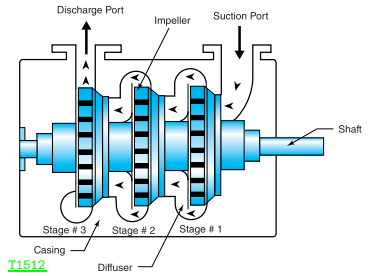


T1513 (a) Single acting— simplex (b) Double acting— duplex

Centrifugal Compressor



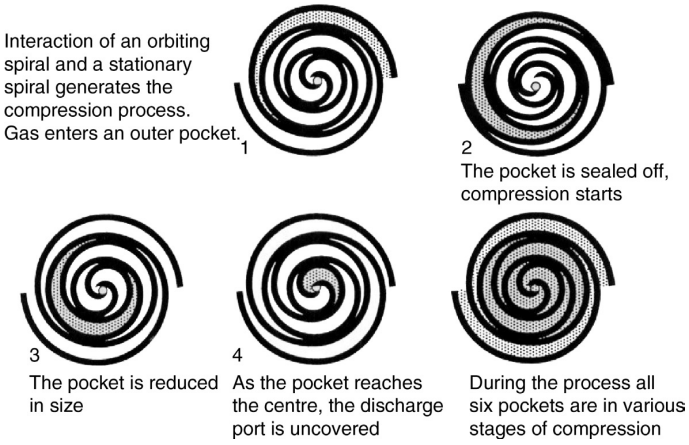
T1511



T1512

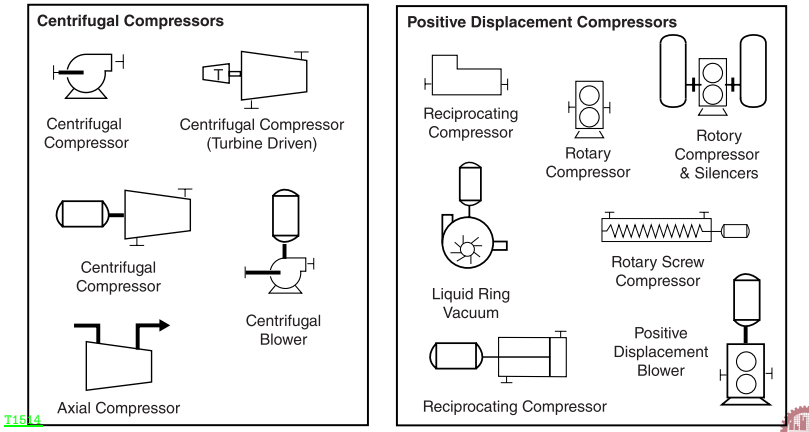
During operation, gas enters a centrifugal compressor at the suction inlet and is accelerated radially by moving impellers. In a centrifugal compressor, the impeller discharges into a circular, narrow chamber called the diffuser. This narrow opening completely surrounds the impellers. As back-pressure builds in the impeller, gas velocity is accelerated through the diffuser assembly and into a circular volute. As high-velocity gas moves through the diffuser and into the volute, kinetic energy is converted into pressure as gas speed slows in the ever-widening volute before exiting the discharge port.

Scroll Compressor



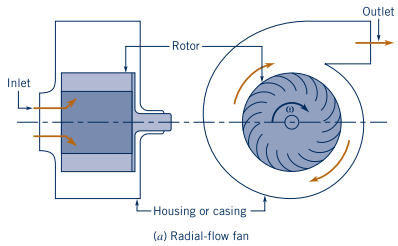
T1532

Compressor Symbols

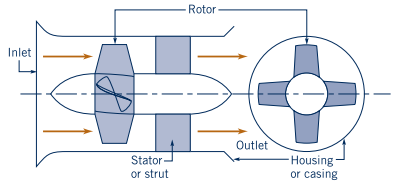


T1514

Fan



(a) Radial-flow fan



(b) Axial-flow fan

T1517

Blower

T1533

T1534