DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS (R18A0315)

3RD YEAR SEM-1 BTECH MECHANICAL ENGINEERING (R18A0315)

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

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COURSE OBJECTIVES

UNIT - 1	**CO1:** To provide student with knowledge on the application of fluid power in process, construction and manufacturing Industries.
UNIT - 2	CO2: To study the fundamental principles, design and operation of hydraulic and pneumatic machines, components and systems and their application in recent automation revolution.
UNIT - 3	CO3: To provide students with an understanding of the fluids and components utilized in modern industrial fluid power system.
UNIT - 4	CO4:To develop a measurable degree of competence in the design, construction and operation of fluid power circuits.
UNIT - 5	CO5: To emphasize basic theory, components sizing, construction and function, how to read pneumatics and fluid power circuit diagrams using the correct symbols and troubleshooting techniques.

UNIT 1

FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS

CO1: **To provide student with knowledge on the application of fluid power in process, construction and manufacturing Industries**

UNIT – I (SYLLABUS)

Introduction to Fluid power

- Advantages and Applications
- Fluid power systems
- Types of fluids
- Properties of fluids and selection
- Basics of Hydraulics
- Advantages and Applications
- Fluid power systems
- Types of fluids
- Properties of fluids and selection
- Basics of Hydraulics

LECTURE	LECTURE TOPIC	KEY ELEMENTS	Learning objectives
1	**FLUID POWER PRINICIPLES AND HYDRAULIC PUMPS** Introduction to Fluid power	Basics of Fluid Power.	Understanding of basics of fluid power (B2)
2	Advantages and Applications	Advantages and Applications	Understanding of general applications. (B2) Apply law of Pascal (B3)
3	Fluid power systems	Elements of Fluid Power systems	Understanding fluid power(B2)
4	Types of fluids	Classification of Fluids	Understanding the types of fluids (B2)
5	Properties of fluids and selection	Basic properties of fluids	Analysis of fundamental properties of fluids (B3) Analysis of suitable fluid for a particular application (B3)
6	Basics of Hydraulics	Hydrostatic Law	Remember Hydrostatic Law (B1)

LECTURE 1

Introduction to Fluid power

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Fluid Power

Technology that deals with generation, control and transmission of power, using pressurized fluids.

•Fluid power is used to push, pull, regulate or drive virtually all the machines of modern industries.

Ex: Hydraulic jack, Hydraulic brake, power steering, drive machine tools, robots, control aeroplanes

Fluid transport – sole objective is to deliver fluid from one location to another to accomplish some useful purpose

Ex: pumping stations for pumping water to homes, cross country gas lines

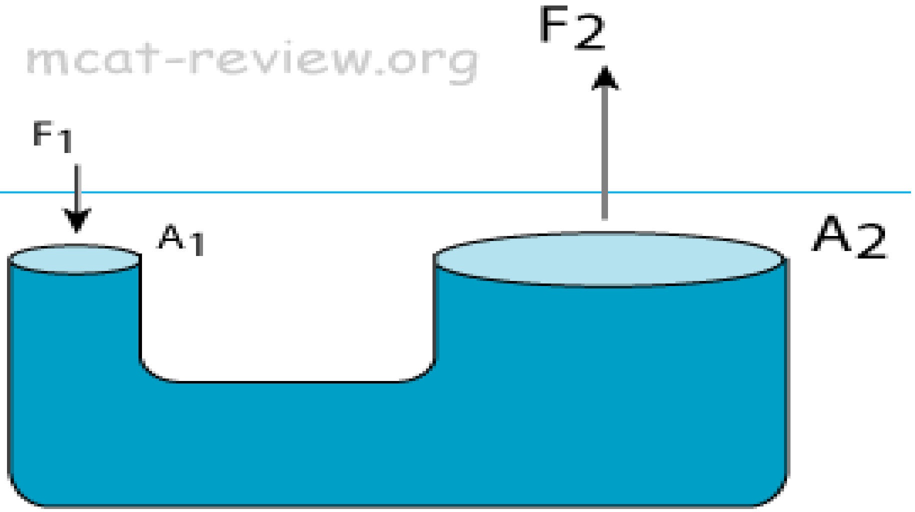
Difference between hydraulics and pneumatic

Liquids (hydraulics) – incompressible – high pressure application – high force and torque – accuracy and precision Have definite mass and volume Volume is equal to volume of liquid

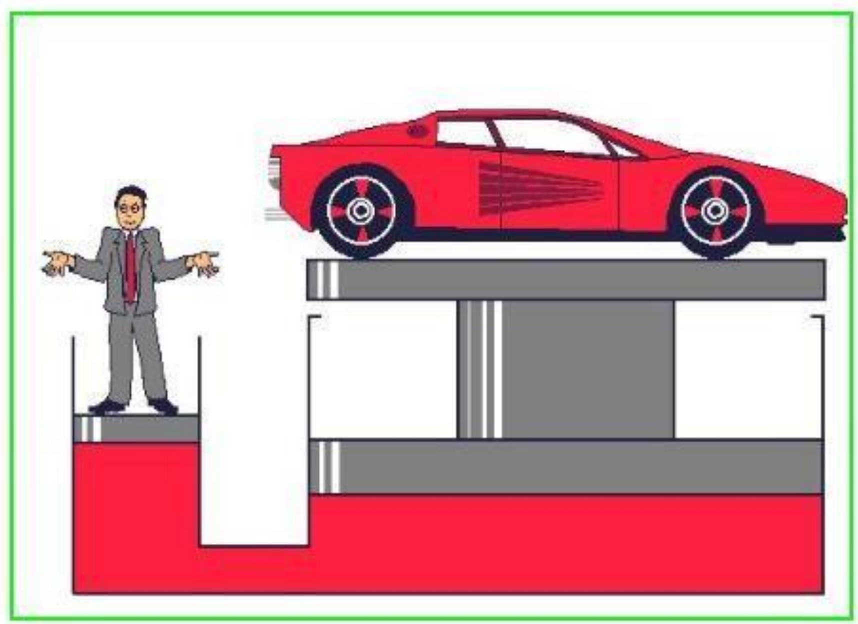
Gases (pneumatics) – compressible – low pressure applications – low force and torque – low accuracy and precision Have definite mass but not volume Volume depends on pressure & temperature

Pascal's law

- **Pascal's law** states that pressure exerted anywhere in a confined incompressible fluid is transmitted equally in all directions throughout the fluid.



$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$



- **P1 = P2** (since the pressures are equal throughout).

- Since pressure equals force per unit area, then it follows that

$$\frac{F1}{A1} = \frac{F2}{A2}$$

- Because the volume of fluid pushed down on the left side equals the volume of fluid that is lifted up on the right side, the following formula is also true.

$$V1 = V2$$

by substitution,

$$A1\ D1 = A2\ D2$$

A = cross sectional area

D = the distance moved

$$A1/A2 = D2/D1$$

Types of hydraulic fluid

- Water- Inexpensive, corrosive, no lubricity
- Petroleum oil- Excellent lubricity, tendency to oxidise
- Water glycol- Water and glycol,35-55% of water, good fire resistance, not good for high bearing load.
- Water oil emulsion- contains 40% of water, good fire resistance, inexpensive.

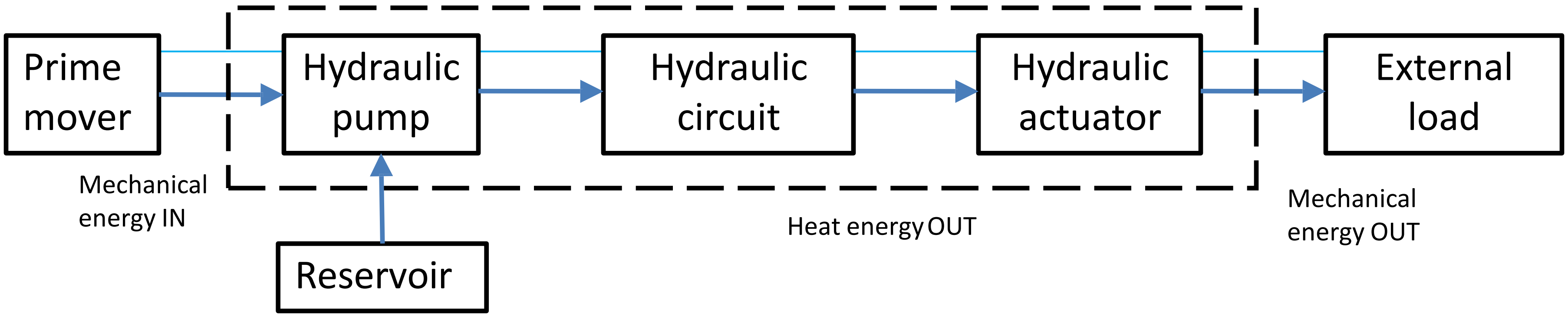
Primary function of hydraulic fluid

- Transmit power
- Lubricate moving part
- Seal clearances between mating parts
- Dissipate heat
- Compatible with hydraulic components
- Should bear physical & chemical changes

Properties of hydraulic fluid

- Good lubrication
- Ideal viscosity
- Chemical stability
- Compatibility with system materials
- High degree of incompressibility
- Fire resistance
- Good heat-transfer capability
- Low density
- Foam resistance
- No toxicity
- Low volatility

Structure of Hydraulic systems



- A tank (reservoir) to hold the hydraulic oil
- A pump to force the oil through the system
- An electric motor or other power source to drive the pump
- Valves to control oil direction, pressure and flow rate
- An actuator to convert the pressure of the oil to do useful work
- Piping

Advantages

- Fluid power systems are simple, easy to operate and can be controlled accurately:
- Multiplication and variation of forces:
- Multifunction control
- Constant force or torque
- Low weight to power ratio

APPLICATION

- Automation-Automated transfer machine
- Aviation-Landing wheels on planes
- Industry-Drills,grinders,rivertting machine
- Construction equipment-Excavators, bucket loader, dozers

Drawbacks

- Oils are messy
- Leakage is impossible
- Hydraulic lines can burst
- Noise from pumps
- Fire at hot atmosphere
- Compressed air tanks are explosive.

Pump – Converts Mechanical Energy to Hydraulic Energy.

Pump pushes the fluid into the hydraulic system.

- The function of a pump is to convert mechanical energy into hydraulic energy.
- It is the heart of any hydraulic system because it generates the force necessary to move the load.
- Mechanical energy is delivered to the pump using a prime mover such as an electric motor.
- Partial vacuum is created at the inlet due to the mechanical rotation of pump shaft.
- Vacuum permits atmospheric pressure to force the fluid through the inlet line and into the pump.
- The pump then pushes the fluid mechanically into the fluid power actuated devices such as a motor or a cylinder.

Pump – Converts Mechanical Energy to Hydraulic Energy.

Pump pushes the fluid into the hydraulic system.

Broad Classification

i)Non-positive Displacement Pump or (hydrodynamic pumps)

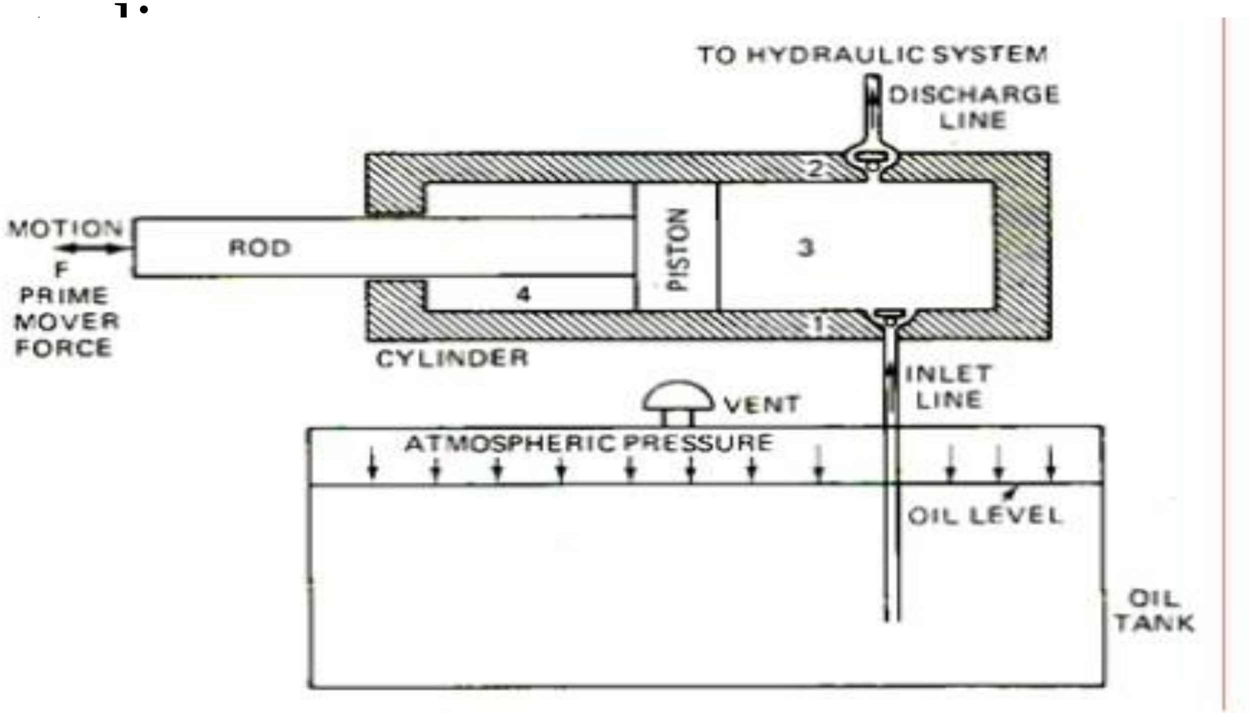
ii) Positive Displacement Pump or (hydrostatic pumps)

Pumping Theory

A partial vacuum is created at pump inlet due to internal operation of pump.

Atmospheric pressure push the fluid out of oil tank.

The pump mechanically pushes the fluid out of the disch



- Check Valve -1 Pump inlet line
- Check Valve -2 Pump Discharge

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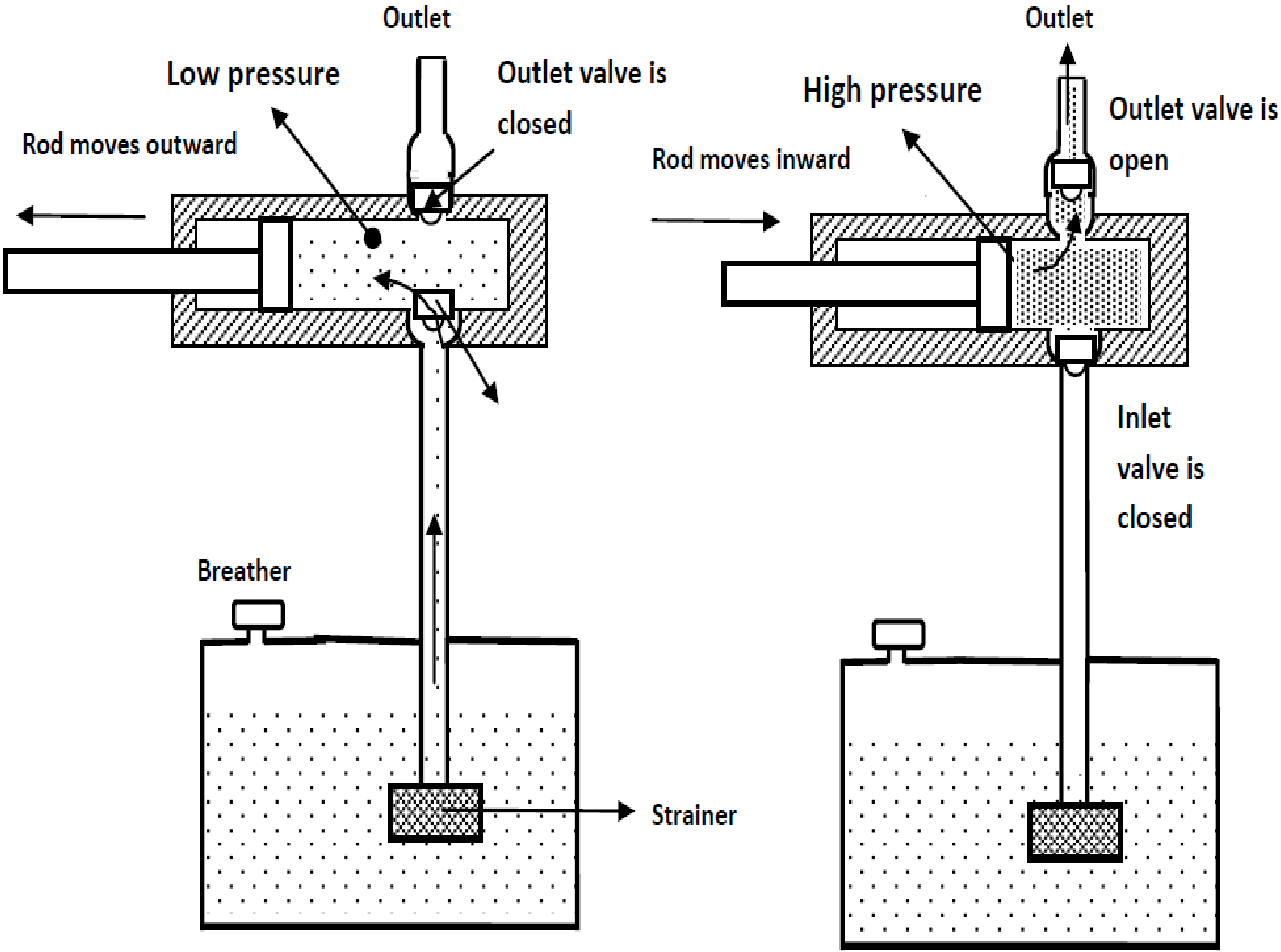

Outlet
Low pressure
Outlet valve is
closed
Rod moves outward
Breather
Strainer
Outlet
High pressure
Outlet valve is
open
Rod moves inward
Inlet
valve is
closed

- A positive displacement hydraulic pump is a device used for converting mechanical energy into hydraulic energy.

- It is driven by a prime mover such as an electric motor. It basically performs two functions.

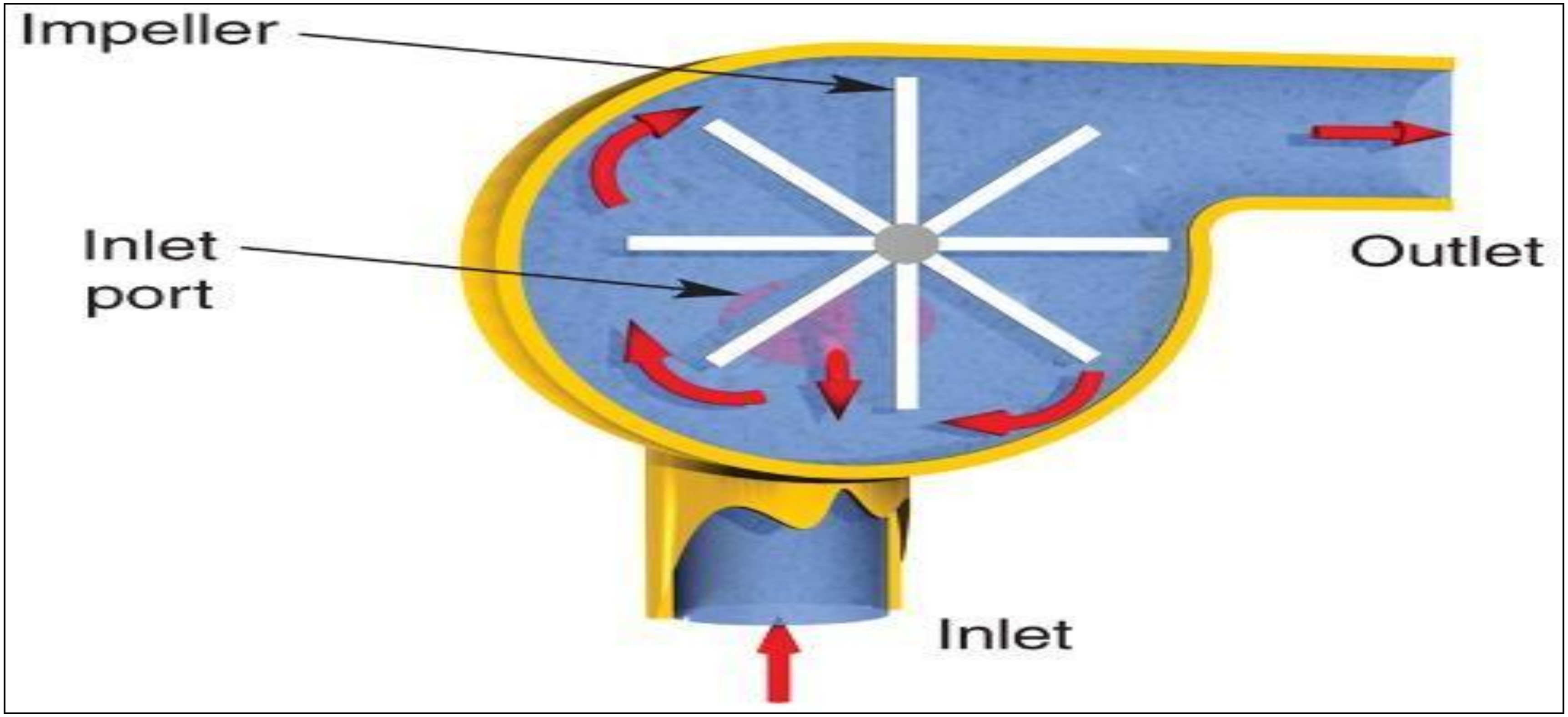
- First, it creates a partial vacuum at the pump inlet port. This vacuum enables atmospheric pressure to force the fluid from the reservoir into the pump.

- Second, the mechanical action of the pump traps this fluid within the pumping cavities, transports it through the pump and forces it into the hydraulic system.

- It is important to note that pumps create flow not pressure. Pressure is created by the resistance to flow

Basic Pump Classifications

- Non-positive-displacement pump



Non-positive Displacement Pump

- It produces a continuous flow.
- It does not provide a positive internal seal against slippage.
- Output varies considerably as pressure varies. If the output port the pump were blocked off, the pressure would rise, and output would decrease to zero.
- Although the pumping element would continue moving, flow would stop because of slippage inside the pump.

Centrifugal and propeller pumps are examples of non-positive-displacement pumps.

Positive Displacement Pump

•In a positive-displacement pump, slippage is negligible compared to the pump's volumetric output flow.

•If the output port were plugged, pressure would increase instantaneously to the point that the pump's pumping element or its case would fail (probably explode, if the drive shaft did not break first).

•Universally used for **Fluid Power**.

•It push a fixed amount of fluid into the Hydraulic System per revolution of shaft

Gear, Vane, Piston are the examples of Positive Displacement Pump

Differences between positive displacement pumps and non-positive displacement pumps

Positive Displacement Pumps	Non-positive Displacement Pumps
The flow rate does not change with head	The flow rate decreases with head
The flow rate is not much affected by the viscosity of fluid	The flow rate decreases with the viscosity
Efficiency is almost constant with head	Efficiency increases with head at first and then decreases

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Classification of Positive Displacement Pumps

1. Gear Pumps

a. External gear pumps
b. Internal gear pumps
c. Lobe pumps
d. Screw Pumps

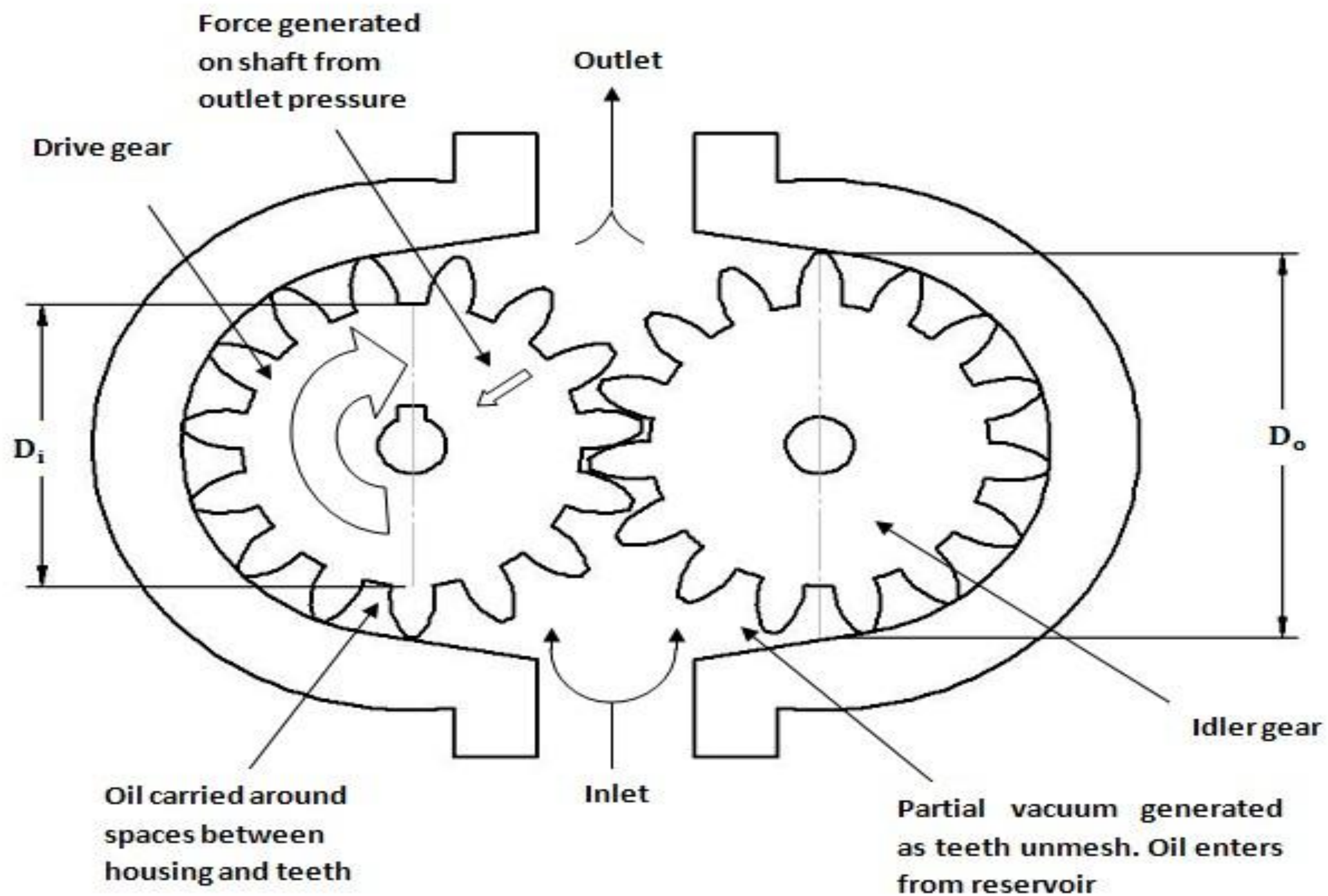
2. Vane Pumps

a. Unbalanced Vane Pumps
b. Balanced Vane Pumps

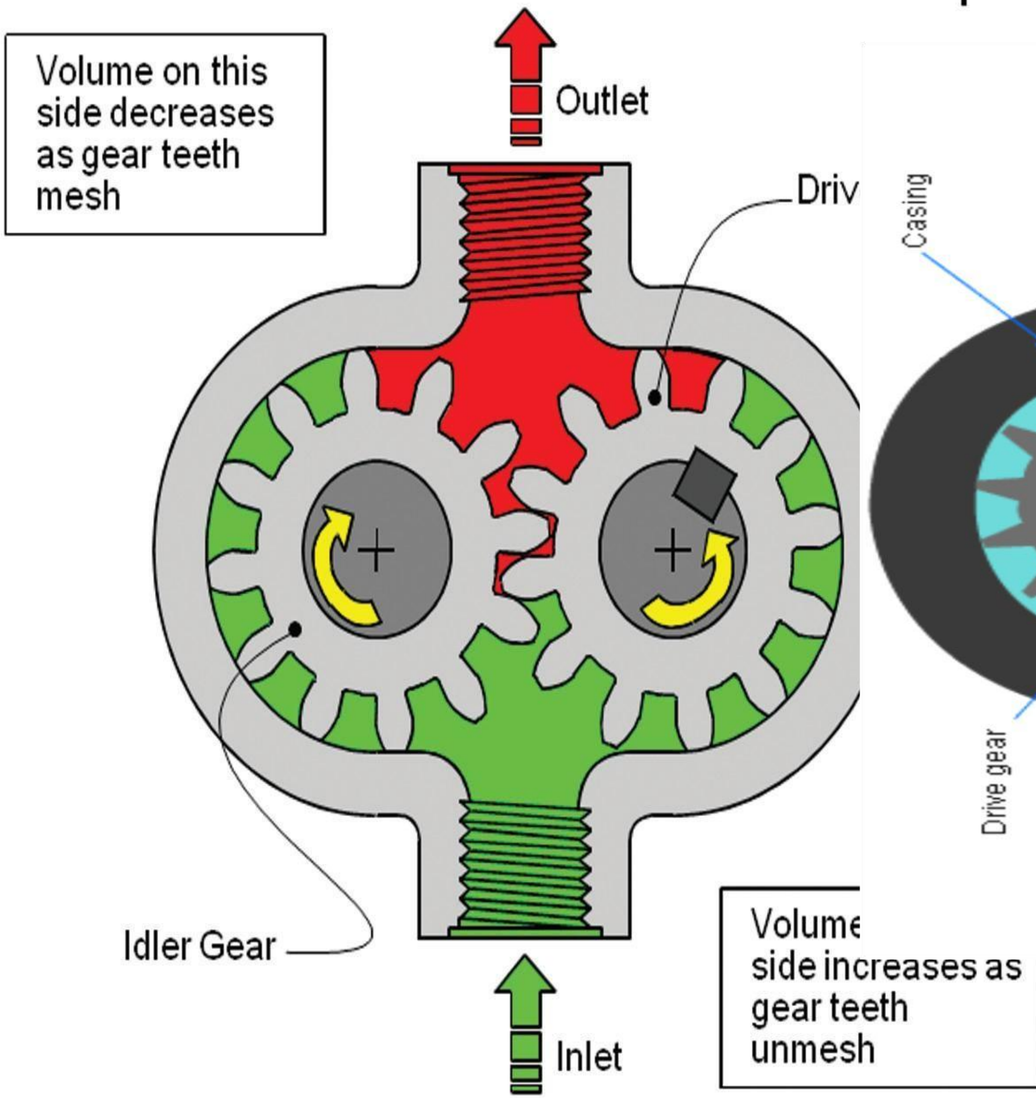
3. Piston Pumps

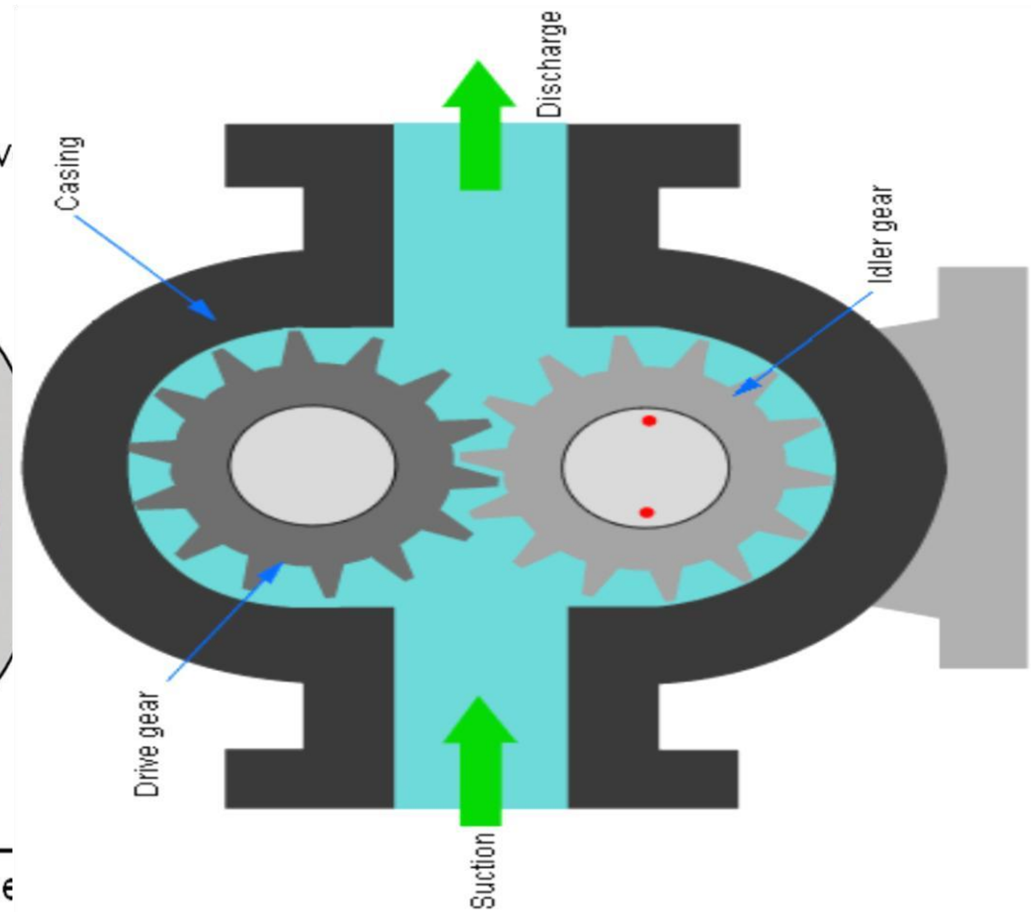
a. Axial Design
b. Radial Design

Gear pumps are less expensive but limited to pressures below 140 bar. It is noisy in operation than either vane or piston pumps. Gear pumps are invariably of fixed displacement type, which means that the amount of fluid displaced for each revolution of the drive shaft is theoretically constant.


Force generated
on shaft from
outlet pressure
Outlet
Drive gear
D_i
D_o
Idler gear
Oil carried around
spaces between
housing and teeth
Inlet
Partial vacuum generated
as teeth unmesh. Oil enters
from reservoir

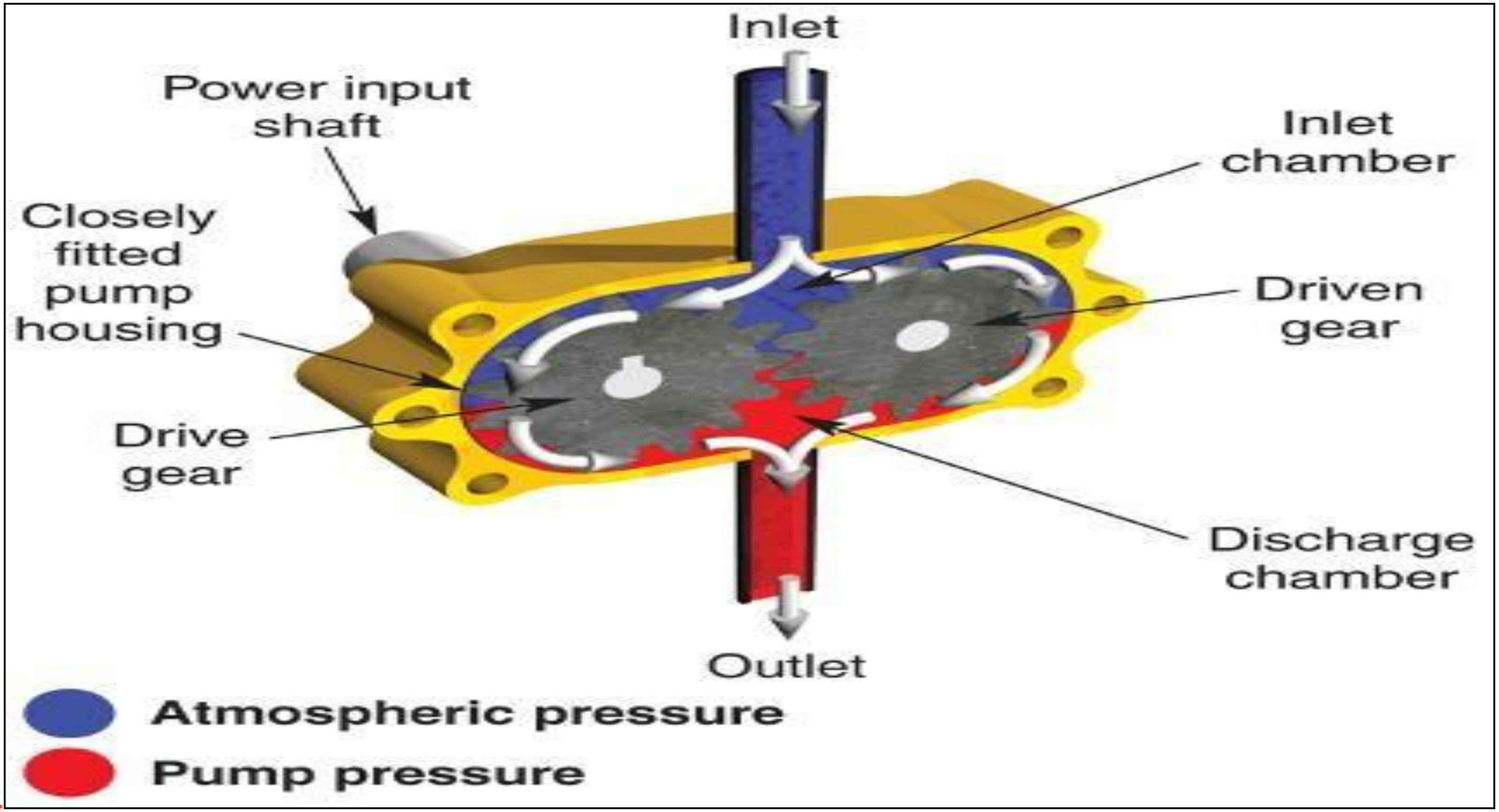
External Gear Pump





Pump Design, Operation, and Application

- Gear pumps are commonly used



Pump Design, Operation, and Application

- Pumping action of gear pumps results from unmeshing and meshing of the gears
  - As the gears unmesh in the inlet area, low pressure causes fluid to enter the pump
  - As the pump rotates, fluid is carried to the pump discharge area
  - When the gears mesh in the discharge area, fluid is forced out of the pump into the system

Pump Design, Operation, and Application

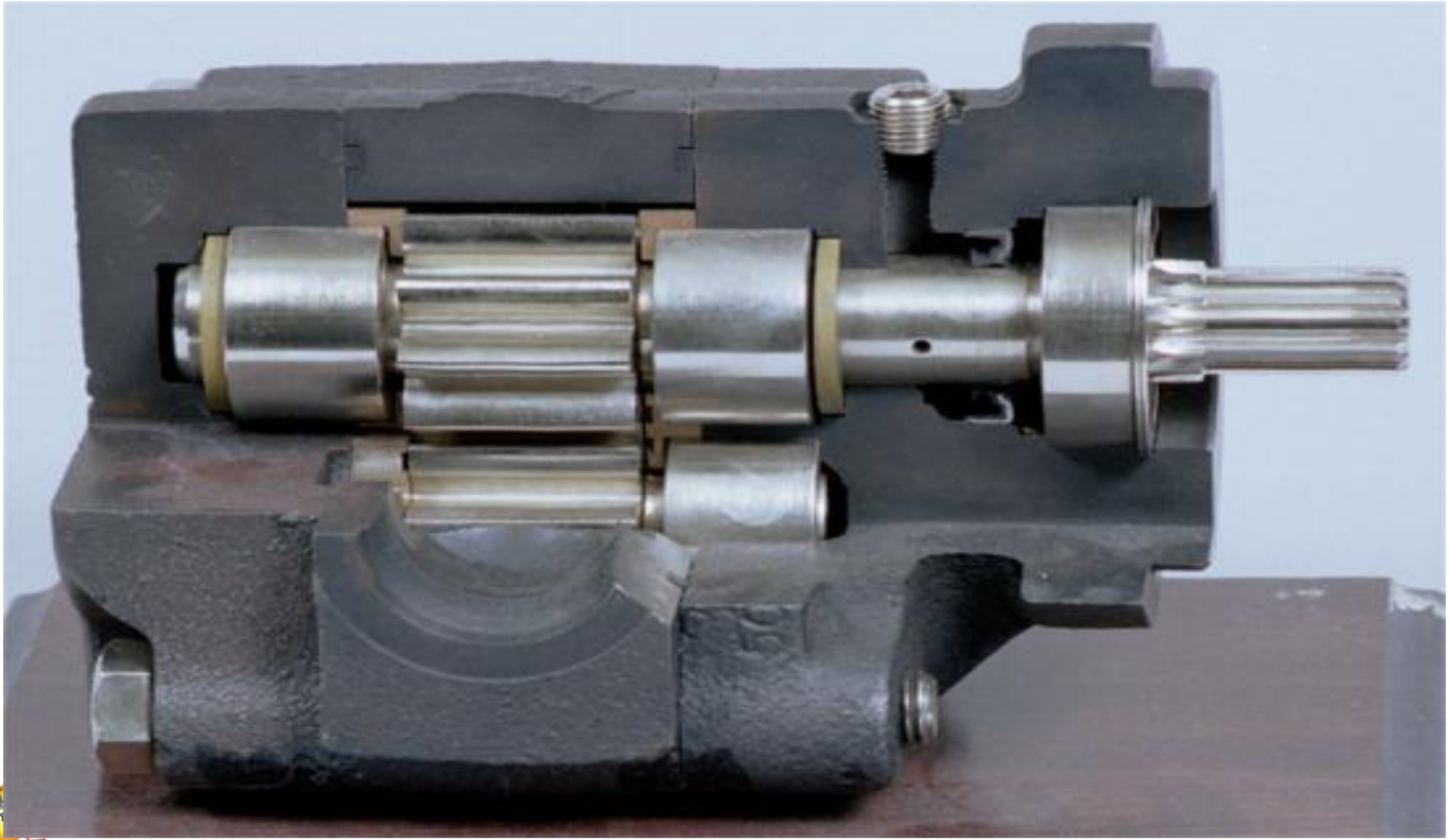
- Gear pumps are available in a wide variety of sizes
  - Flow outputs from below 1 gpm to 150 gpm
  - Pressure rating range up to 3000 psi

External gear pump

- External gear pumps are the most popular hydraulic pumps in low-pressure ranges due to their long operating life, high efficiency and low cost.
- They are generally used in a simple machine The most common form It consist of a pump housing in which a pair of precisely machined meshing gears runs with minimal radial and axial clearance.
- One of the gears, called a driver, driven by a prime mover. The driver drives another gear called a follower.. As the teeth come out of mesh at the centre, a partial vacuum is formed which draws fluid into the inlet chamber. Fluid is trapped between the outer teeth and the pump housing, causing a continual transfer of fluid from inlet chamber to outlet chamber where it is discharged to the system.
- Pump displacement is determined by: volume of fluid between each pair of teeth; number of teeth; and speed of rotation
- When the outlet flow is resisted, pressure in the pump outlet chamber builds up rapidly and forces the gear diagonally outward against the pump inlet. When the system pressure increases, imbalance occurs. This imbalance increases mechanical friction and the bearing load of the two gears. Hence, the gear pumps are operated to the maximum pressure rating stated by the manufacturer

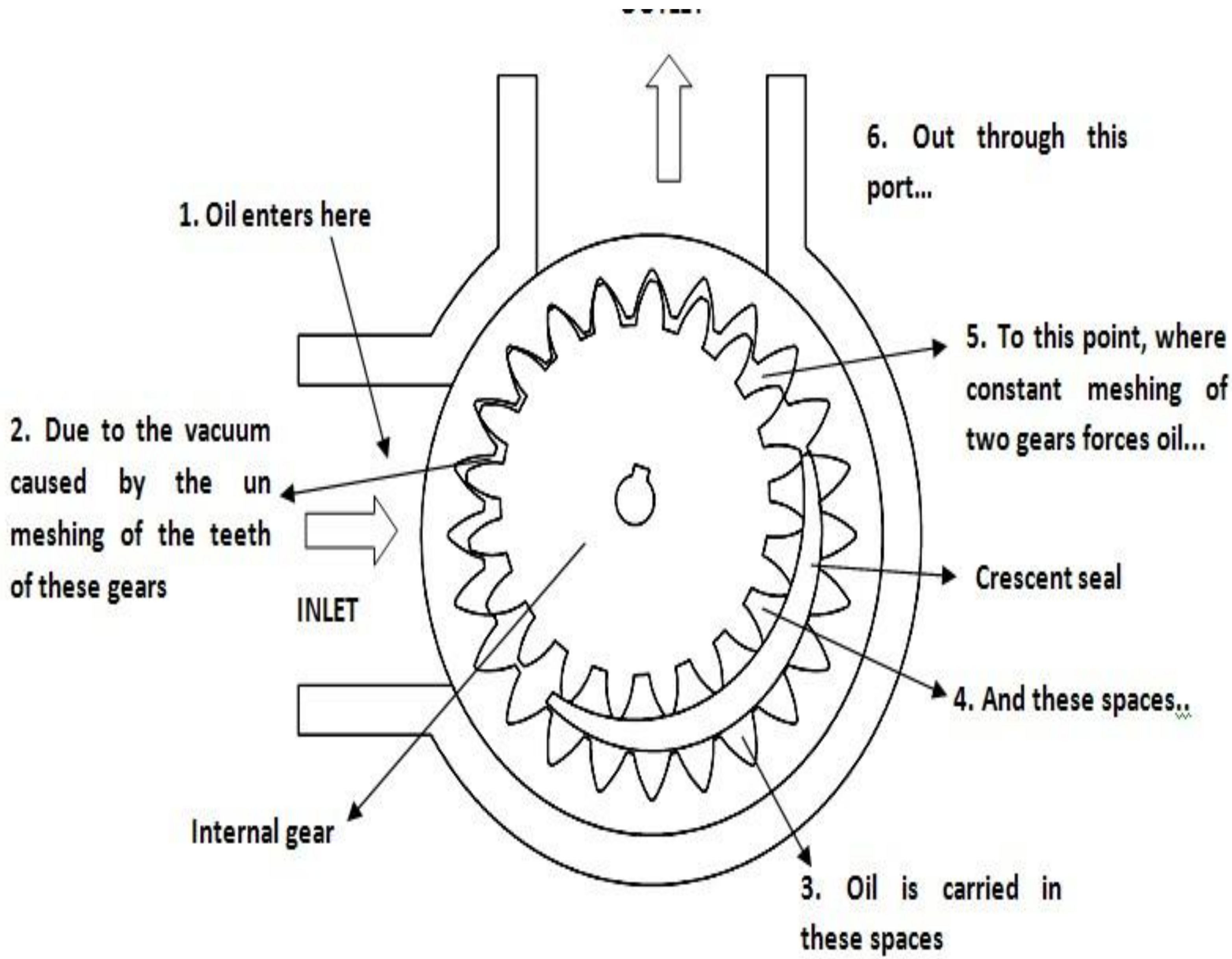
Basic Pump Classifications

- Gear pumps are fixed-delivery pumps



Internal gear pump

- The main gear is keyed to the drive shaft, and rotates concentric in the pump casing.
- Idler is located on an eccentric pin on the front cover to rotate freely and meshes with main gear when assembled.
- A crescent shaped partition precision machined on the front cover maintains a small, but positive clearance to achieve perfect scaling between parts.
- As the gears come out of mesh, a partial vacuum is created, forcing the fluid to rush into the pump casing and fill in the voids between the teeth.
- Both gears rotating in the same direction of rotation gently transfer the fluid to the delivery port. The resulting action is a smooth-steady flow; low in pulsation, noise and vibration

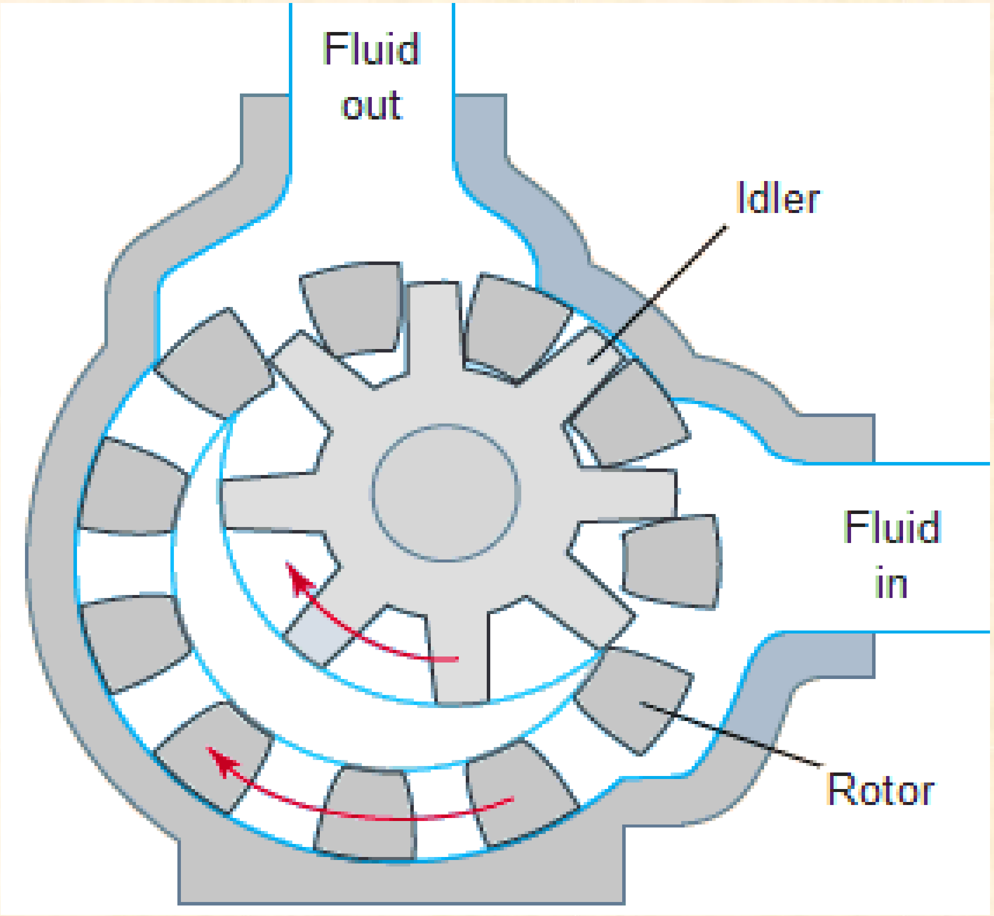


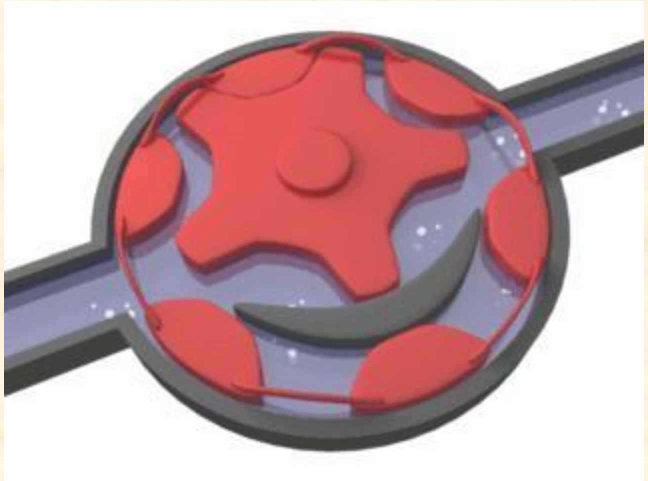
1. Oil enters here
2. Due to the vacuum caused by the un meshing of the teeth of these gears
INLET
Internal gear
3. Oil is carried in these spaces
4. And these spaces..
Crescent seal
5. To this point, where constant meshing of two gears forces oil...
6. Out through this port...

ADVANTAGES : -

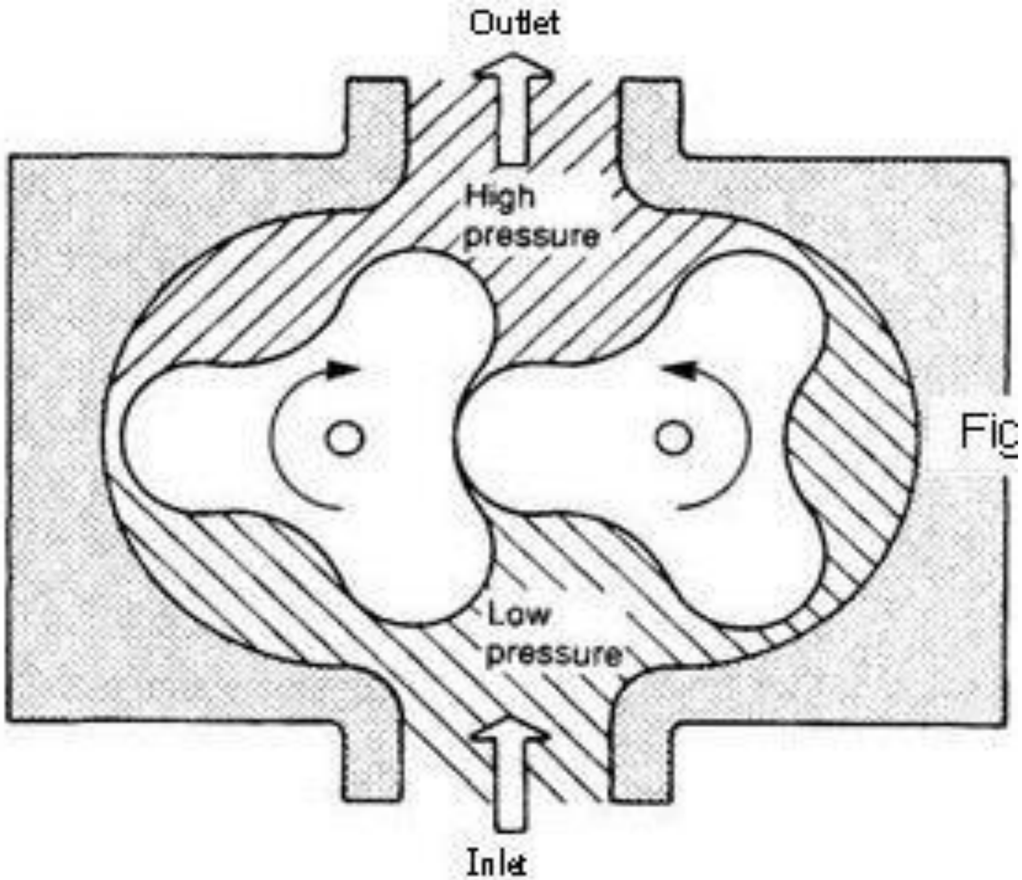
- Only two moving parts
- Non-pulsating discharge
- Excellent for high-viscosity liquids
- Constant and even discharge regardless of pressure conditions
- Operates well in either direction
- Single adjustable end clearance
- Easy to maintain

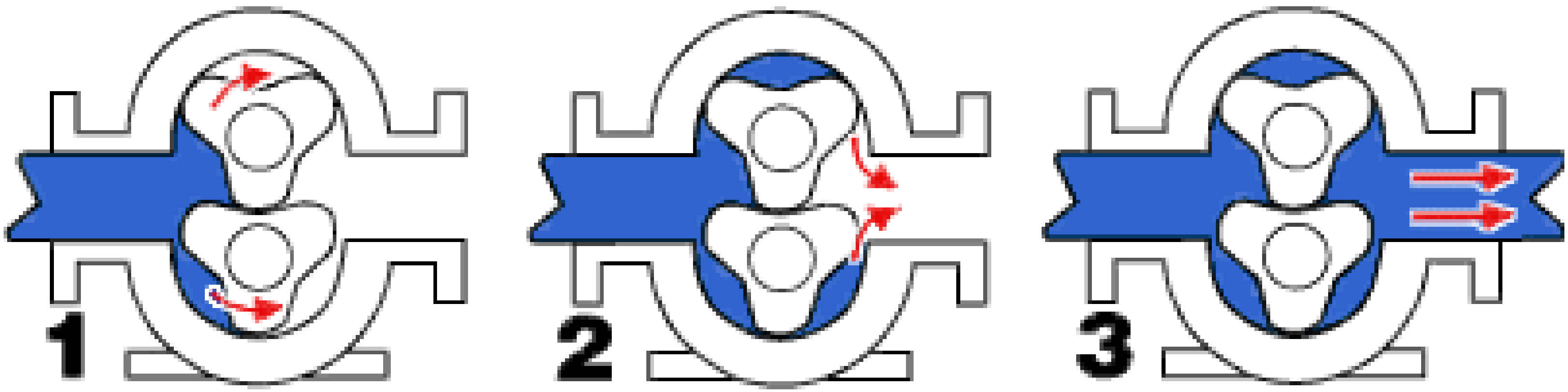
INTERNAL GEAR PUMP





Lobe pump





1.As the lobes come out of mesh, they create expanding volume on the inlet side of the pump. Liquid flows into the cavity and is trapped by the lobes as they rotate.

2.Liquid travels around the interior of the casing in pockets between the lobes and the casing (it does not pass between the lobes).

3.Finally, the meshing of the lobes forces the liquid through the outlet port under pressure.

- Lobe pumps are frequently used in food applications because they are good at handling solids without inflicting damage to the product.

- Solid particle size can be much larger in lobe pumps than in other positive displacement types.

- Because lobes do not make contact, and clearances are not as close as in other positive displacement pumps, this design handles low-viscosity liquids with diminished performance.

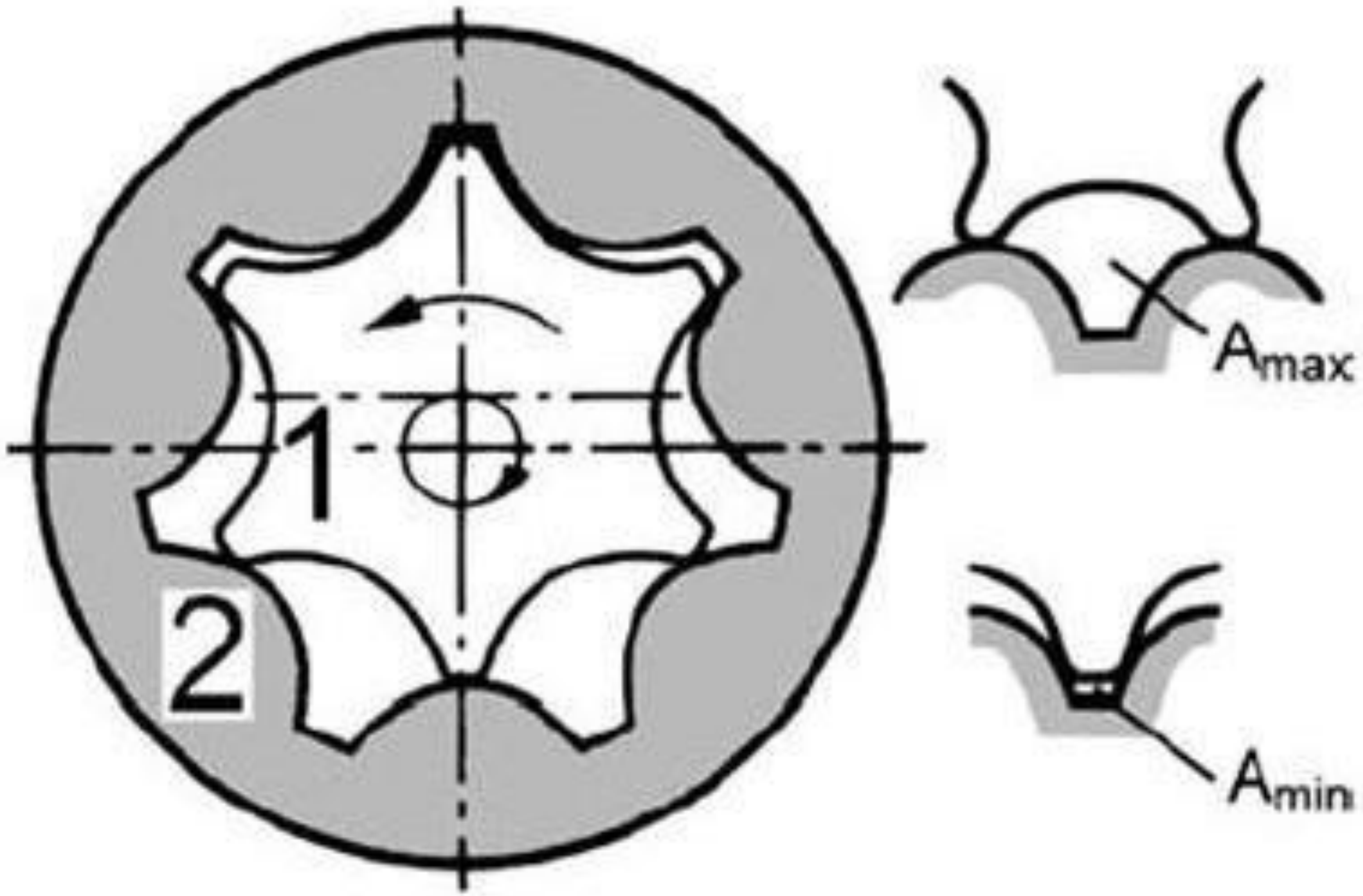
- Loading characteristics are not as good as other designs and suction ability is low.

- High-viscosity liquids require reduced speeds to achieve satisfactory performance.

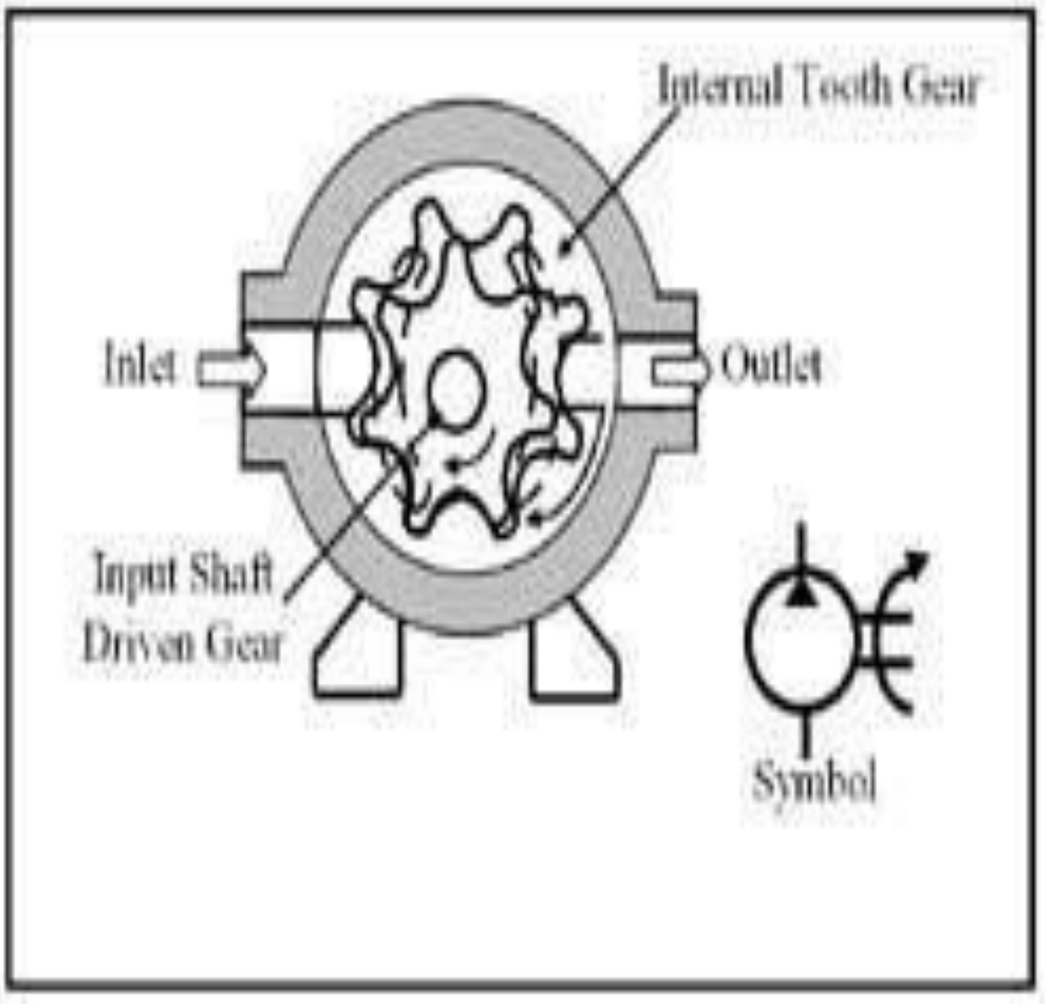
- Reductions of 25% of rated speed and lower are common with high-viscosity liquids.

GEOROTOR PUMP

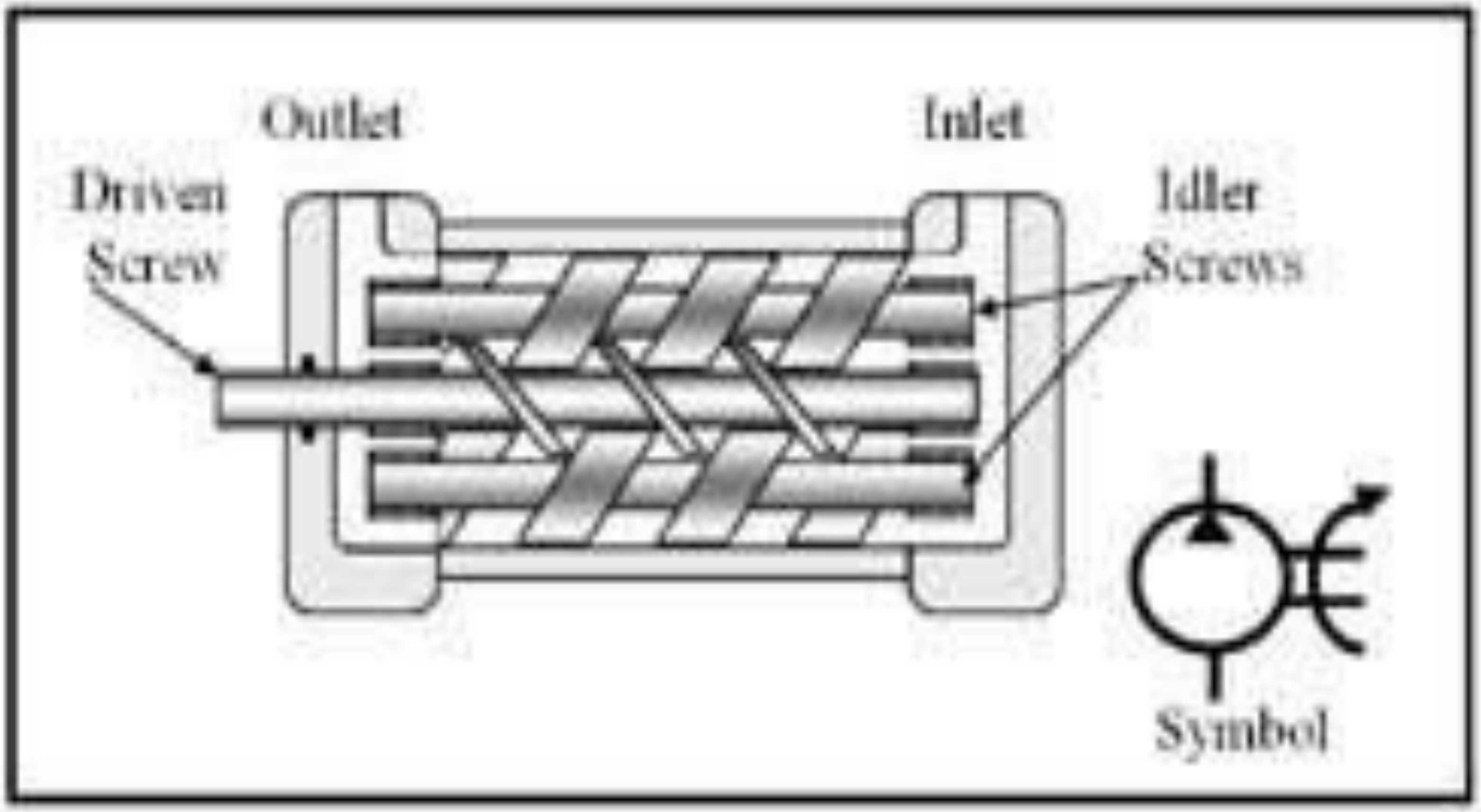
- Gerotor pumps operate in the same manner as internal gear pumps. The inner gear rotor is called a gerotor element. The gerotor element is driven by a prime mover and during the operation drives outer gear rotor around as they mesh together.
- The gerotor has one tooth less than the outer internal idler gear. Each tooth of the gerotor is always in sliding contact with the surface of the outer element. The teeth of the two elements engage at just one place to seal the pumping chambers from each other. On the right-hand side of the pump, pockets of increasing size are formed, while on the opposite side, pockets decrease in size.
- The pockets of increasing size are suction pockets and those of decreasing size are discharge pockets. Therefore, the intake side of the pump is on the right and discharge side on the left.
- Pumping chambers are formed by the adjacent pair of teeth, which are constantly in contact with the outer element, except for clearance as the rotor is turned, its gear tips are accurately machined so that they precisely follow the inner surface of the outer element. The expanding chambers are created as the gear teeth withdraw.

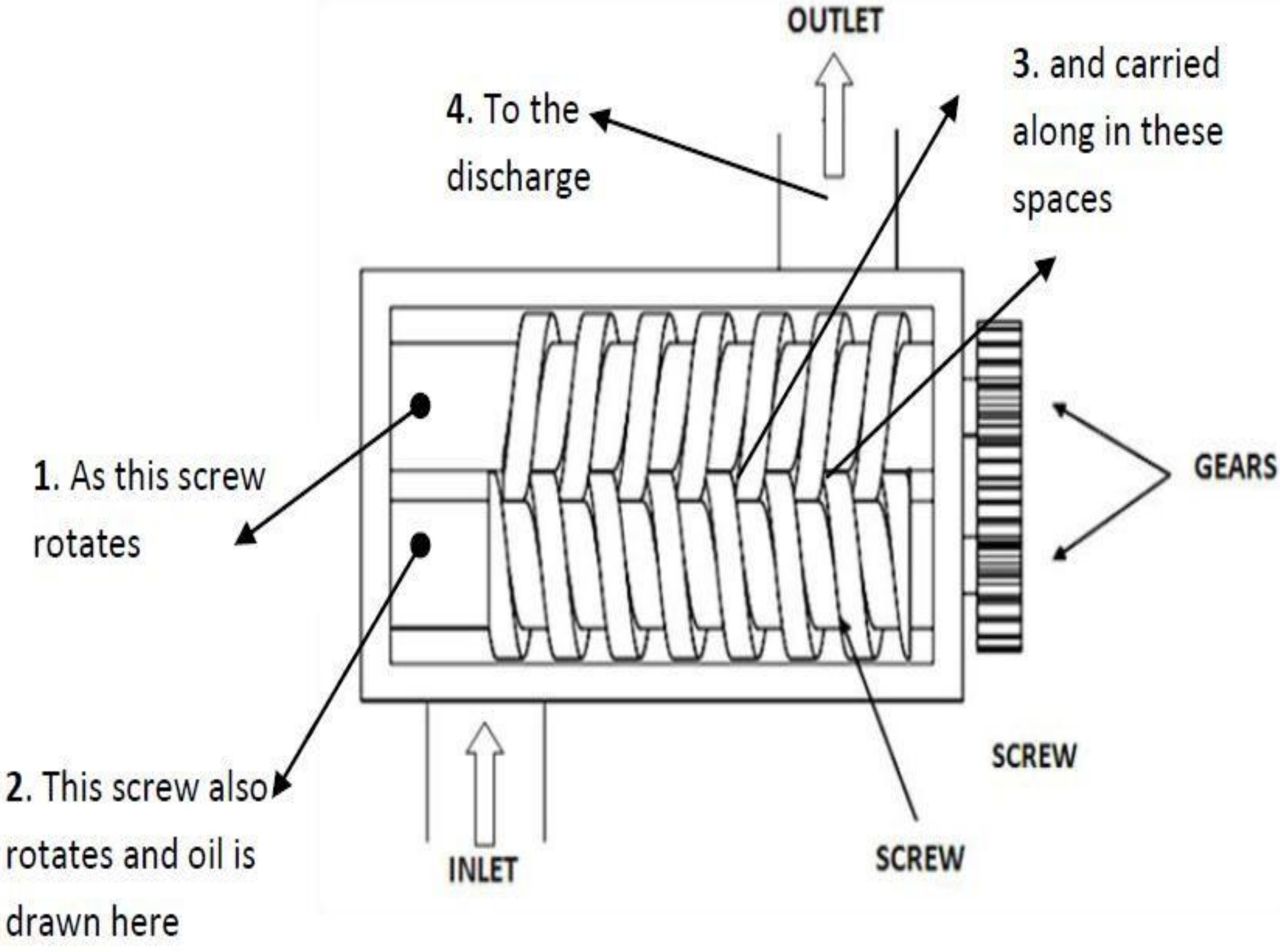

1
2
Amax
Amin

GEROTOR PUMP



SCREW PUMP




OUTLET
4. To the
discharge
3. and carried
along in these
spaces
1. As this screw
rotates
GEARS
SCREW
2. This screw also
rotates and oil is
drawn here
INLET
SCREW

- A two-screw pump consists of two parallel rotors with inter-meshing threads rotating in a closely machined casing.

- The driving screw and driven screw are connected by means of timing gears. When the screws turn, the space between the threads is divided into compartments.

- As the screws rotate, the inlet side of the pump is flooded with hydraulic fluid because of partial vacuum.

- When the screws turn in normal rotation, the fluid contained in these compartments is pushed uniformly along the axis toward the center of the pump, where the compartments discharge the fluid.

- The fluid does not rotate but moves linearly as a nut on threads. Thus, there are no pulsations at a higher speed; it is a very quiet operating

Advantage:

It has very smooth flow,

Flow from the outlet is smooth and continuous.

Disadvantage: screw pumps are not highly efficient.

This design pump often is used to supercharge other pumps, as a filter pump, or a transfer pump at low pressure.

Unbalanced Vane Pump with Fixed Delivery

The main components of the pump are the cam surface and the rotor.

The rotor contains radial slots splined to drive shaft and rotates inside the cam ring.

Each radial slot contains a vane, which is free to slide in or out of the slots due to centrifugal force.

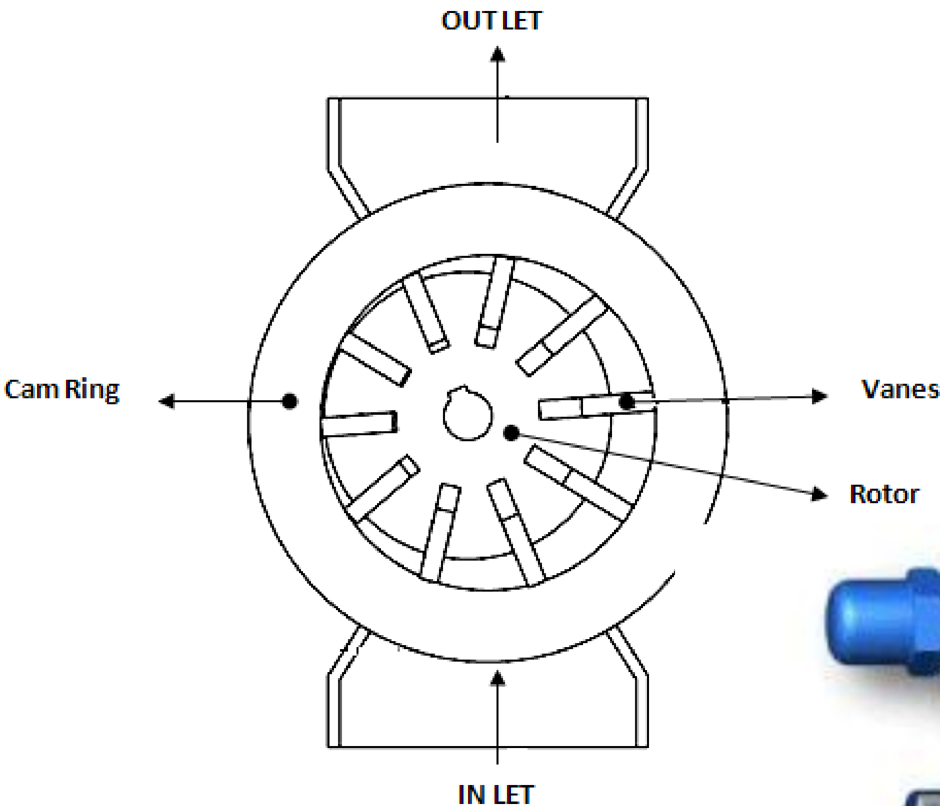
The vane is designed to mate with surface of the cam ring as the rotor turns. The cam ring axis is offset to the drive shaft axis.

When the rotor rotates, the centrifugal force pushes the vanes out against the surface of the cam ring.

The vanes divide the space between the rotor and the cam ring into a series of small chambers.

During the first half of the rotor rotation, the volume of these chambers increases, thereby causing a reduction of pressure.

This is the suction process, which causes the fluid to flow through the inlet port.


OUT LET
Cam Ring
Vanes
Rotor
IN LET

- During the second half of rotor rotation, the cam ring pushes the vanes back into the slots and the trapped volume is reduced.

- This positively ejects the trapped fluid through the outlet port.

- In this pump, all pump action takes place in the chambers located on one side of the rotor and shaft, and so the pump is of an unbalanced design.

- The delivery rate of the pump depends on the eccentricity of the rotor with respect to the cam ring.

Pressure-Compensated Variable Displacement Vane Pump

NOTE-Write theory of unbalanced vane pump and explain these point

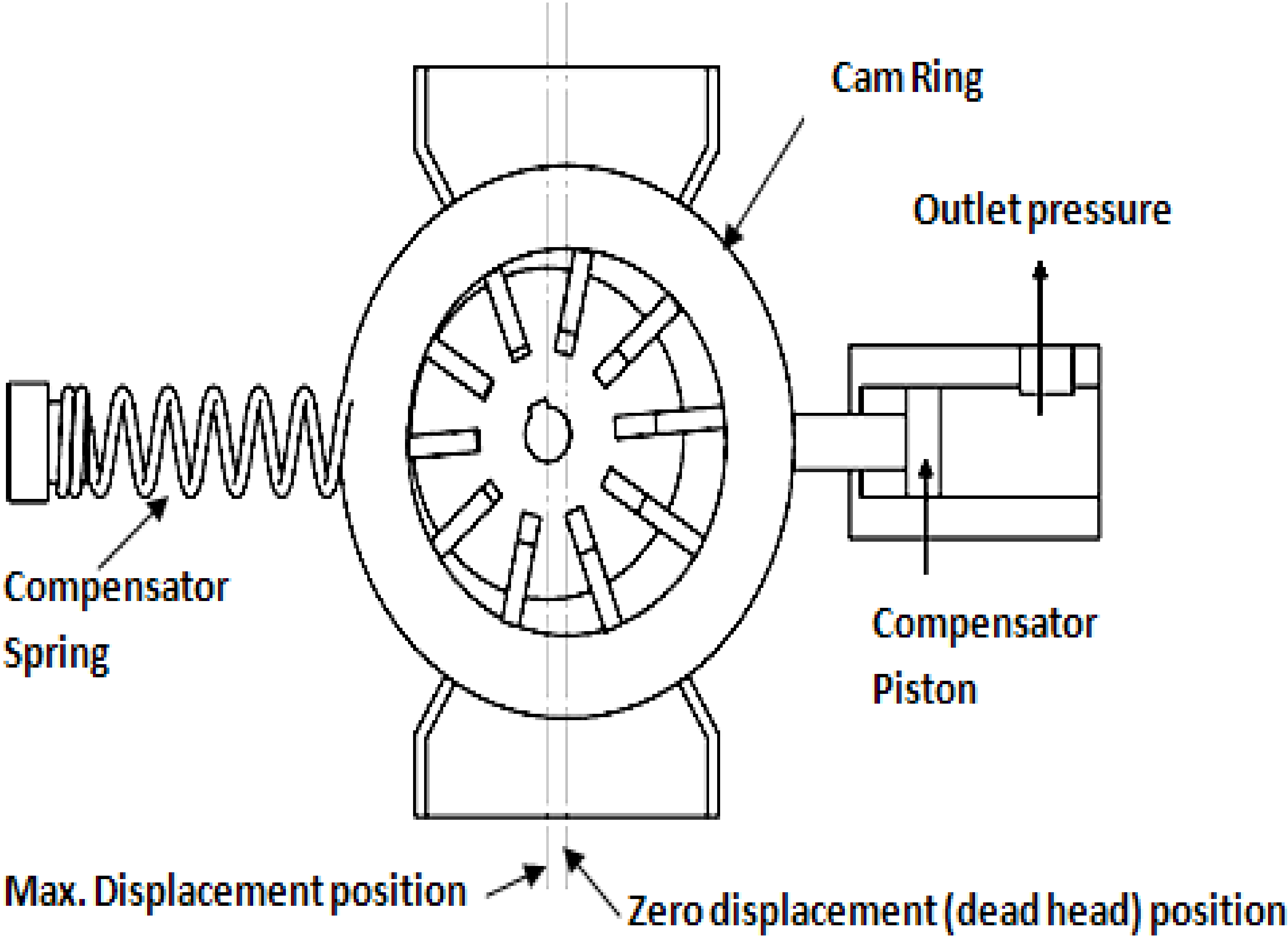
- Variable displacement feature can be brought into vane pumps by varying eccentricity between the rotor and the cam ring.

- Here in this pump, the stator ring is held against a spring loaded piston.
- The system pressure acts directly through a hydraulic piston on the right side.
- This forces the cam ring against a spring-loaded piston on the left side.

- If the discharge pressure is large enough, it overcomes the compensated spring force and shifts the cam ring to the left.

- This reduces the eccentricity and decreases the flow. If the pressure continues to increase, there is no eccentricity and pump flow becomes zero.This reduces the eccentricity and decreases the flow.

- If the pressure continues to increase, there is no eccentricity and pump flow becomes zero.


Cam Ring
Outlet pressure
Compensator
Spring
Compensator
Piston
Max. Displacement position
Zero displacement (dead head) position

Balanced vane pump

- **Balanced vane pump** has two intake ports and two outlet ports and they are diametrically opposite to each other.
- An elliptical housing is used in balanced vane pump rather than cam ring that is used in unbalanced vane pump.
- This configuration creates two diametrically opposed volumes.
- The two high pressure zones balance the forces on the rotor shaft and hence complete hydraulic balance is achieved.
- These descriptions are the only difference from unbalanced vane pump other than this construction and working principle is as same as the unbalanced vane pump

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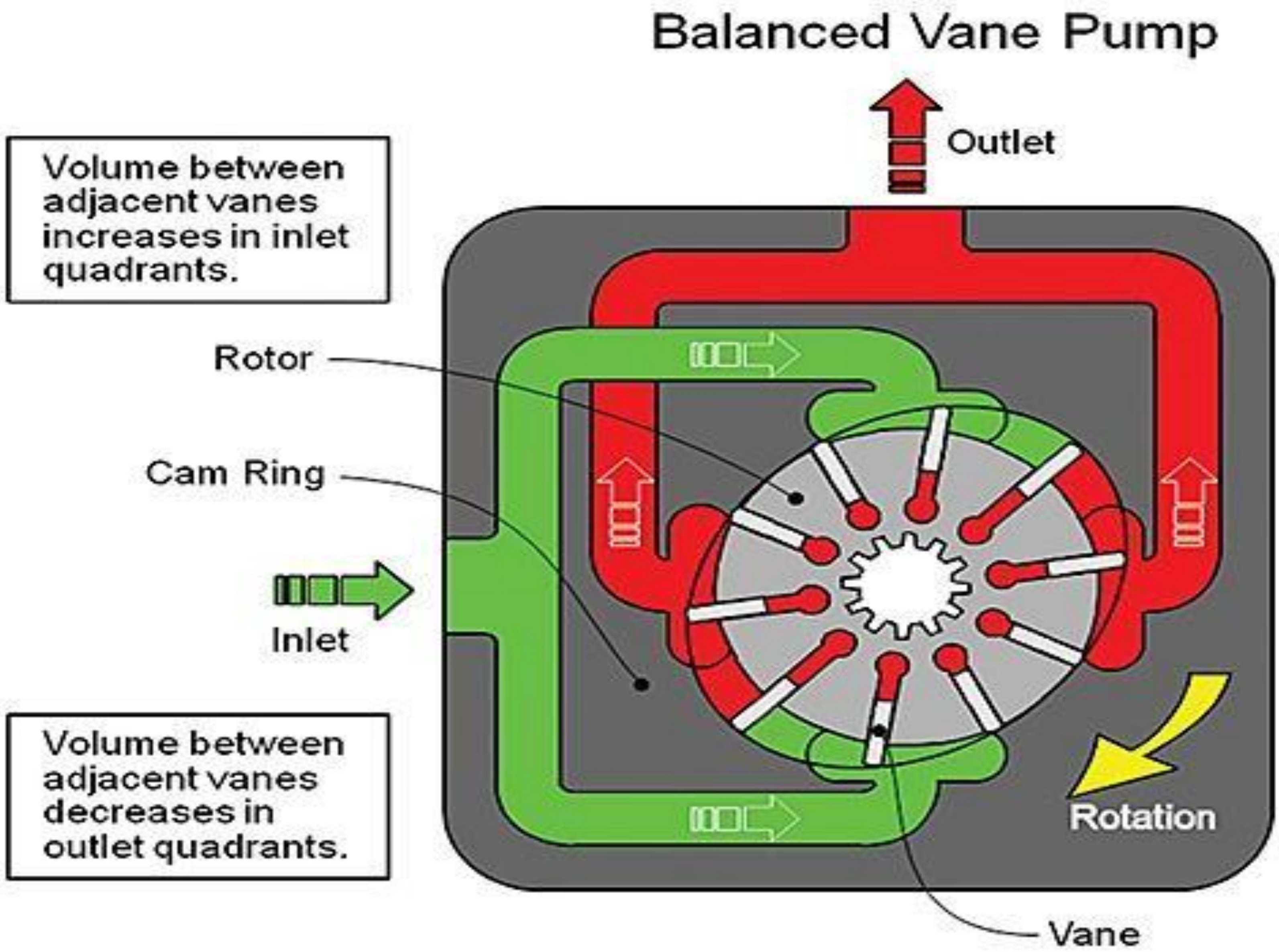

Balanced Vane Pump
Outlet
Volume between adjacent vanes increases in inlet quadrants.
Rotor
Cam Ring
Inlet
Volume between adjacent vanes decreases in outlet quadrants.
Rotation
Vane

- **Advantages of balanced vane pump**
- Permits higher operating pressures as the balanced design of pump eliminates the bearing side loads.
- Balanced vane pumps have much improved services lives over simpler unbalanced vane pumps.
- **Disadvantages of balanced vane pump**
- Balanced vane pumps are fixed displacement machines and so the displacement cannot be varied.
- The balanced vane pumps are difficult to design as variable displacement pump because of its symmetrical construction.
- **Advantages of vane pump**
- Vane pumps give constant delivery for a set rotor speed.
- Vane pumps are robust, self-priming.
- Vane pump provides uniform discharge with negligible pulsations.
- Vane pump vanes are self-compensating for wear.
- The vanes can be easily replaced..
- They occupy lesser space

Bent axis piston pump

- It contains a cylinder block rotating with a drive shaft. However, the centerline of the cylinder block is set at an offset angle relative to the centerline of the drive shaft.

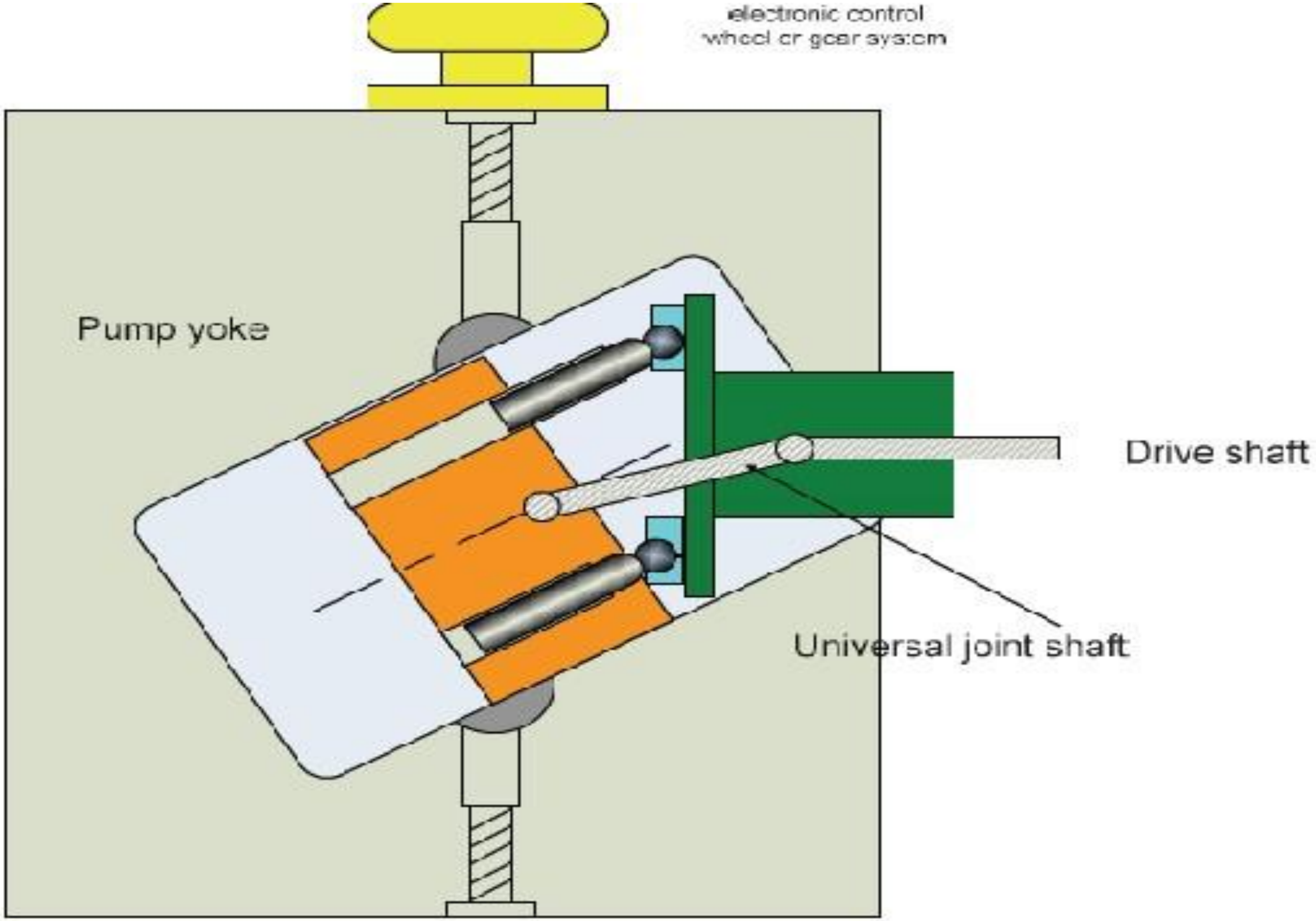
- The cylinder block contains a number of pistons arranged along a circle. The piston rods are connected to the drive shaft flange by a ball and socket joints.

- The pistons are forced in and out of their bores as the distance between the drive shaft flange and cylinder block changes.

- A universal link connects the cylinder block to the drive shaft to provide alignment and positive drive.

- The volumetric displacement of the pump depends on the offset angle . No flow is produced when the cylinder block is centerline. Angle can vary from 0 to a maximum of about 30 degree. For a fixed displacement, units are usually provided with 23 or 30 offset angles

Bent Axis fixed displacement pumps



Bent axis pump

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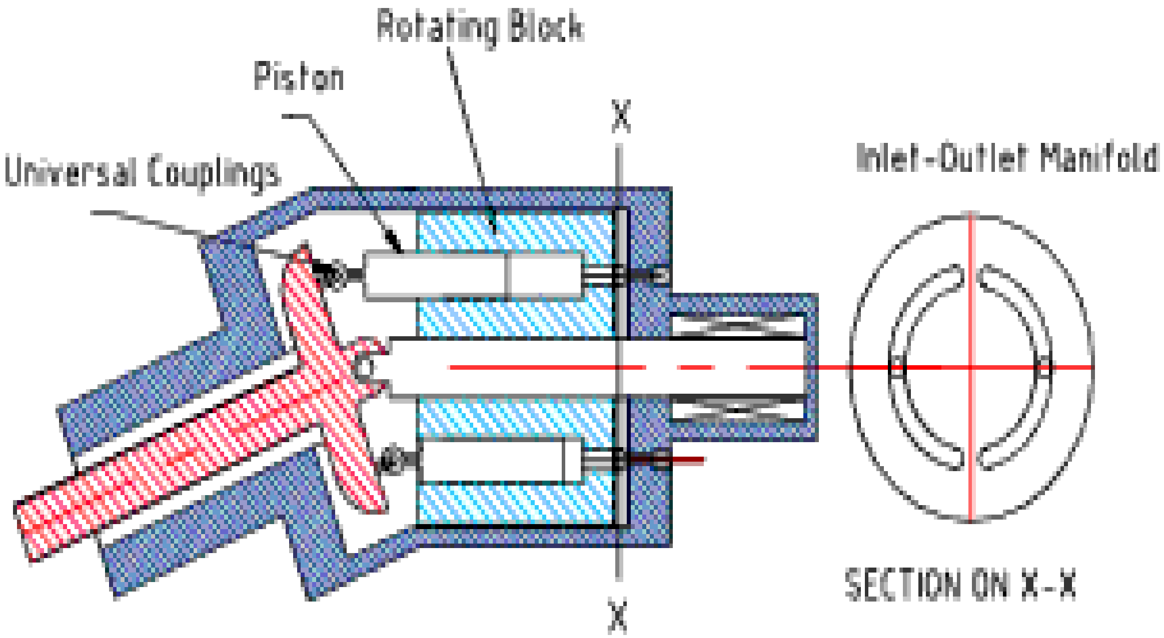
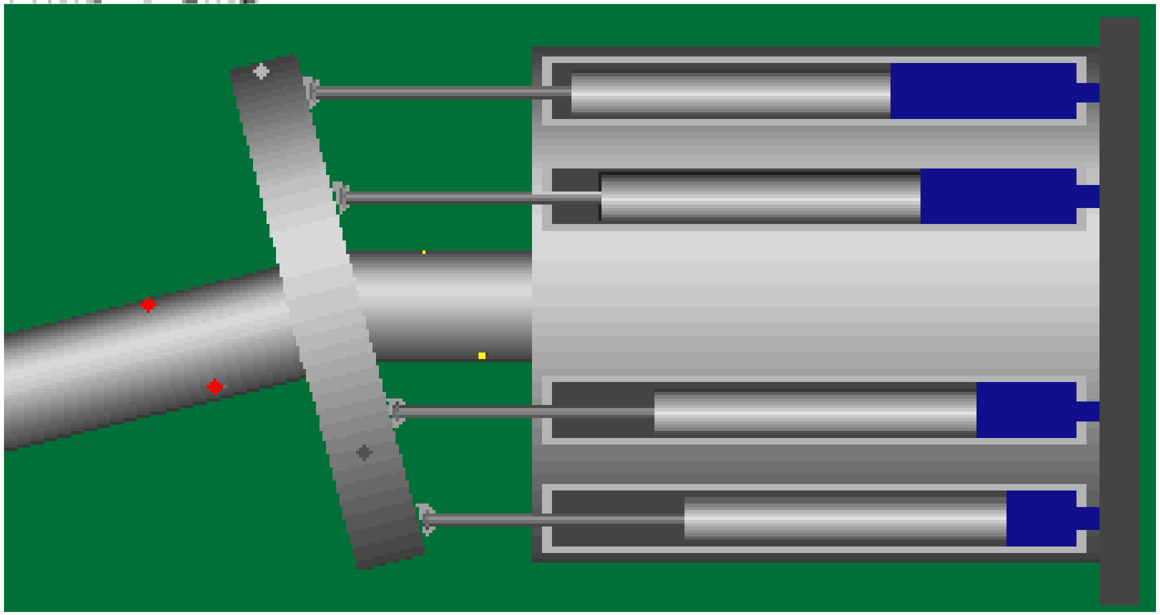
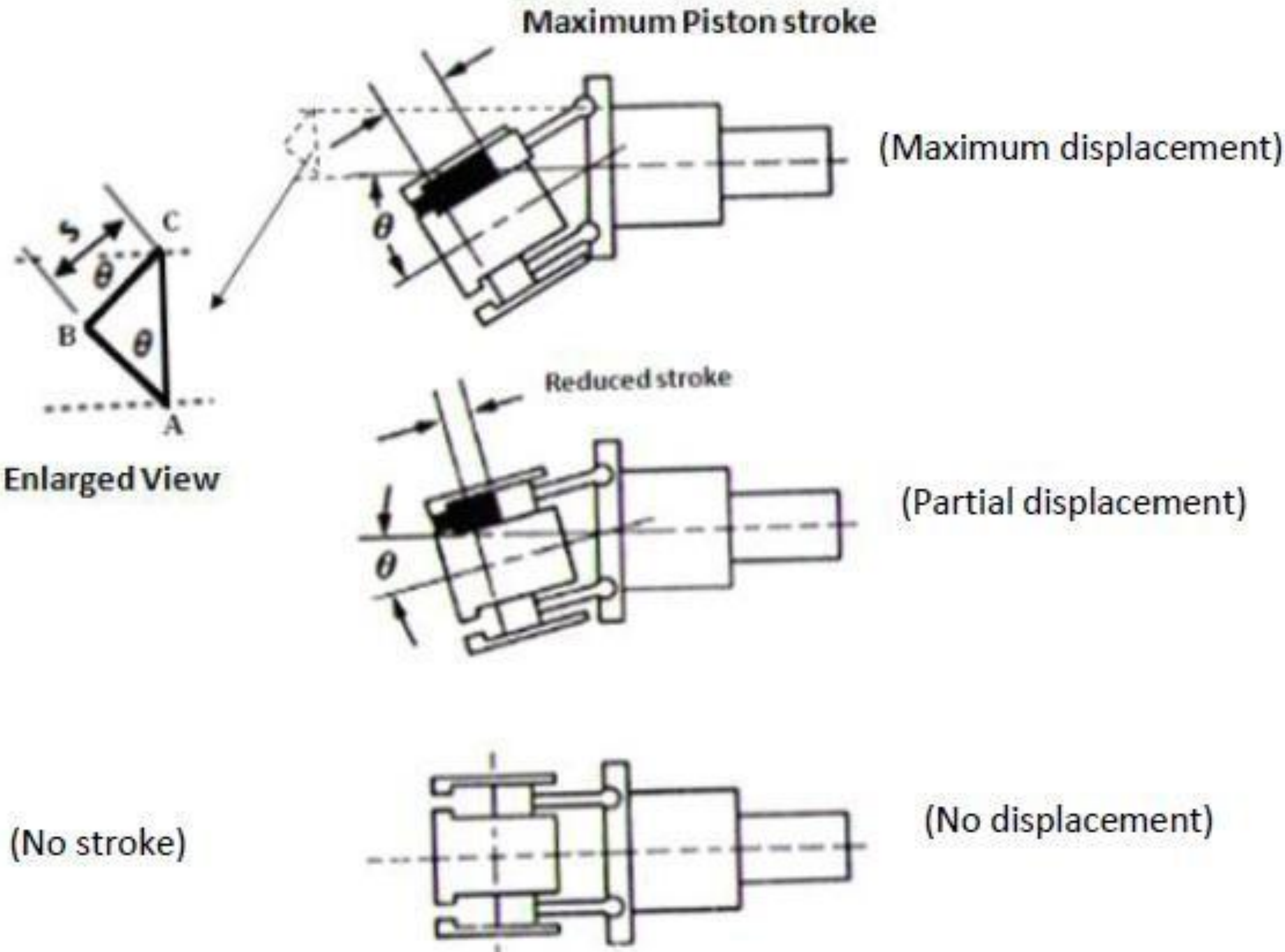


Bent Axis Pump




Maximum Piston stroke
(Maximum displacement)
S
C
θ
B
θ
A
θ
Enlarged View
Reduced stroke
(Partial displacement)
θ
(No stroke)
(No displacement)

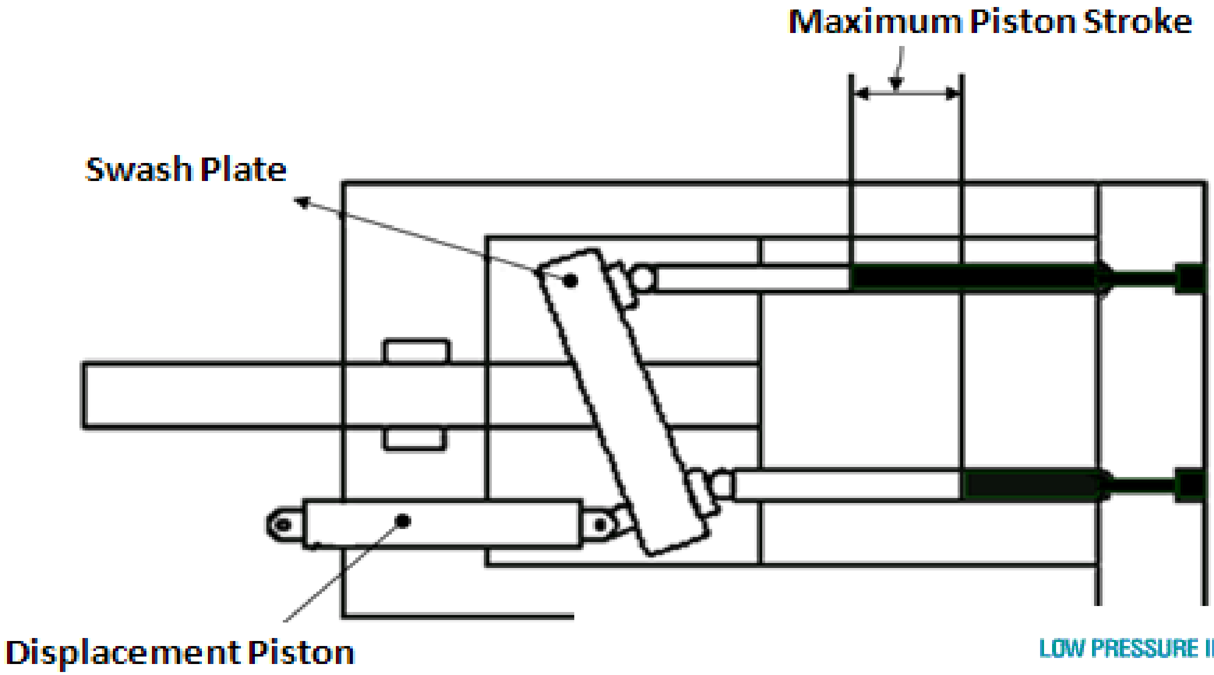
SWASH PLATE PISTON PUMP

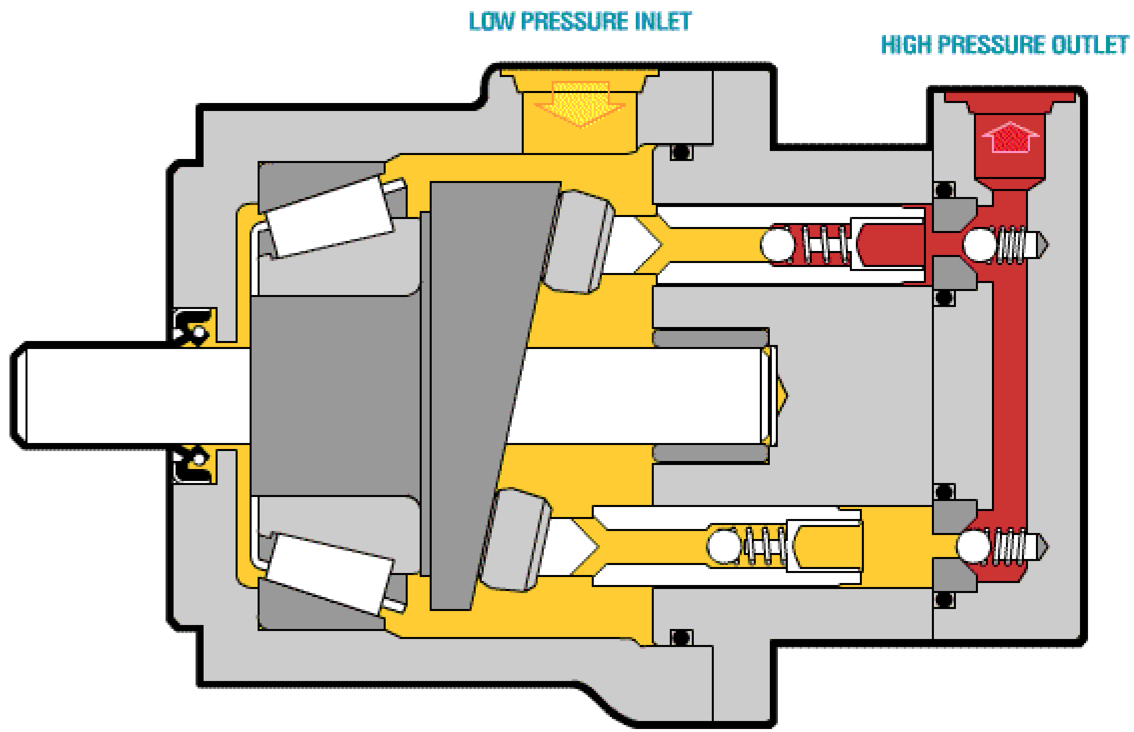
- The cylinder block and drive shaft are located on the same centerline. The pistons are connected to a shoe plate that bears against an angled swash plate.

- As the cylinder rotates, the pistons reciprocate because the piston shoes follow the angled surface of the swash plate.

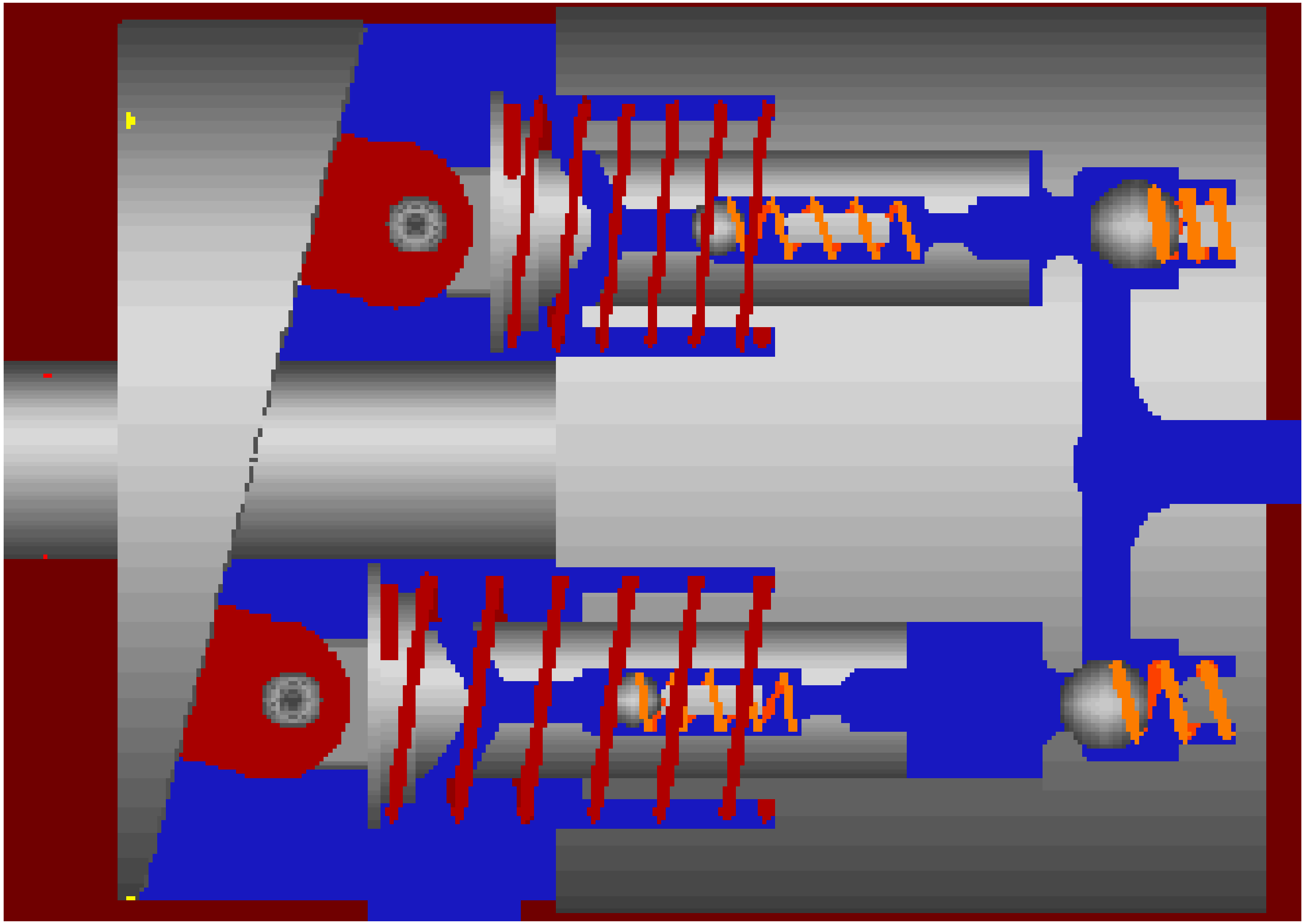
- The outlet and inlet ports are located in the valve plate so that the pistons pass the inlet as they are being pulled out and pass the outlet as they are being forced back in.

- This type of pump can also be designed to have a variable displacement capability. The maximum swash plate angle is limited to 17.5° by construction.

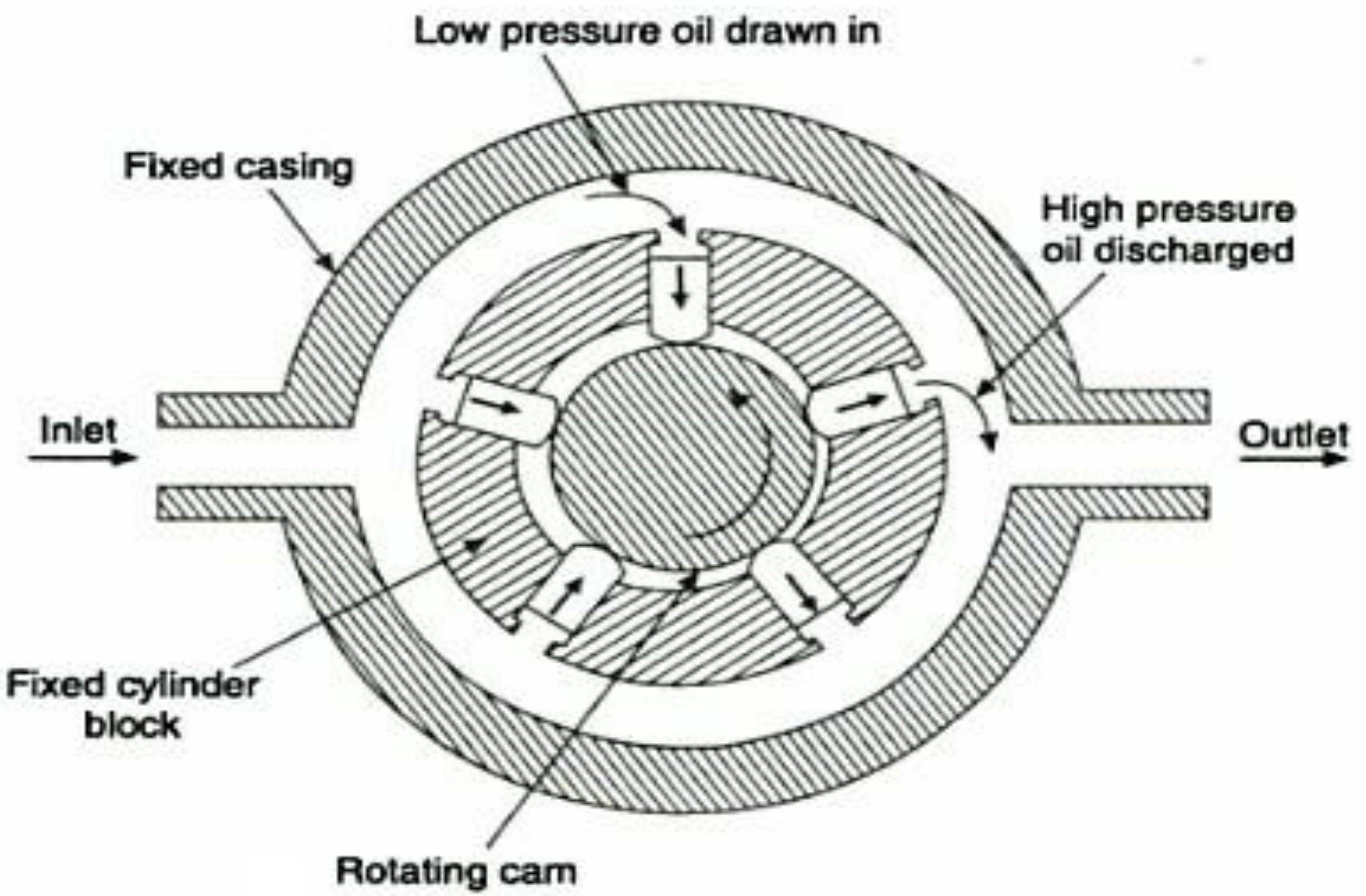

Maximum Piston Stroke
Swash Plate
Displacement Piston


LOW PRESSURE INLET
HIGH PRESSURE OUTLET

Swash plate piston pump



1.Radial Piston pump

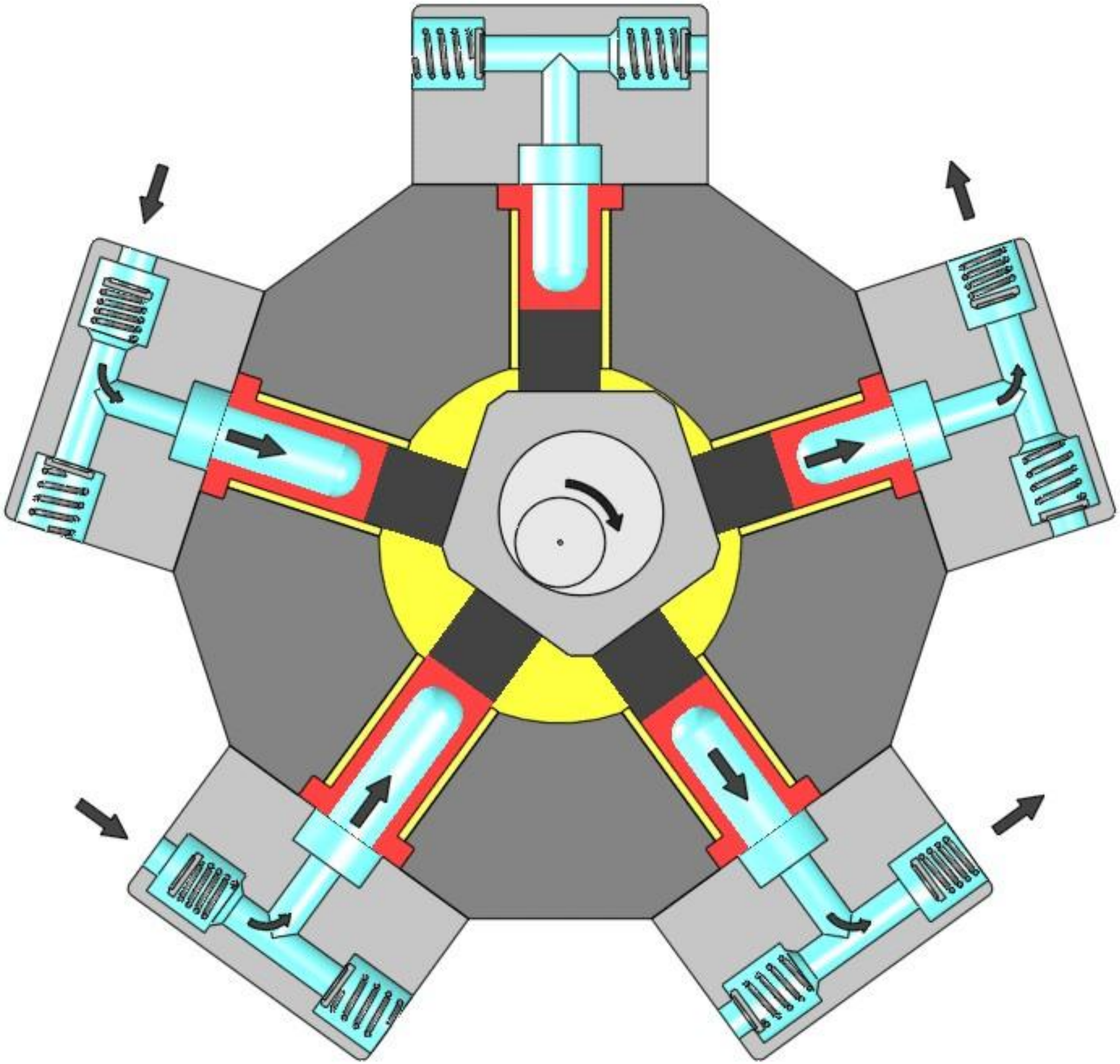


Radial piston pumps (rotating cam).

As far as the construction principle of radial piston pumps is concerned, radial bores in which pistons are accommodated replace the radial slots. Further, in this case, a rotating cam pushes in the radial pistons. This cam is an integral part of the driving shaft. As the shaft rotates (by a prime mover electric motor/engine), the cam also rotates.

The pistons are accommodated in the cylinder block, which is held stationary. The rotation of the cam pushes in the piston to deliver the oils. In the earlier revolution, the piston would have slid in, to suck the oil, which would be forced out by the cam rotation and pushing of the piston .

In certain designs of radial piston pumps .. the driving shaft transmits the rotation to the cylinder block and the cam is made stationary. Otherwise, the principle of operation remains the same. The advantage of a multiple piston pump is the absence of pulsating flow that is characteristic of single piston pumping arrangement.



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Advantages

- high efficiency
- high pressure (up to 1,000 bar)
- low noise level
- no axial internal forces at the drive shaft bearing
- high reliability

UNIT 2

HYDRAULIC ACTUATORS AND CONTROL COMPONENTS

CO2: To provide student with knowledge on the application of fluid power in process, construction and manufacturing Industries

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UNIT – II (SYLLABUS)

Hydraulic Actuators

- Cylinders – Types and construction, Application, Hydraulic cushioning
- Hydraulic motors
- Control Components: Direction Control, Flow control and pressure control valves –
- Types, Construction and Operation – Servo and Proportional valves

LECTURE	LECTURE TOPIC	KEY ELEMENTS	Learning objectives
1	**HYDRAULIC ACTUATORS AND CONTROL COMPONENTS** Hydraulic Actuators: Cylinders	Basic functions	Understanding functions of actuators (B2)
2	Types and construction	Classification	Understanding the types & constructions of actuators (B2)
3	Application	Real world application	Apply in real world systems (B3)
4	Hydraulic cushioning	Load Vs operating Pressure	Understanding load Vs Pressure (B2)
5	Hydraulic motors	Continuous rotary actuators Semi rotary actuators	Understanding the types of hydraulic motors (B2)
6	Control Components : Direction Control ,flow control & pressure control	Function of DC Valve & working	Understanding direct control valves , flow control & pressure control (B2)

LECTURE 1

HYDRAULIC ACTUATORS AND CONTROL COMPONENTS

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Fluid Power Actuators:

- Linear hydraulic actuators –Single acting, Double acting
- Special cylinders like tandem, Rodless, Telescopic
- Cushioning mechanism.

Hydraulic Motors, types – Gear, Vane, Piston (axial and radial) – performance of motors.

Difference Between Pump and Actuator

- Pump performs the function of adding energy to the fluid of a hydraulic system for transmission to some other location.
- Hydraulic actuator (cylinders, motors) just do the opposite.
- They extract energy from the fluid and convert it to mechanical energy to perform useful work.

What is hydraulic actuators ?

Hydraulic actuators are devices used to convert pressure energy of the fluid into mechanical energy.

Depending on the type of actuation, hydraulic actuators are classified as follows:

1. Linear actuator: For linear actuation (hydraulic cylinders).
2. Rotary actuator: For rotary actuation (hydraulic motor).
3. Semi-rotary actuator: For limited angle of actuation (semi-rotary actuator).

Hydraulic linear actuators

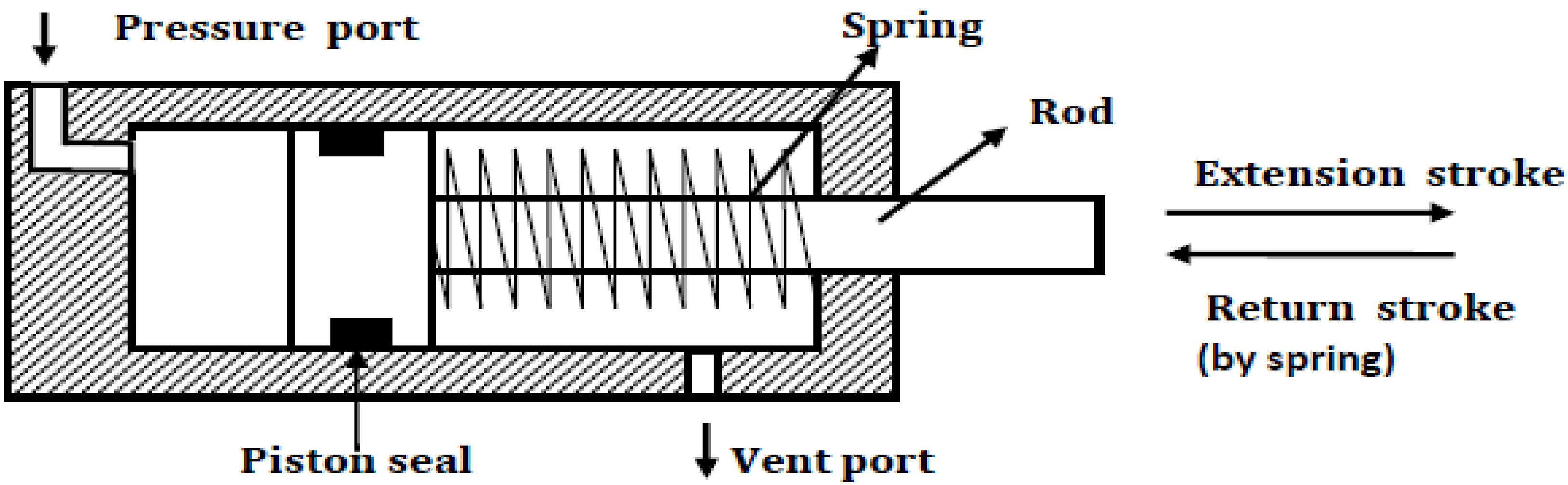
- Usually referred to as cylinders, rams and jacks

- Hydraulic cylinders extend and retract a piston rod to provide a push or pull force to drive the external load along a straight-line path

Hydraulic cylinders are of the following types:

- Single-acting cylinders.
- Double-acting cylinders.
- Telescopic cylinders.
- Tandem cylinders.

Single-Acting Cylinders



- It consists of a piston inside a cylindrical housing called barrel.
- One end of the piston there is a rod, which can reciprocate.
- Opposite end, there is a port for the entrance and exit of oil.
- Produce force in one direction by hydraulic pressure acting on the piston.
- (Single-acting cylinders can exert a force in the extending direction only.)
- The return of the piston is not done hydraulically.
- In single-acting cylinders, retraction is done either by gravity or by a spring.

Gravity-Return Single-Acting Cylinder

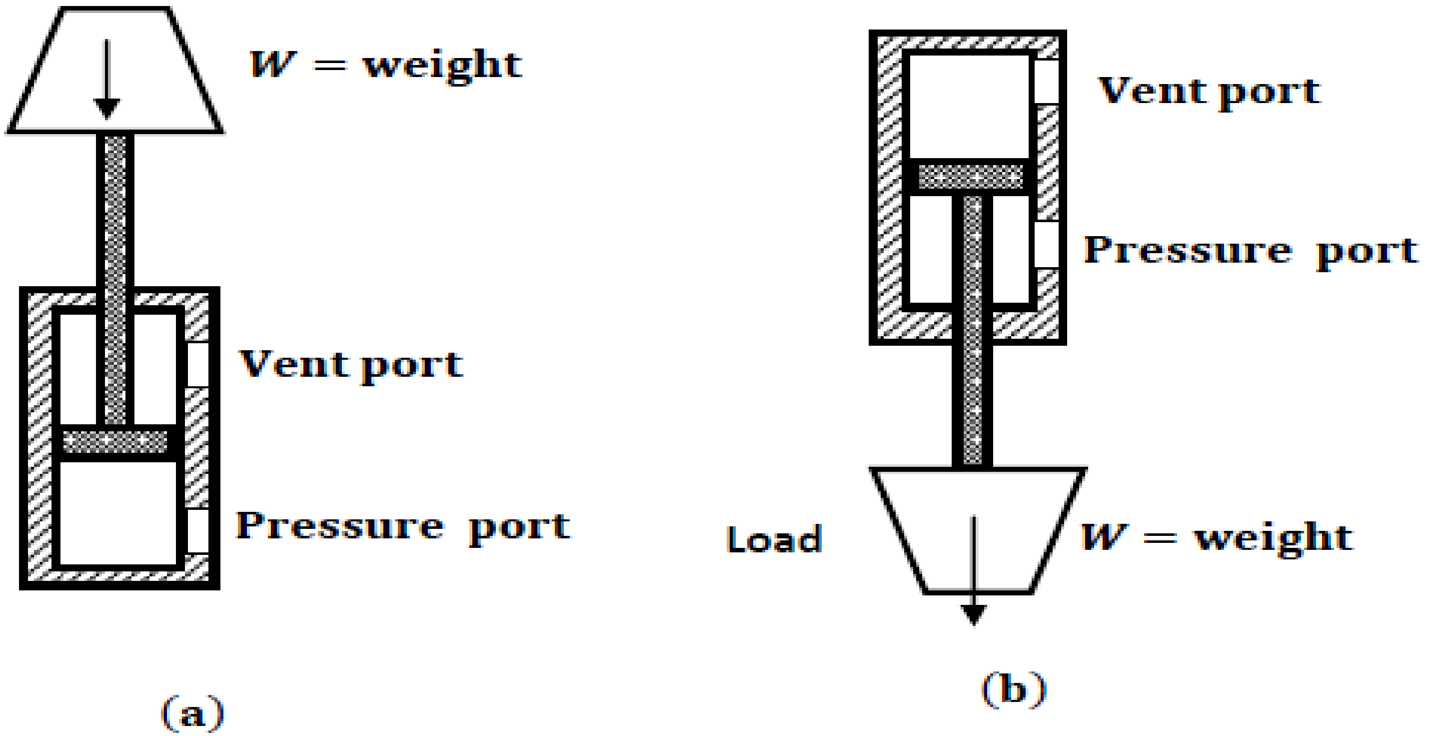


Figure 1.2 Gravity-return single-acting cylinder: (a) Push type; (b) pull type

Push Type: The cylinder extends to lift a weight against the force of gravity by applying oil pressure at the blank end.

Pull Type: gravity-return-type single-acting cylinder, the cylinder lifts the weight by retracting.

Spring-Return Single-Acting Cylinder

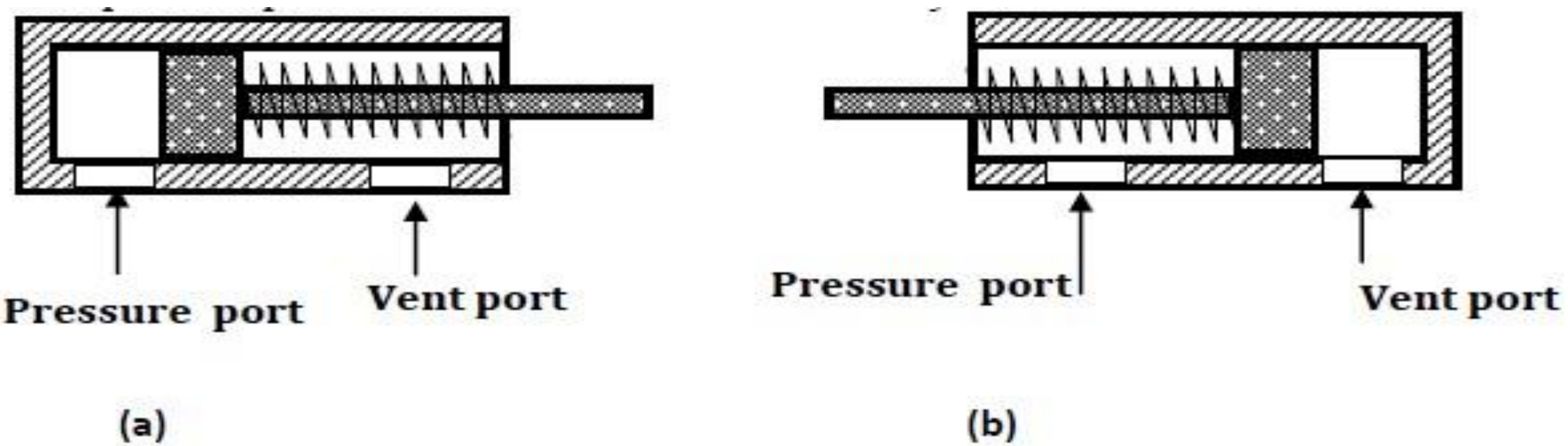
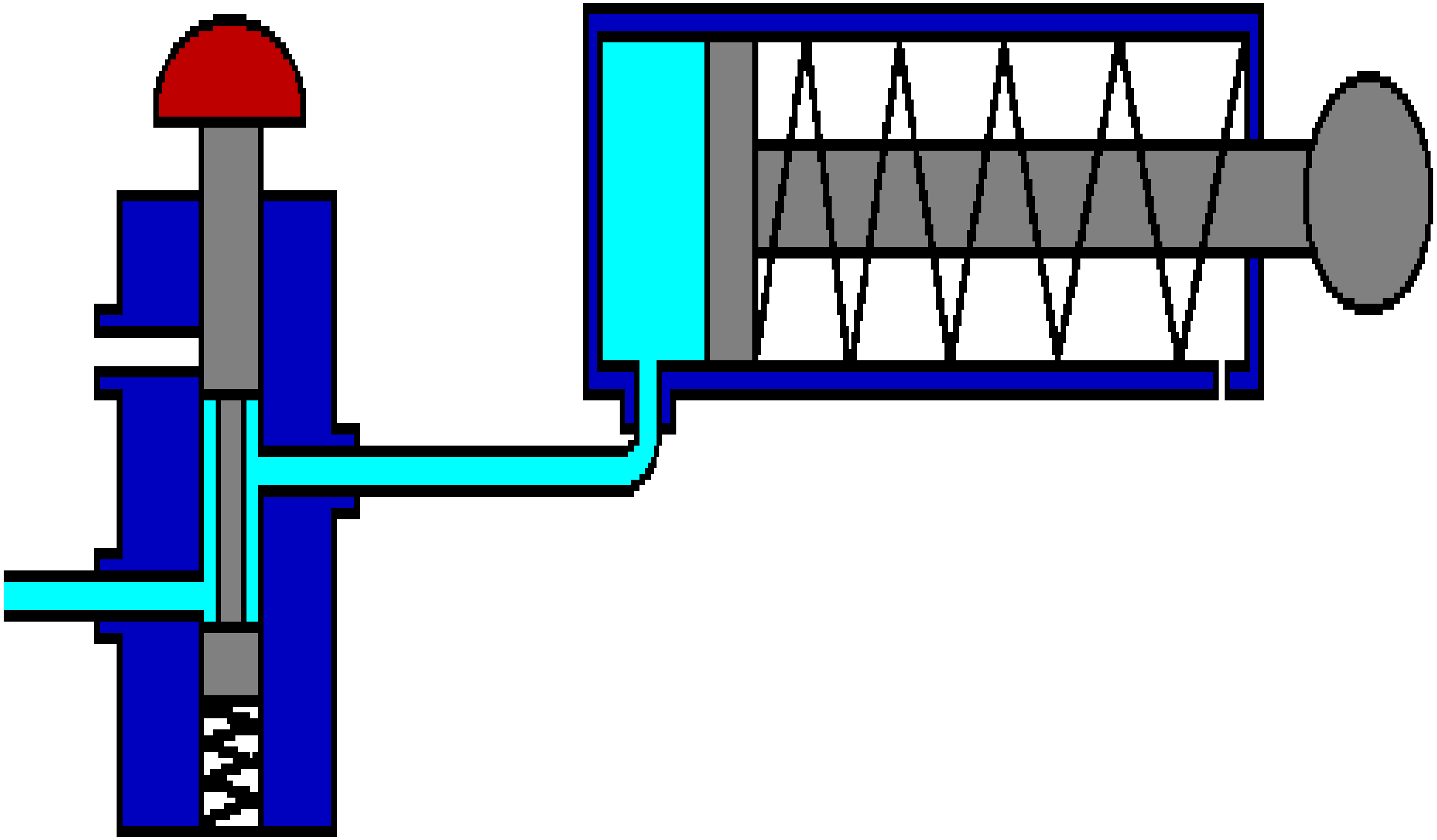


Figure 1.3 (a) Push- and (b) pull-type single-acting cylinders

Push Type the pressure is sent through the pressure port situated at the blank end of the cylinder. When the pressure is released, the spring automatically returns the cylinder to the fully retracted position. The vent port is open to atmosphere so that air can flow freely in and out of the rod end of the cylinder.

Pull Type the cylinder retracts when the pressure port is connected to the pump flow and extends whenever the pressure port is connected to the tank. Here the pressure port is situated at the rod end of the cylinder.

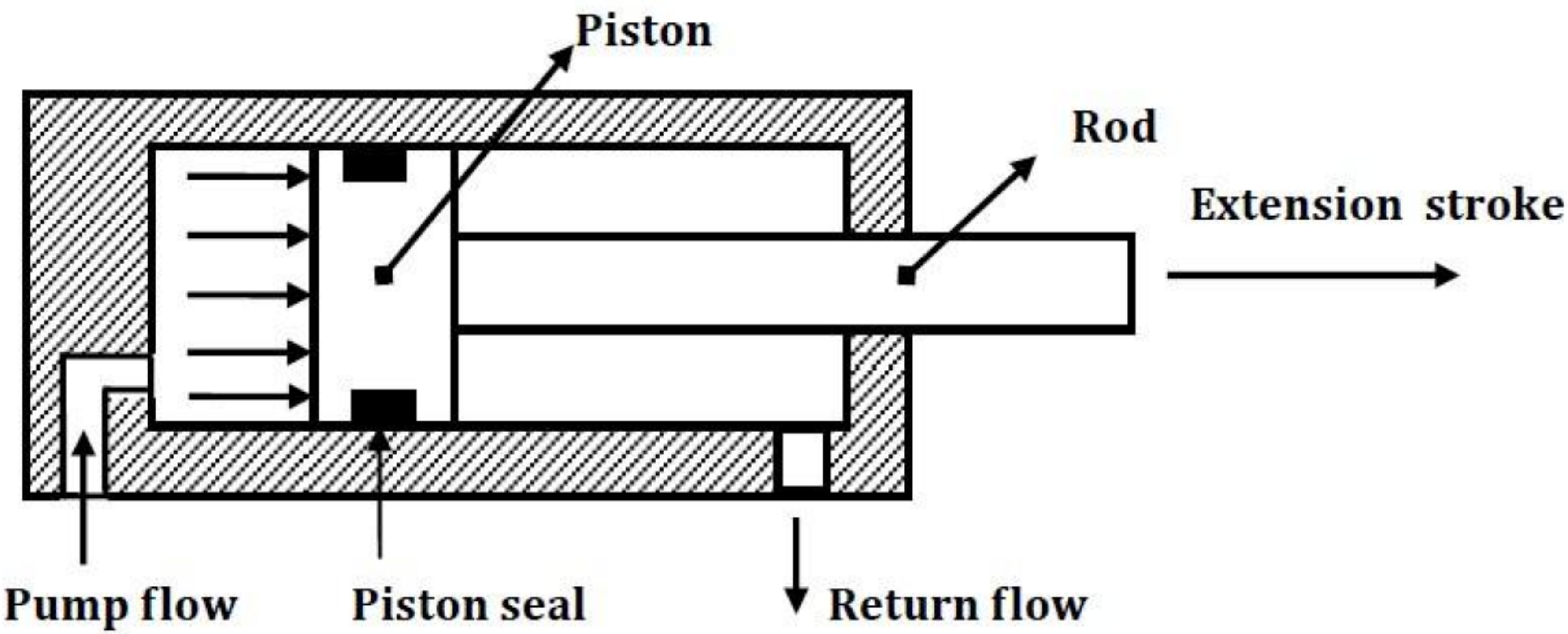


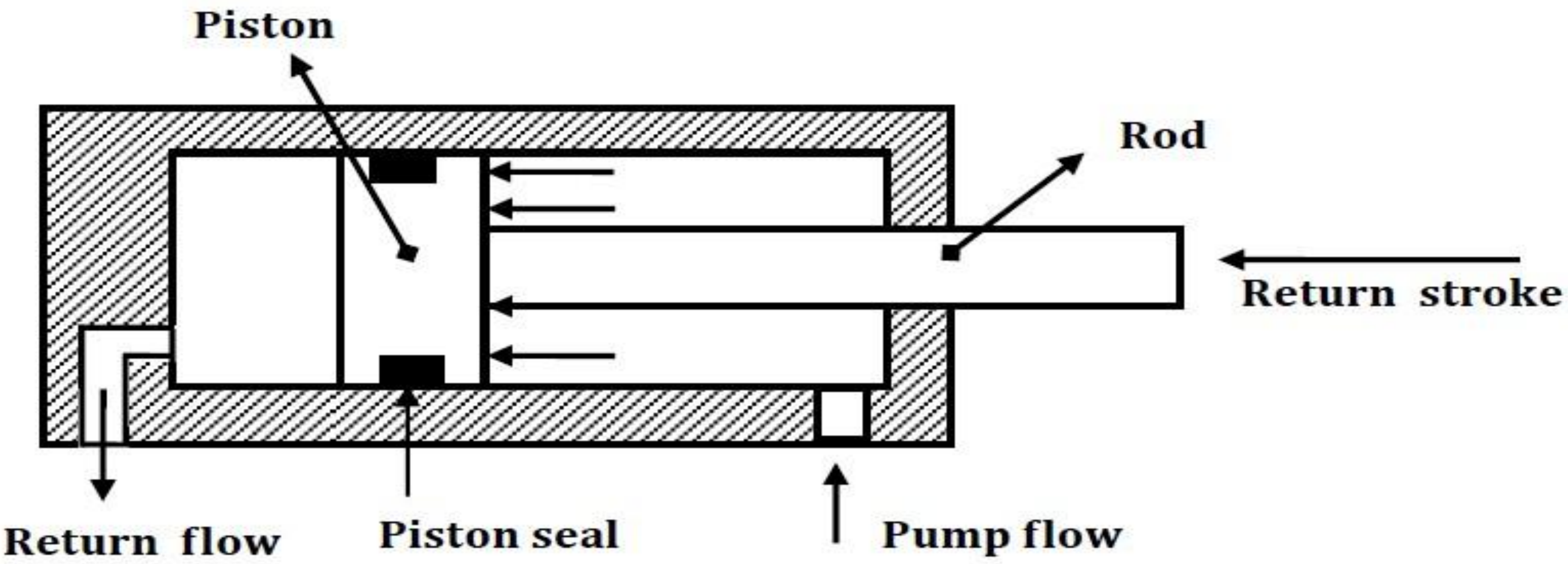
Double-Acting Cylinder

There are two types of double-acting cylinders:

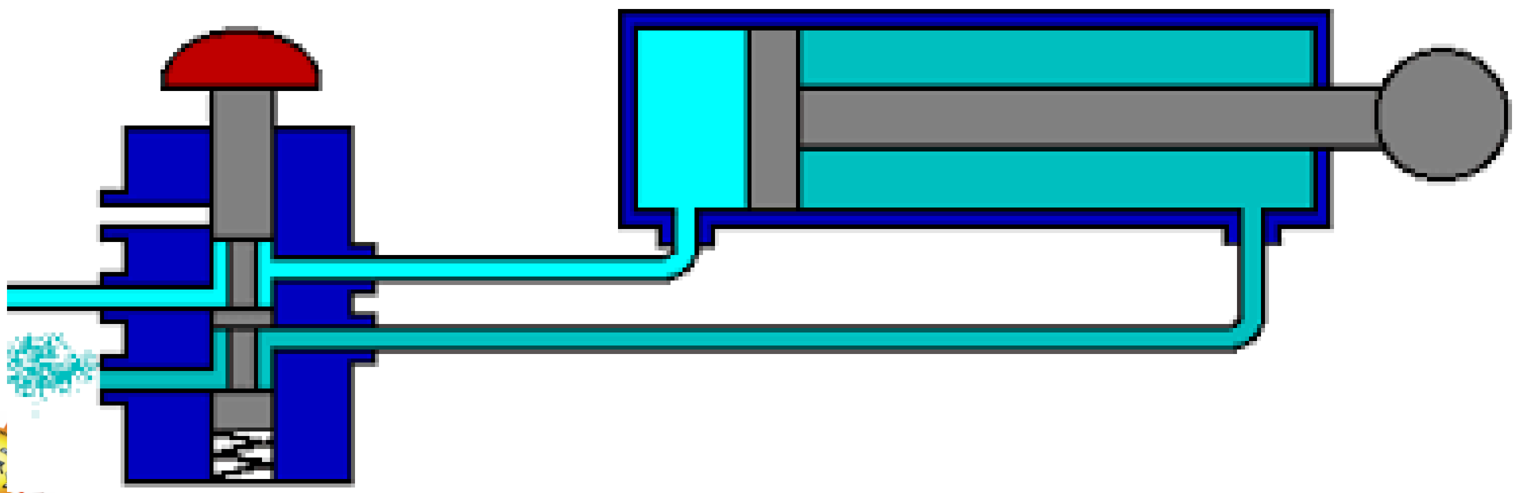
1. Double-acting cylinder with a piston rod on one side.
2. Double-acting cylinder with a piston rod on both sides.

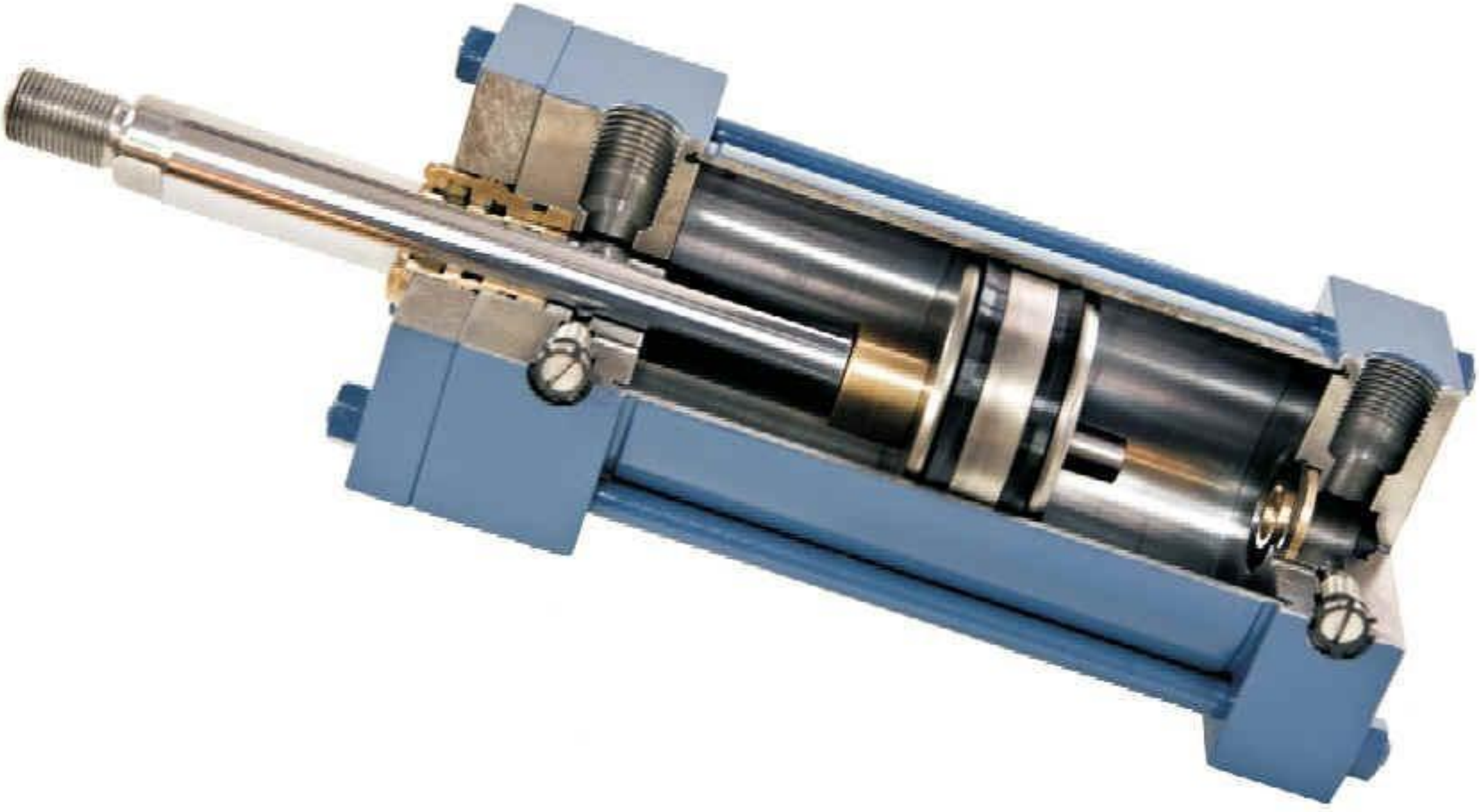
Double-acting cylinder with a piston rod on one side



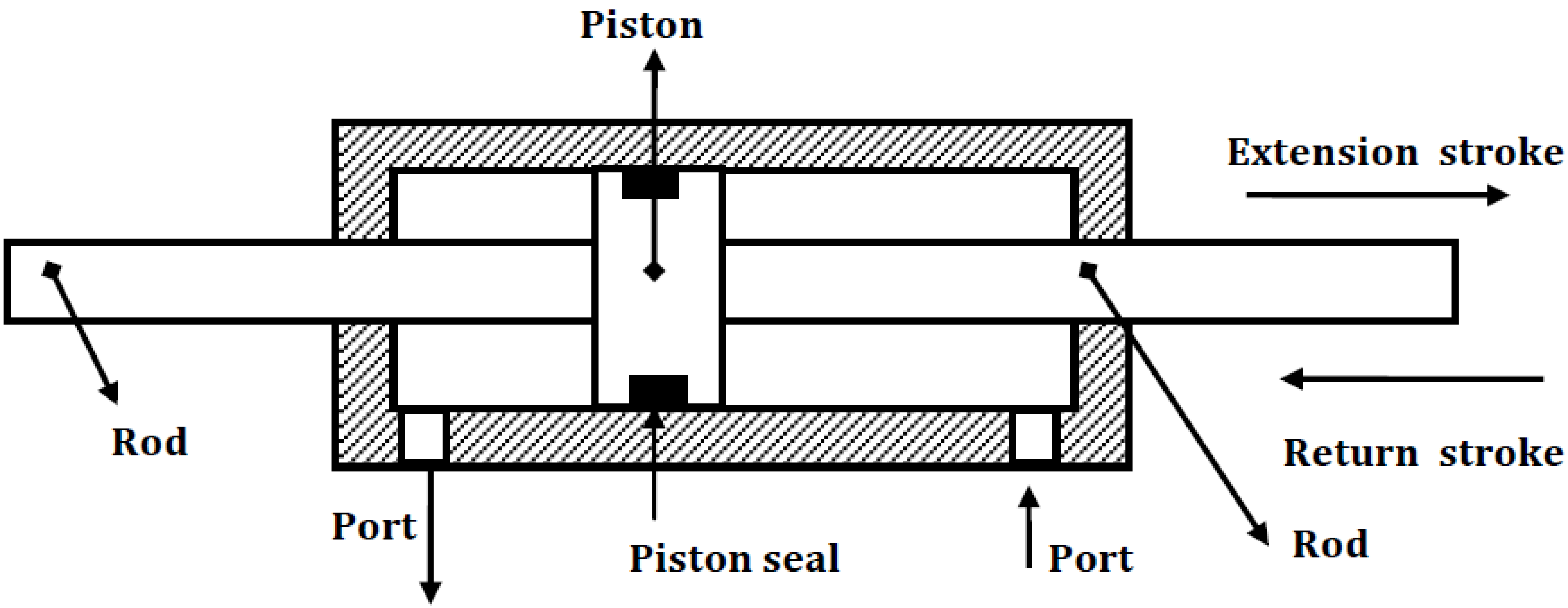


To extend the cylinder, the pump flow is sent to the **blank-end port**. The fluid from the **rod-end port** returns to the reservoir. To retract the cylinder, the pump flow is sent to the **rod-end port** and the fluid from the **blank-end port** returns to the tank



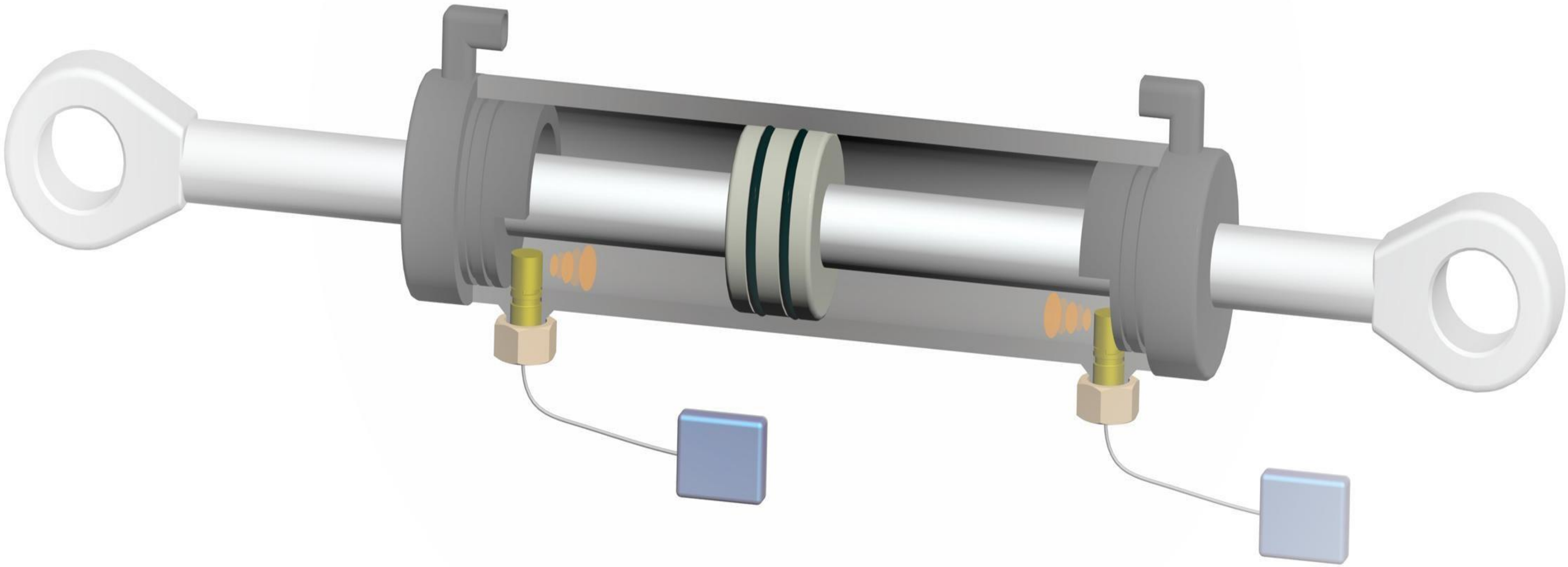


Double-Acting Cylinder with a Piston Rod on Both Sides



This cylinder can be used in an application where work can be done by both ends of the cylinder, thereby making the cylinder more productive.

Double-rod cylinders can withstand higher side loads because they have an extra bearing, one on each rod, to withstand the loading.



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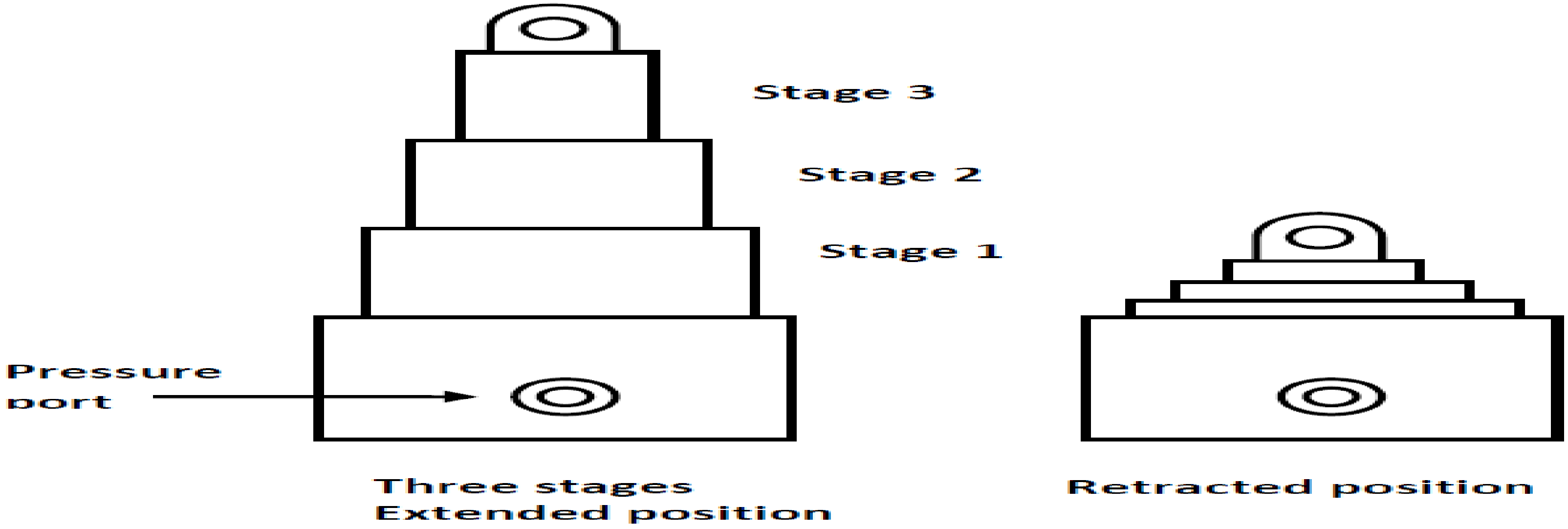
Telescopic Cylinder

Telescopic cylinder is used when a long stroke length and a short retracted length are required.

The telescopic cylinder extends in stages, each stage consisting of a sleeve that fits inside the previous stage.

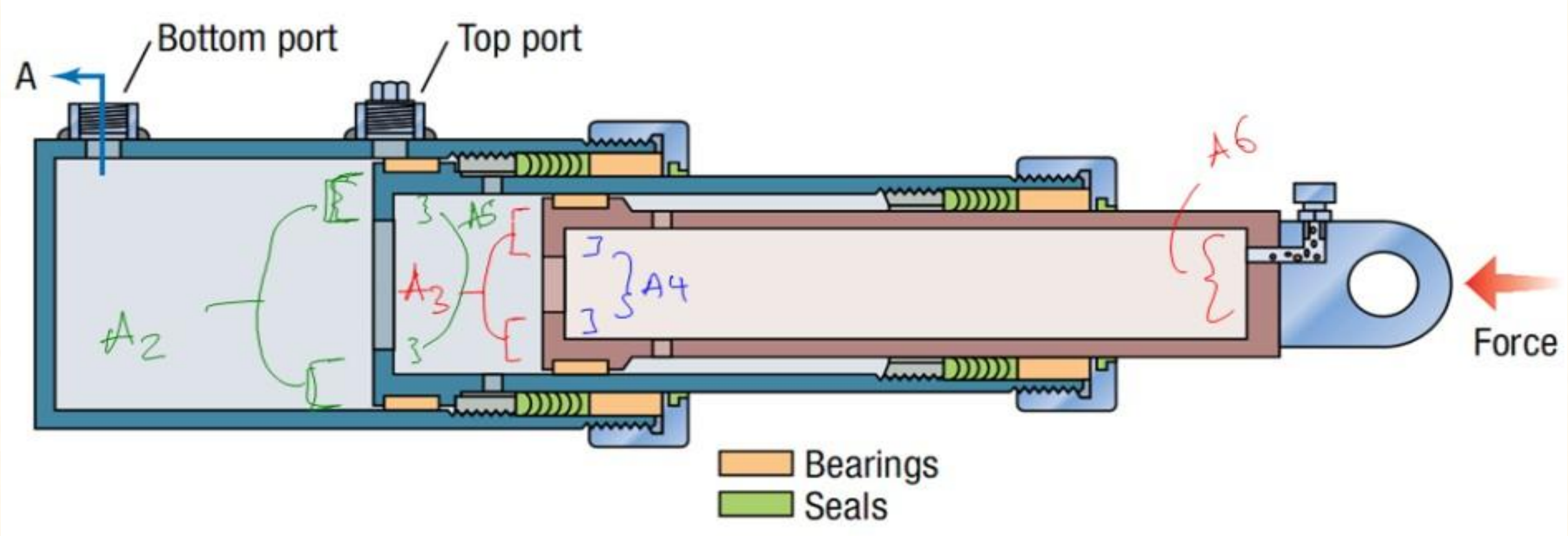


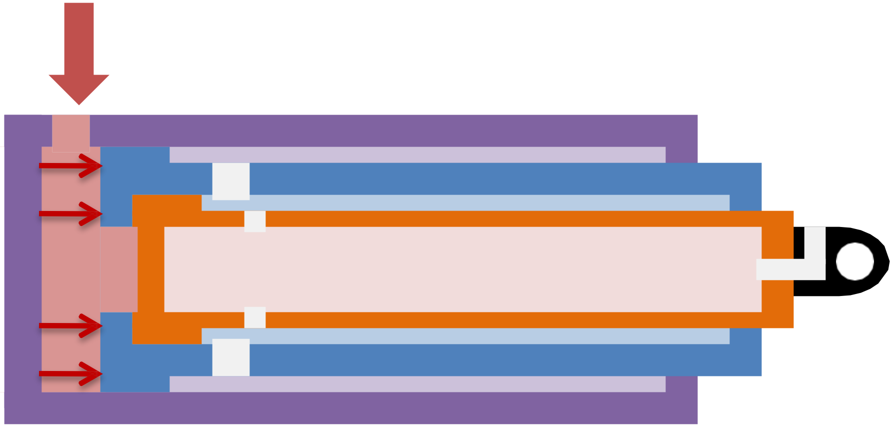
- They generally consist of a nest of tubes and operate on the displacement principle.

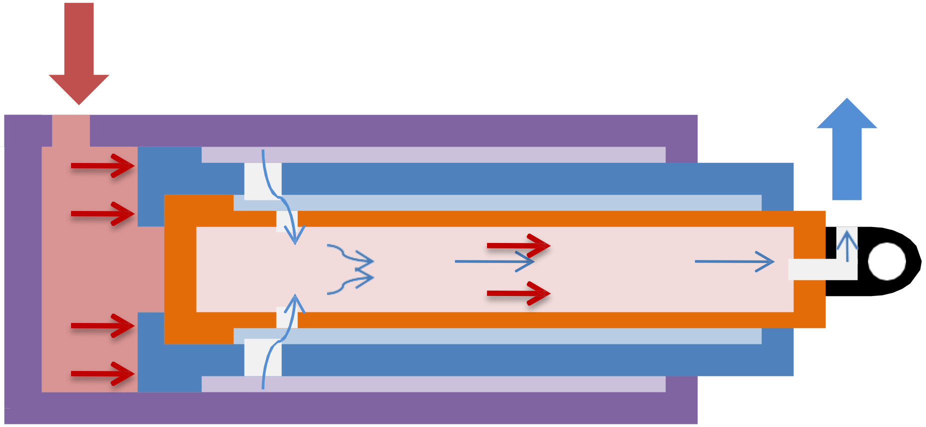
- The tubes are supported by bearing rings, the innermost (rear) set of which have grooves or channels to allow fluid flow.

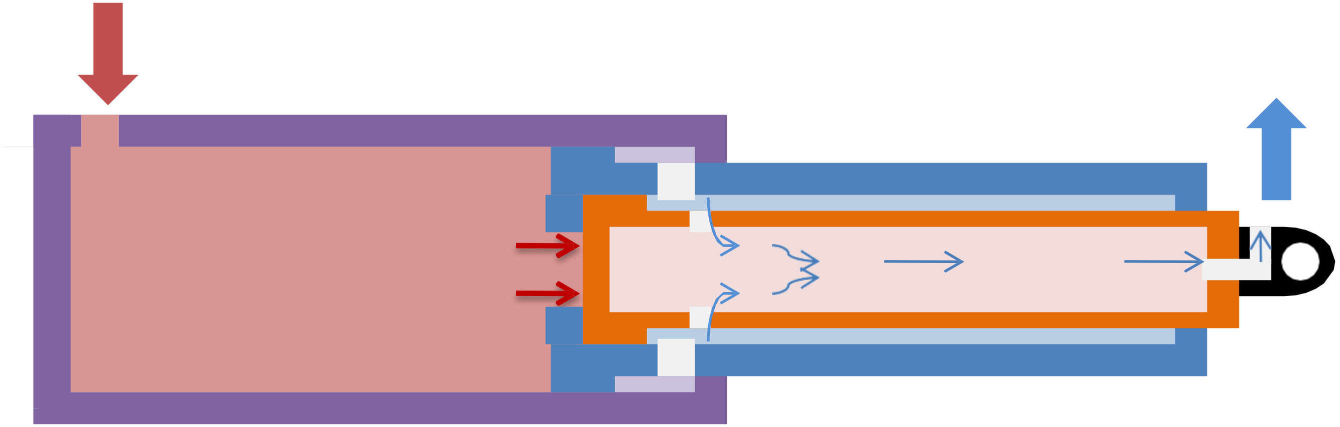
- The front bearing assembly on each section includes seals and wiper rings.

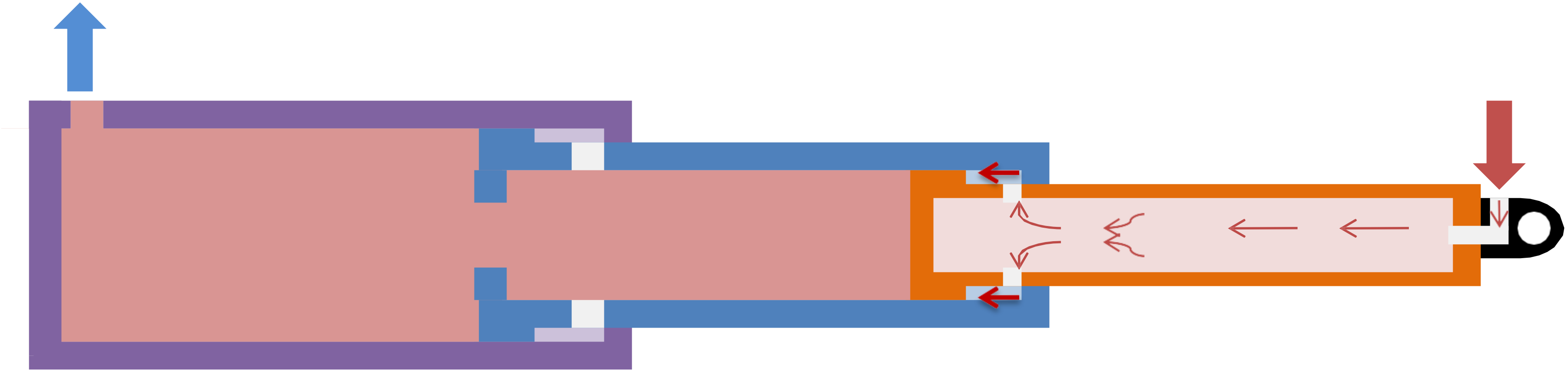
- Stop rings limit the movement of each section, thus preventing separation.
- When the cylinder extends, all the sections move together until the outer section is prevented from further extension by its stop ring.
- The remaining sections continue out-stroking until the second outermost section reaches the limit of its stroke; this process continues until all sections are extended, the innermost one being the last of all.
- For a given input flow rate, the speed of operation increases in steps as each successive section reaches the end of its stroke. Similarly, for a specific pressure, the load-lifting capacity decreases for each successive section.

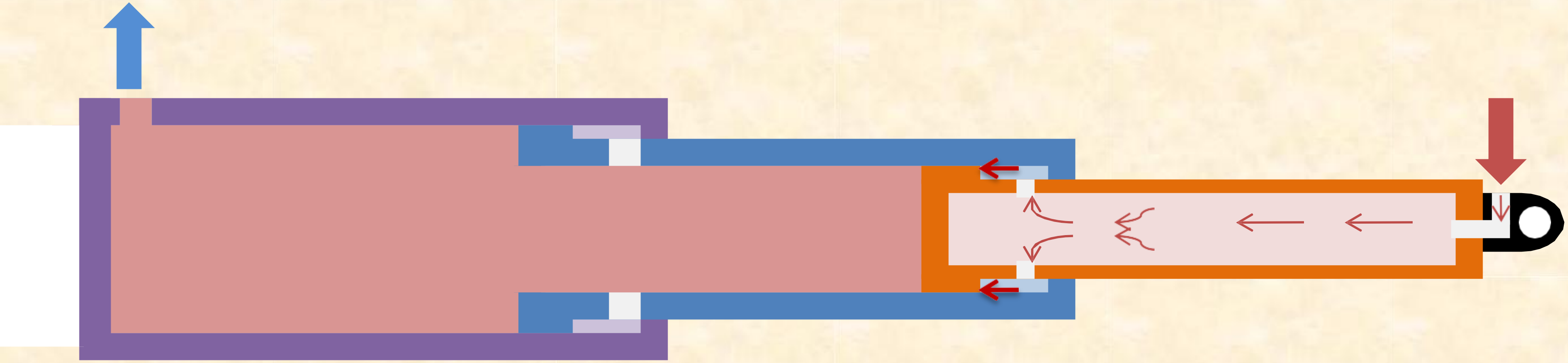


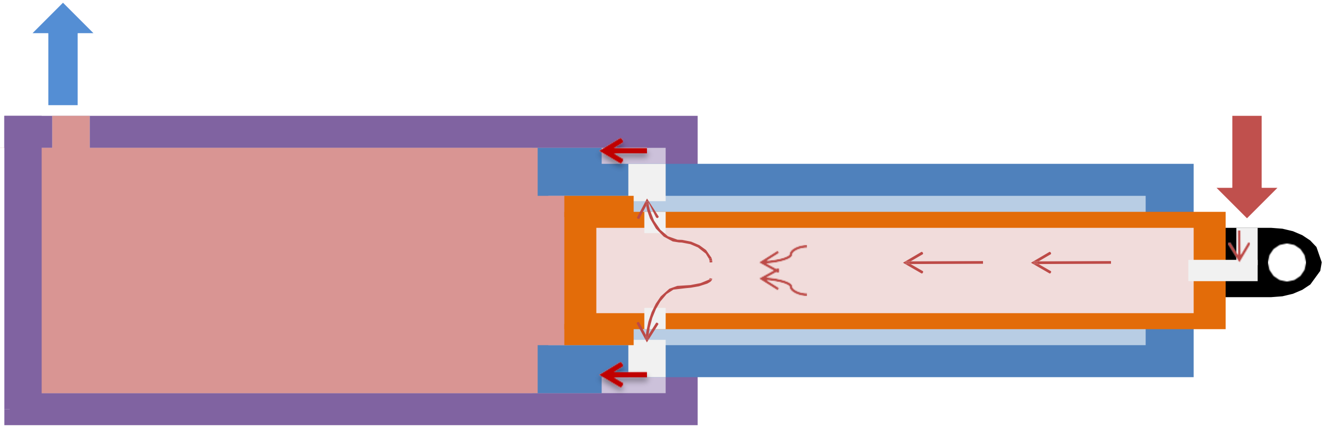




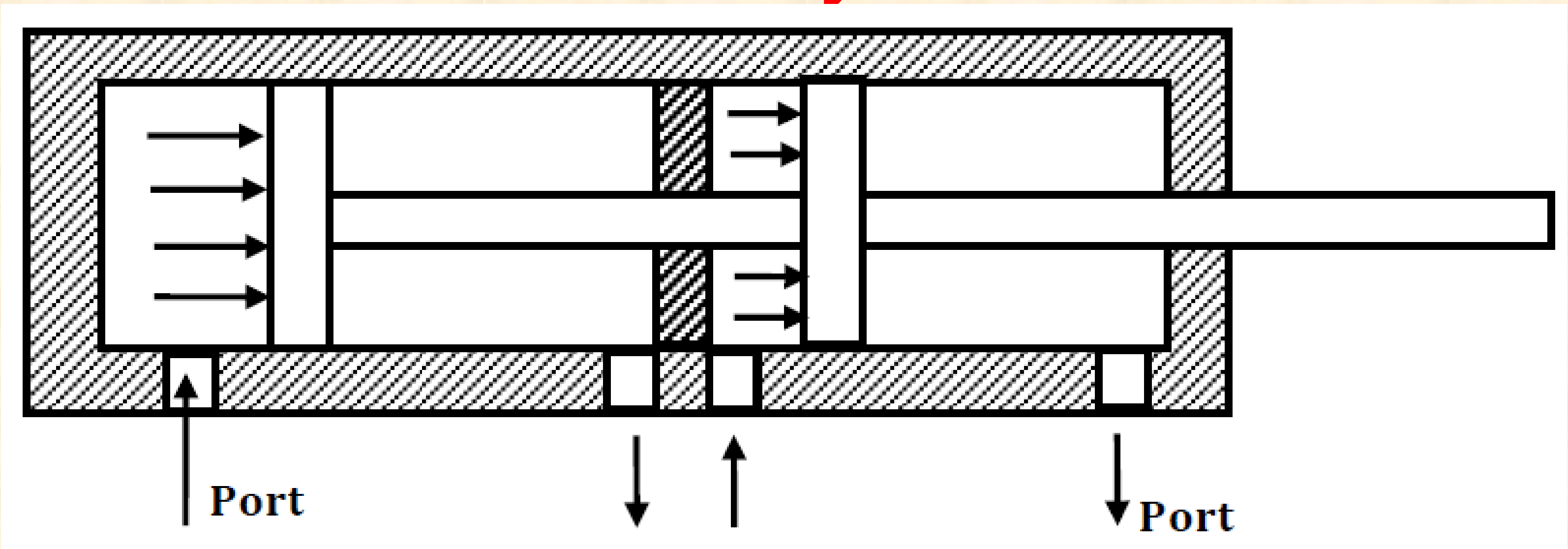








Tandem Cylinder



➢Used in applications where a large amount of force is required from a small-diameter cylinder.

➢Pressure is applied to both pistons, resulting in increased force because of the larger area.

➢The drawback is that these cylinders must be longer than a standard cylinder to achieve an equal speed because flow must go to both pistons.

UNIT 3

Accumulators, Intensifiers, Industrial hydraulic circuits

CO3: To provide students with an understanding of the fluids and components utilized in modern industrial fluid power system.

UNIT – III (SYLLABUS)

Accumulators, Intensifiers, Industrial hydraulic circuits

Regenerative, Pump Unloading, Double-Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Hydrostatic transmission, Mechanical hydraulic servo systems

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LECTURE	LECTURE TOPIC	KEY ELEMENTS	Learning objectives
1	**HYDRAULIC CIRCUITS AND SYSTEMS** Accumulators	Types & Function	Understanding the types & functions of accumulators (B2)
2	Intensifiers	Types & Function	Understanding the types & functions of intensifiers (B2)
3	Industrial hydraulic circuits	Types & Function	Understanding the types & functions of intensifiers (B2)
4	Regenerative pump	Working & Function	Understanding the regenerative pump (B2)
5	Pump Unloading	Need of unloading a pump	Understanding pump unloading (B2) Analyze pump unloading (B4)
6	Double-Pump	Working of a double acting pump	Understanding of working of double acting pump (B2)

LECTURE 1

HYDRAULIC CIRCUITS AND SYSTEMS

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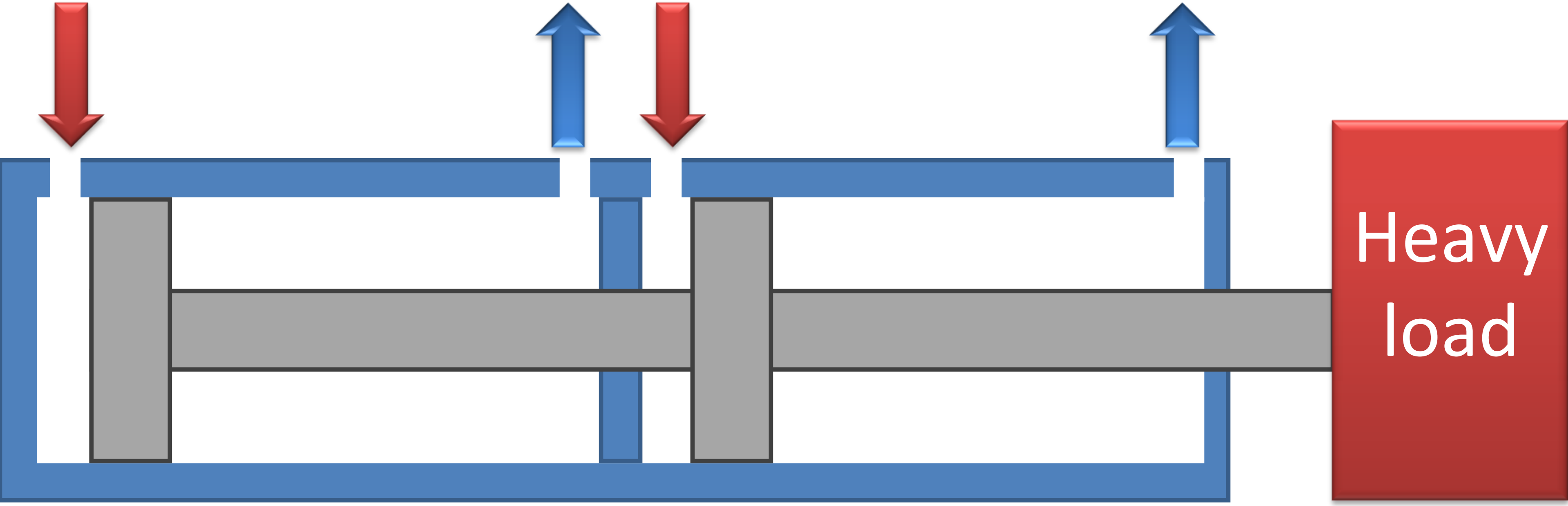

Heavy
load

Rodless Cylinders

Rodless cylinders are linear devices that use pressurized fluid to move a load within power transfer operations.

A rodless cylinder should be used if the footprint of the area is small, when the load needs to be moved some distance from the cylinder itself, and when the load must move within the length of the cylinder.

They are suitable for long-stroke applications because they are protected from bending, piston binding, and uneven seal wear.

Rodless cylinders are used in a variety of material handling, loading, feeding, lifting, and web cutting applications.

They are also used in sliding carriers, conveyors, and spraying equipment. They are made of aluminum, steel, stainless steel, or plastic and driven by an electric motor, pneumatic or hydraulic assembly, or electrohydraulic pump.

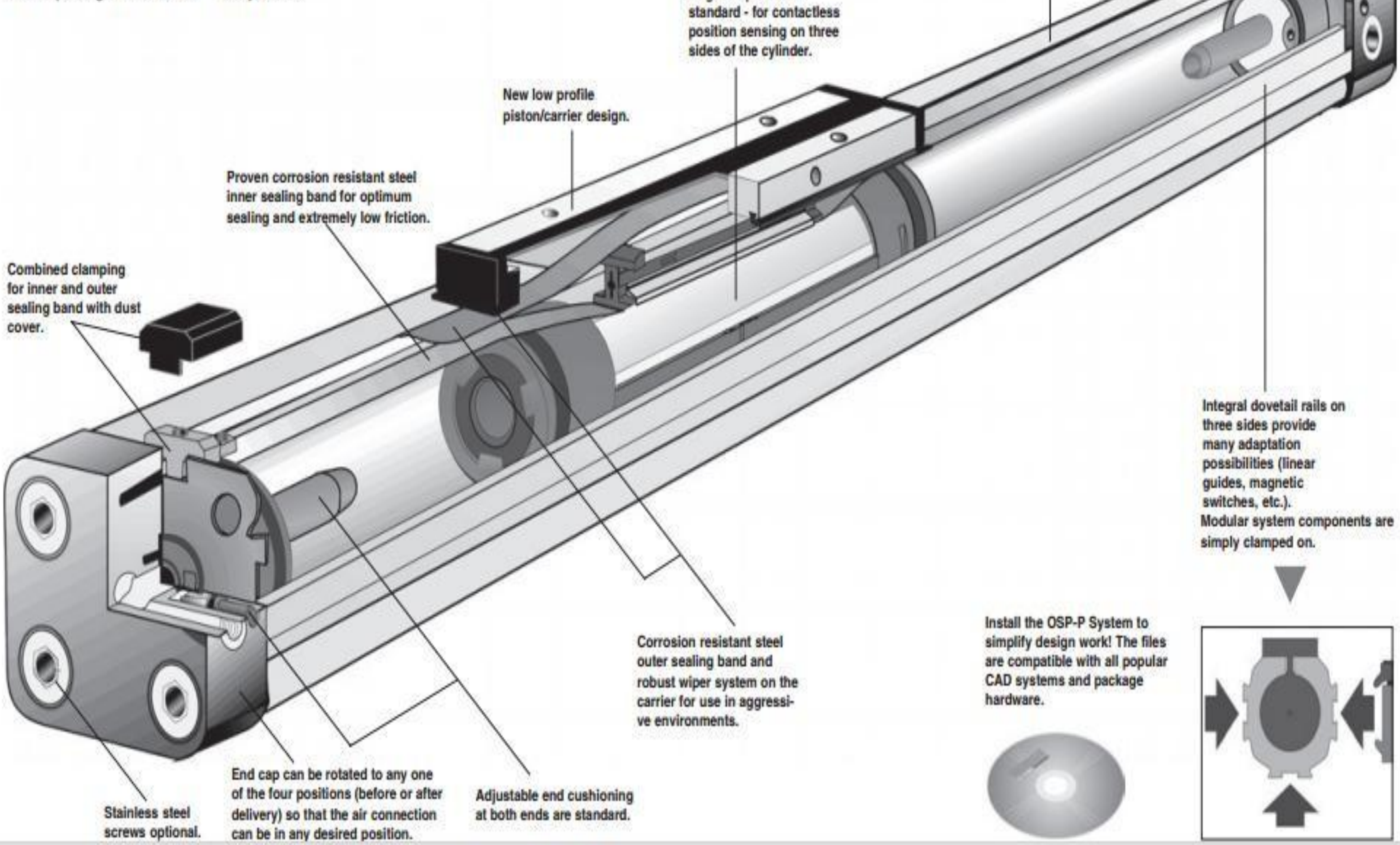
- **Rodless air cylinders:**
  - These have no piston rod. They are actuators that use a mechanical or magnetic coupling to impart force, typically to a table or other body that moves along the length of the cylinder body, but does not extend beyond it.

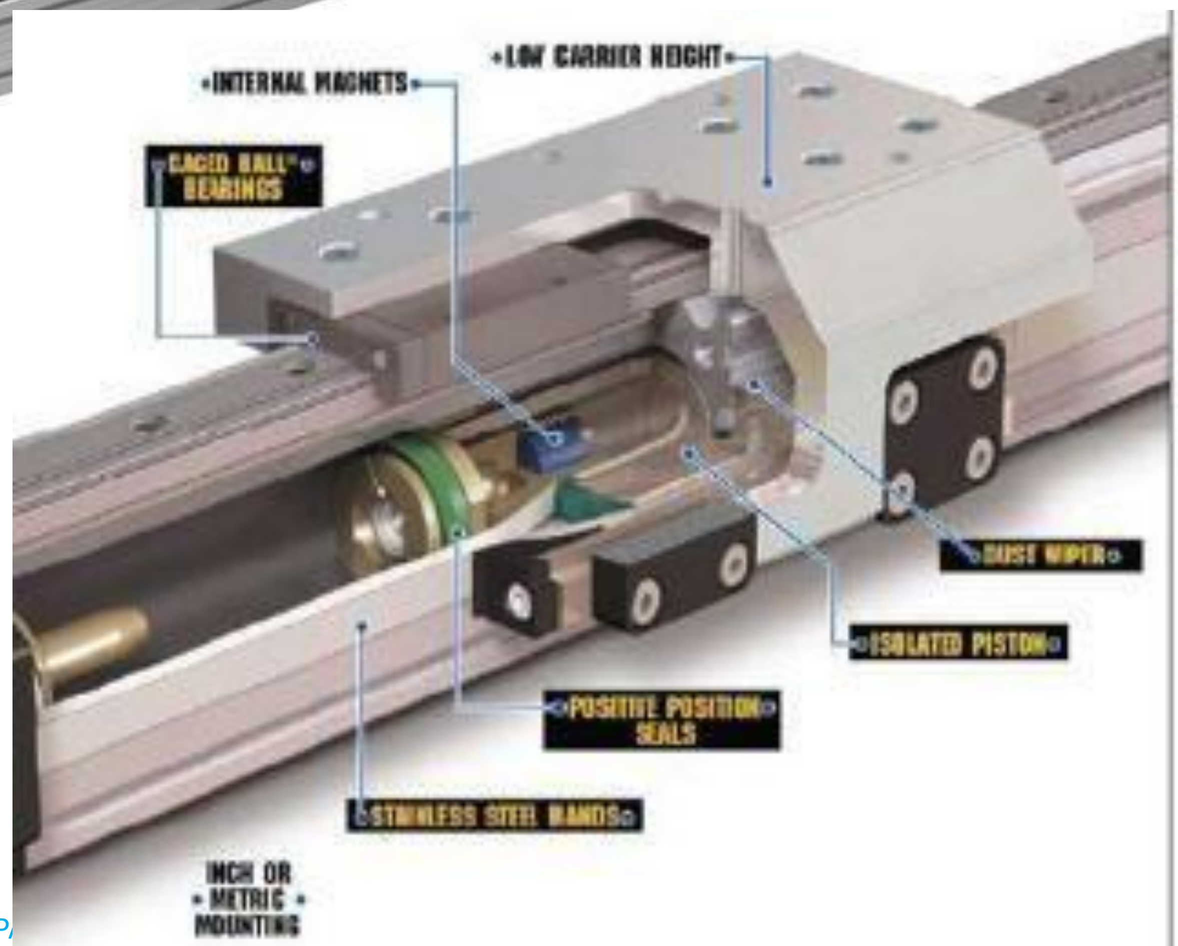
ORIGA offers design engineers complete flexibility. The well known ORIGA cylinder has been further developed into a combined linear actuator, guidance and control package. It forms the linear drive system.

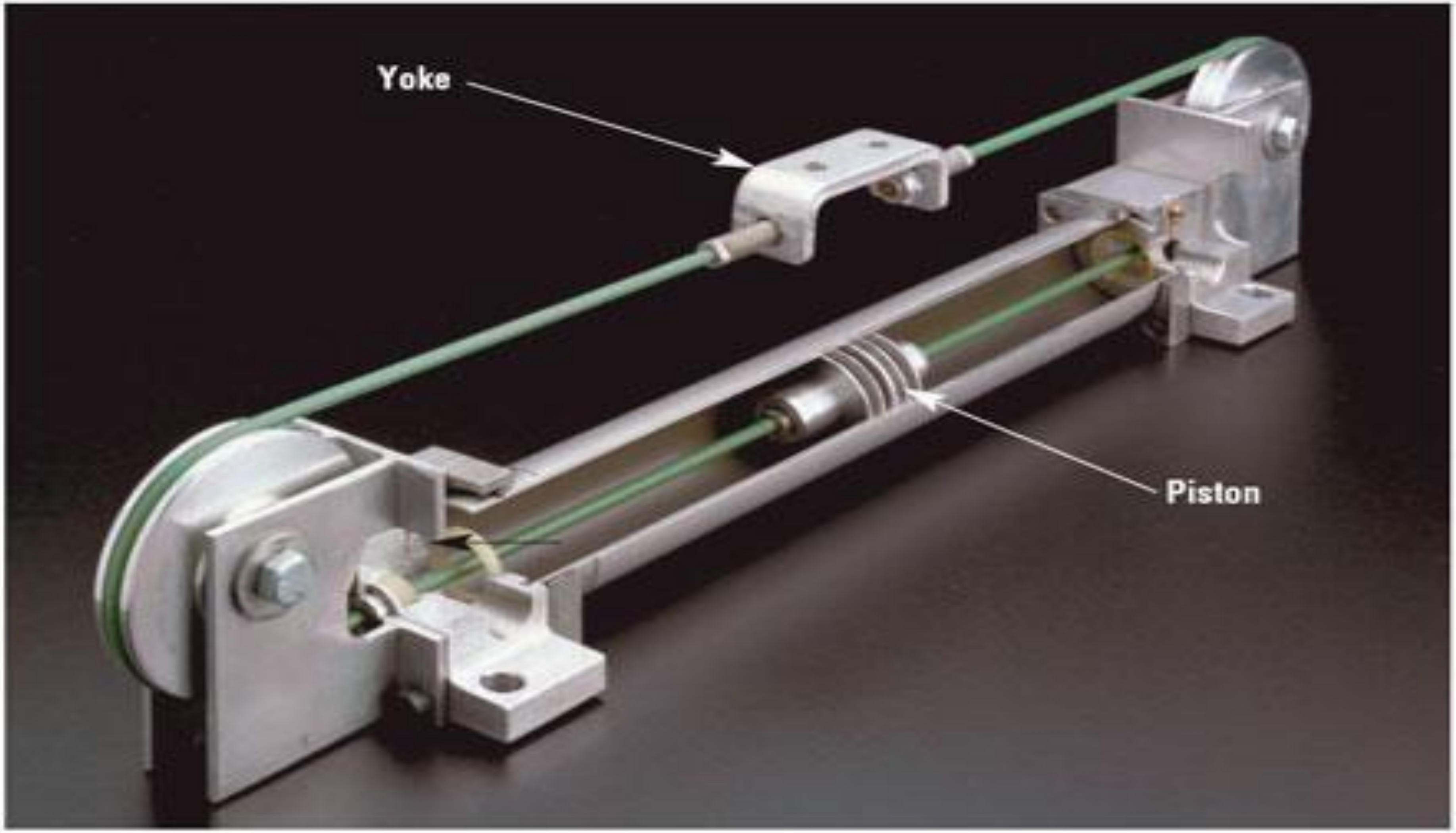
All additional functions are designed into modular system components which replace the previous series of cylinders.

components such as linear guides, brakes, valves, magnetic switches etc. to be fitted to the cylinder itself. This solves many installation

The modular system concept forms an ideal basis for additional customer-specific functions.




LOW CARRIER HEIGHT
INTERNAL MAGNETS
CAGED BALL BEARINGS
DUST WIPER
ISOLATED PISTON
POSITIVE POSITION SEALS
STAINLESS STEEL BANDS
INCH OR METRIC MOUNTING



Cutaway of cable cylinder shows how the piston is connected to the yoke through a cable assembly. A plastic cover around the cable limits leakage and extends seal life.

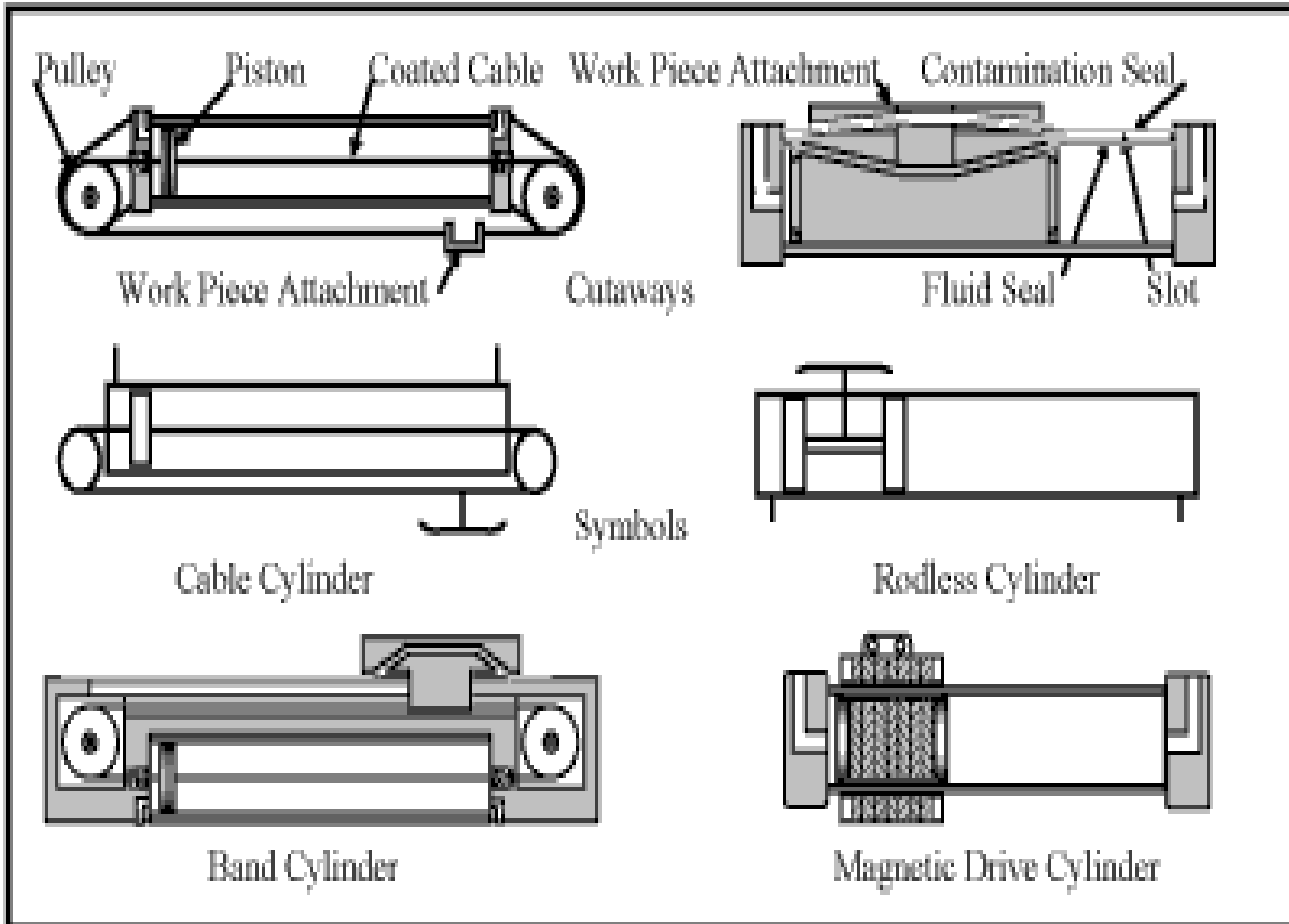
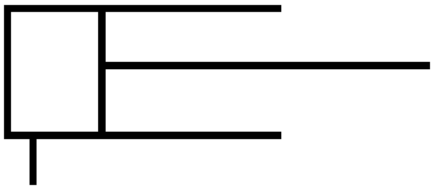
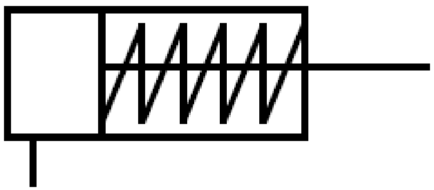
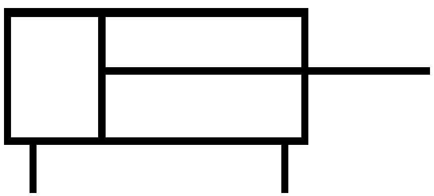
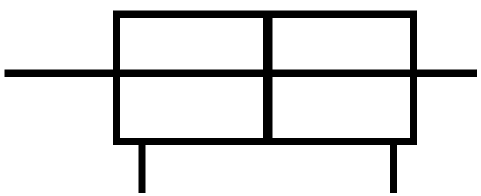
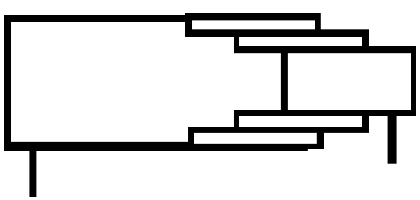
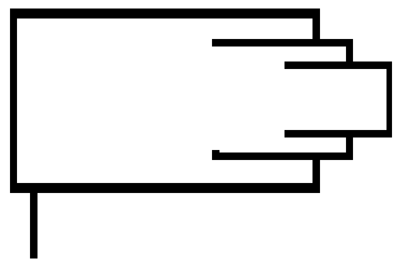
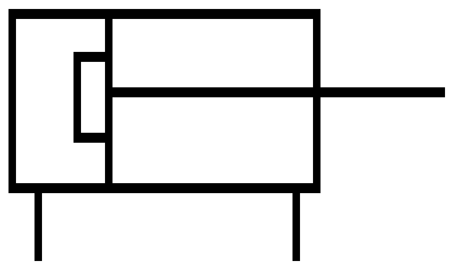
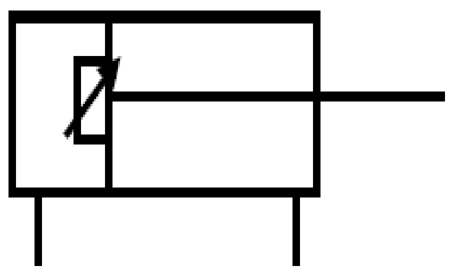
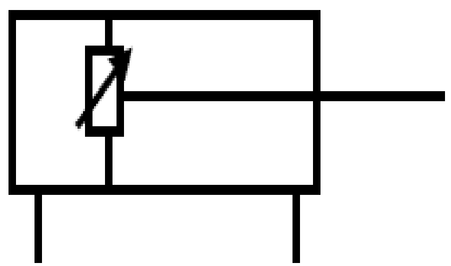

Pulley
Piston
Coated Cable
Work Piece Attachment
Contamination Seal
Work Piece Attachment
Cutaways
Fluid Seal
Slot
Symbols
Cable Cylinder
Rodless Cylinder
Band Cylinder
Magnetic Drive Cylinder

Table 1.2 Graphical symbols of different linear actuators

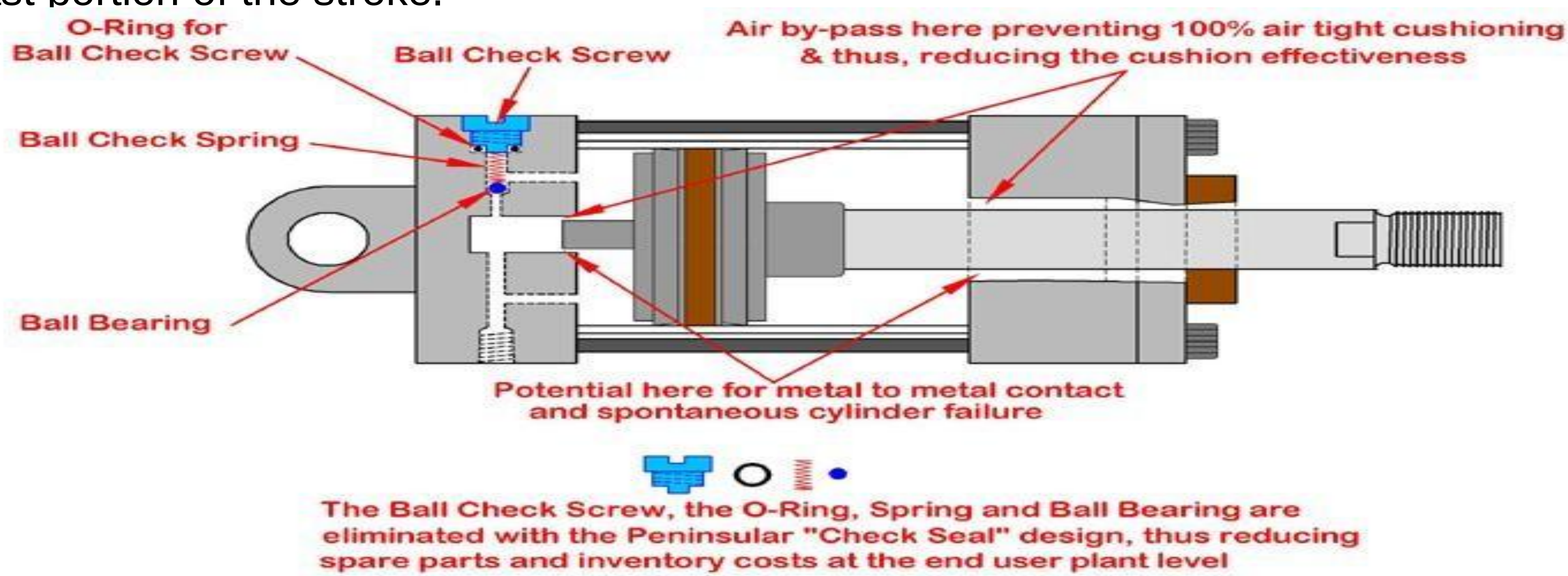
S. No.	**Graphical Symbols**	**Explanation**
1.		Single-acting cylinder with unspecified return
2.		Single-acting cylinder with spring return
3.		Double-acting cylinder –single piston rod
4.		Double-acting cylinder –doublepiston rod
5.		Telescopic cylinder–double acting

6.		Telescopic cylinder–single acting
7.		Double-acting cylinder– fixed cushion on one side
1.		Double-acting cylinder–variable cushion on one side
9.		Double-acting cylinder–variable cushion on both sides

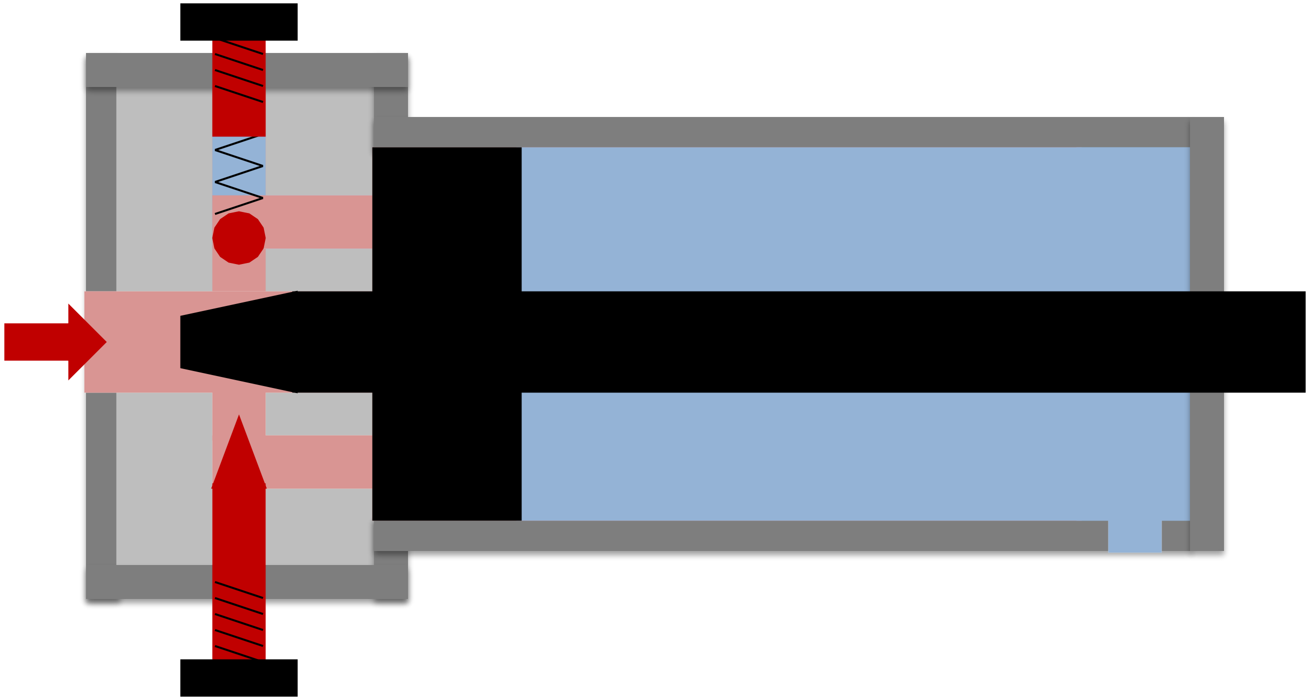
Cushioning arrangement for cylinders- need

Due to inertia forces of the moving parts at the end of the piston travel, the piston will hit the cylinder head at full speed.

Due to cushioning arrangement the piston head slowly retarded or cushioned during last portion of the stroke.



The fluid is normally expelled through the outlet port direct but when the cushioning boss enters the recess, the fluid around the piston is trapped. The only way the fluid can escape is through the secondary path, which is restricted by a needle valve. The needle valve is adjusted so that the piston is slowed up over the last part of its stroke by a pressure build up in the fluid escaping past the needle valve.



- Extension
- F = p X A_p
- $V_{ext} = Q_{in}$

N/ m²

- 3

m /s

/ A_p

m/s

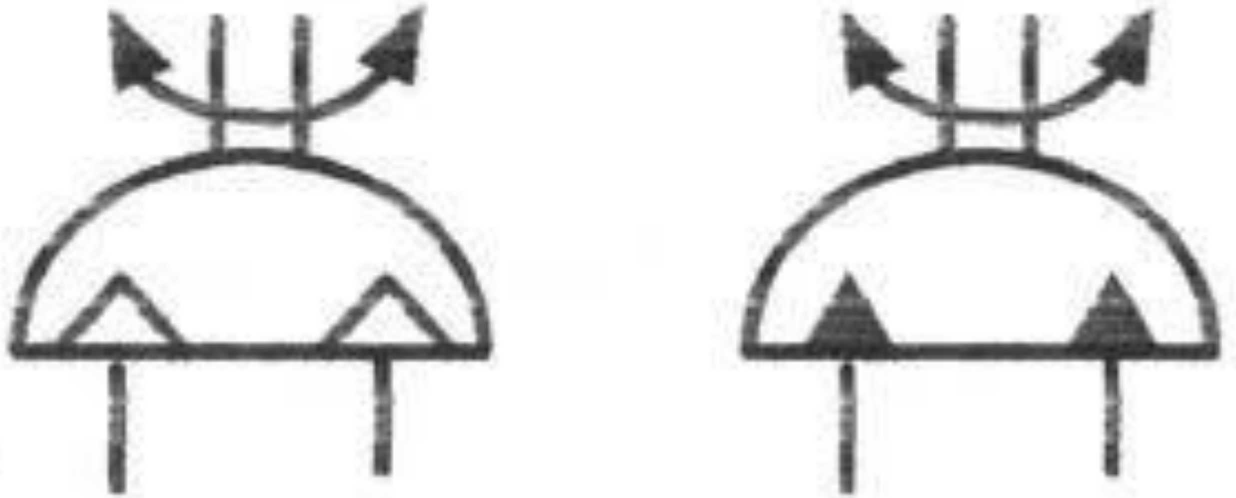
- Retraction

m²

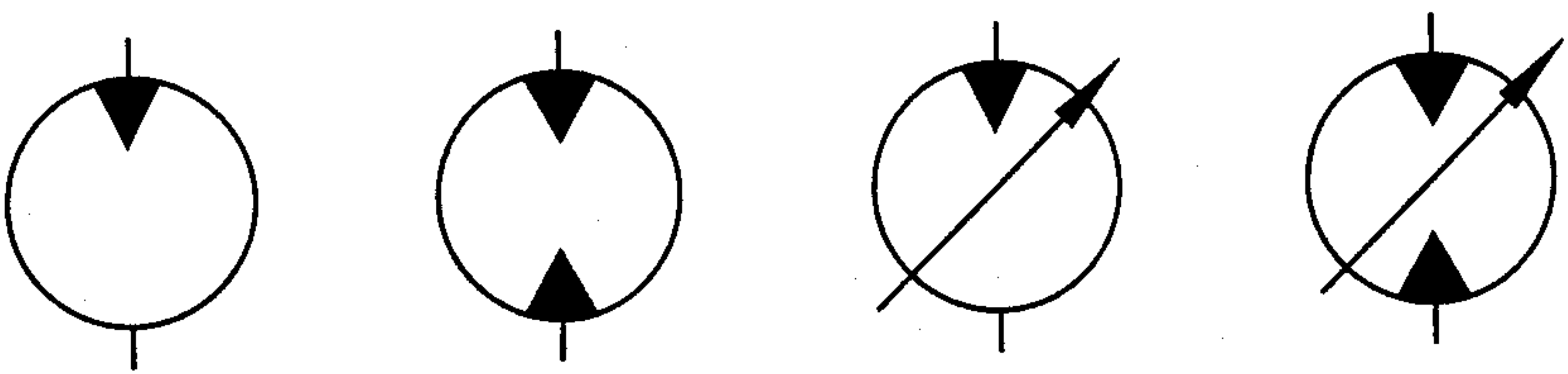
$F = p \; X \; (A_P - A_r)$ N/ m²

$V_{ext} = Qin \; / \; (A_P - A_r)$ m/s

m³/s m²



Pneumatic Hydraulic



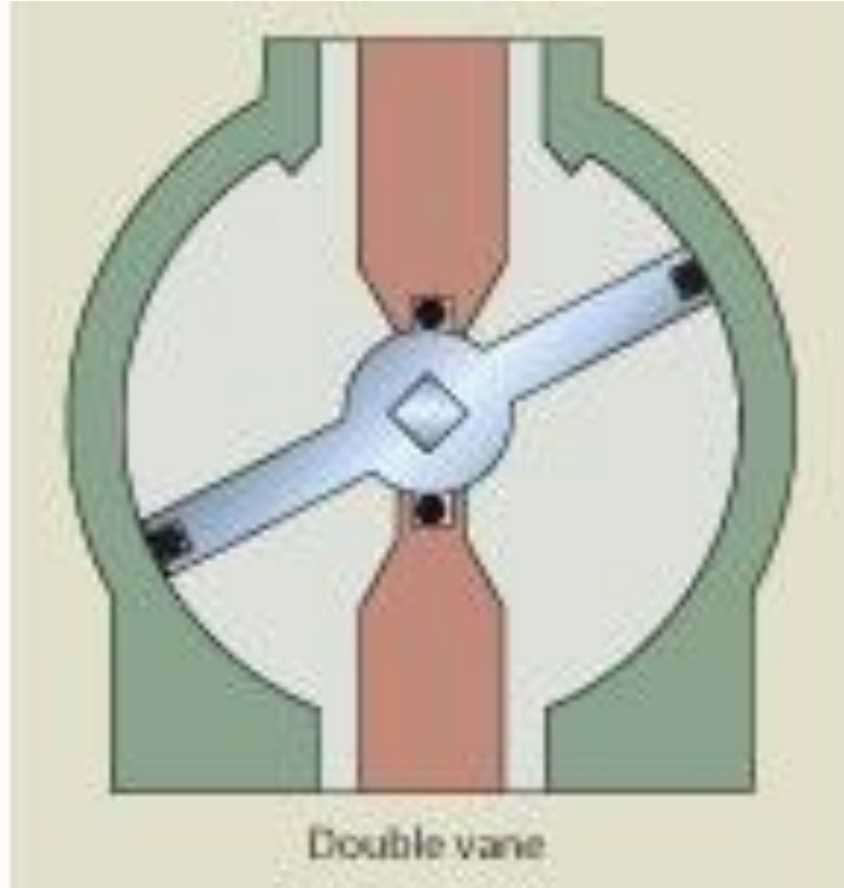
Uni-directional, fixed displacement

Bi-directional (reversible), fixed displacement

Uni-directional, variable displacement

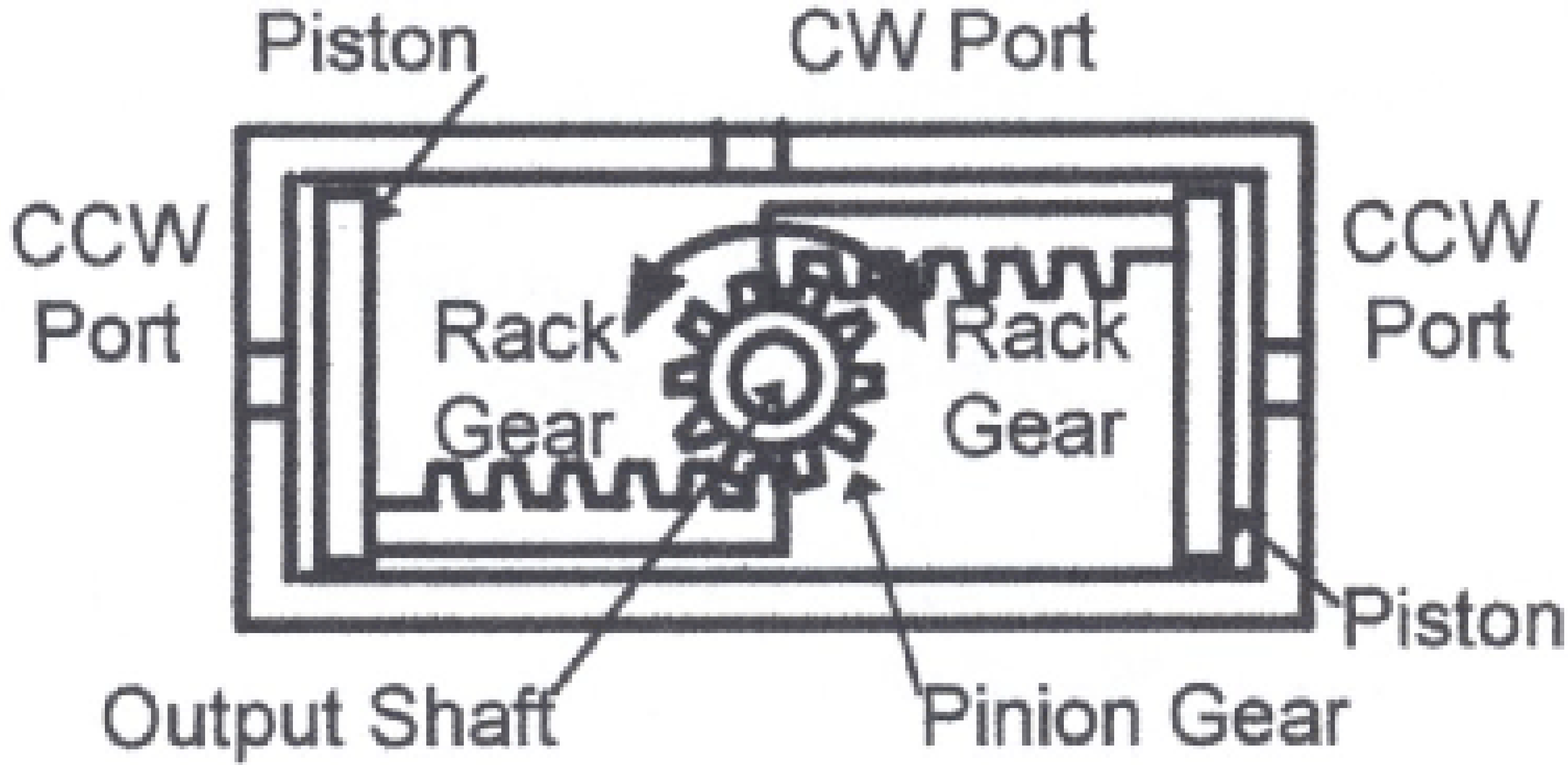
Bi-directional (reversible) variable displacement

Vane-Type Rotary



The maximum rotation of vane rotary actuators is limited to approximately 280° in a single-vane model and approximately 100° in the double-vane configuration.

Rack-and-pinion rotary actuator



Spiral -Shaft Rotary actuator.