19MEE09
FLUID POWER CONTROL SYSTEMS

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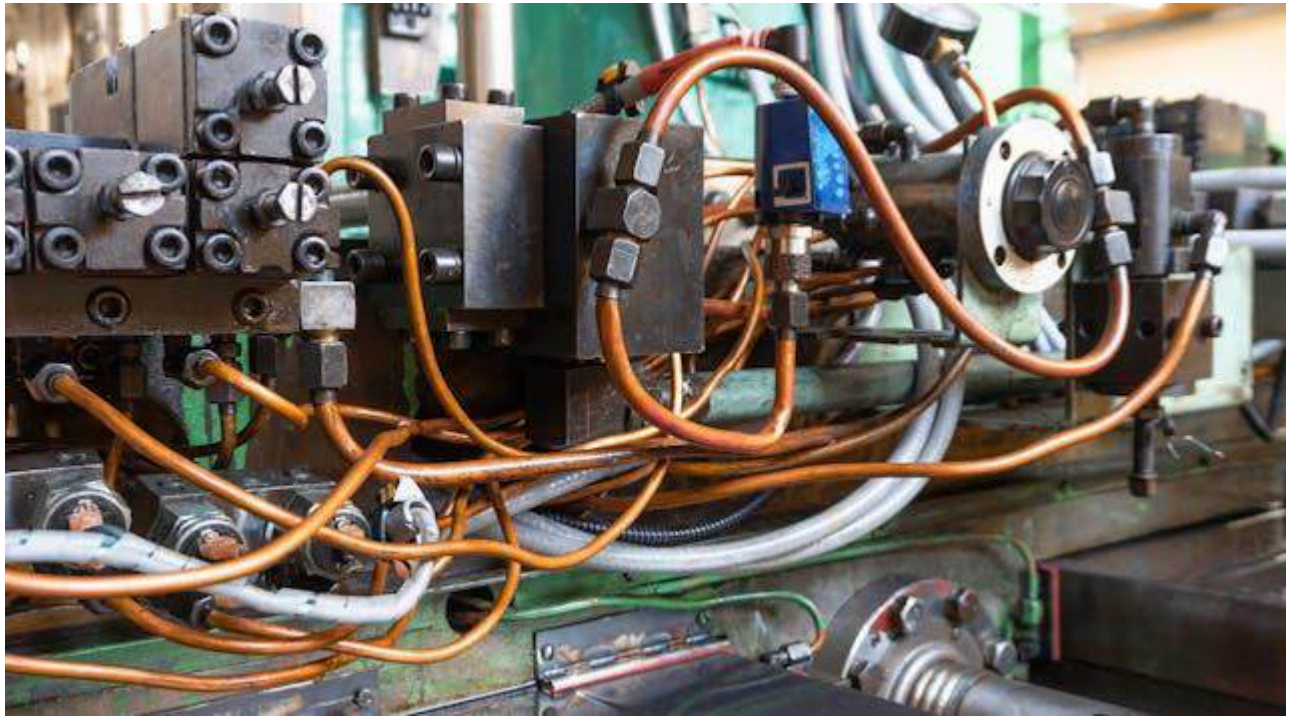
UNIT 1
FLUID POWER SYSTEMS AND FUNDAMENTALS

Introduction to fluid power, Advantages of fluid power, Application of fluid power system. Types of fluid power systems, Properties of hydraulic fluids - General types of fluids - Fluid power symbols. Basics of Hydraulics laws. (3)

FLUID POWER



FLUID POWER

Fluid power is a field of engineering and technology that involves the use of fluids (liquids or gases) to transmit and control power. It encompasses both **hydraulics,** which uses liquid fluids (like oil or water), and **pneumatics,** which uses compressed gases (typically air).

Fluid power systems are essential in various industries, as they allow for the **generation, control, and transmission of force and motion with high efficiency and reliability**.

Significance of Fluid Power

Fluid power plays a critical role in modern engineering due to its ability to handle large forces, provide precise control, and operate reliably in demanding environments. Whether powering massive excavators or enabling delicate robotic arms, fluid power systems are indispensable for efficient and effective mechanical operations.

ADVANTAGES OF FLUID POWER

1. High Power-to-Weight Ratio

- Fluid power systems can generate high force and torque from compact components, making them suitable for heavy-duty applications where space is limited.
- **2. Precise Control**
- Hydraulic and pneumatic systems allow fine control over speed, force, and position through valves and other control devices.

3. Ease of Transmission

- Power can be easily transmitted over long distances or through complex paths using flexible hoses and piping.

4. Smooth and Steady Motion

- Fluid power provides smooth and vibration-free motion, ideal for applications requiring consistent operation (e.g., elevators, presses).

5. Overload Protection

- Many fluid power systems are designed with pressure relief valves, automatically protecting the system from damage due to excessive loads.

ADVANTAGES OF FLUID POWER

6. Multiplication of Force

- Small input force can be magnified significantly through fluid mechanics, enabling lifting or moving heavy loads with minimal effort.

7. Durability and Reliability

- Properly maintained systems are durable and can operate reliably under extreme conditions, such as high loads, temperatures, and harsh environments.

8. Flexibility and Versatility

- Fluid power systems can be adapted to perform a variety of tasks, from lifting and clamping to rotating and pressing.

9. Quick Response

- Pneumatic systems, in particular, offer rapid response times, making them ideal for applications requiring high-speed operations.

10. Safety in Hazardous Environments

- Pneumatics, which use compressed air, are inherently safer in environments with fire or explosion risks since air is non-flammable.

ADVANTAGES OF FLUID POWER

11. Simple Reversal

- Reversing the direction of motion or rotation in fluid power systems can be achieved easily by controlling the flow direction.

12. Compact and Scalable

- Fluid power systems are easily scalable for small or large operations, fitting a variety of applications ranging from small tools to massive industrial equipment.

APPLICATION OF FLUID POWER SYSTEM

APPLICATION OF FLUID POWER SYSTEM

1. Industrial Applications

- **Hydraulic Presses:** Used for metal forming, stamping, and molding in manufacturing industries.
- **Injection Molding Machines:** Utilized in the plastics industry for precise shaping of products.
- **Material Handling:** Hydraulic cranes, forklifts, and conveyors for moving heavy loads.
- **Machine Tools:** Powering operations like cutting, grinding, and machining.
- **Robotics:** Actuators for controlling robotic arms and grippers.

APPLICATION OF FLUID POWER SYSTEM

2. Mobile Equipment

- **Construction Equipment:**
  - Excavators, bulldozers, backhoes, and loaders rely on hydraulics for movement and lifting.
- **Agricultural Machinery:**
  - Tractors, harvesters, and irrigation systems use fluid power for operation.
- **Transport Vehicles:**
  - Hydraulic systems for steering, braking, and suspension in buses, trucks, and trains.

3. Aerospace

- **Landing Gear Systems:** Hydraulics provide the power to extend and retract landing gear.
- **Flight Control Systems:** Control of rudders, ailerons, and flaps is often achieved using hydraulic actuators.
- **Cargo Handling:** Lifts and ramps for loading/unloading cargo planes.

APPLICATION OF FLUID POWER SYSTEM

4. Automotive

- **Braking Systems**: Hydraulic brakes in cars, motorcycles, and trucks.
- **Power Steering**: Fluid power assists in steering systems for easier maneuverability.

5. Marine Applications

- **Ship Steering Systems**: Hydraulic systems control rudders.
- **Winches and Cranes**: Used on ships for lifting cargo and anchors.
- **Stabilizers**: Hydraulics help stabilize ships in rough seas.

6. Mining and Oil & Gas

- **Drilling Rigs**: Hydraulic systems power drilling equipment in oil exploration and mining.
- **Underground Mining Machinery**: Hydraulics are used for tunneling, drilling, and hauling materials.
- **Blowout Preventers (BOP)**: Used in oil rigs to prevent uncontrolled pressure surges.

APPLICATION OF FLUID POWER SYSTEM

7. Healthcare and Medicine

- **Medical Equipment:**
  - Hydraulic hospital beds, surgical tables, and patient lifts.
- **Dental Chairs:** Pneumatic or hydraulic systems enable smooth adjustments.
- **Prosthetics:** Fluid power systems enable movement in artificial limbs.

8. Packaging and Automation

- **Pneumatic Systems:**
  - Used in automated packaging lines for sorting, filling, capping, and sealing products.
- **Pick-and-Place Robots:** Pneumatics enable rapid movement for assembly operations.
- **Conveyor Systems:** Powered by fluid systems for precise material handling.

APPLICATION OF FLUID POWER SYSTEM

9. Power Generation

- **Hydroelectric Power Plants:**
  - Turbines operate using fluid dynamics.
- **Wind Turbines:**
  - Hydraulics control blade angles for efficiency.
- **Nuclear Power Plants:**
  - Hydraulic actuators operate safety and control mechanisms.

10. Entertainment and Simulation

- **Amusement Rides:** Hydraulic systems control the movement of rides for safety and precision.
- **Simulators:** Pneumatic and hydraulic systems are used in flight, driving, and military simulators for realistic motion feedback.

APPLICATION OF FLUID POWER SYSTEM

11. Defence and Military

- **Weapon Systems:** Fluid power is used in recoil systems, missile launchers, and radar controls.
- **Tanks and Armored Vehicles:** Hydraulics power turret rotation and gun elevation.
- **Aircraft Carriers:** Hydraulic catapults launch aircraft.

TYPES OF FLUID POWER SYSTEMS

1. Hydraulic Systems

Definition: A hydraulic system is a type of fluid power system that uses liquids (typically hydraulic oil) to transmit power and perform work. Liquids, being nearly incompressible, allow for precise control and the transmission of large forces.

Characteristics:

- High-pressure operation (typically 1,000–10,000 psi or more).
- Smooth and precise control.
- High force output due to liquid incompressibility.
- Operates at moderate speeds.
- Requires robust components to handle pressure.

Components:

1. **Hydraulic Pump**: Converts mechanical energy into hydraulic energy.
2. **Reservoir**: Stores the hydraulic fluid.
3. **Hydraulic Actuators**:
    1. **Cylinders** (linear motion).
    2. **Motors** (rotational motion).
4. **Valves**: Control fluid direction, pressure, and flow (e.g., directional control valves, pressure relief valves).
5. **Filters**: Remove contaminants from the fluid.
6. **Hoses and Pipes**: Transfer hydraulic fluid between components.

Applications:

- **Construction Equipment**: Excavators, loaders, bulldozers.
- **Manufacturing**: Hydraulic presses, injection molding machines.
- **Aerospace**: Flight control systems, landing gear.
- **Automotive**: Power steering, braking systems.
- **Marine**: Steering and deck machinery.
- **Energy Sector**: Hydraulic turbines, drilling rigs.

TYPES OF FLUID POWER SYSTEMS

2. Pneumatic Systems

Definition: A pneumatic system is a fluid power system that uses compressed air (or inert gases) to transmit power and perform work. Gases are compressible, making these systems lightweight and fast.

Characteristics:

- Operates at low pressure (up to 120 psi).
- Faster response times compared to hydraulics.
- Suitable for low-to-medium force applications.
- Cleaner (air is the medium), but less precise than hydraulics.
- No risk of fluid leaks.

Components:

1. **Compressor**: Converts mechanical energy into compressed air.
2. **Receiver Tank**: Stores compressed air.
3. **Actuators**:
    1. **Cylinders** (linear motion).
    2. **Air motors** (rotational motion).
4. **Valves**: Regulate pressure, flow, and direction (e.g., flow control valves, solenoid valves).
5. **Filters, Regulators, and Lubricators (FRL Unit)**: Ensure clean air, control pressure, and add lubrication.
6. **Pipes and Tubing**: Transport compressed air to components.

Applications:

- **Manufacturing and Assembly**: Robotic arms, pick-and-place systems.
- **Power Tools**: Air drills, sanders, and nail guns.
- **Transportation**: Air brakes in buses and trains.
- **Packaging Industry**: Bottle filling, sealing, and labeling systems.
- **HVAC Systems**: Dampers and valve actuators.

TYPES OF FLUID POWER SYSTEMS

3. Hybrid Fluid Power Systems

Definition:

A hybrid fluid power system combines hydraulic and pneumatic principles to leverage both benefits. For example, compressed air can drive a hydraulic pump or hydraulic systems can store energy using pneumatic accumulators.

Characteristics:

- Increased energy efficiency.
- Utilizes both compressibility (air) and incompressibility (liquid) properties.
- Suitable for specialized or high-performance applications.

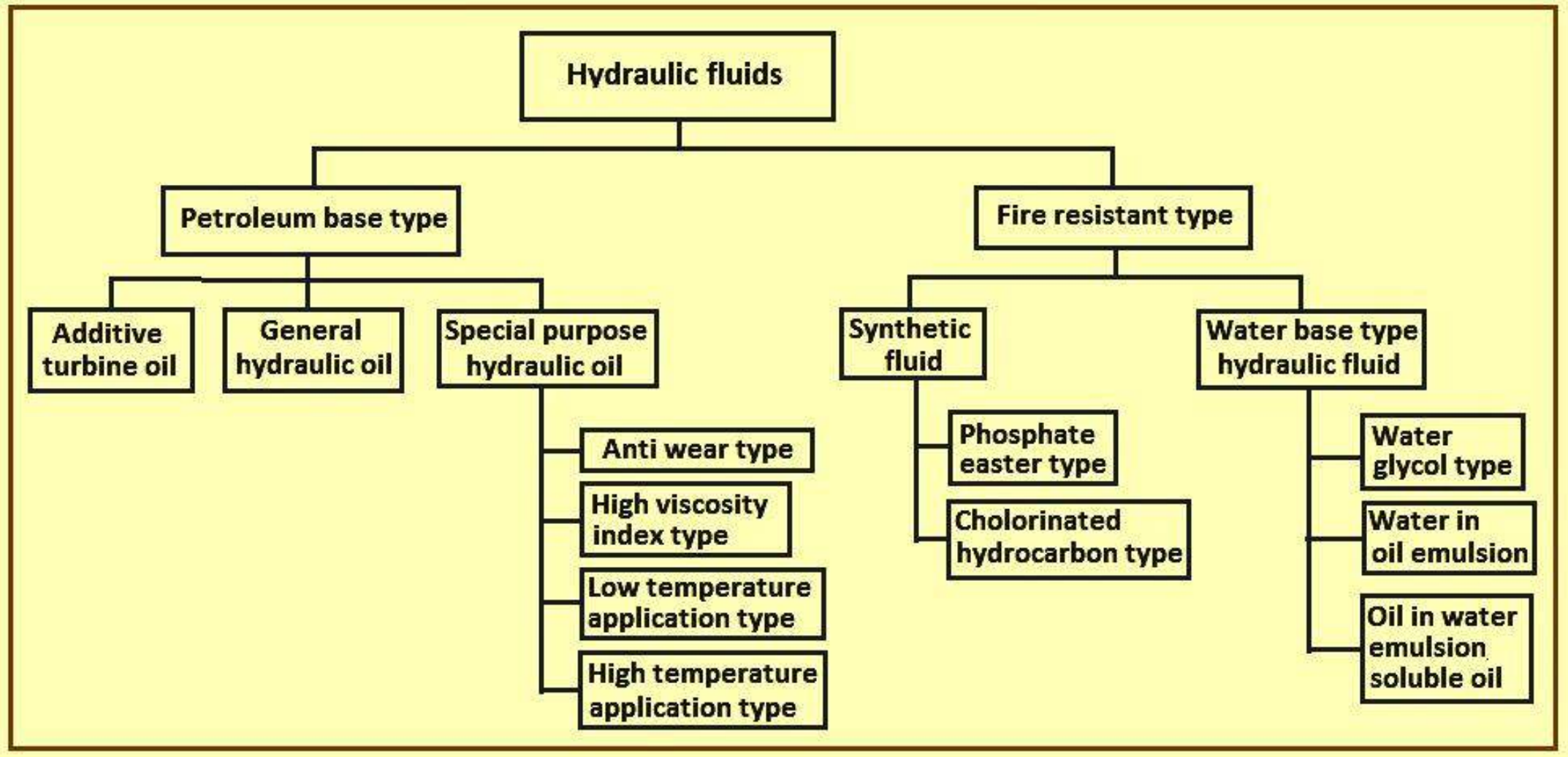
Components:

1. **Air-Driven Hydraulic Pumps**: Generate hydraulic pressure using compressed air.
2. **Pneumatic and Hydraulic Actuators**: Work in conjunction for specific tasks.
3. **Valves and Controls**: Manage both air and fluid flow.
4. **Accumulators**: Store energy (pneumatic or hydraulic).
5. **Energy Recovery Systems**: Capture and reuse energy during operation.

Applications:

- **Industrial Automation**: Energy-efficient systems for heavy-duty machinery.
- **Renewable Energy**: Hydraulic wind turbines with pneumatic energy storage.
- **Military**: Advanced control systems for vehicles and equipment.
- **Medical Devices**: Surgical robots combining hydraulic precision and pneumatic speed.

TYPES OF HYDRAULIC FLUIDS



DESIRABLE PROPERTIES OF HYDRAULIC FLUIDS

1. Viscosity Characteristics

- **Stable Viscosity:** Should maintain optimal viscosity across a wide range of temperatures.
- **Low Viscosity Change:** Minimal changes in viscosity with temperature variations (high viscosity index).

2. Thermal Stability

- Should resist breakdown at elevated temperatures.
- Must have good heat transfer properties to dissipate heat effectively.

3. Lubricating Ability

- Must provide proper lubrication to reduce wear and friction between moving parts.

4. Oxidation Resistance

- Should resist oxidation to prevent the formation of sludge, varnish, and corrosive by-products.

5. Low Compressibility

- Should be incompressible to ensure efficient power transmission.

6. Chemical Stability

- Should resist chemical degradation over time and under operating conditions.

7. Corrosion Protection

- Should protect hydraulic system components from rust and corrosion.

DESIRABLE PROPERTIES OF HYDRAULIC FLUIDS

8. Foaming Resistance

- Should resist foaming to maintain efficient power transmission and prevent cavitation.

9. Good Demulsibility

- Should separate water quickly to prevent emulsification, which can degrade performance.

10. Fire Resistance

- For specific applications, hydraulic fluids should have fire-resistant properties to minimize risks in high-temperature environments.

11. Low Toxicity

- Should be safe to handle, with minimal environmental and health impacts.

12. High Bulk Modulus

- Should ensure stiffness in the fluid to prevent energy loss in transmission.

13. Compatibility

- Should be compatible with seals, gaskets, and materials in the hydraulic system.

14. Cleanliness

- Must be free of contaminants like dirt and particles to prevent system damage.

15. Low Volatility

- Should have a low vapor pressure to minimize evaporation losses.

BASICS OF HYDRAULICS LAWS

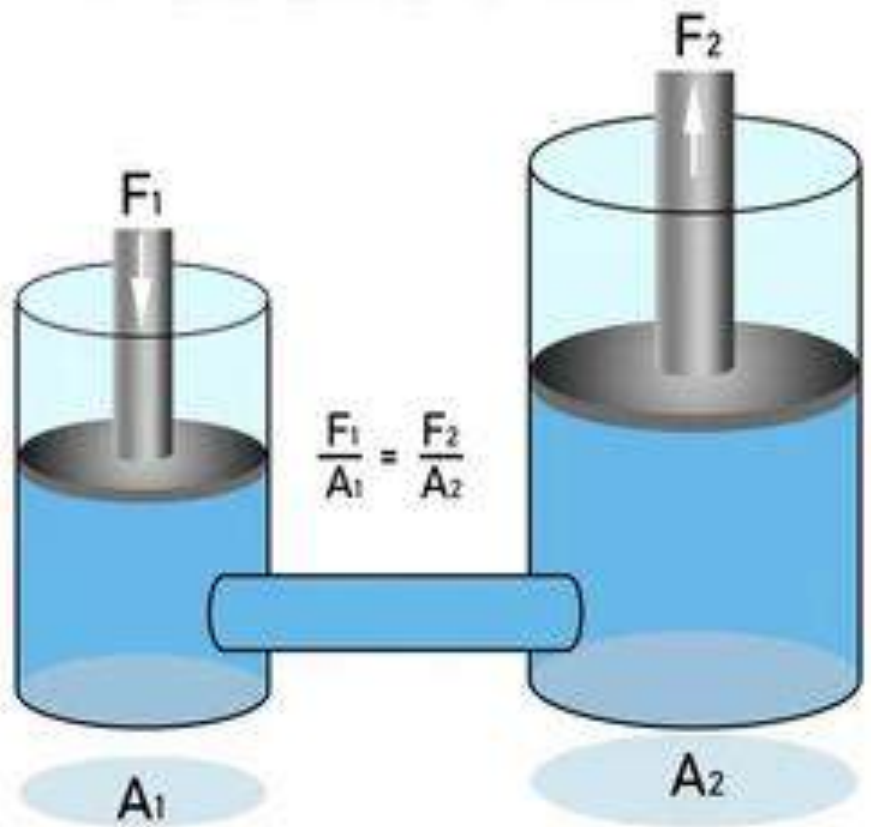
Law	Key Concept	Application
Pascal's Law	Pressure transmission in fluids	Force multiplication in hydraulics
Continuity Equation	Conservation of mass flow	Design of pipes and nozzles
Bernoulli's Principle	Conservation of energy in fluid flow	Flow analysis and pressure drop
Boyle's Law	Pressure-volume relationship for gases	Pneumatics and air removal in systems
Archimedes' Principle	Buoyant force on submerged objects	Level sensing in reservoirs
Newton's Second Law	Force is proportional to momentum change	Actuator force calculation
Hydrostatic Law	Pressure increases with depth	Tank and reservoir design

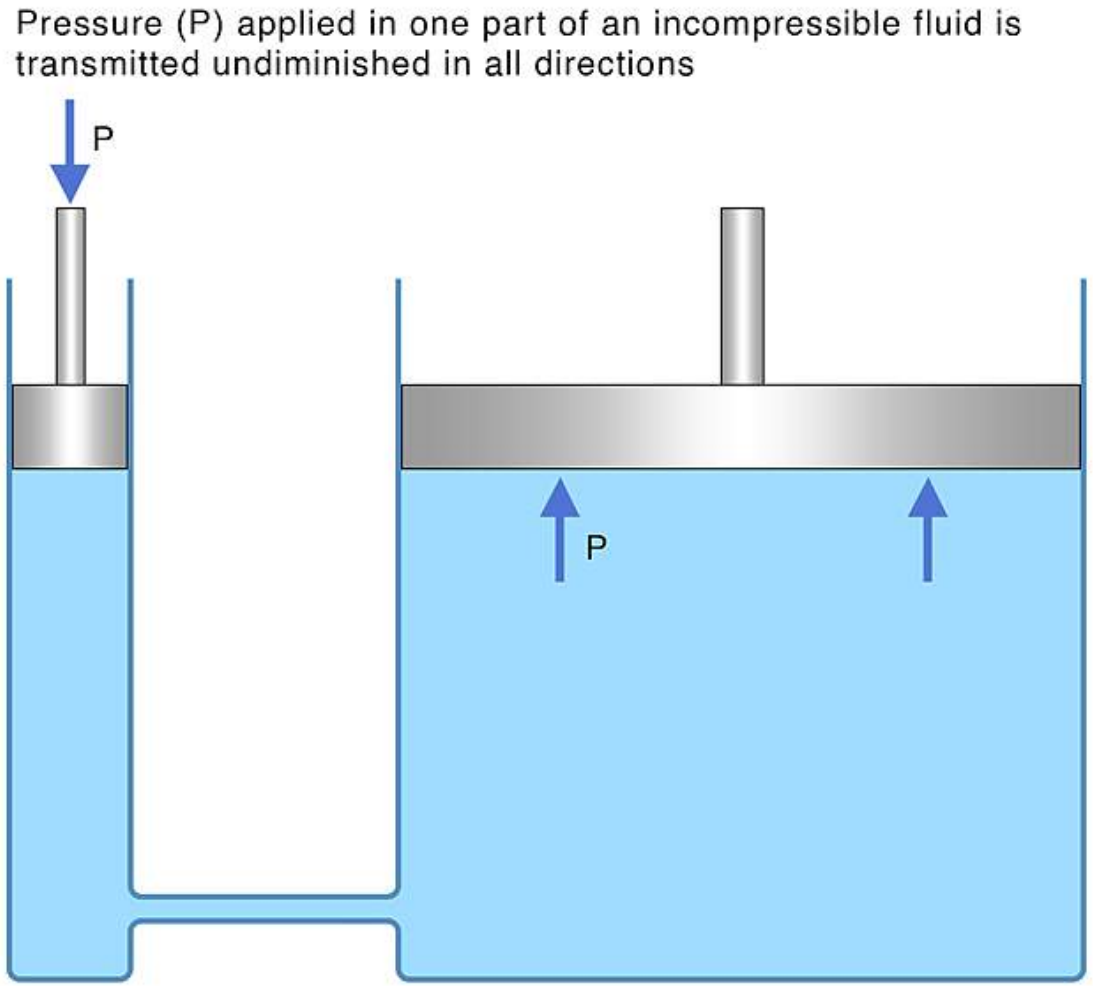
PASCAL'S LAW

Pascal's law, also known as Pascal's principle, states that any change in pressure in a confined fluid is transmitted throughout the fluid without any loss. This means the pressure at any point in the fluid is the same in all directions.

- The pressure change is transmitted to all parts of the fluid and the walls of the container.
- The pressure acts at right angles to any surface in contact with the fluid.
- The pressure at a point in a static fluid is the same across all planes passing through that point.

PASCAL'S LAW


F₂
F₁
F₁/A₁ = F₂/A₂
A₁
A₂


Pressure (P) applied in one part of an incompressible fluid is transmitted undiminished in all directions
P
P

PASCAL'S LAW

A hydraulic press has a small piston with a diameter of 0.05 m and a large piston with a diameter of 0.20 m. If a force of 150 N is applied to the small piston,

calculate:

1. The pressure applied to the small piston.
2. The force exerted by the large piston.

PASCAL'S LAW

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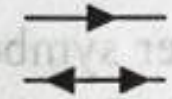
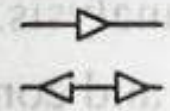
Pressure on the small piston: 76.4 kPa

The force exerted by the large piston: 2400 N

HYDRAULIC SYMBOLS

3.2. PUMPS AND MOTORS

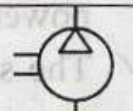
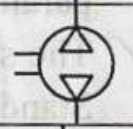
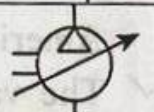
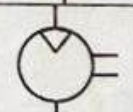
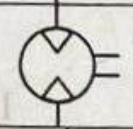
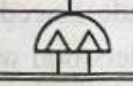
✓ Pumps and motors are the energy producing devices to the fluid power systems. The basic general graphic symbols related to them are given below :

Circle		Represents a pump, motor, or any rotary devices.
Filled triangle		Indicates the direction of flow for hydraulic fluid (system).
Unfilled triangle		Indicates the direction of flow for pneumatic fluid (system).
Line with an arrow		Indicates the variable displacement.

✓ Table 3.1 presents the various standard symbols used for pumps and motors.

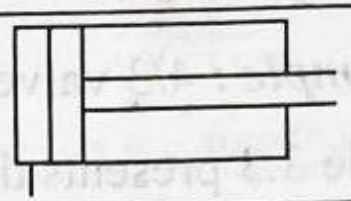
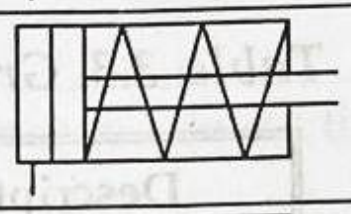
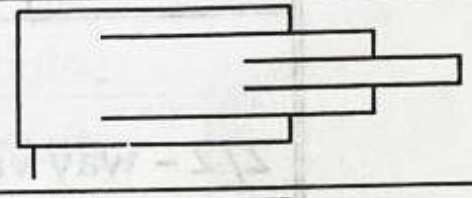
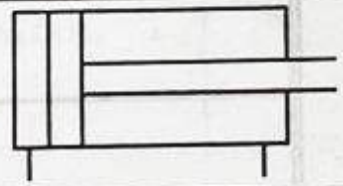
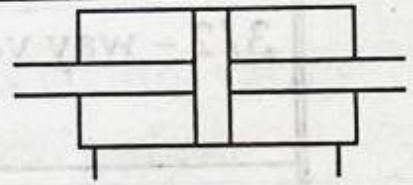
HYDRAULIC SYMBOLS

Table 3.1. Graphic symbols used for pumps and motors

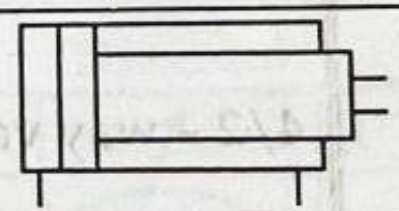
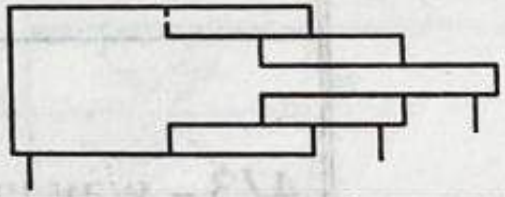
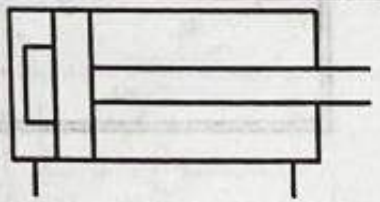
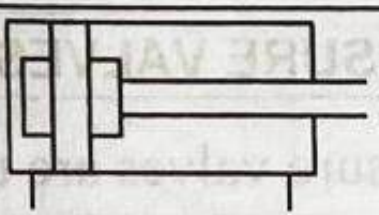
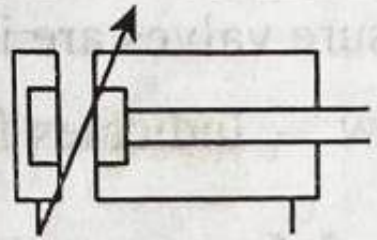
Description	Symbol	Diagram	
		Hydraulic	Pneumatic
Fixed displacement, unidirectional pump	S1		
Fixed displacement, bidirectional pump	S2		
Variable displacement, unidirectional pump	S3		
Variable displacement, bidirectional pump	S4		
Fixed displacement, unidirectional motor	S5		
Fixed displacement, bidirectional motor	S6		
Variable displacement, unidirectional motor	S7		
Variable displacement, bidirectional motor	S8		
Oscillating motor	S9		

HYDRAULIC SYMBOLS

Table 3.2. Graphic symbols used for cylinders

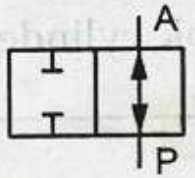
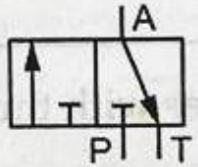
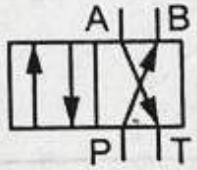
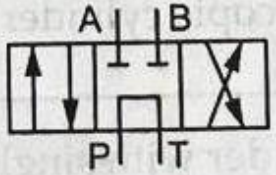
Description	Symbol	Diagram
Single acting cylinder, returned by external force	S10	
Single acting cylinder, with spring return	S11	
Single acting telescopic cylinder	S12	
Double acting cylinder with single piston rod	S13	
Double acting cylinder with through piston rod	S14	

HYDRAULIC SYMBOLS

Differential cylinder	S15	
Double acting telescopic cylinder	S16	
Double acting cylinder with single end position cushioning	S17	
Double acting cylinder with end position cushioning at both ends	S18	
Double acting cylinder with adjustable end position cushioning at both ends	S19	

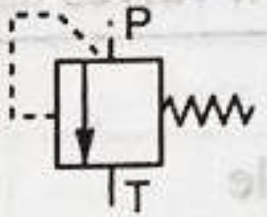
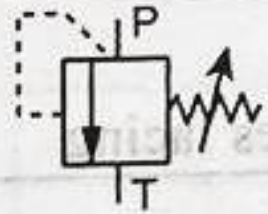
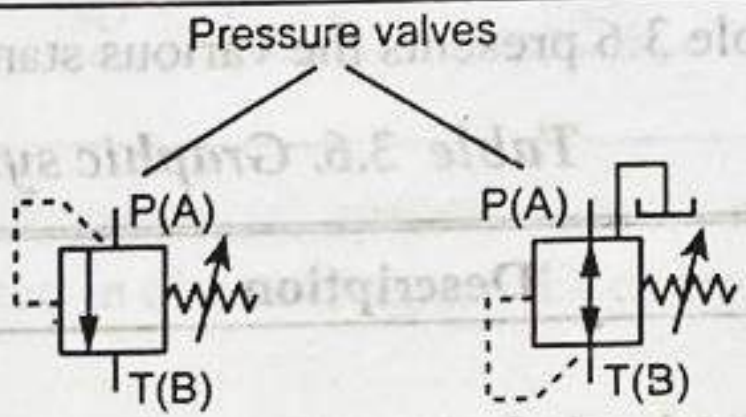
HYDRAULIC SYMBOLS

Table 3.3. Graphic symbols used for directional control valves

Description	Symbol	Diagram
2/2 – way valve	S20	
3/2 – way valve	S21	
4/2 – way valve	S22	
4/3 – way valve	S23	

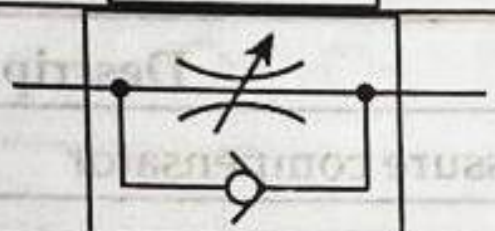
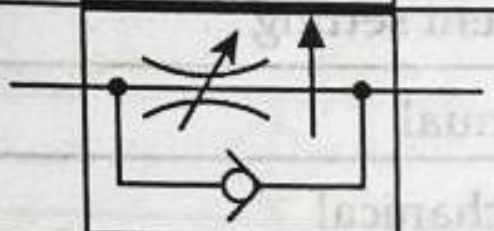
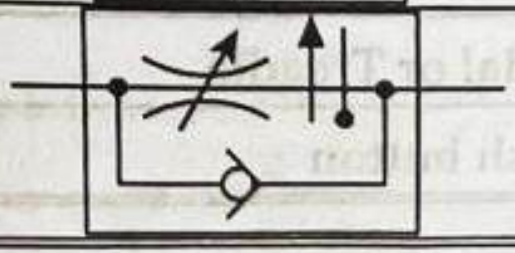
HYDRAULIC SYMBOLS

Table 3.4. Graphic symbols used for pressure valves

Description	Symbol	Diagram
Set pressure relief valve	S24	
Adjustable pressure relief valve	S25	
3-way pressure regulator	S26	

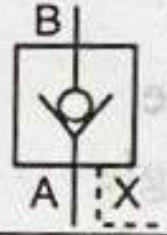
HYDRAULIC SYMBOLS

Table 3.5. Graphic symbols used for flow control valves

Description	Symbol	Diagram
Adjustable flow control valve with throttle	S27	
Adjustable flow control valve with orifice	S28	
Adjustable with bypass	S29	
Adjustable and pressure compensated with bypass	S30	
Adjustable temperature and pressure compensated	S31	

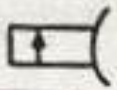
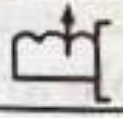
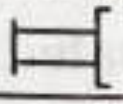
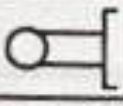
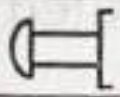
HYDRAULIC SYMBOLS

Table 3.6. Graphic symbols used for non-return valves

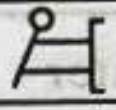
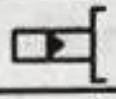
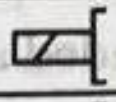
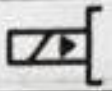
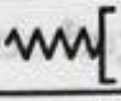
Description	Symbol	Diagram
Spring loaded non-return valve	S32	
Unloaded non-return valve	S33	
Pilot controlled non-return valve	S34	
Shut-off valve	S35	

HYDRAULIC SYMBOLS

Table 3.7. Graphic symbols used for methods of operation

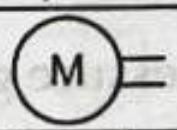
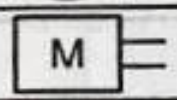
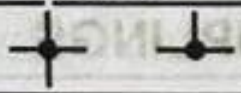
Description	Symbol	Diagram
Pressure compensator	S36	
Detent setting	S37	
Manual	S38	
Mechanical	S39	
Pedal or Treadle	S40	
Push button	S41	

HYDRAULIC SYMBOLS

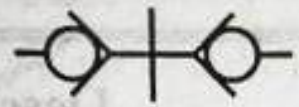
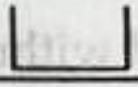
Description	Symbol	Diagram
Lever	S42	
Pilot pressure	S43	
Solenoid	S44	
Solenoid controlled, pilot pressure operated	S45	
Spring	S46	
Servo	S47	

HYDRAULIC SYMBOLS

Table 3.8. Graphic symbols used in energy transmission

Description	Symbol	Diagram
Hydraulic pressure source	S48	
Electric motor	S49	
Non-electric drive unit	S50	
Pressure, power, return line		
Control (pilot) line		
Drain line		
Plugged port	S51	
Flexibtle line	S52	
Line connection	S53	

HYDRAULIC SYMBOLS

Line crossing	S54	
Exhaust, continuous	S55	
Quick-acting coupling connected with mechanically opening non-return valves	S56	
Vented reservoir	S57	
Pressurized reservoir	S58	
Filter	S59	
Cooler	S60	
Heater	S61	

HYDRAULIC SYMBOLS

Description	Symbol	Diagram
Accumulator	S62	
Spring loaded accumulator	S63	
Gas charged accumulator	S64	
Weighted accumulator	S65	

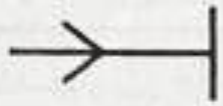
HYDRAULIC SYMBOLS

Table 3.9. Graphical symbols used for measuring devices

Description	Symbol	Diagram
Pressure gauge	S66	
Thermometer	S67	
Flowmeter	S68	
Filling level indicator	S69	

HYDRAULIC SYMBOLS

Table 3.10. Graphical symbols used for measuring devices

Description	Symbol	Diagram
Coupled without check valve	S70	
Coupled with check valve	S71	
Half of quick release-coupling without valve	S72	
Half of quick release-coupling with check valve	S73	

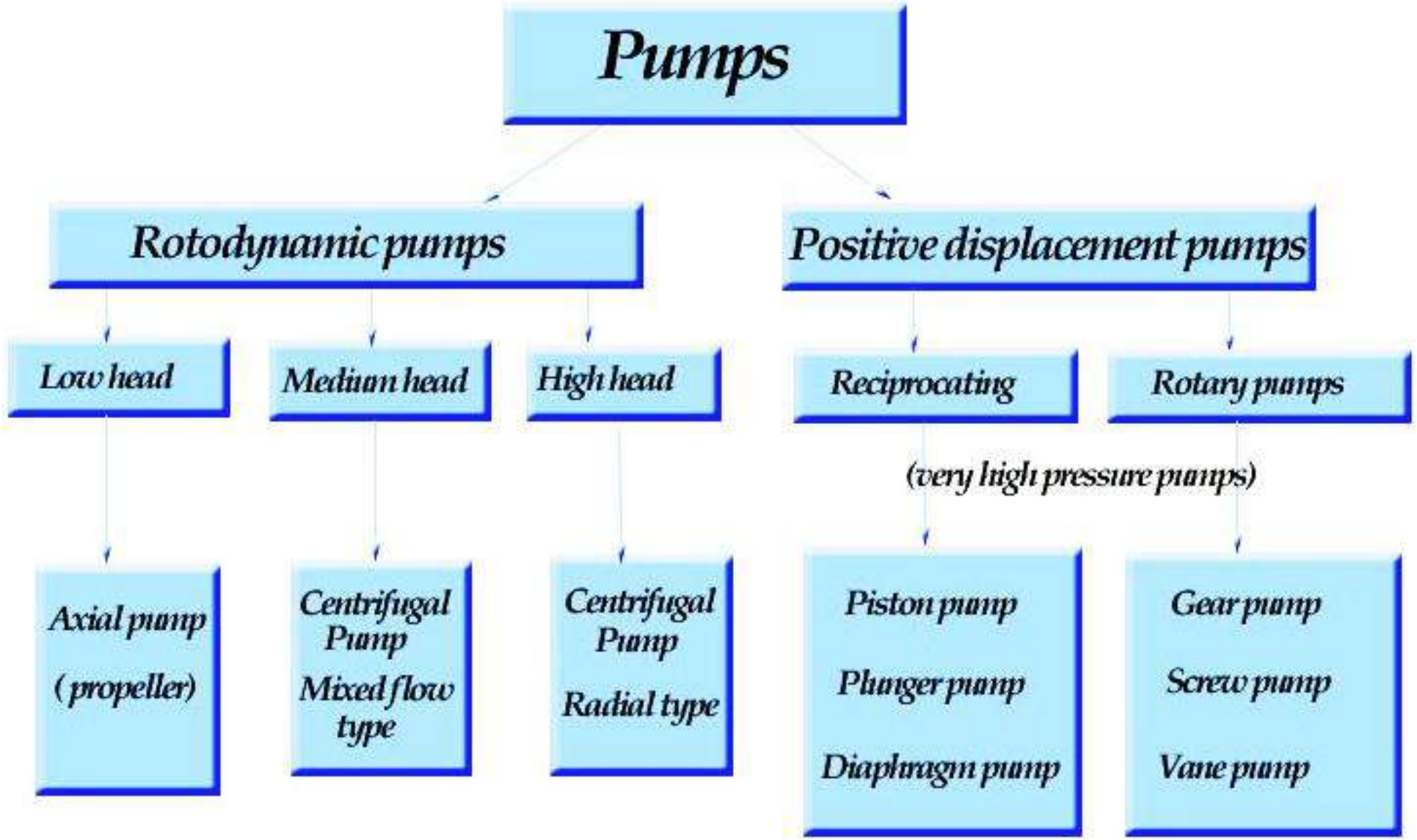
UNIT 2 FLUID POWER DRIVES

Sources of Hydraulic Power: Pumping theory - Pump classification - Gear pump, Vane Pump, piston pump, construction and working of pumps - pump performance - Variable displacement pumps. Hydraulic motors - principle of working, calculation of discharge, power and efficiency. Fluid Power Actuators: Linear hydraulic actuators - Types of hydraulic cylinders - Single acting, double acting special cylinders - tandem – Rod-less - Telescopic. Cushioning mechanism. Rotary actuators. (8)

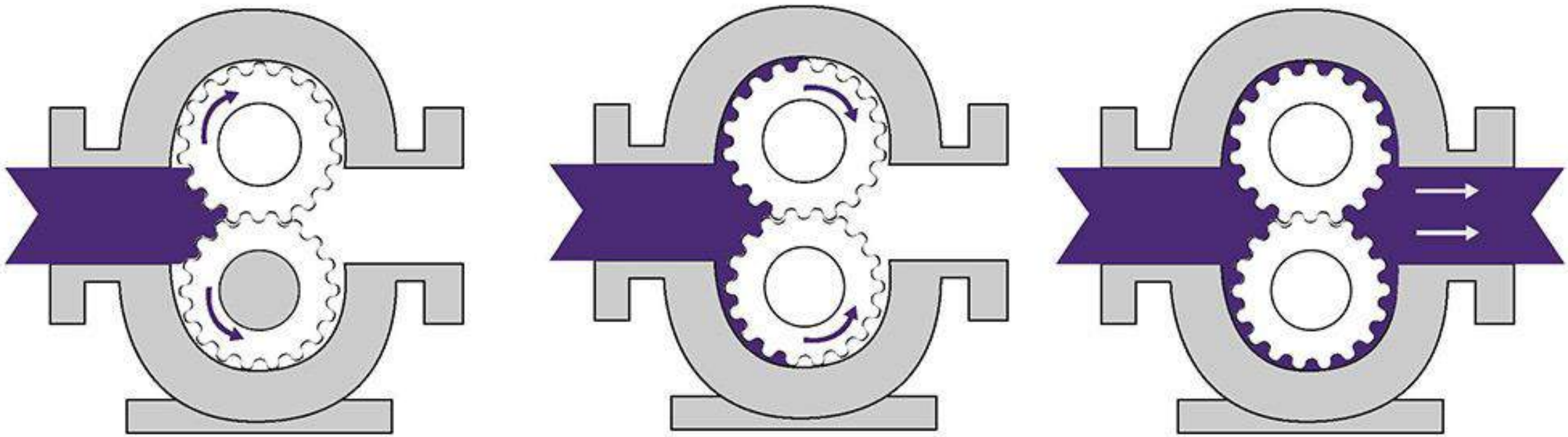
PUMP

- A Pump is generally used to induce flow or raise the pressure of a liquid.
- Pump converts mechanical energy to hydraulic energy.
- The energy conversion depends on the type of pump and how it's powered.
- The efficiency of a pump depends on its size and maintenance.
- Well-maintained, high-quality pumps can be up to 90% efficient.

PUMP CLASSIFICATION

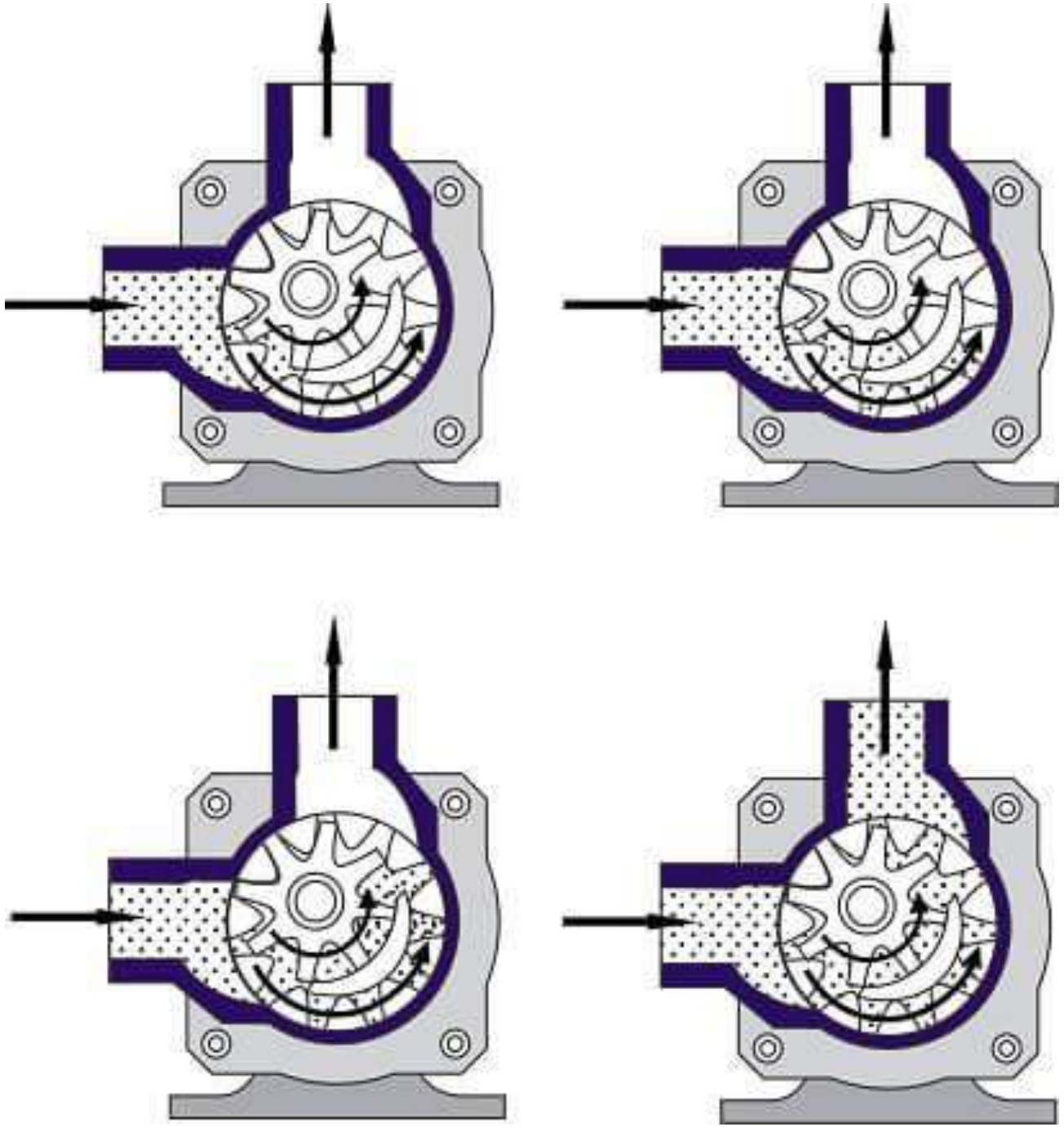


EXTERNAL GEAR PUMP

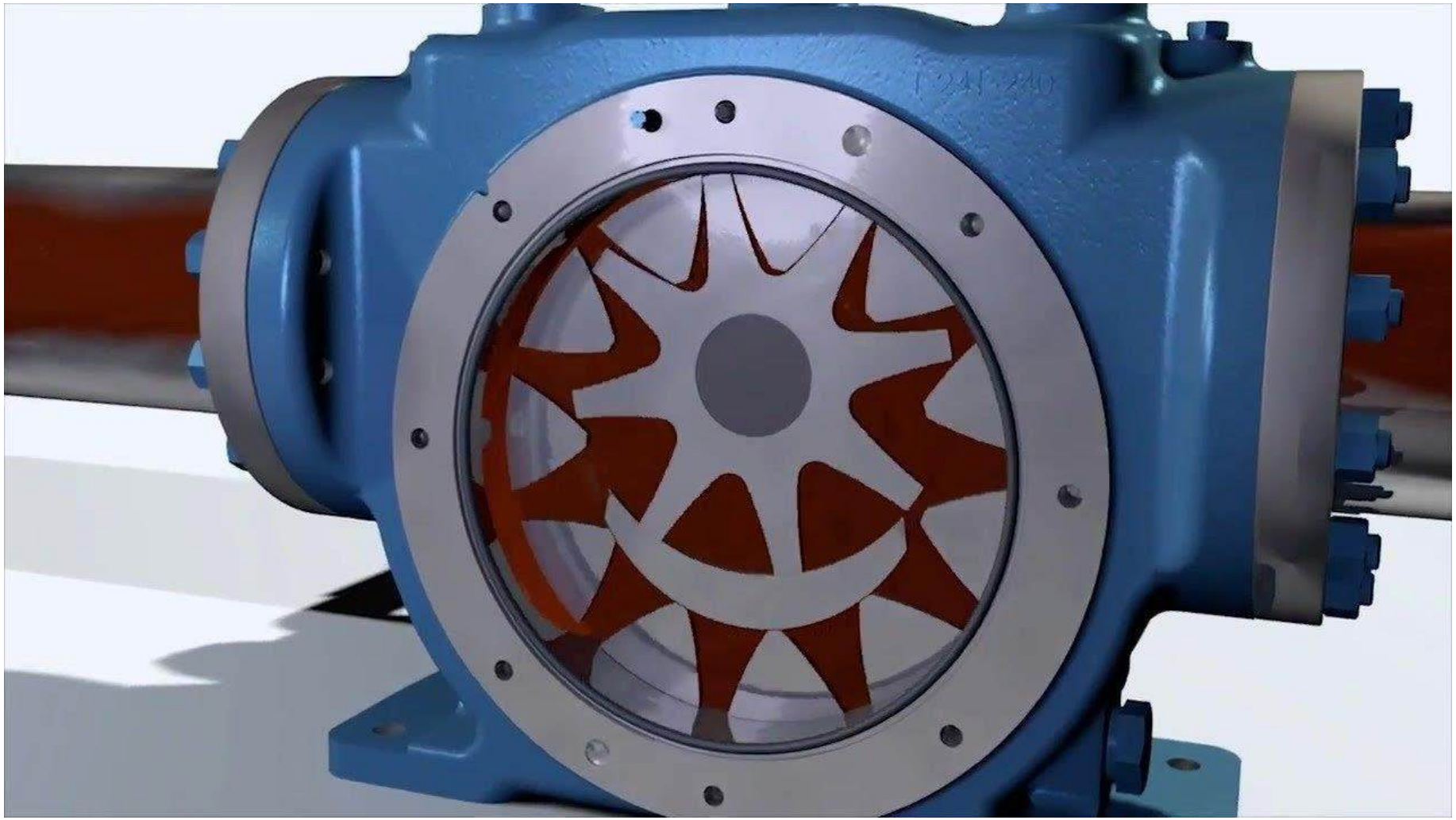


EXTERNAL GEAR PUMP

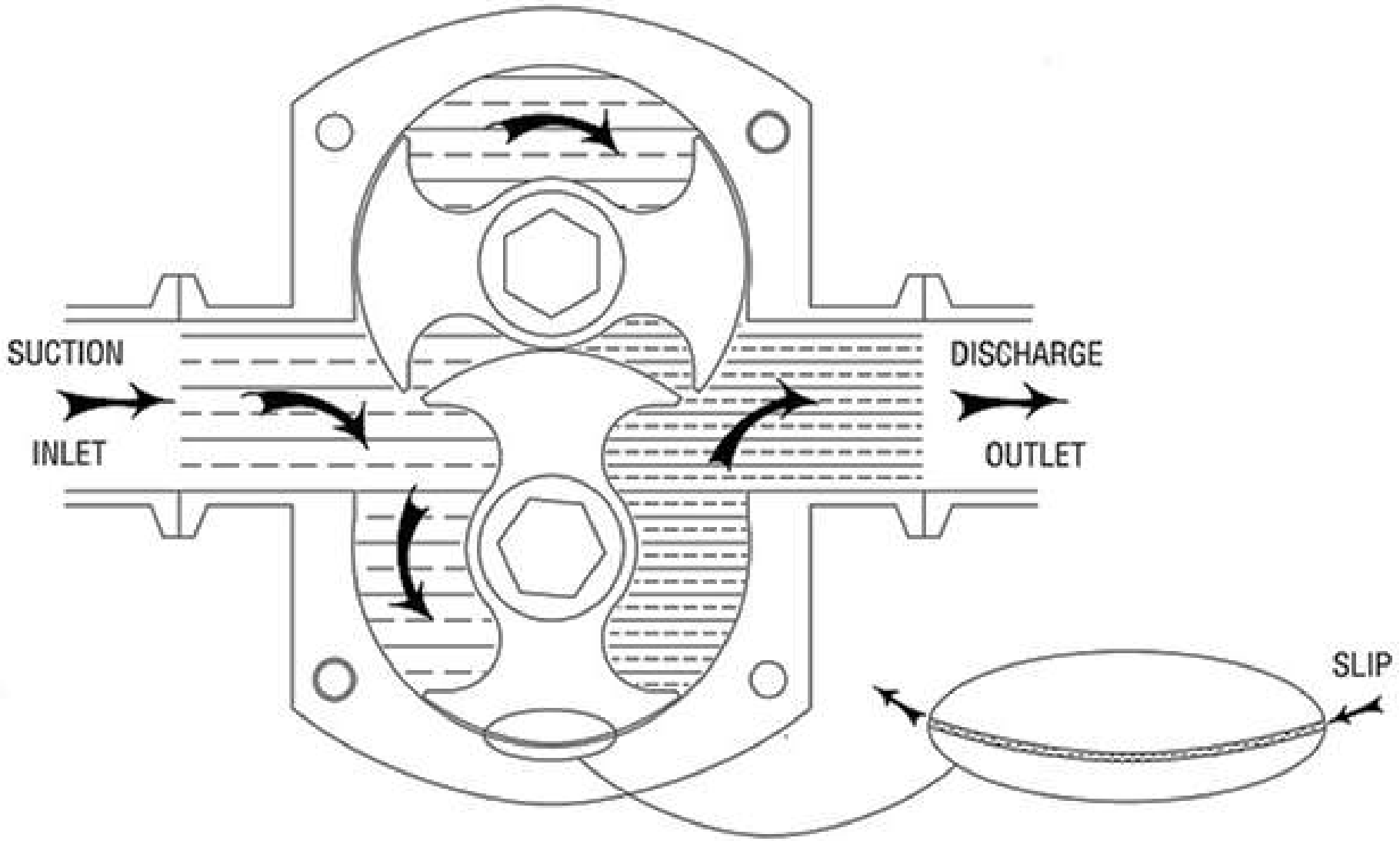
INTERNAL GEAR PUMP



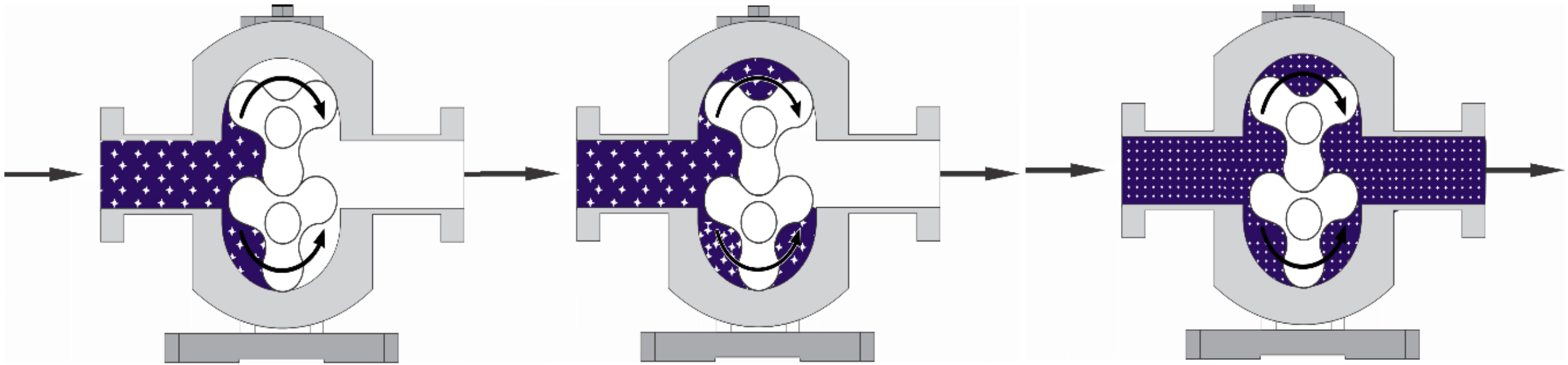
INTERNAL GEAR PUMP



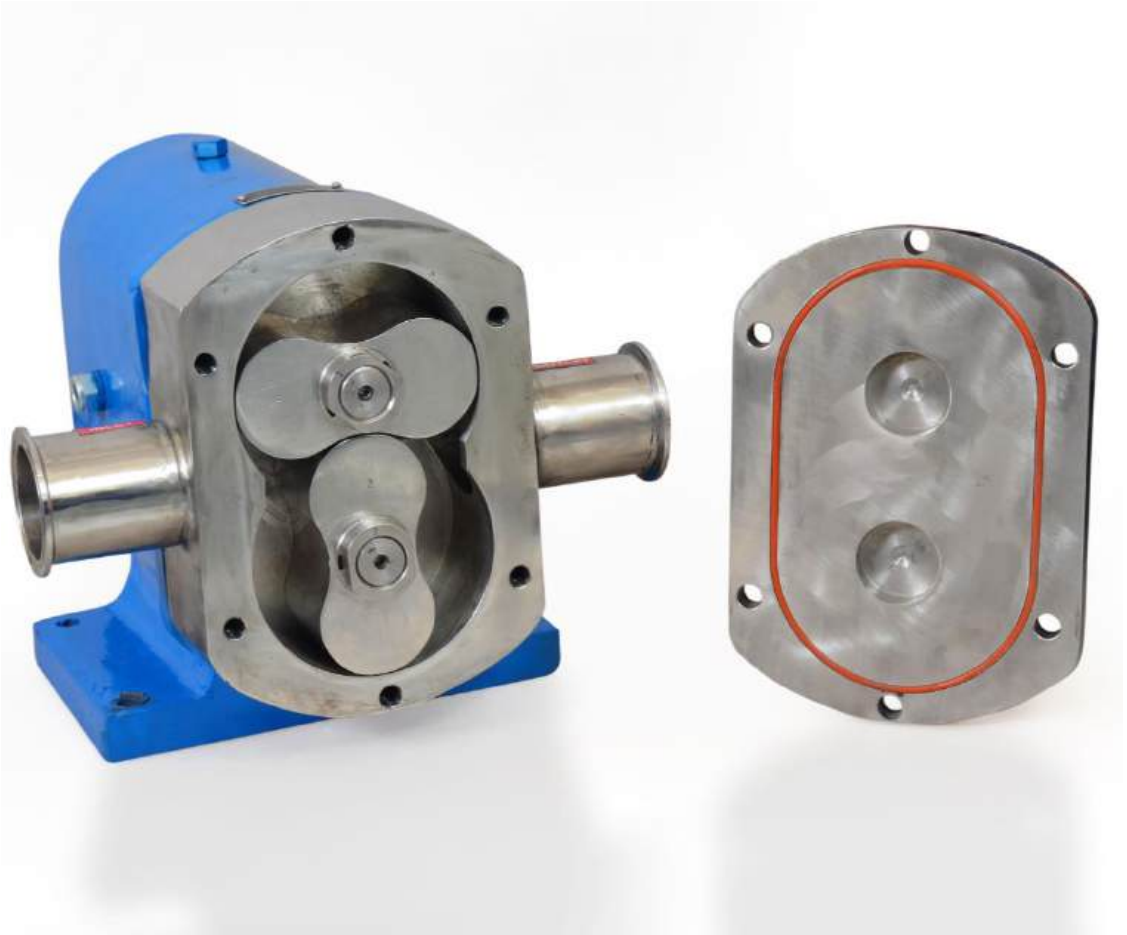
LOBE PUMP

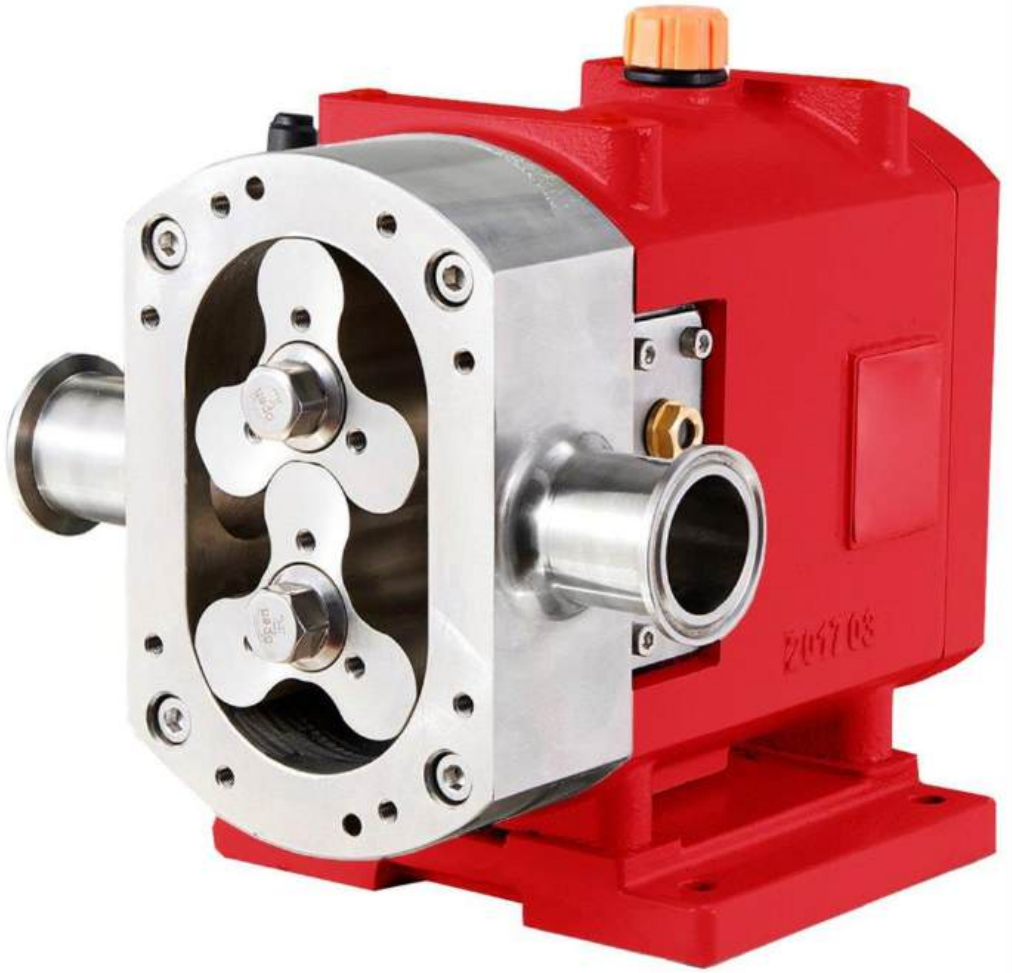


LOBE PUMP

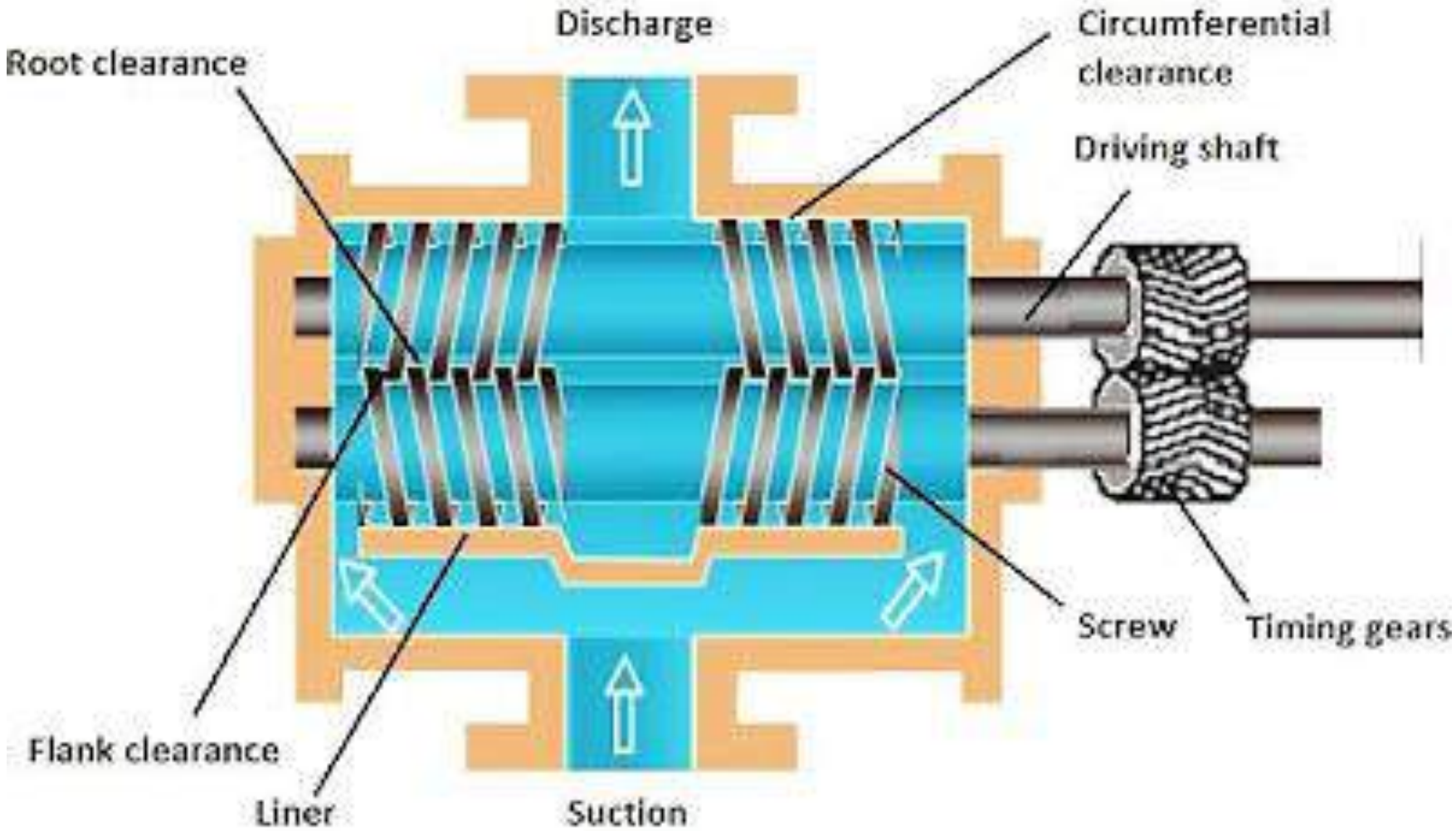


LOBE PUMP

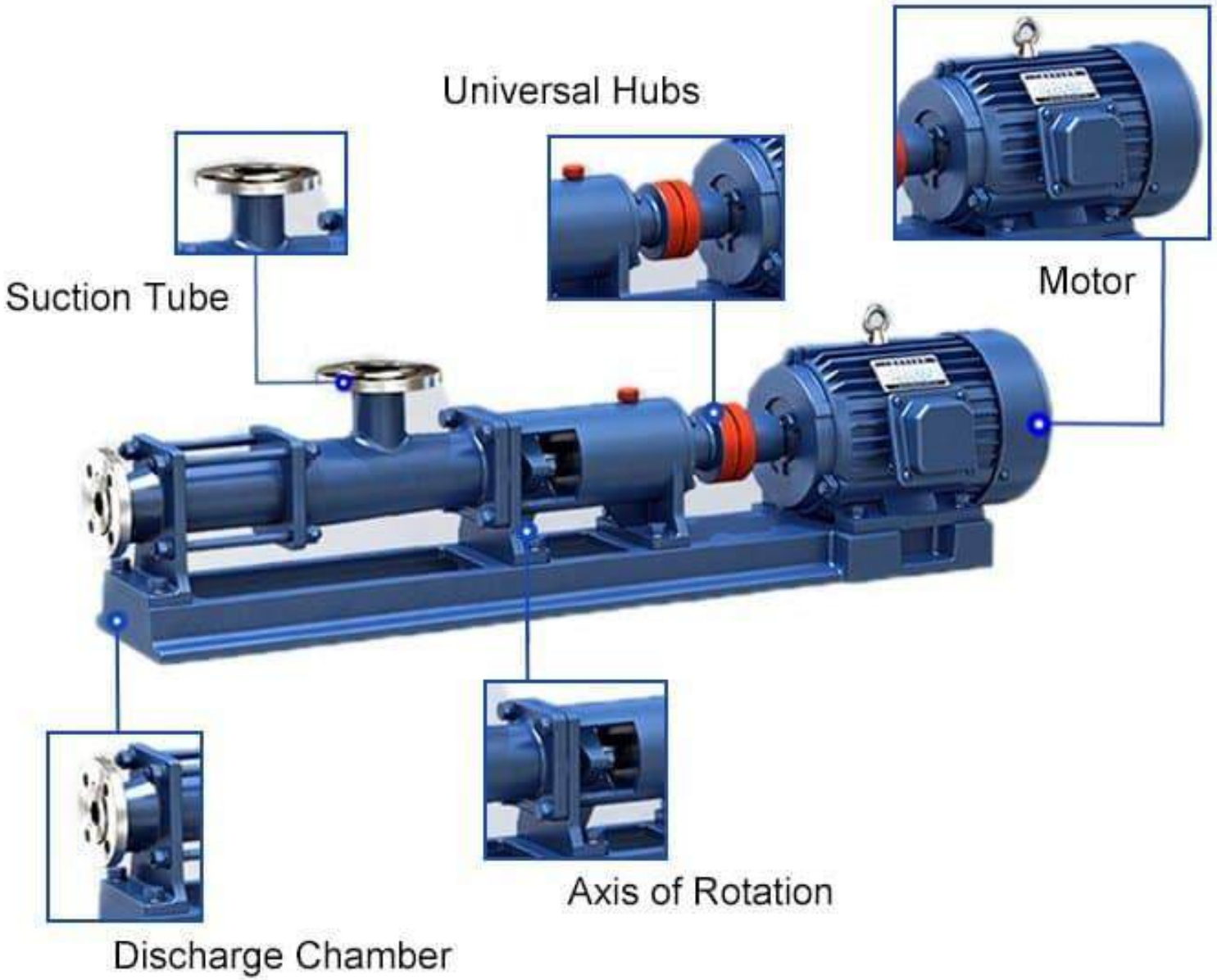




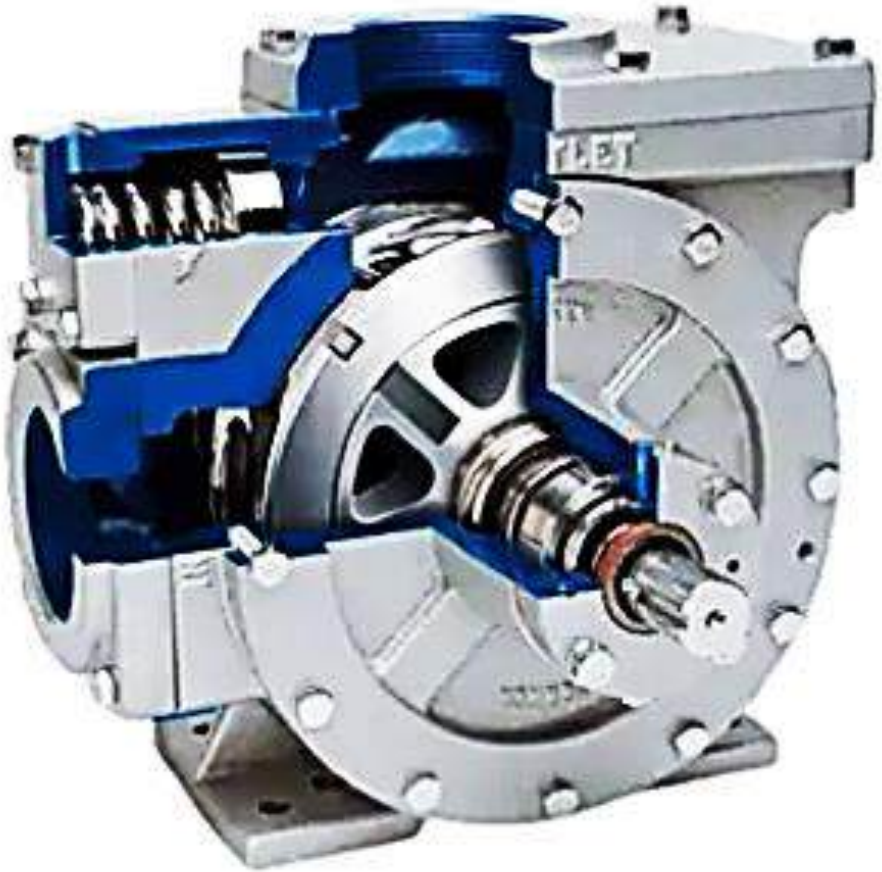
SCREW PUMP

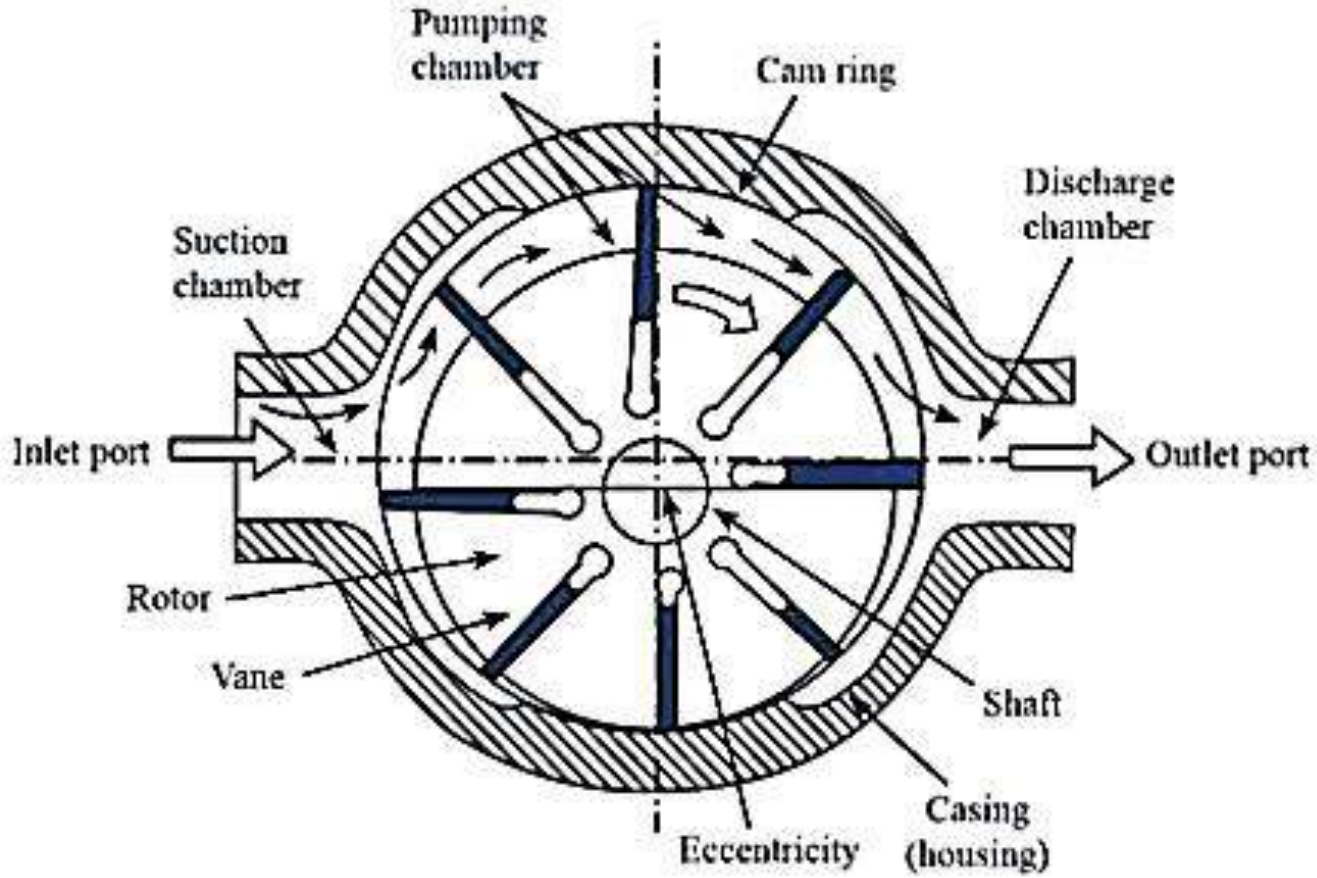

Discharge
Root clearance
Circumferential clearance
Driving shaft
Screw
Timing gears
Flank clearance
Liner
Suction

SCREW P

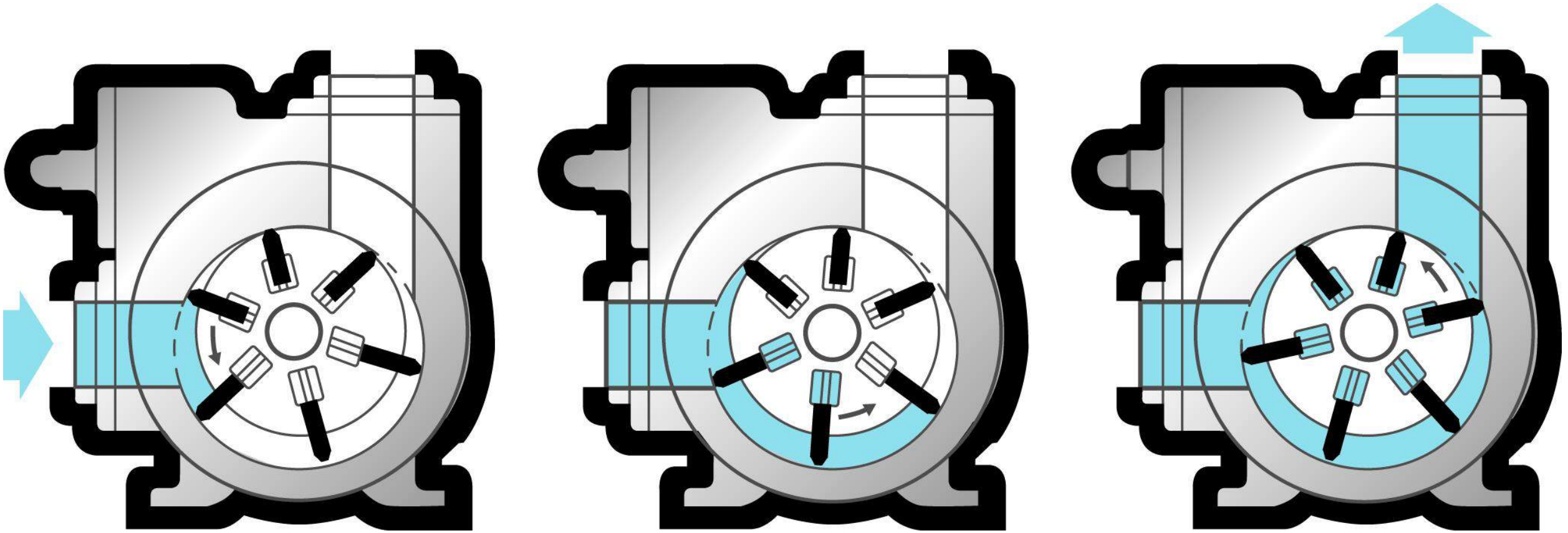

Universal Hubs
Suction Tube
Motor
Axis of Rotation
Discharge Chamber

VANE PUMP

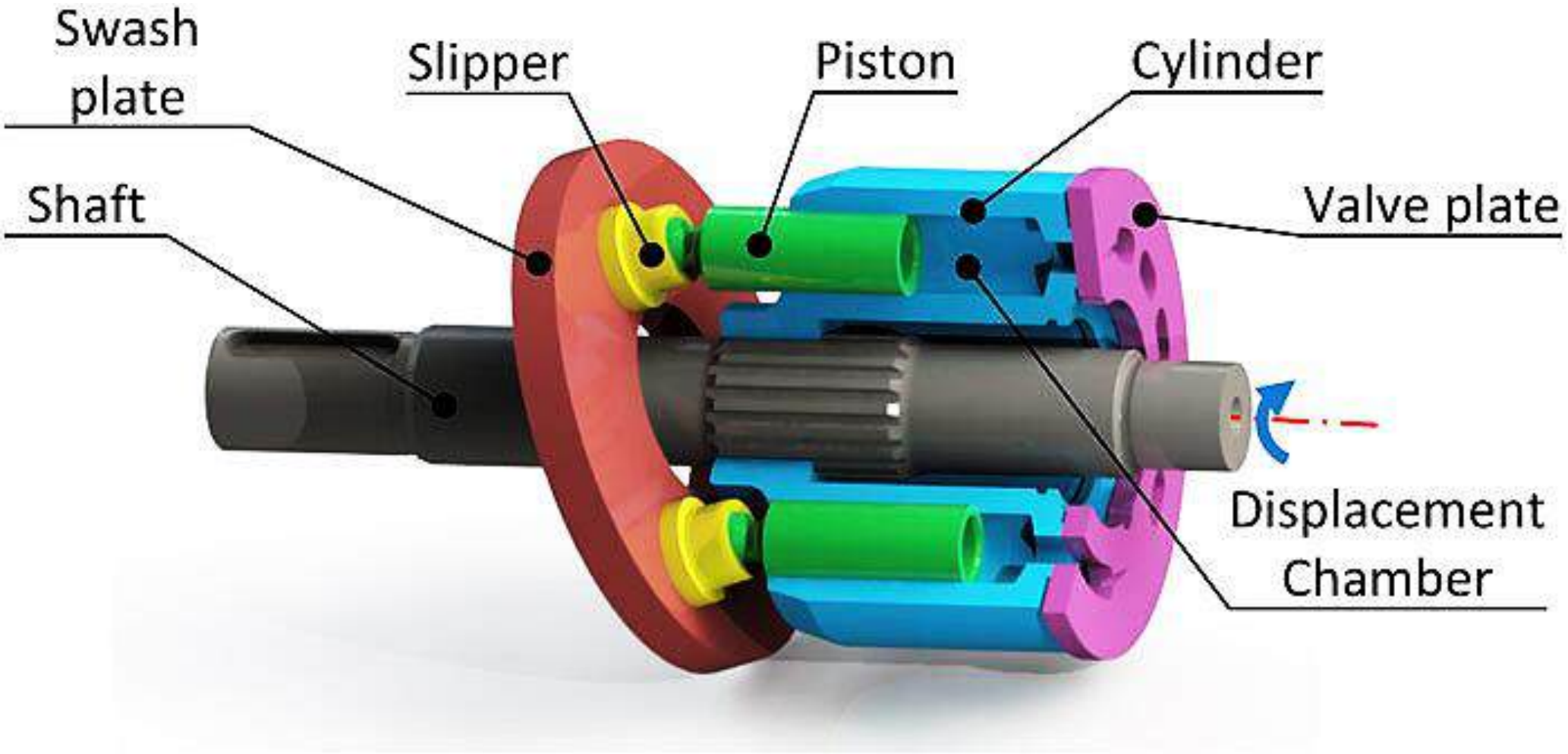



Pumping chamber
Cam ring
Discharge chamber
Suction chamber
Inlet port
Outlet port
Rotor
Vane
Shaft
Casing (housing)
Eccentricity

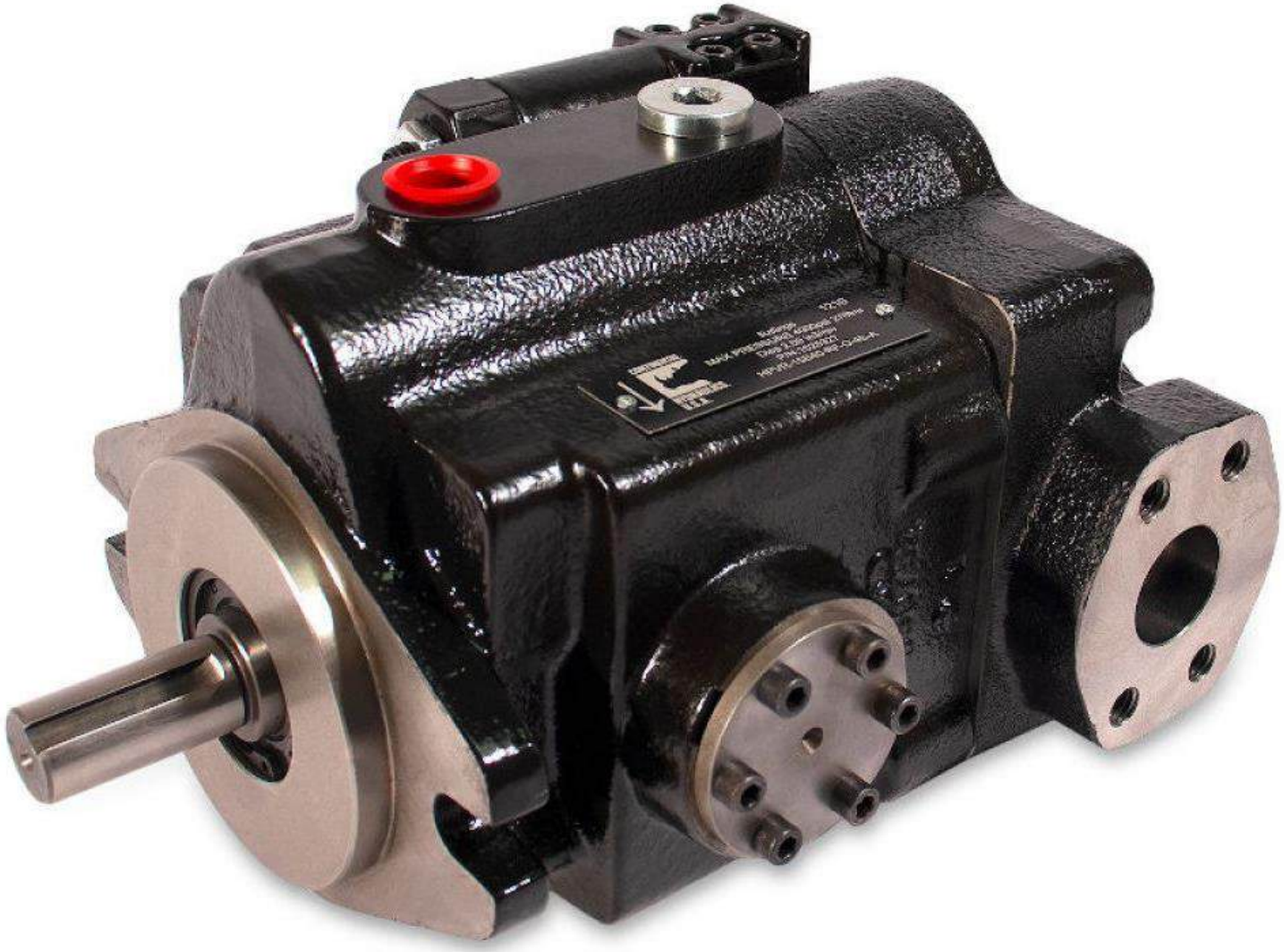
VANE PUMP



AXIAL PISTON PUMP (SWASH PLATE TYPE)

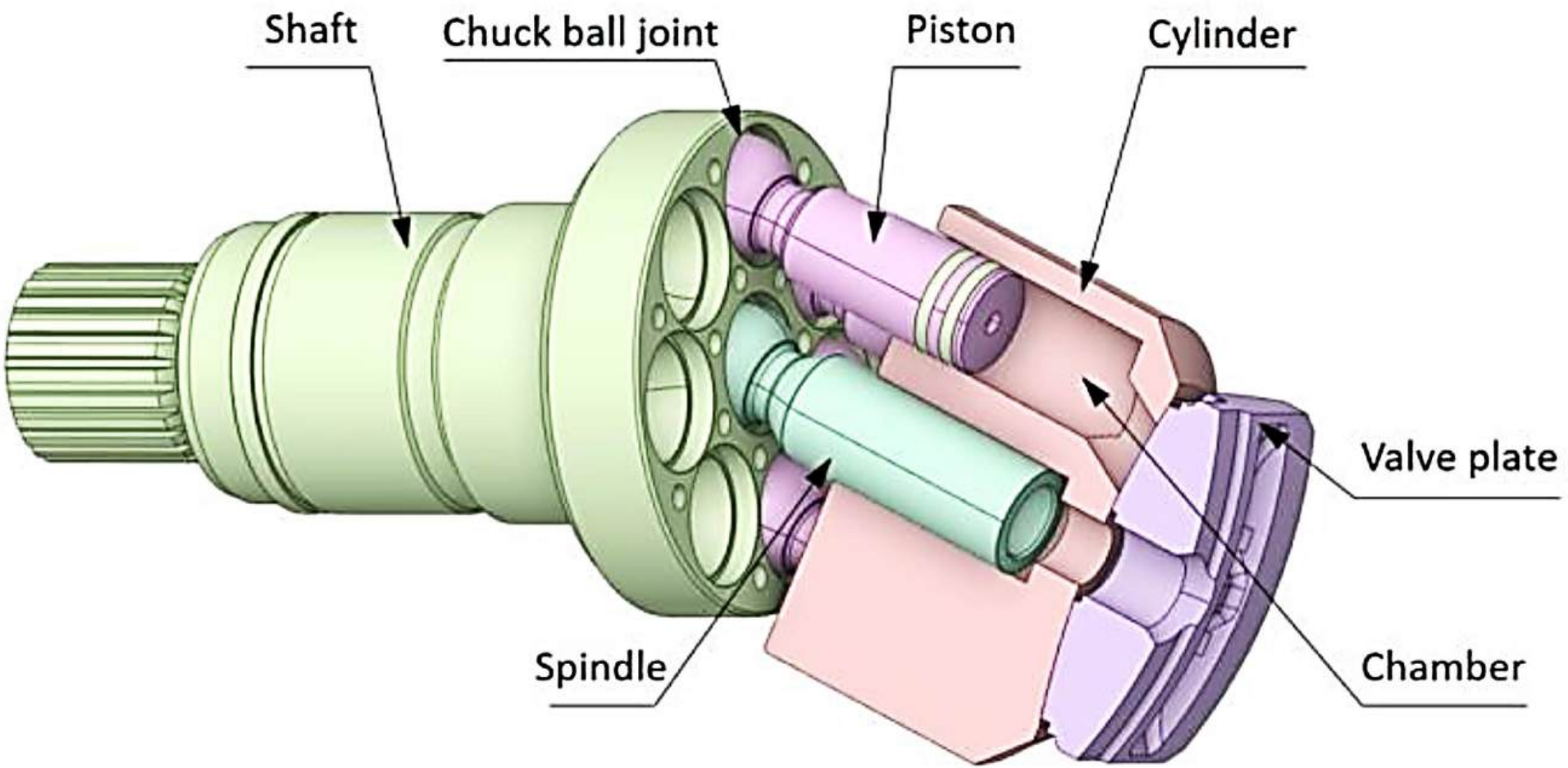


AXIAL PISTON PUMP (SWASH PLATE TYPE)

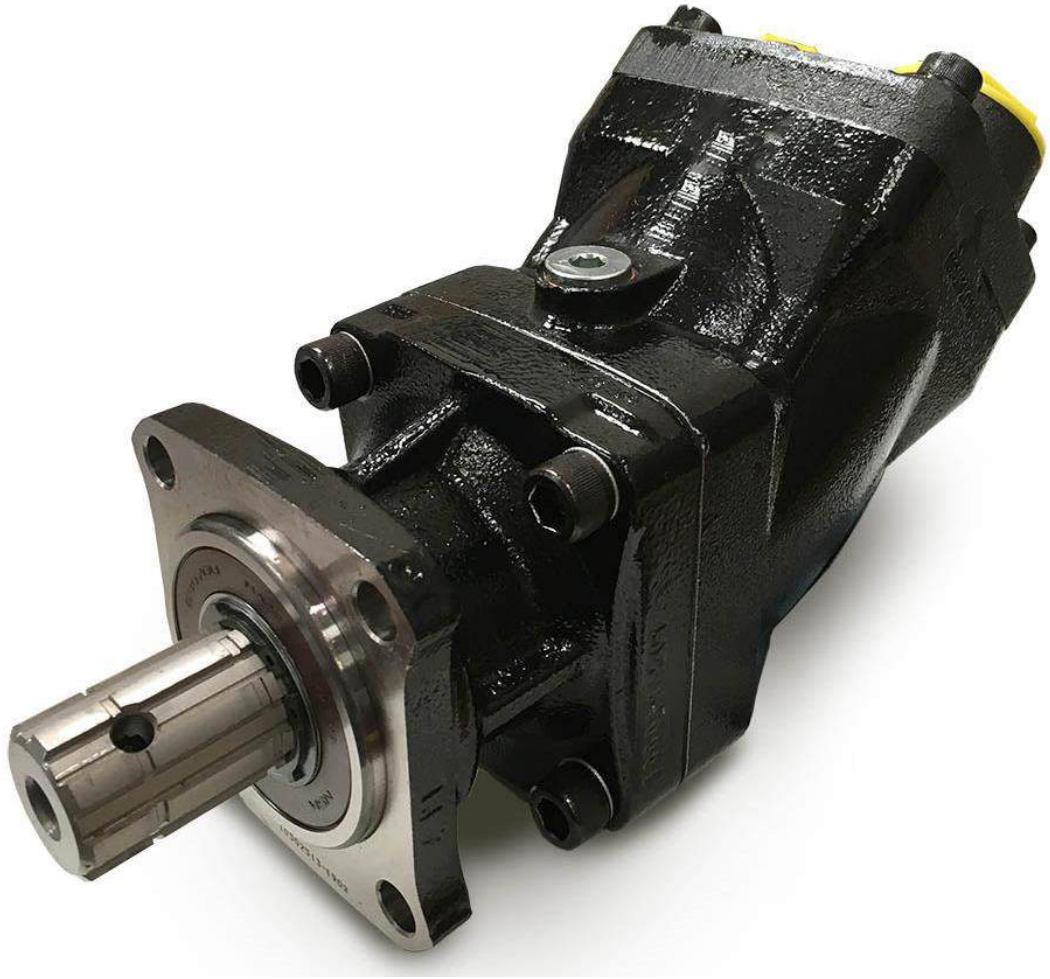


AXIAL PISTON PUMP (SWASH PLATE TYPE)

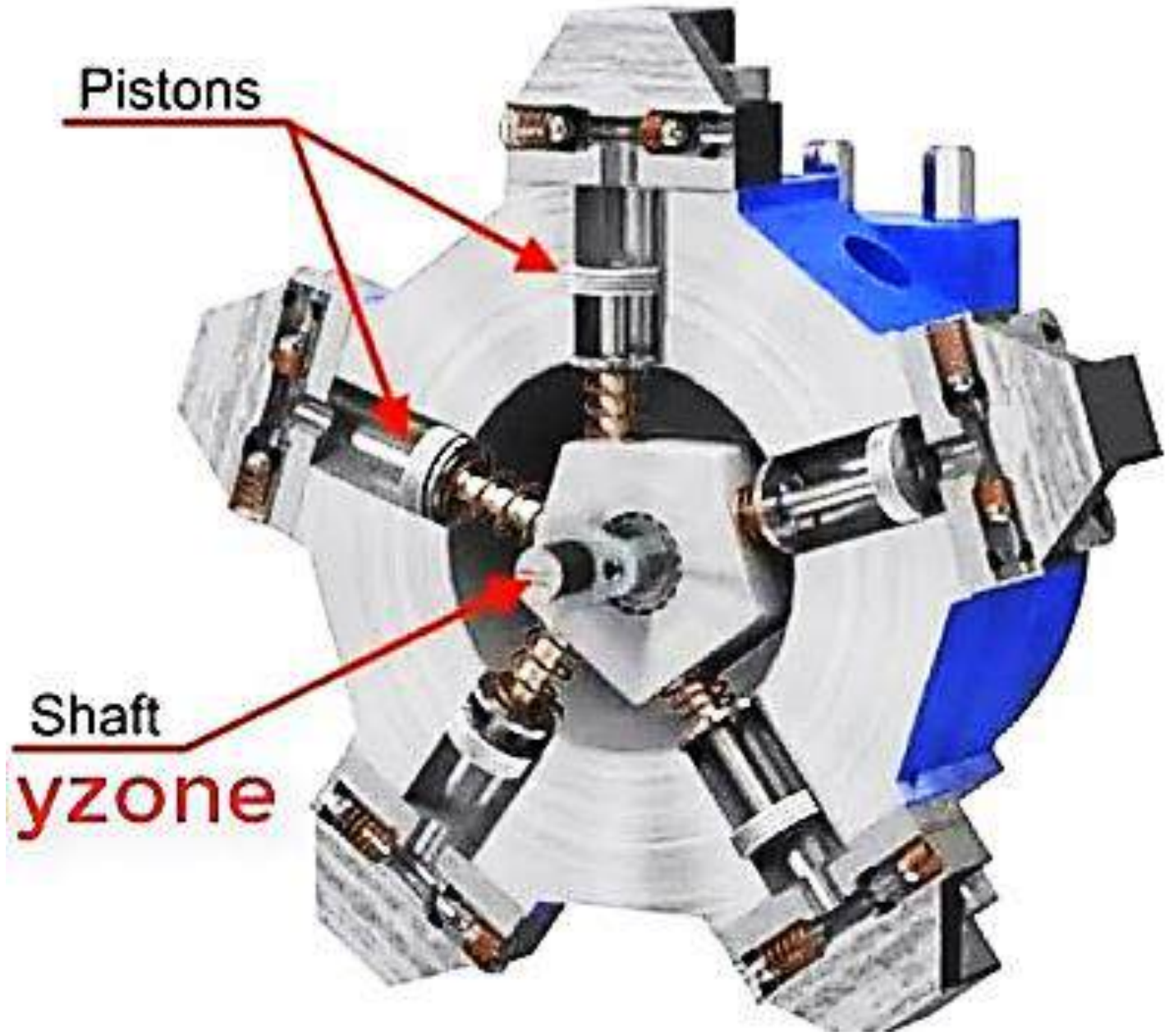
AXIAL PISTON PUMP (BENT-AXIS TYPE)



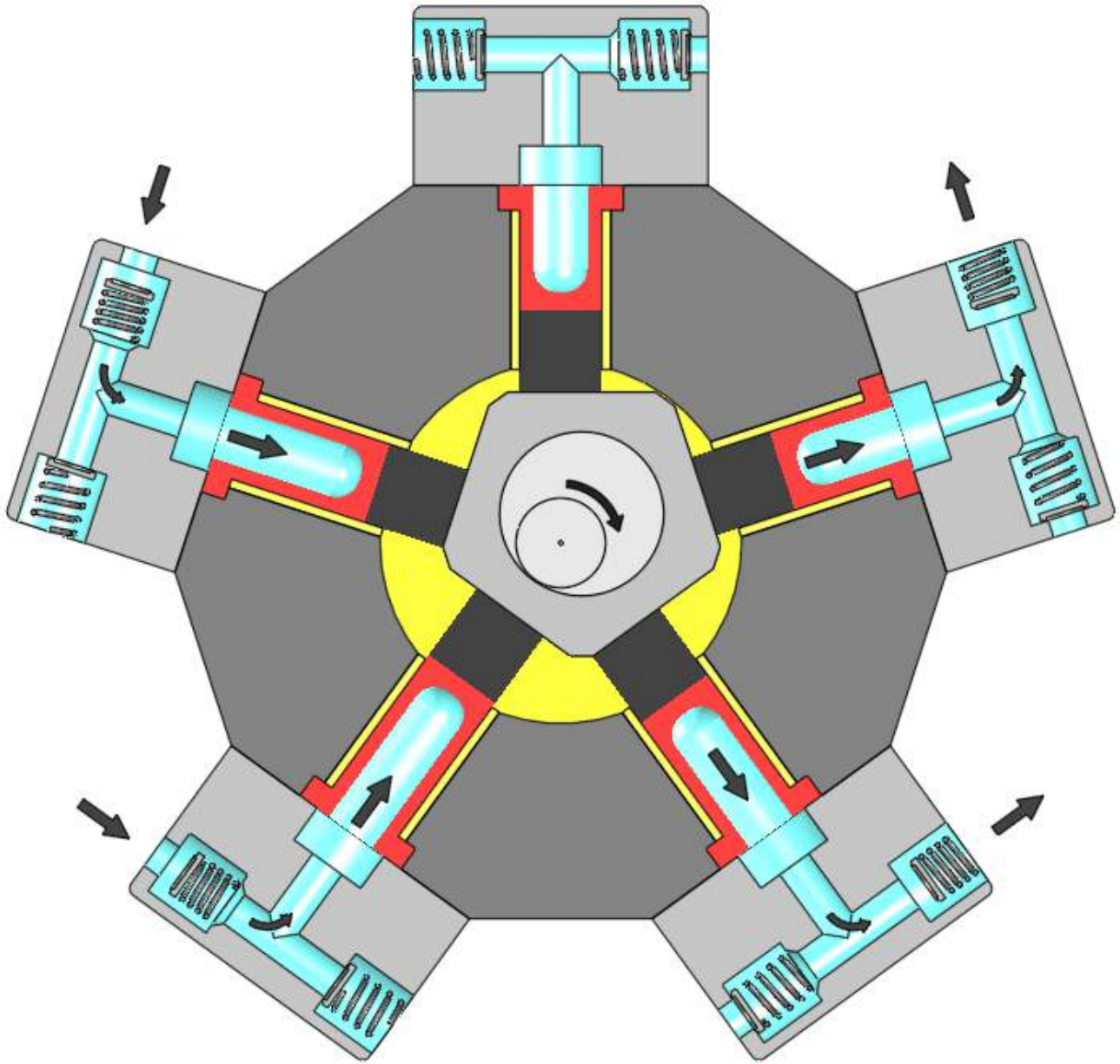
AXIAL PISTON PUMP (BENT-AXIS TYPE)



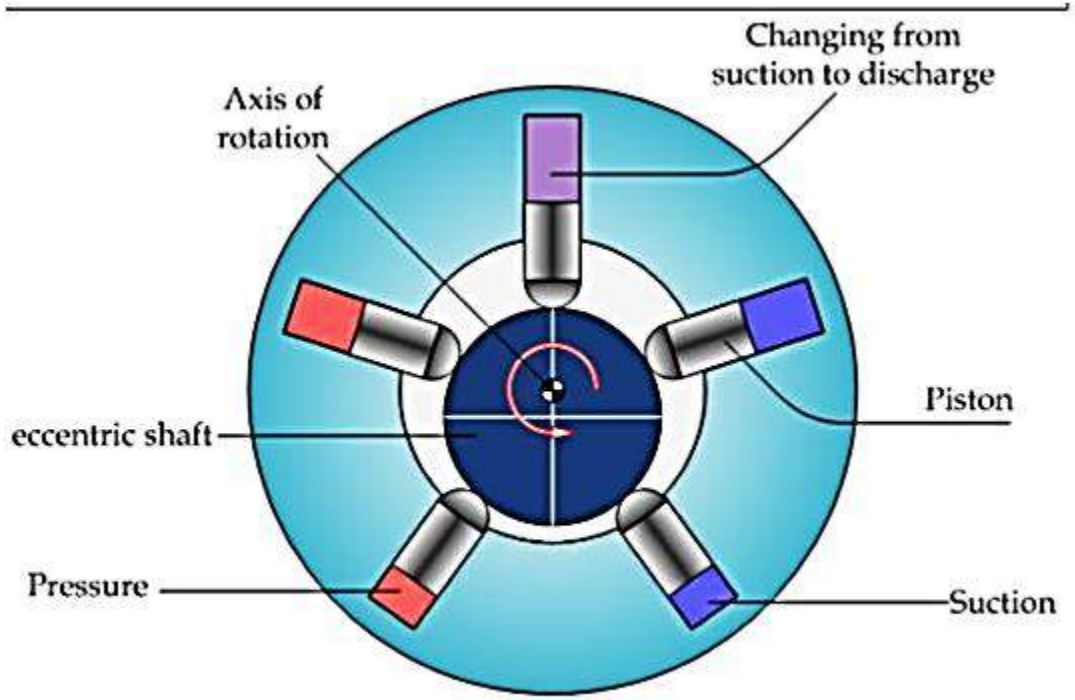
RADIAL PISTON PUMP



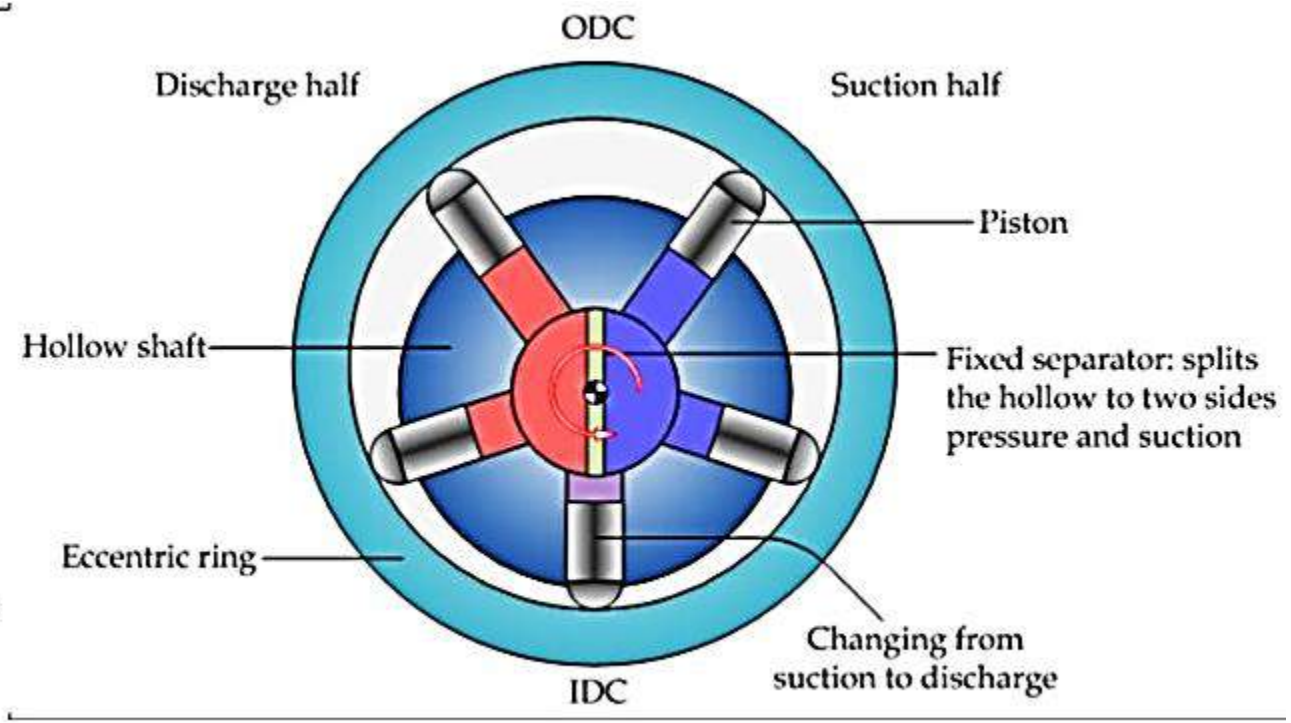
RADIAL



RADIAL PISTON PUMP



Rotating Cam type



Rotating Cylinder type

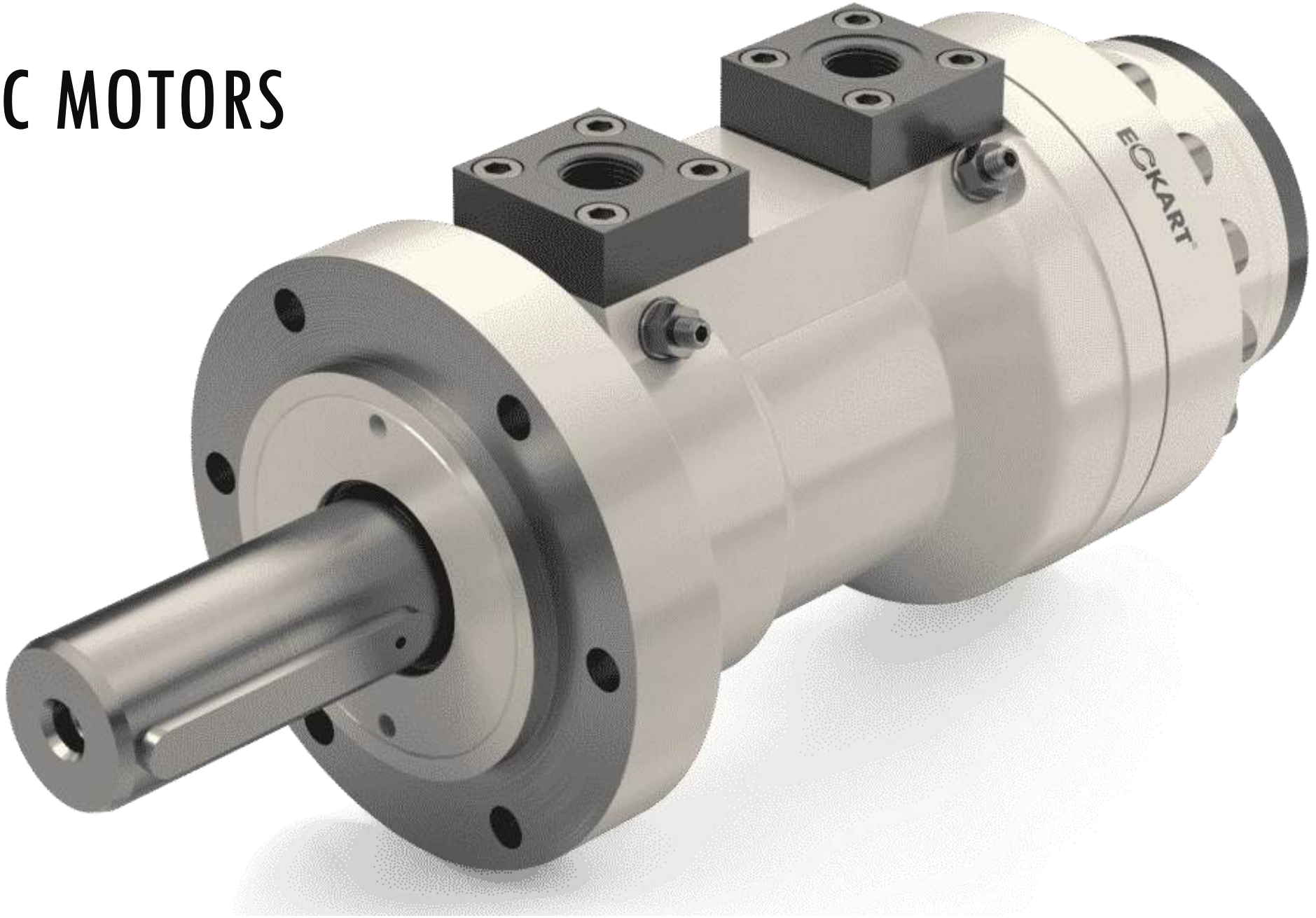
HYDRAULIC ACTUATORS

- Linear actuator or Hydraulic cylinders
- Rotary actuator
  - Continuous rotary actuators or hydraulic motors
  - Semi-continuous rotary actuators or oscillation fluid motors

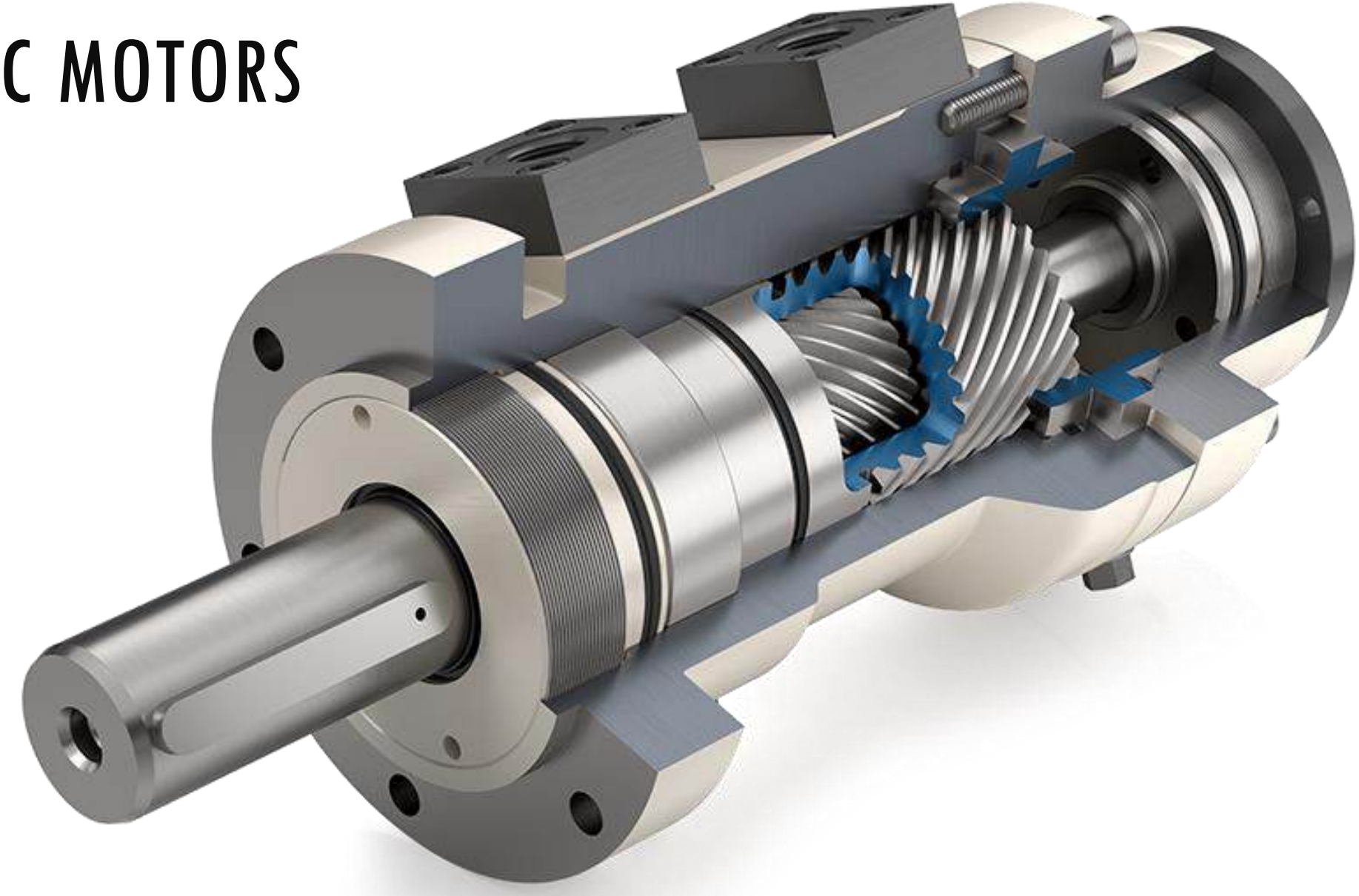
HYDRAULIC MOTORS

- A hydraulic motor converts hydraulic energy into mechanical energy, resulting in a rotating shaft.
- It uses hydraulic pressure and flows to generate the required torque and rotation

HYDRAULIC MOTORS



HYDRAULIC MOTORS



HYDRAULIC MOTORS - TYPES

(A) Gear Motors

- **Principle:** Uses intermeshing gears to transfer hydraulic energy into rotational motion.
- **Features:**

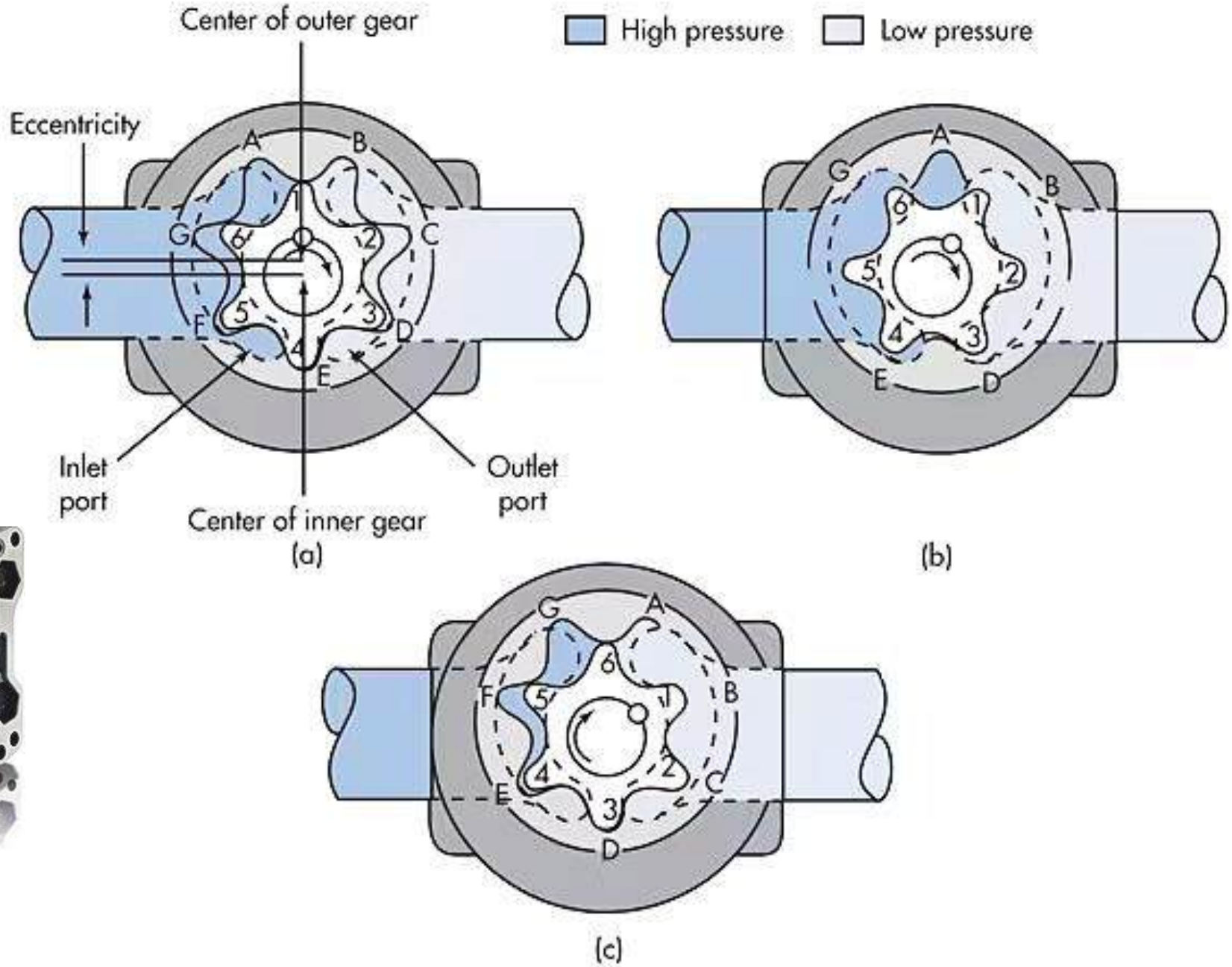
Simple design, compact, and cost-effective
Medium speed and pressure capability
Used in mobile and industrial applications

Types of Gear Motors:

1. **External Gear Motors** – Two meshing gears rotate inside a housing.
2. **Internal Gear Motors** – One gear is inside another, reducing size and increasing efficiency.
3. **Gerotor Motors** – Uses an inner and outer gear to generate smooth torque output.

- **Applications:** Conveyor belts, agricultural machinery, automotive power steering.

GEAR MOTORS


Center of outer gear
High pressure
Low pressure
Eccentricity
A
B
C
D
E
F
G
1
2
3
4
5
6
Inlet port
Outlet port
Center of inner gear
(a)
(b)
(c)

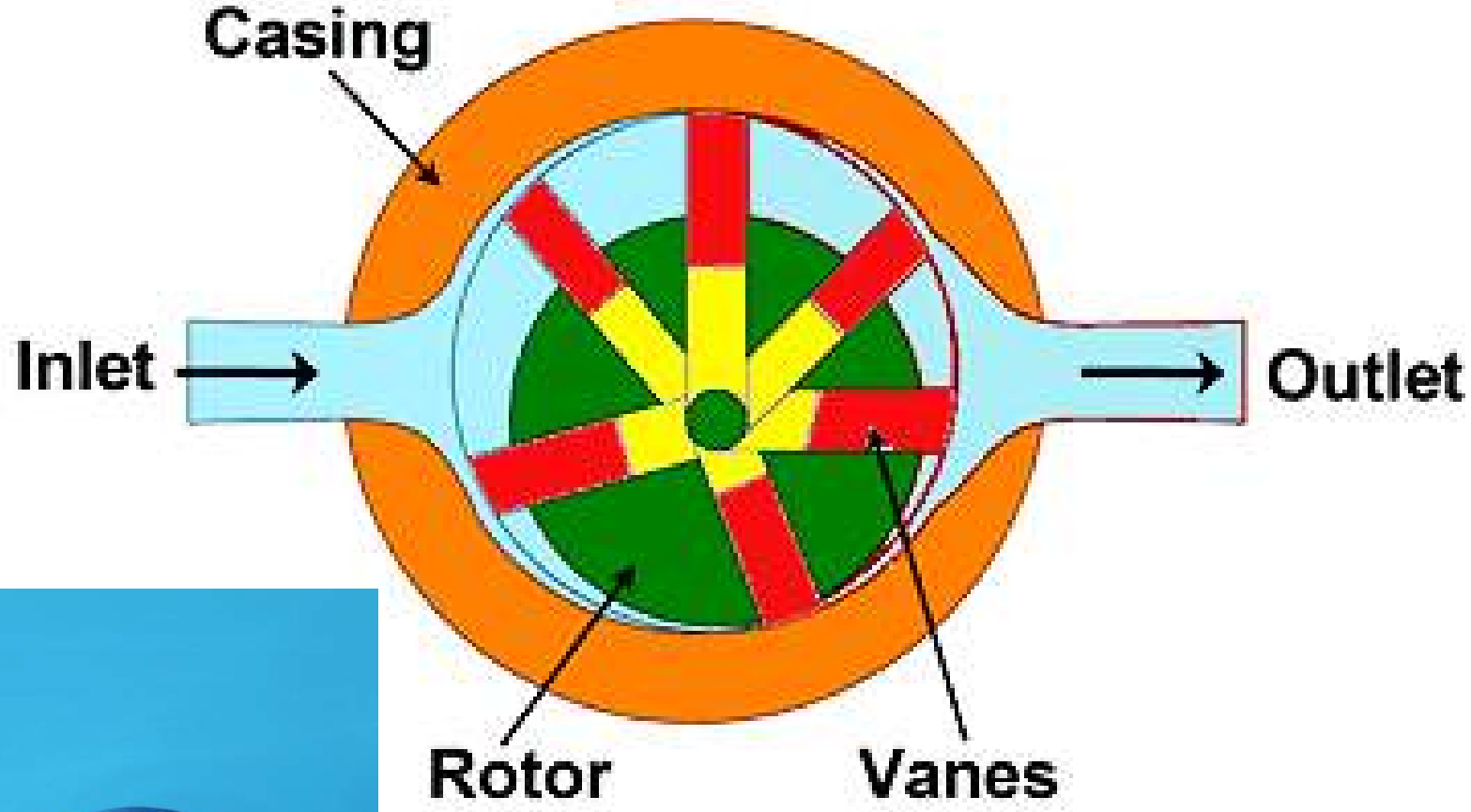
HYDRAULIC MOTORS - TYPES

(B) Vane Motors

- **Principle:** Uses sliding vanes inside a rotor to generate motion as hydraulic pressure moves the vanes outward.
- **Features:**

  Provides smooth and quiet operation
  Moderate efficiency and durability
  Limited to medium torque applications
- **Applications:** Injection moulding machines, machine tools, industrial automation.

VANE MOTORS

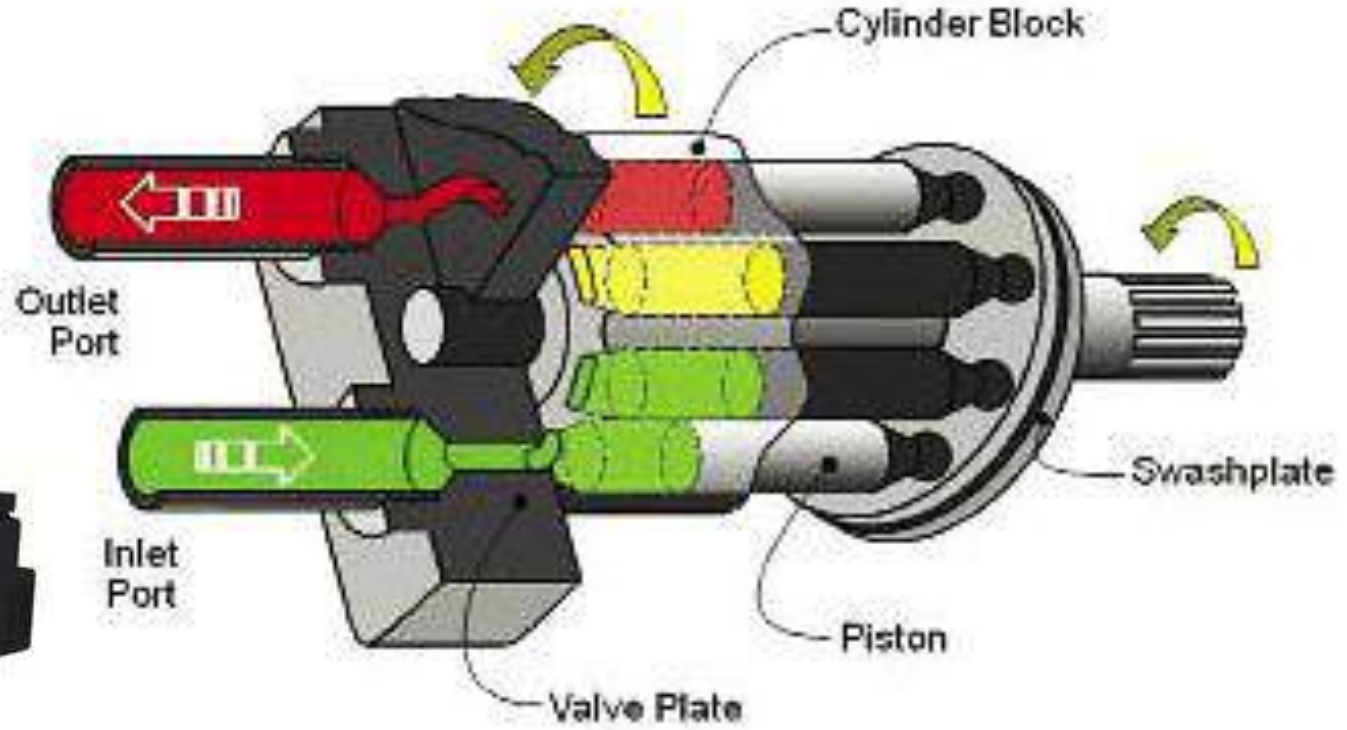


HYDRAULIC MOTORS - TYPES

(C) Piston Motors

- **Principle:** Uses reciprocating pistons to generate rotational motion, providing high efficiency and torque.
- **Features:**
  - Best efficiency and power-to-weight ratio
  - Handles high-pressure and variable speed
  - Expensive and complex
- **Types of Piston Motors:**
  - **Axial Piston Motors** – Pistons arranged parallel to the shaft (used in high-pressure applications).
  - **Radial Piston Motors** – Pistons arranged radially around the shaft (ideal for very high torque).
- **Applications:** Heavy-duty construction equipment, winches, cranes, marine propulsion.

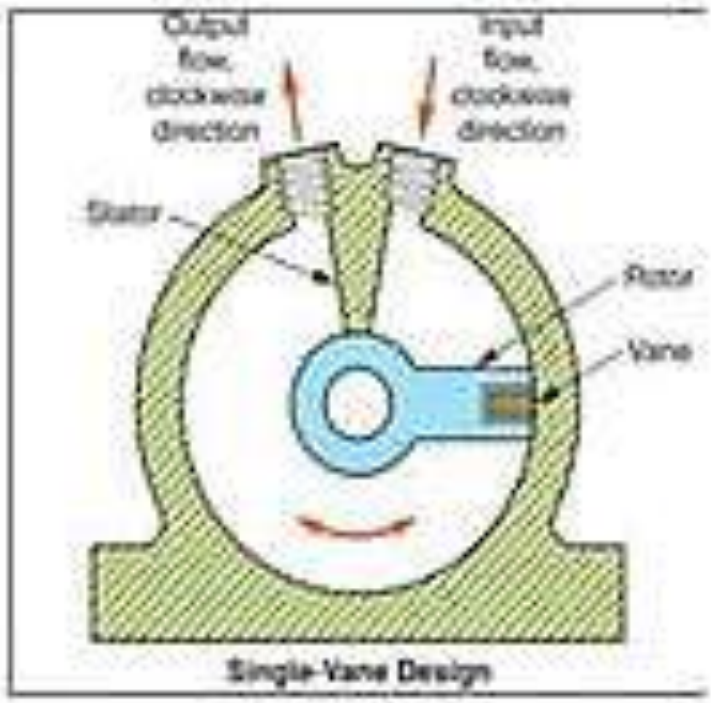
PISTON MOTORS

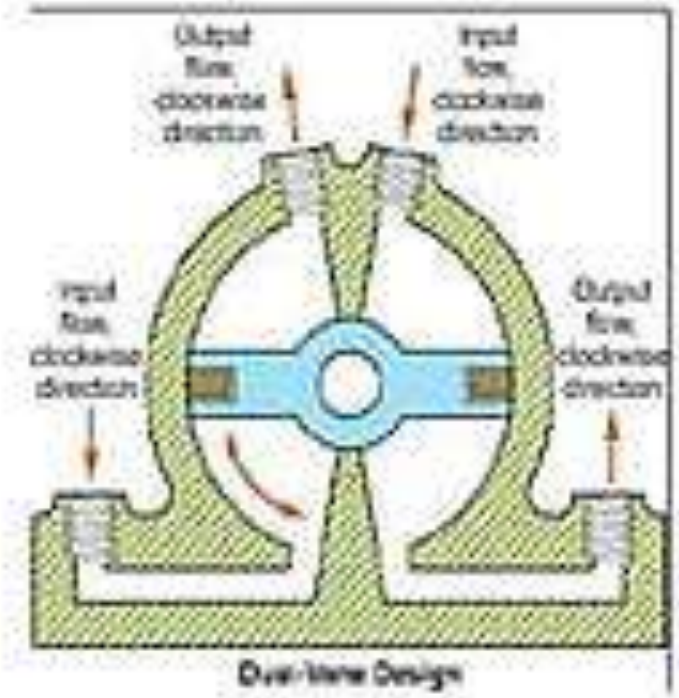


LIMITED ROTATION HYDRAULIC MOTORS

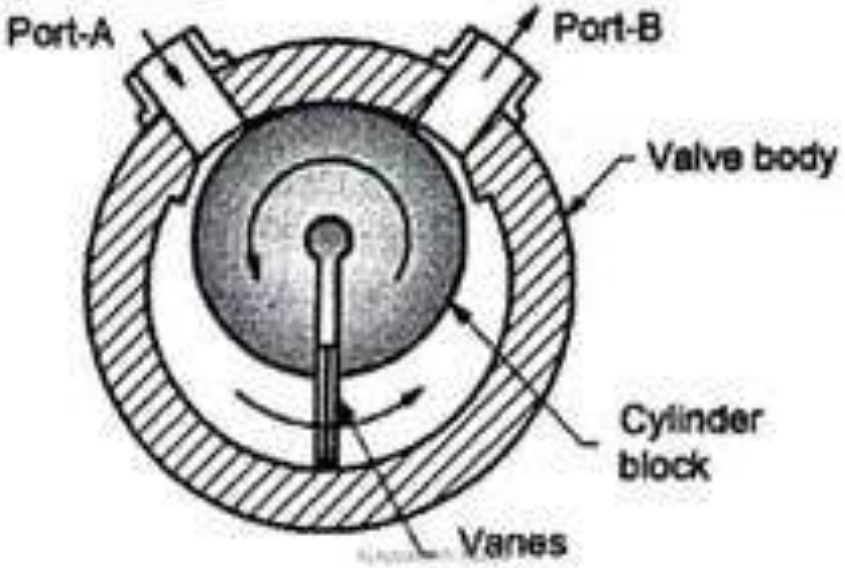
- A limited rotation hydraulic motor (also called oscillation motor) provides rotary output motion over a finite angle.
- This device produces high instantaneous torque in either direction and requires only a small space and simple mountings.
- This type provides about 280° of rotation.
- Used in applications where a precise, controlled rotational movement within a limited angle is required, such as in **robotic arms, machine tool positioning, steering mechanisms, valve actuators, and certain types of industrial machinery** where only a partial rotation is needed for operation; essentially anywhere high torque is required within a defined rotational range.

LIMITED ROTATION HYDRAULIC MOTORS

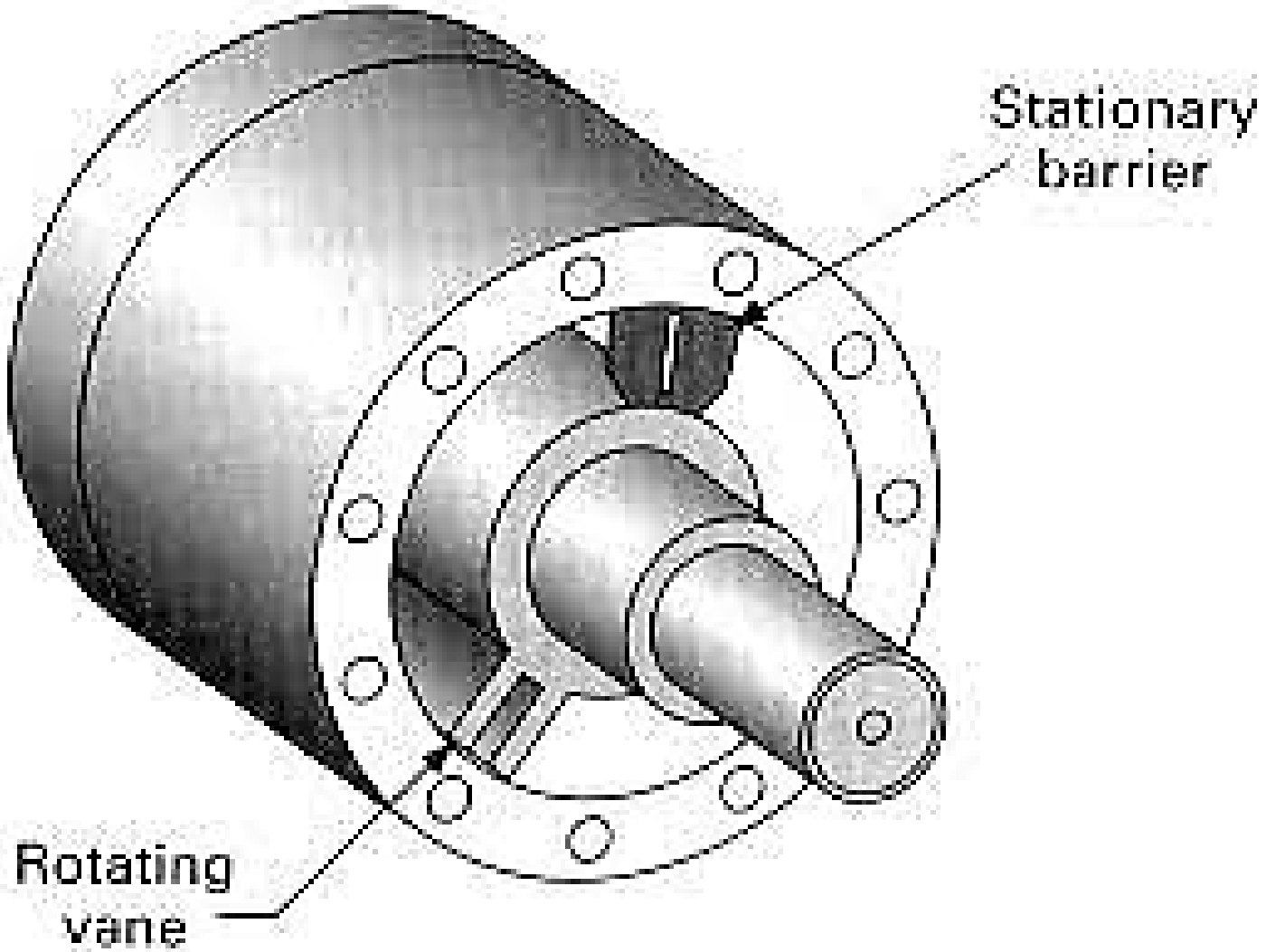




Vane Type Motor:



LIMITED ROTATION HYDRAULIC MOTORS



HYDRAULIC MOTORS

HYDRAULIC MOTORS

HYDRAULIC CYLINDERS

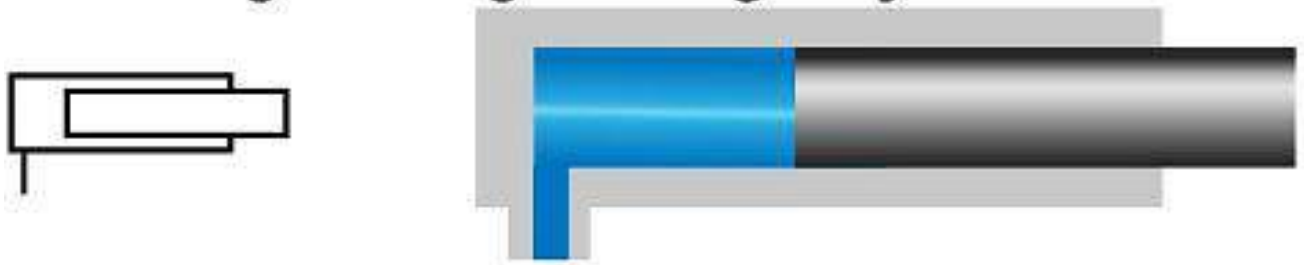
- A hydraulic cylinder is a hydraulic actuator that provides linear motion when hydraulic energy is converted into mechanical movement.
- They are widely used throughout almost every hydraulic machine for moving, lifting, clamping, steering, etc.

HYDRAULIC CYLINDERS

HYDRAULIC CYLINDERS

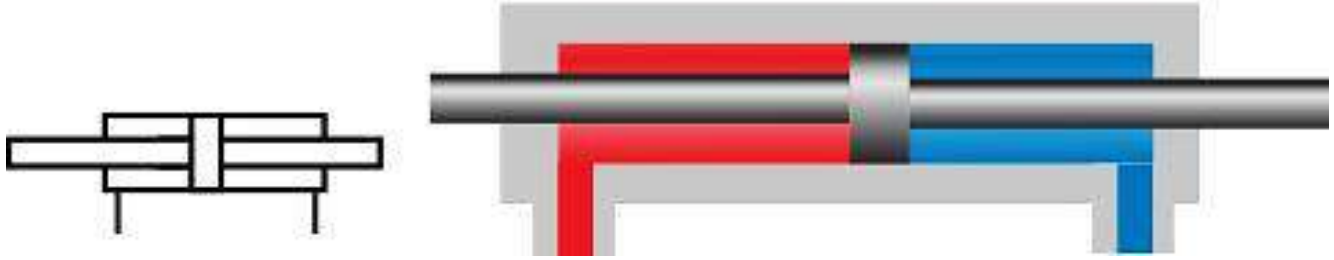
HYDRAULIC CYLINDERS

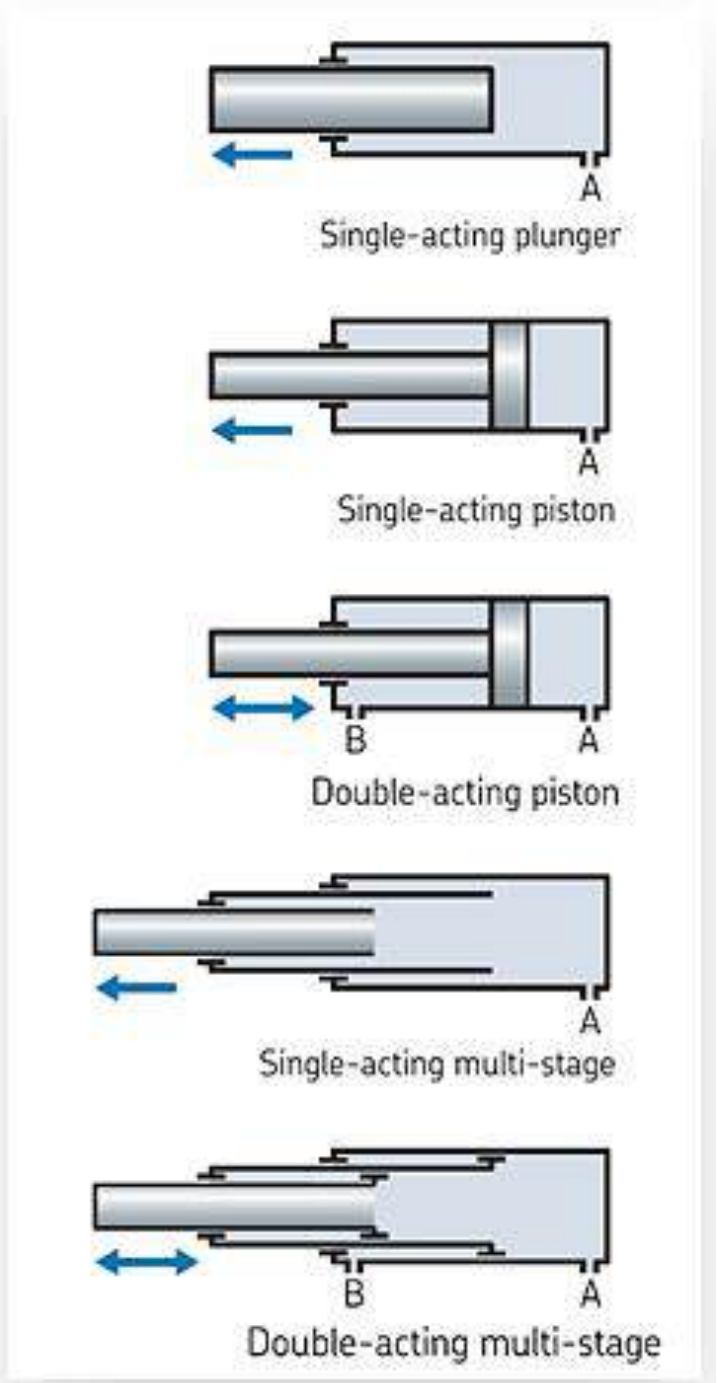
Single Acting or Plunger Cylinder



Double Acting Cylinder

Double Acting Double Rod Cylinder





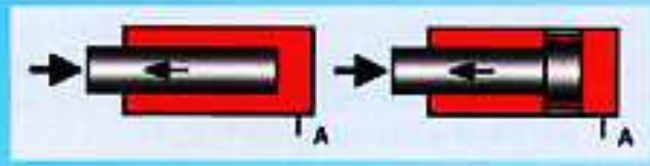
Hydraulic actuators: cylinders

Cylinder types:

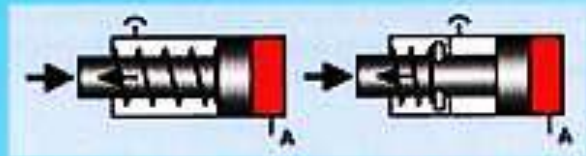
Single acting:

work can be done only in one direction

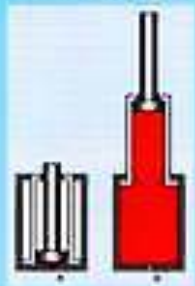
Plunger



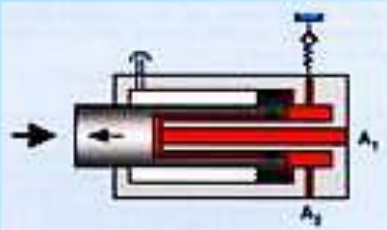
Piston



Telescopic



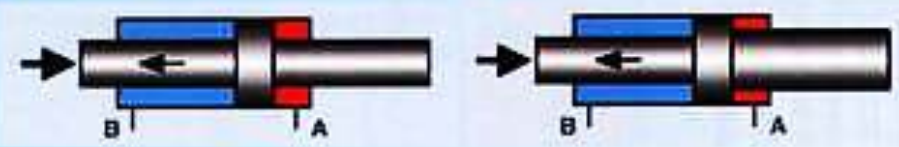
Fast moving



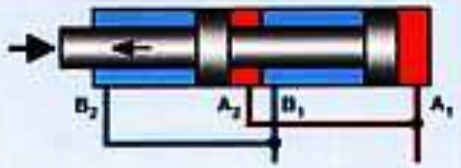
Double acting piston:

Work is done in both directions

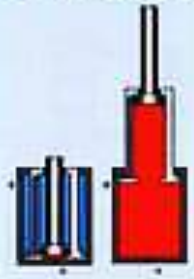
Piston rod on both sides



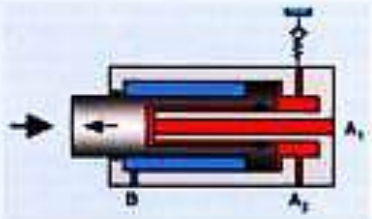
Tandem



Telescopic



Fast moving



HYDRAULIC CYLINDERS

Light Duty Cylinders

- Light duty cylinders are typically cylinders used for stationary equipment, indoors in a factory environment and may be characterized by:
- System pressures up to 160 bar (2300psi)
- Temperature up to 70°C (160°F)
- Rare instances of pressure spikes above system pressure
- Minimal side loads acting on guides
- Environment with moderate temperature fluctuations and relatively free of contaminates

HYDRAULIC CYLINDERS

Medium Duty Cylinders

- Medium-duty cylinders are typically used in agriculture, and off-highway equipment and may be characterized by:
- System pressures up to 250bar (3625psi)
- Temperature up to 90°C (195°F)
- Moderate pressure spikes above system pressure
- Environment with moderate temperature fluctuations with climate and typical external contaminates such as dust and moisture

HYDRAULIC CYLINDERS

Heavy Duty Cylinders

- Heavy-duty cylinders are typically used in off-highway earthmoving, mining and forestry equipment and may be characterized by:
- System pressures of 400bar (5800psi) or more
- Temperatures exceeding 90°C (195°F)
- Regular pressure spikes above system pressure
- Heavy side loads acting on guides, usually due to heavy components and high accelerations.
- Tough environments with wide-ranging temperature fluctuations and typically harsh external contaminants

HYDRAULIC CYLINDER APPLICATIONS

HYDRAULIC

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HYDRAULIC TOOLS