# ***HYDRAULIC DRIVES***

# HYDRAULIC MOTORS

# HYDRAULIC MOTORS

- DIFFERENT FORMS OF ENERGY
- HYDRAULIC SYSTEM
- TYPES OF ACTUATORS
- WHAT IS A HYDRAULIC MOTOR ?
- COMPARISON BETWEEN ELECTRIC & HYDRAULIC MOTORS
- TYPES OF HYDRAULIC MOTORS
- RADIAL PISTON MOTORS
- CRANK SHAFT - RADIAL PISTON MOTORS
- WORKING PRINCIPLE OF SAI MOTORS
- APPLICATIONS OF HYDRAULIC MOTORS
- CASE STUDY & QUESTION AND ANSWERS
- STUDY OF RADIAL PISTON MOTOR COMPONENTS
- ASSEMBLY / TESTING / MAINTENANCE

# HYDRAULIC MOTORS

## DIFFERENT FORMS OF ENERGY

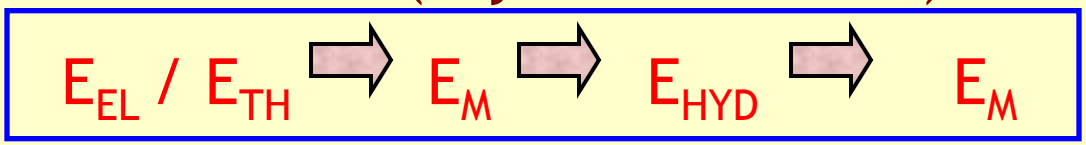
$E_{EL}$ → Electrical Energy

$E_{TH}$ → Thermal Energy

$E_M$ → Mechanical Energy produced by an Electrical Motor or an Oil Engine

$E_{HYD}$ → Hydraulic Energy from Hydraulic Pump in the system

$E_M$ → Mechanical Energy from Hydraulic Actuator ( Hydraulic Motor)




Energy loss takes place at each step of energy conversion

# HYDRAULIC MOTORS

## DIFFERENT FORMS OF ENERGY

Why do we study or use various form of energies ?

- To suit our requirements
- To make effective use of it
- To control it
- To make it flexible
- To preserve it

# HYDRAULIC MOTORS

## HYDRAULIC SYSTEM

Basic arrangement of a hydraulic system :

1. Prime mover - Electric Motor or Engine
2. Fluid Reservoir - Hydraulic Tank
3. Energy Transfer Medium - Hydraulic Oil
4. Fluid Transfer Unit - Hydraulic Pump
5. Fluid Transfer Medium - Hose and Pipes
6. Controls - Relief Valve, D.C Valve, Flow Control Vv
7. Actuators - Hydraulic Motor, Cylinder

# HYDRAULIC MOTORS

## HYDRAULIC SYSTEM

What is Oil Hydraulics ?

Study of energy conversion from mechanical to hydraulic energy (pressure and flow) and again into mechanical energy (Torque and speed).

In Oil Motors :

Pressure (kg / $cm^2$ or bar) gets converted into Torque (kg-cm)

Flow (lpm) gets converted into speed (rpm)

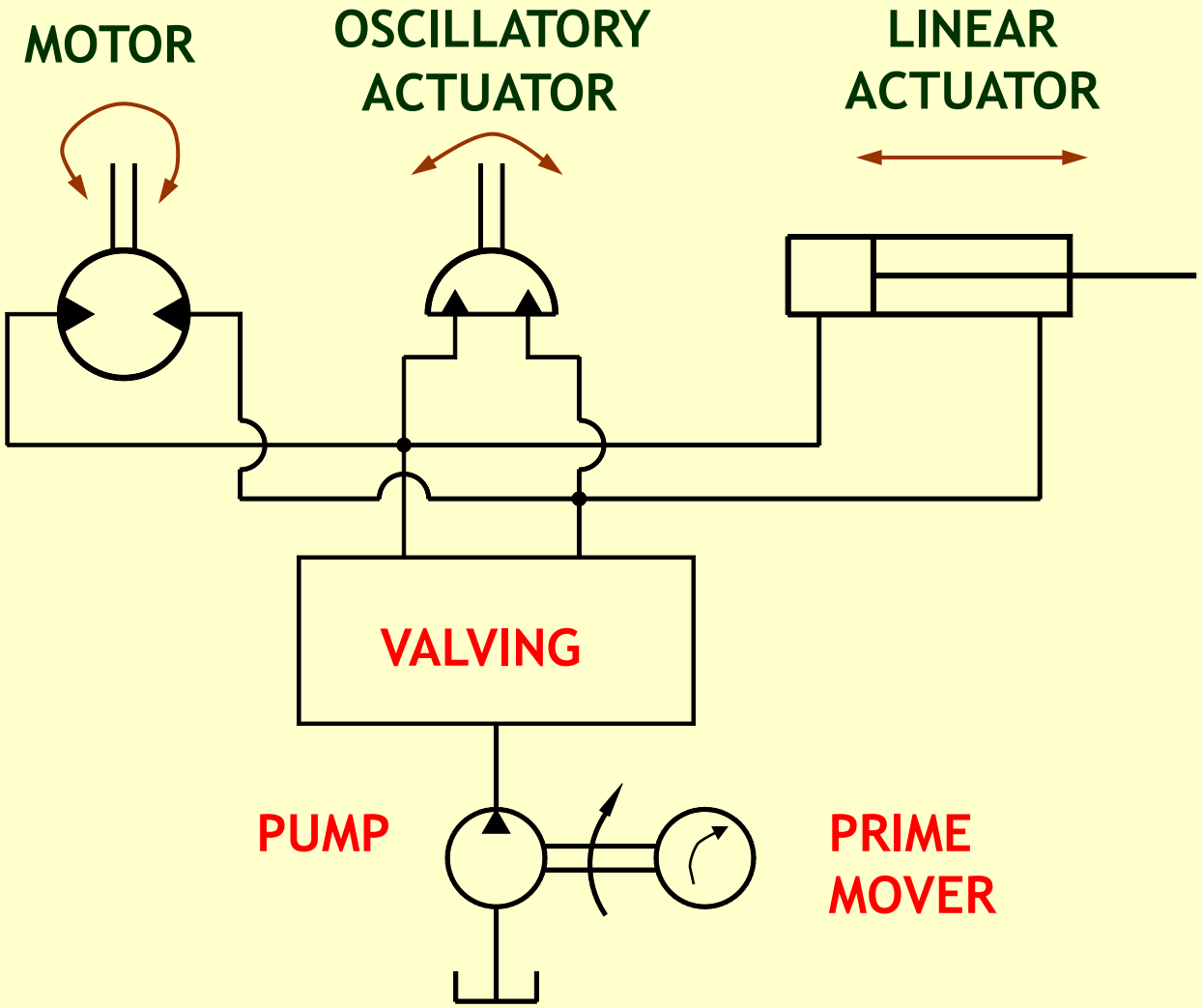
# HYDRAULIC MOTORS

## TYPES OF ACTUATORS

- Linear Actuator - Hydraulic Cylinder
- Oscillatory Actuator - Restricted Rotation Motor
- Rotary Actuator - Hydraulic Motor

# HYDRAULIC MOTORS

- **HYDRAULIC POWER TRANSMISSION**



# HYDRAULIC MOTORS

## WHAT IS A HYDRAULIC MOTOR ?

It is a device which converts the
hydraulic energy (power) generated by a pump into
mechanical energy (power) in the form of
torque and rotation (rpm)

For a Hydraulic Pump, the main function is to -

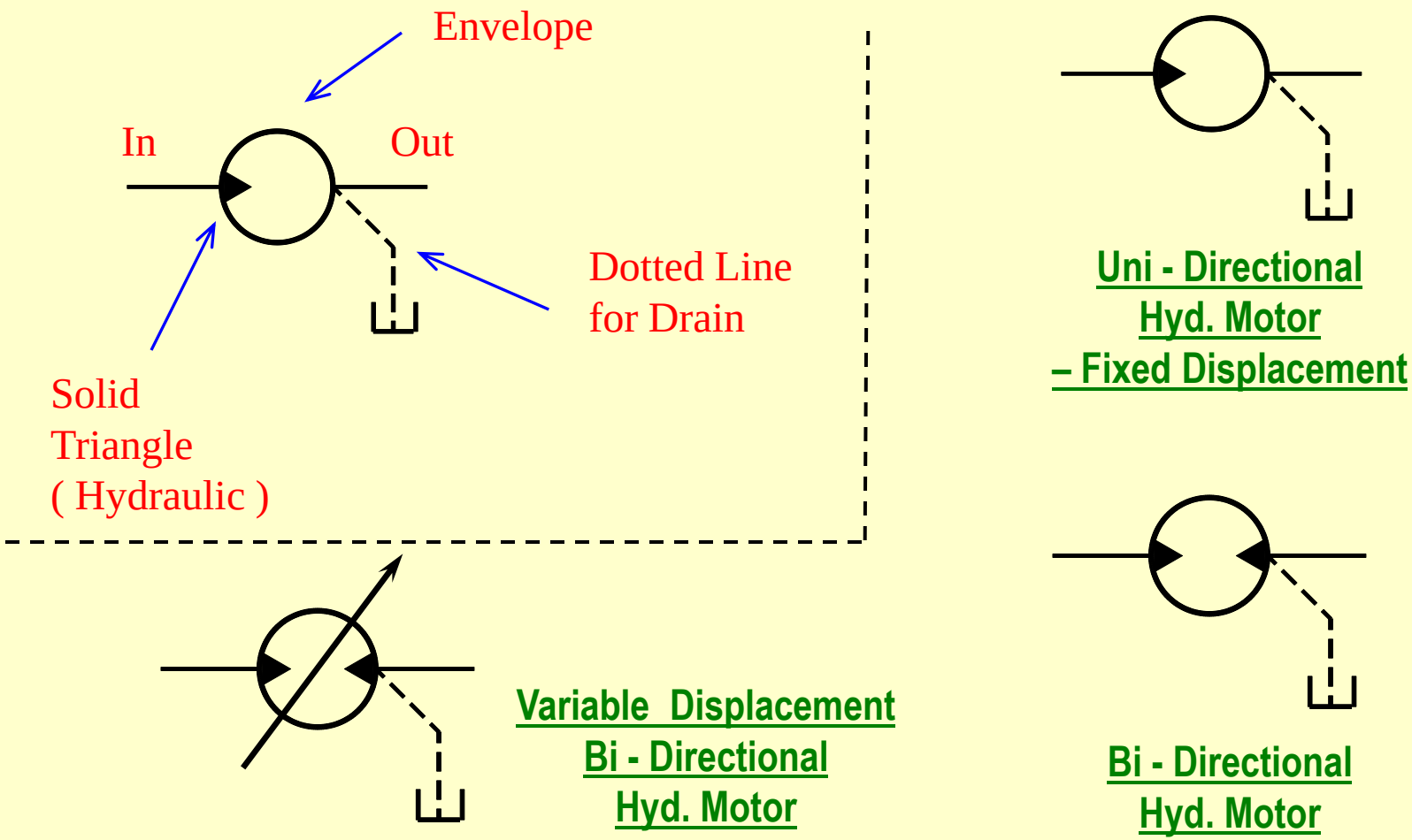
Displace as much oil as possible per revolution.

To achieve this an optimum volumetric efficiency at the cost of mechanical efficiency is required.

On the other hand, the Hydraulic Motors have to deliver maximum mechanical power at the load point.

# HYDRAULIC MOTORS

## HYDRAULIC MOTOR - Graphical Symbols



# HYDRAULIC MOTORS

## SALIENT FEATURES OF A HYDRAULIC MOTOR

- ✓ Extreme range of speed adjustment possible.
- ✓ Torque control throughout the operating speed.
- ✓ Low Inertia.
- ✓ Compactness of space.
- ✓ The fact that they can be stalled indefinitely without damage.
- ✓ Instant reversing of motor's shaft.
- ✓ Dynamic braking easily accomplished.

# HYDRAULIC MOTORS

## SALIENT FEATURES OF A HYDRAULIC MOTOR

**Rapid Reversal**

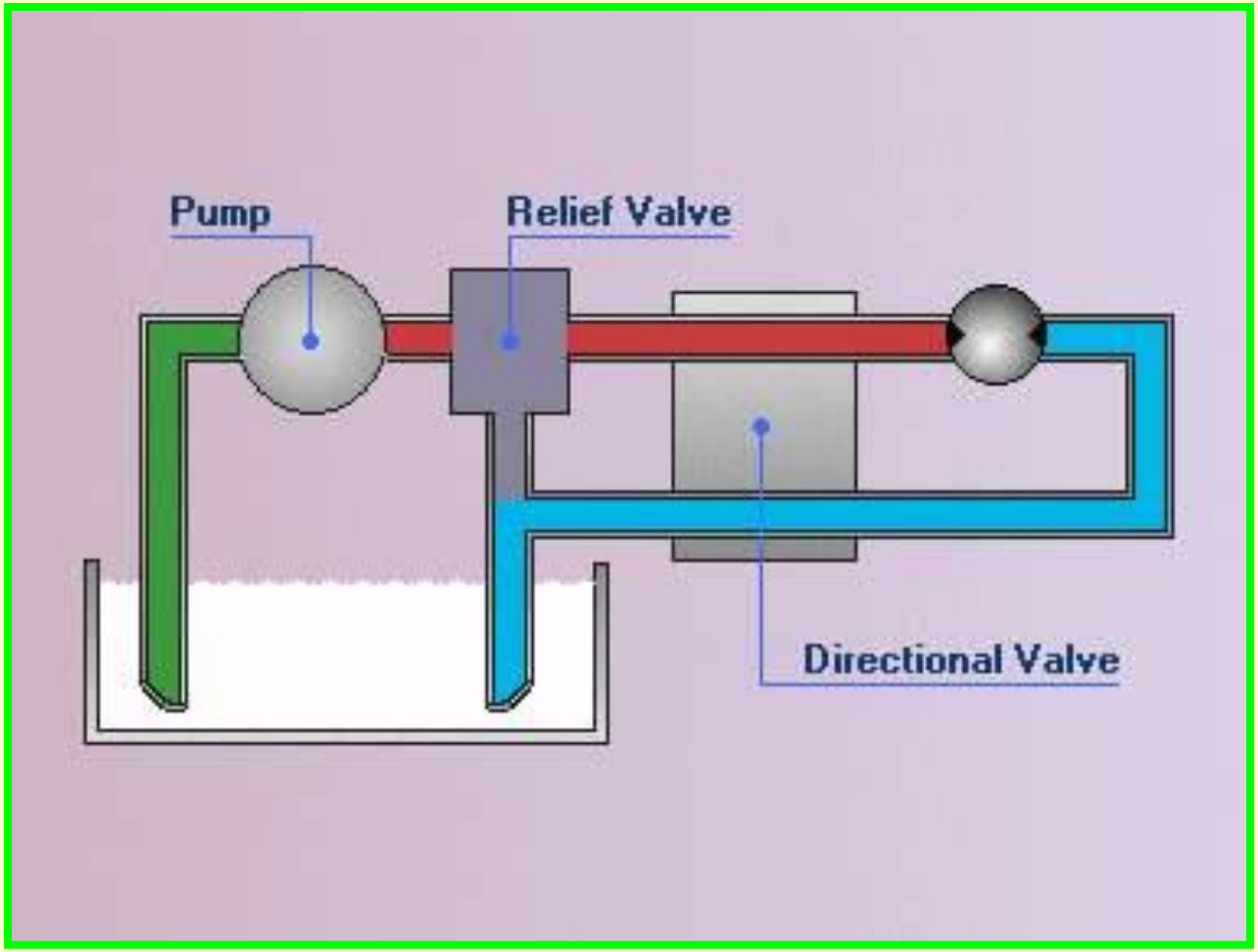
The Rotor Mass of

Hydraulic Motor < Electric Motor

# HYDRAULIC MOTORS

## SALIENT FEATURES OF A HYDRAULIC MOTOR

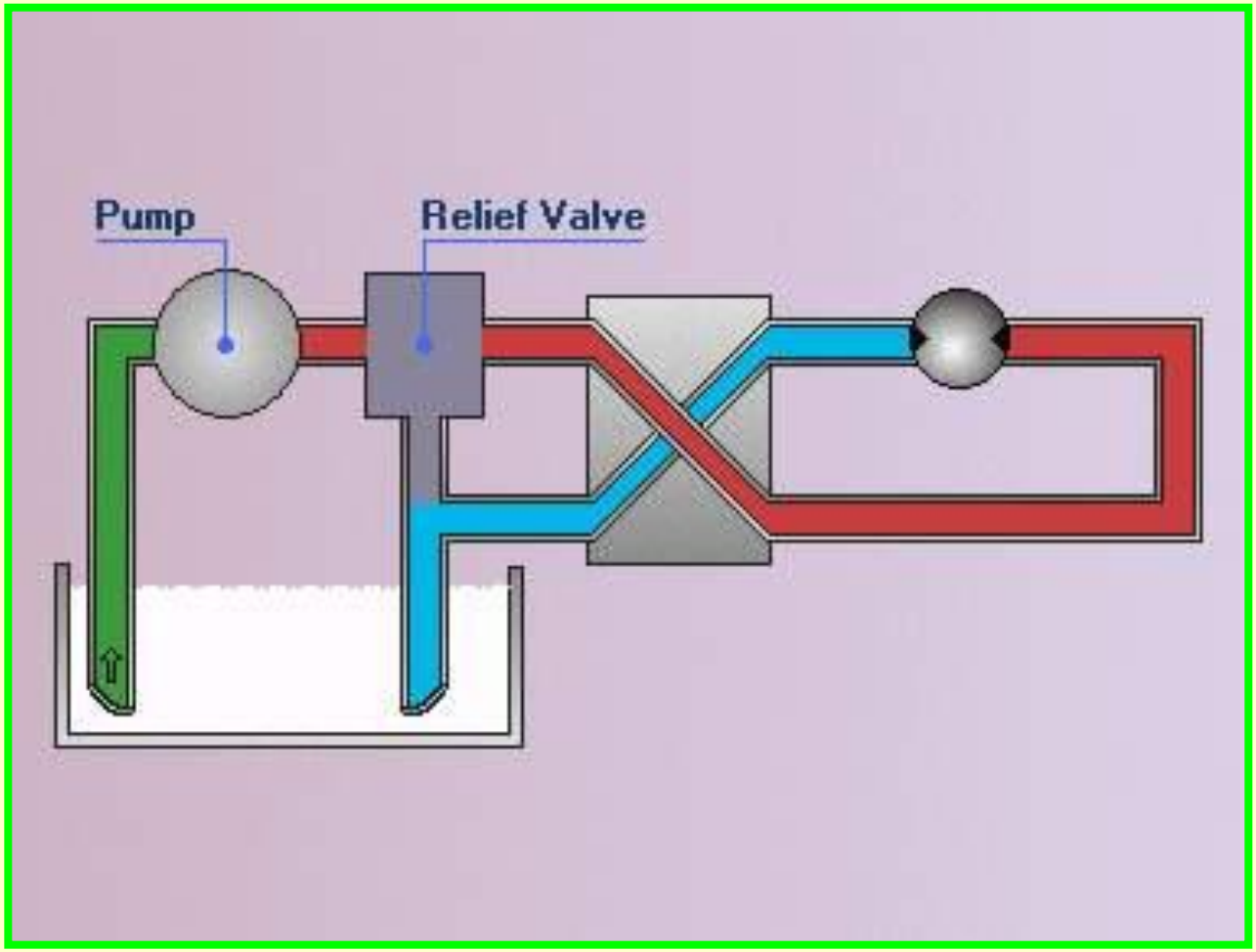
**Rapid Reversal**



# HYDRAULIC MOTORS

- **SALIENT FEATURES OF A HYDRAULIC MOTOR**

**Rapid Reversal**



# HYDRAULIC MOTORS

## SALIENT FEATURES OF A HYDRAULIC MOTOR

### Speed Variation

Electric Motor → Torque Converters

Hydraulic Motor → Simple Flow Control Valve

### Size Comparison

Power Density of

Hydraulic Motor > Electric Motor

# HYDRAULIC MOTORS

## SALIENT FEATURES OF A HYDRAULIC MOTOR

### Stall Performance

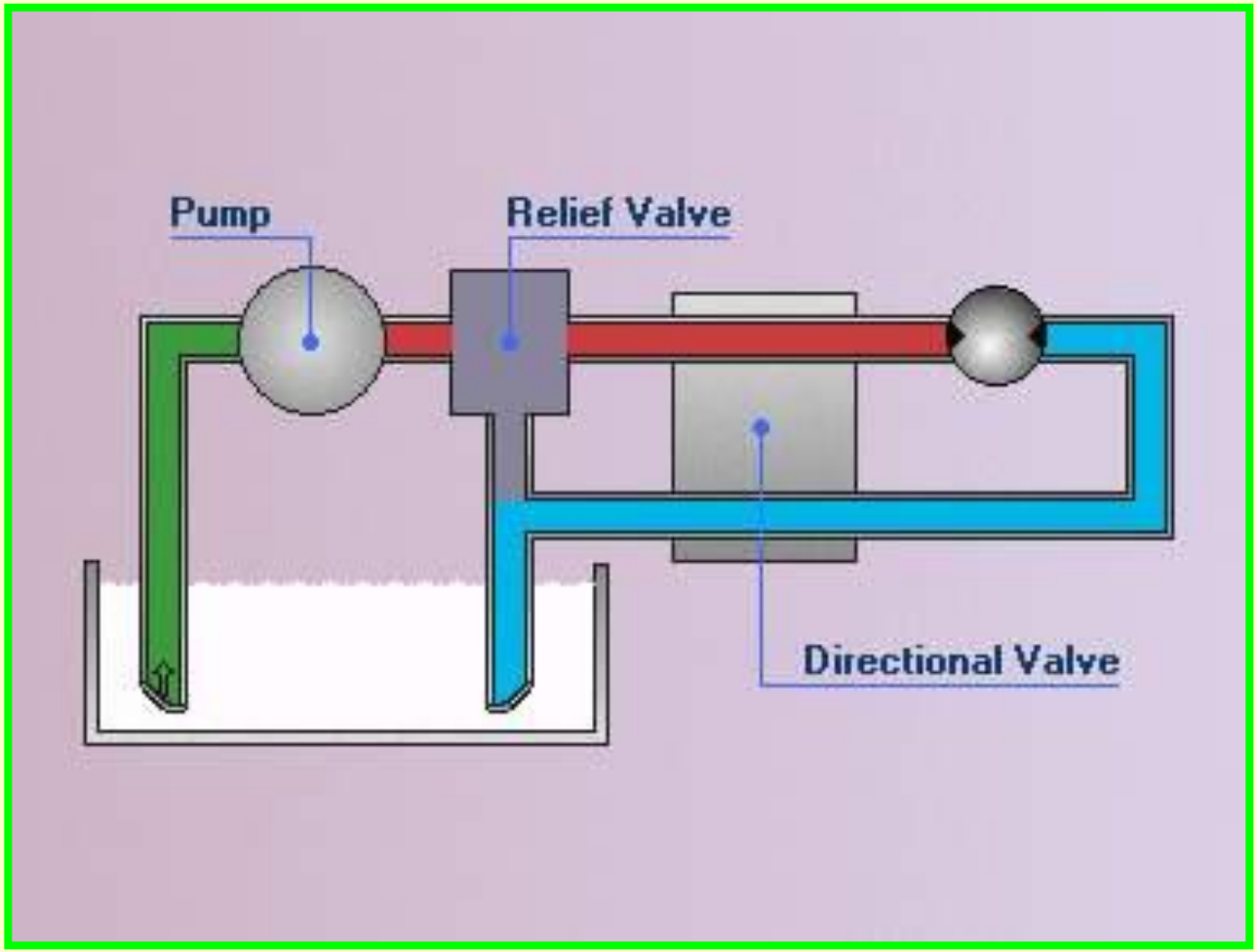
Electric Motor → Trips / Stops

Hydraulic Motor → Stall Torque possible to achieve

# HYDRAULIC MOTORS

- **SALIENT FEATURES OF A HYDRAULIC MOTOR**

  **Stall Performance**



# HYDRAULIC MOTORS

## SALIENT FEATURES OF A HYDRAULIC MOTOR

### Unfavourable Environment

Fluid Motors can be used in Dangerous,

Difficult environment.

### Speed Regulation

$$\text{Speed Regulation} = \frac{\text{No Load Speed} - \text{Loaded Speed}}{\text{No Load Speed}} \times 100$$

Speed Variations

Electric Motor $\rightarrow$ 3 %

Most Hyd. Motors $\rightarrow$ 10 - 15 %

( Except for Radial Piston Motors )

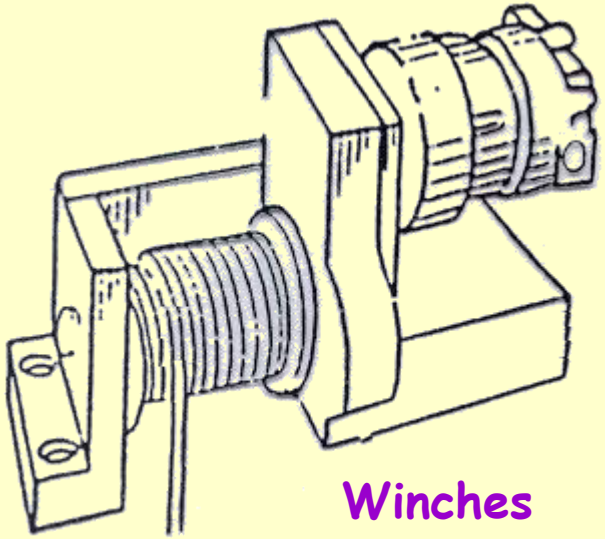
# HYDRAULIC MOTORS

## MAJOR APPLICATIONS

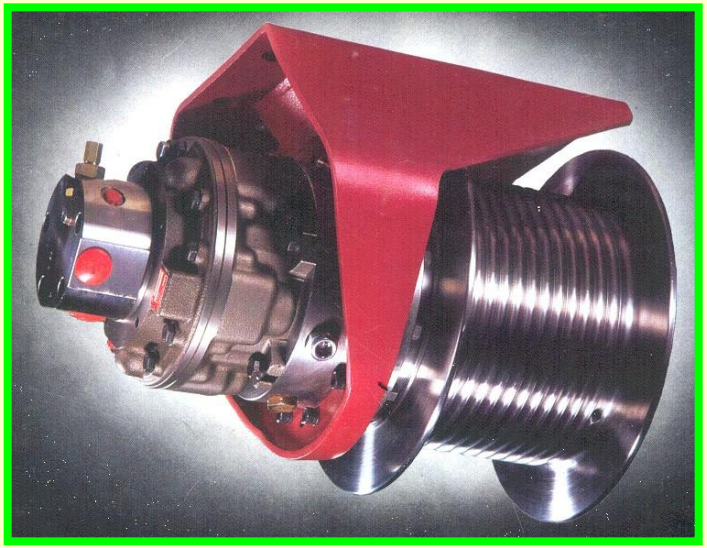
- CONSTRUCTION
- MINING
- MATERIAL HANDLING
- EARTH MOVING
- PLASTICS
- MACHINE TOOLS
- AGRICULTURE
- RAILWAY EQUIPMENT

# HYDRAULIC MOTORS

- **MAJOR APPLICATIONS**

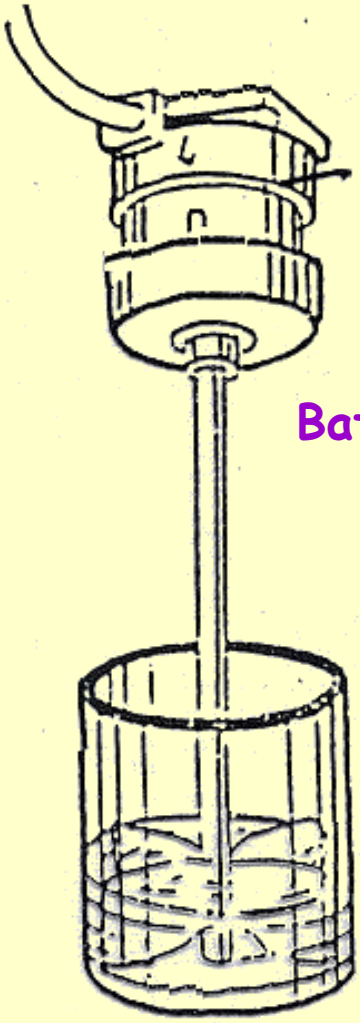


Winches

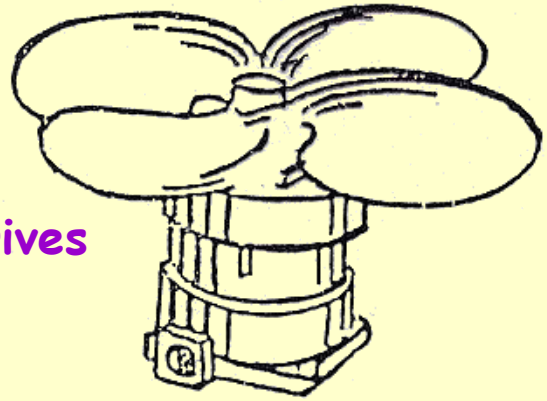


# HYDRAULIC MOTORS

- **MAJOR APPLICATIONS**



Batch Mixers



Fan Drives


*Conveyors*

# HYDRAULIC MOTORS

## WHILE REPLACING AN ELECTRIC MOTOR WITH A HYDRAULIC MOTOR

**Points to be considered :**

- 3 Phase Squirrel cage Electric Motor has twice the starting torque of Hydraulic Motor. The value of the starting torque / running torque to be known.
- Do not consider HP as comparison
- The details of Gear Box , Pulley used at output of Electric Motor to be known.

# HYDRAULIC MOTORS

## CLASSIFICATION OF HYDRAULIC MOTORS

- GEOMETRY OF THE ACTUATING MECHANISM
- SPEED AND TORQUE RATING

**HIGH TORQUE LOW SPEED MOTORS ( HTLS )**

- RADIAL PISTON MOTORS
  - CRANKSHAFT
  - CAM - LOBE
- ORBIT MOTORS
  - GEROTOR
  - GEROLLER

**LOW TORQUE HIGH SPEED MOTORS ( LTHS )**

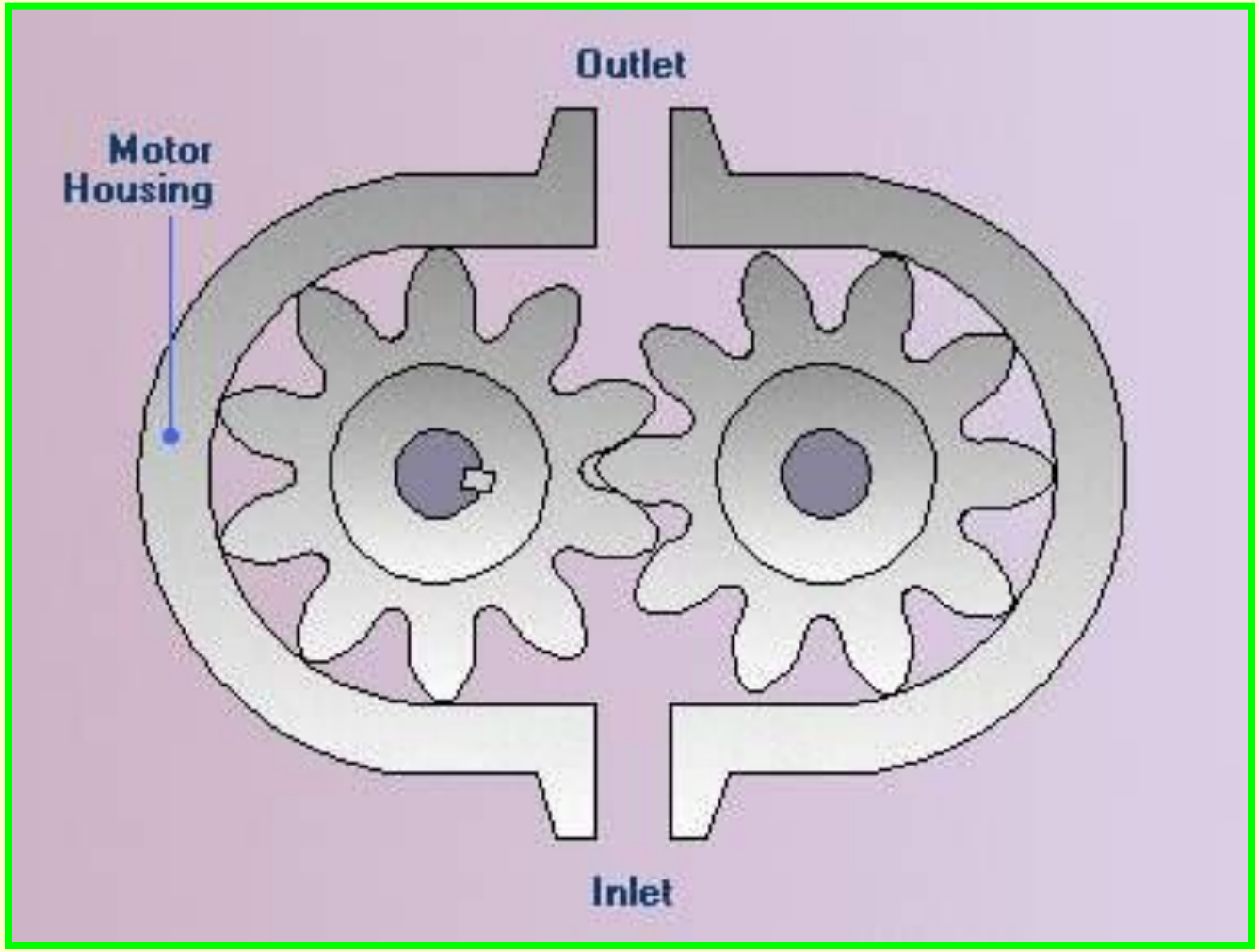
- AXIAL PISTON MOTORS
  - SWASH PLATE
  - BENT AXIS
- GEAR MOTORS
- VANE MOTORS

# HYDRAULIC MOTORS

- **GEAR MOTORS**
  - COMPACT
  - LOW COST
  - LOW EFFICIENCY ( 60% - 70% )
  - SPEED RANGE ( 500 – 3000 rpm )
  - CANNOT BE USED FOR LOW SPEED

# HYDRAULIC MOTORS

- **GEAR MOTORS**



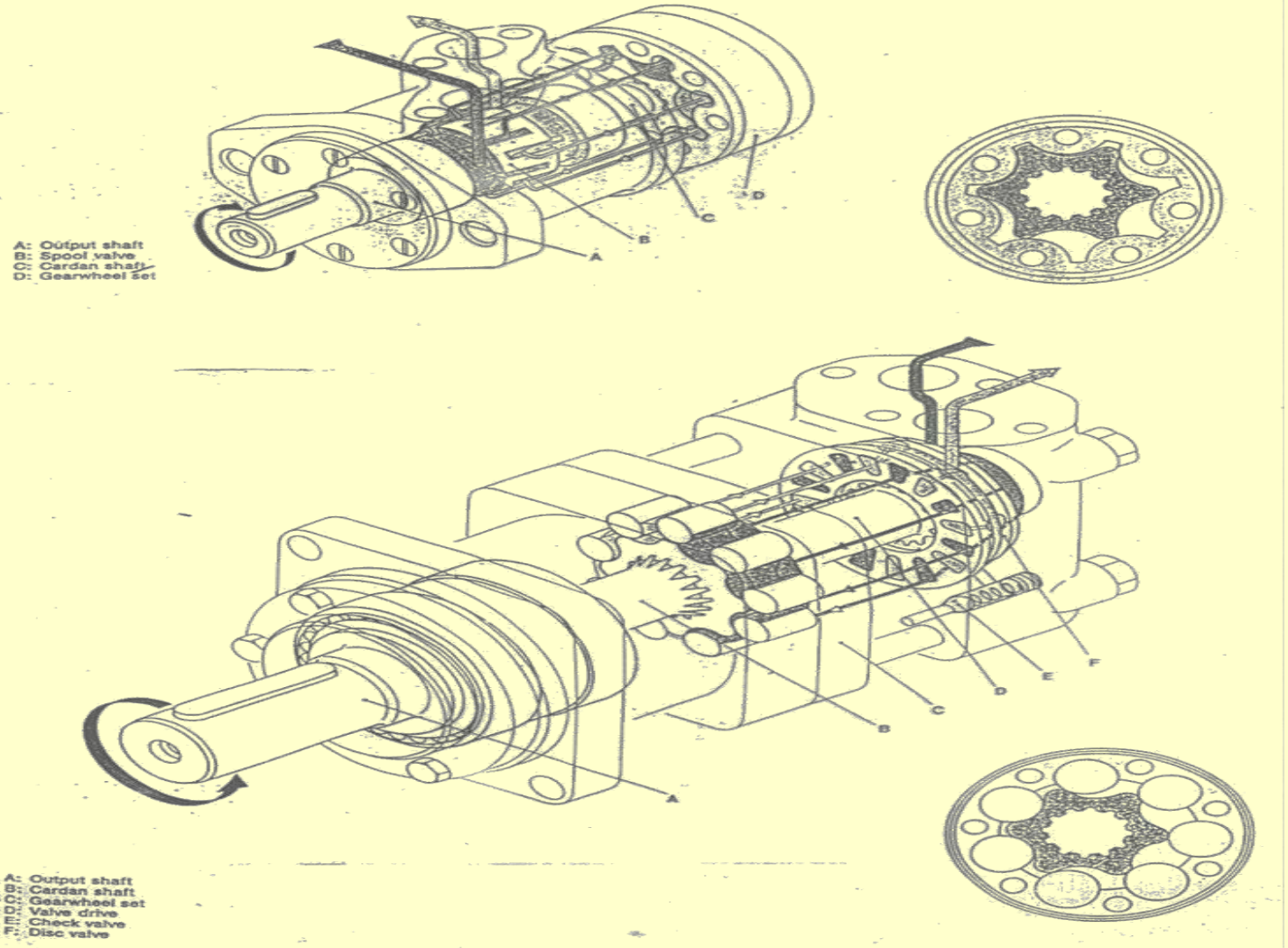
# HYDRAULIC MOTORS

## GEAR RING MOTORS ( ORBIT MOTORS )

- Higher power output for a given outer dimensions.
- Overall efficiency low.
- Volumetric efficiency low.
- Low cost.
- Rotation at low speed not smooth.
- Higher heat generation ( loss of energy )

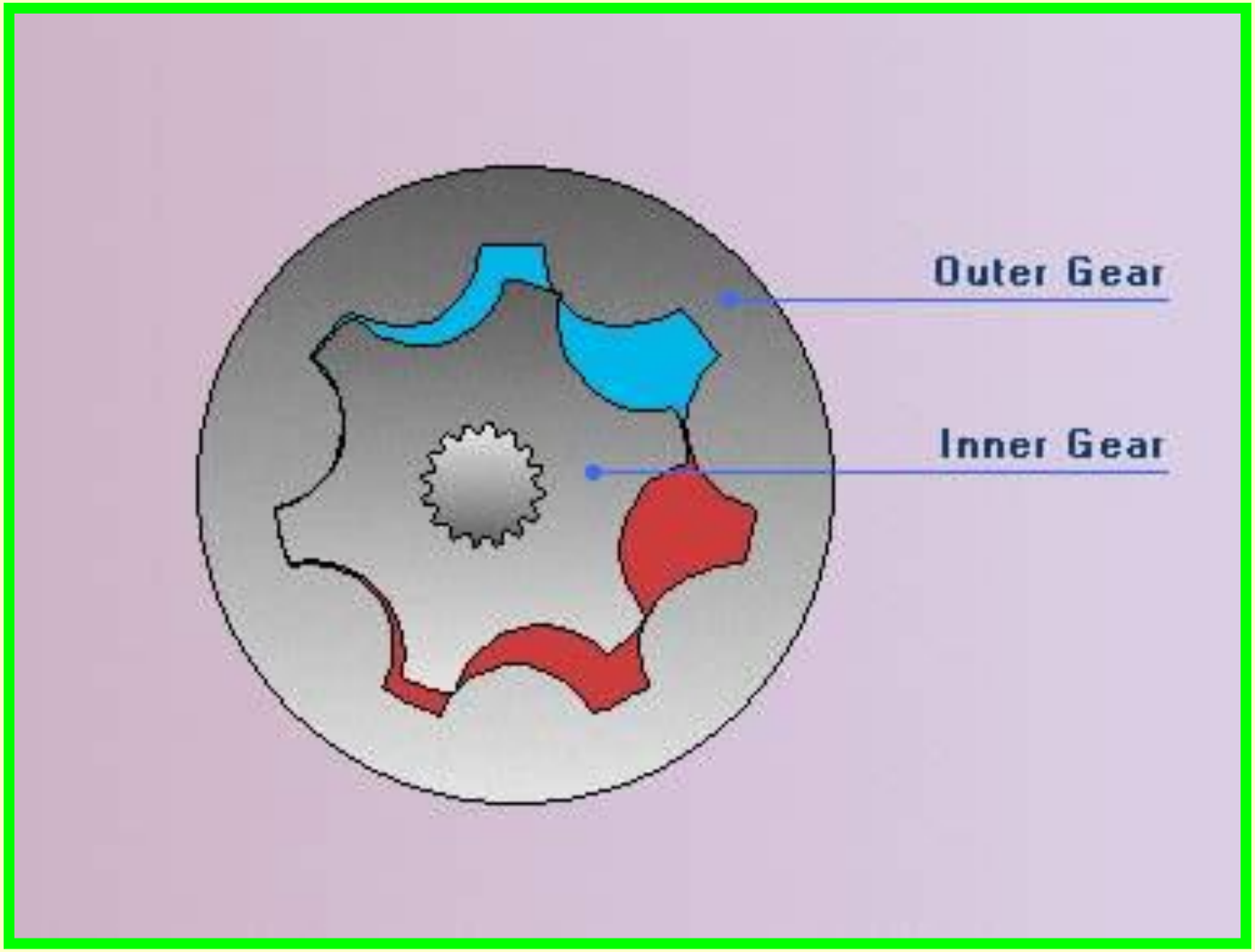
# HYDRAULIC MOTORS

## GEAR RING MOTORS ( ORBIT MOTORS )



# HYDRAULIC MOTORS

- **GEAR RING MOTORS ( ORBIT MOTORS )**



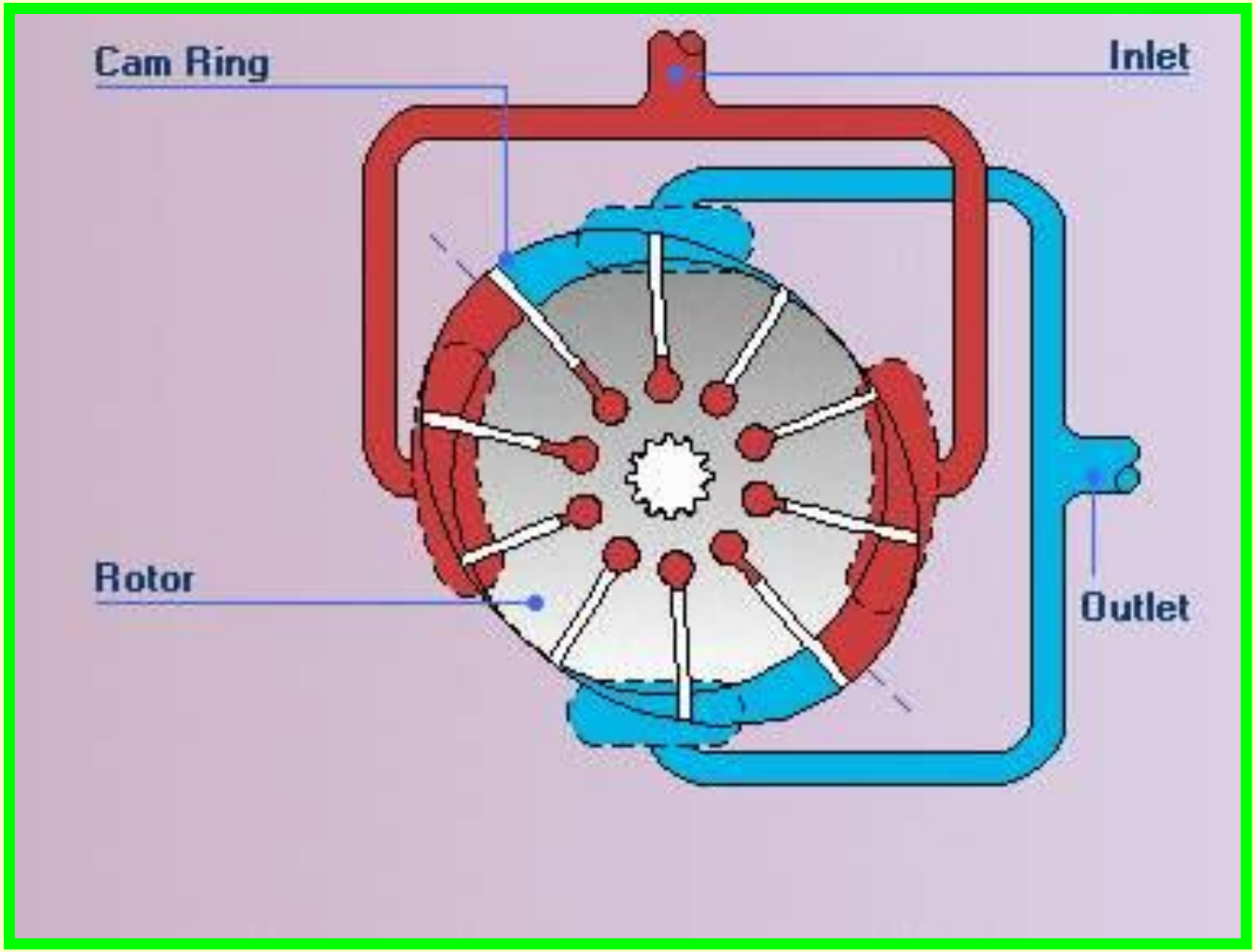
# HYDRAULIC MOTORS

## VANE MOTORS

- DESIGN COMPLICATED
- MANUFACTURING COMPLICATED
- HIGH COST
- MEDIUM TORQUE
- MEDIUM SPEED
- CHANGE OF SPEED WITH CHANGE OF TORQUE POSSIBLE

# HYDRAULIC MOTORS

- **VANE MOTORS**



# HYDRAULIC MOTORS

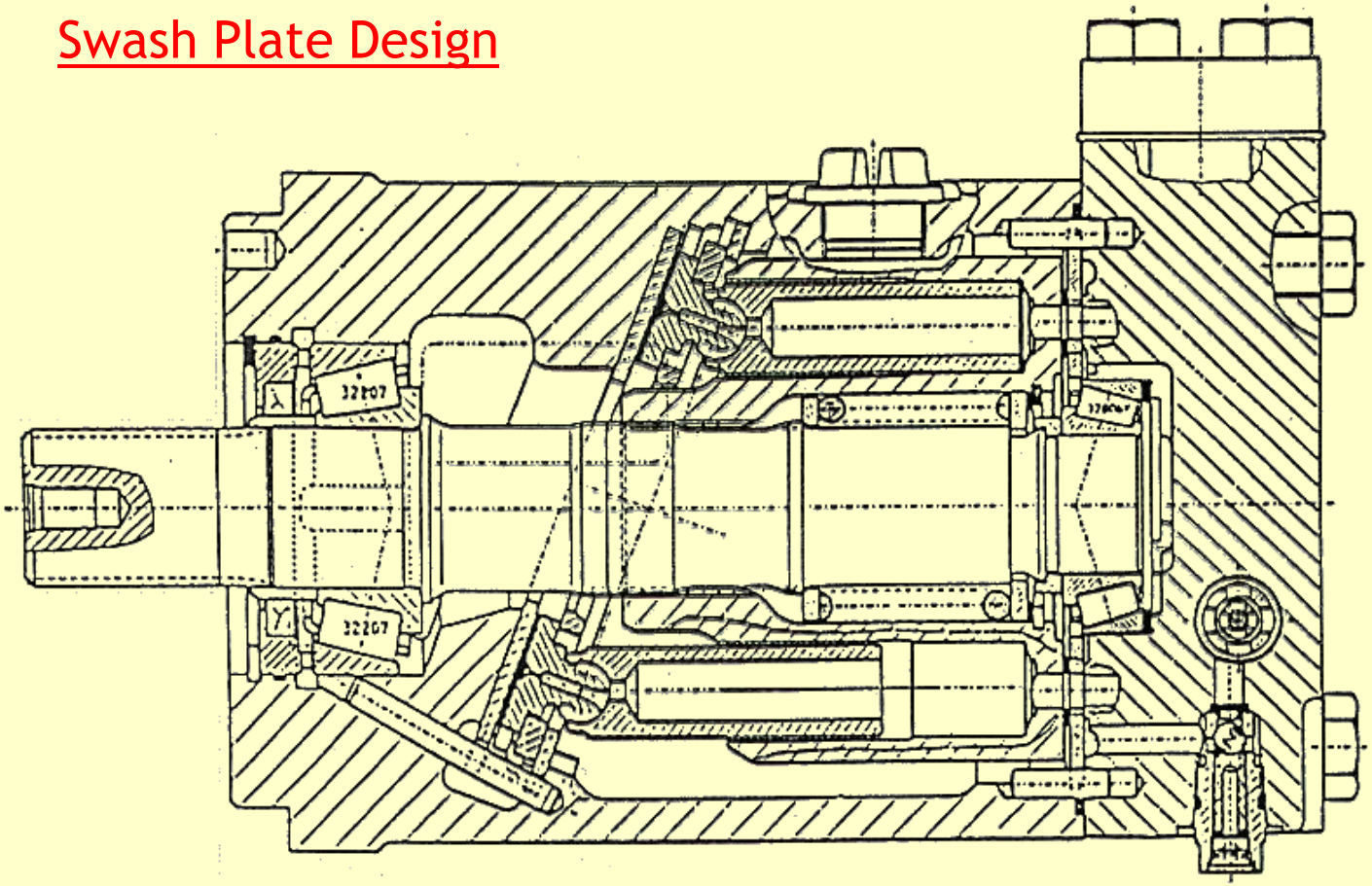
## AXIAL PISTON MOTORS

- LOW TORQUE
- HIGH SPEED
- COMPLICATED DESIGN
- MANUFACTURING DIFFICULT
- HIGH COST
- REVERSING SHAFT OUTPUT EASY
- SPEED CONTROL POSSIBLE
- TORQUE CONTROL POSSIBLE

# HYDRAULIC MOTORS

- **AXIAL PISTON MOTORS**

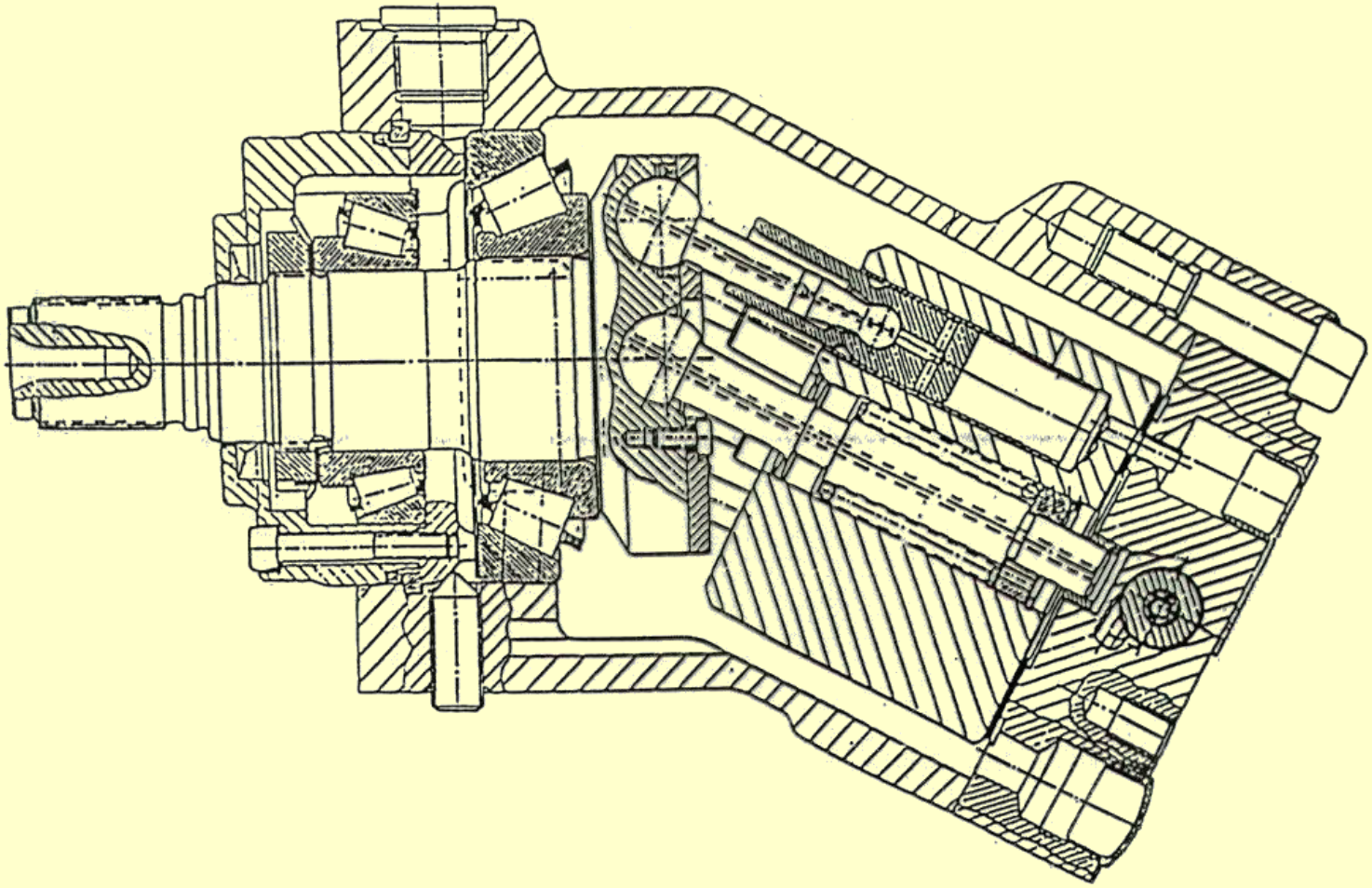
Swash Plate Design



# HYDRAULIC MOTORS

- **AXIAL PISTON MOTORS**

  Bent Axis Design



# HYDRAULIC MOTORS

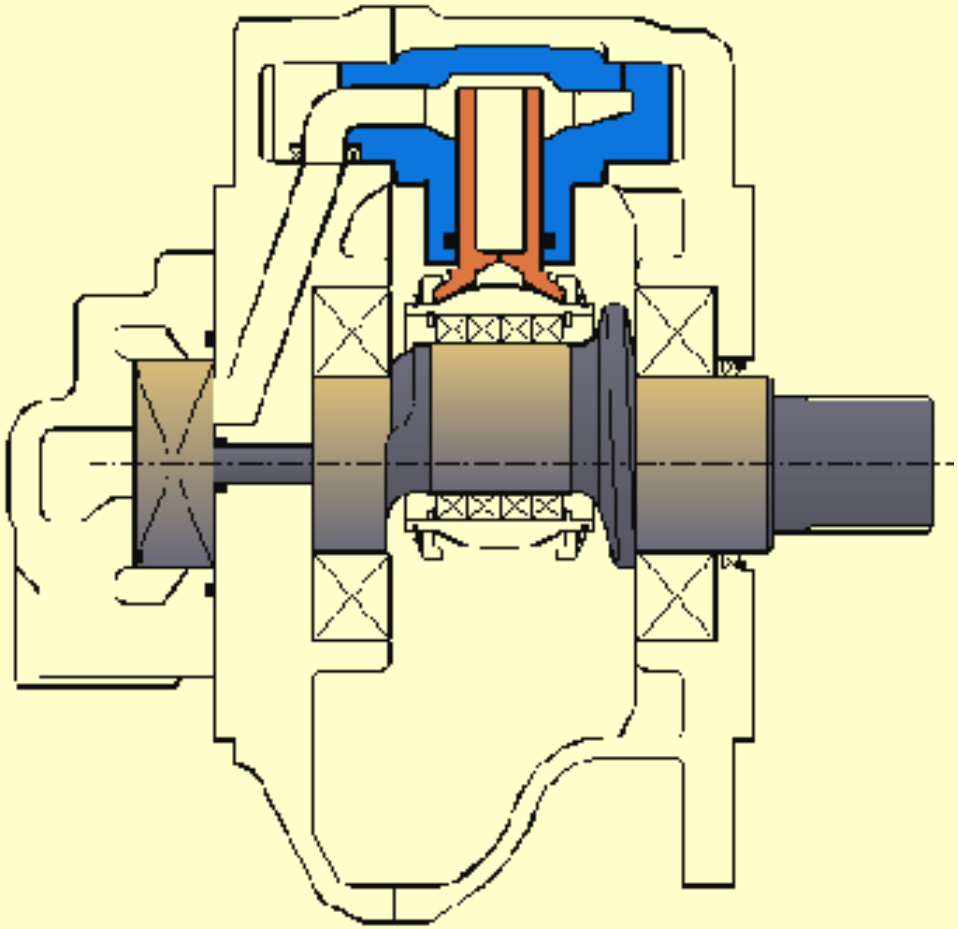
## RADIAL PISTON MOTORS

- HIGH STARTING TORQUE
- HIGH RUNNING TORQUE
- COMPACT IN SIZE (SPECIFIC TORQUE HIGH)
- BI-DIRECTIONAL
- LOW SPEED POSSIBLE ( < 10 rpm)
- TORQUE VARIATION POSSIBLE
- LOW NOISE
- VIBRATION VERY LOW
- HIGH MECHANICAL EFFICIENCY
- HIGH VOLUMETRIC EFFICIENCY
- INSTANT REVERSING POSSIBLE

# HYDRAULIC MOTORS

- **RADIAL PISTON MOTORS**

Crank Shaft Design

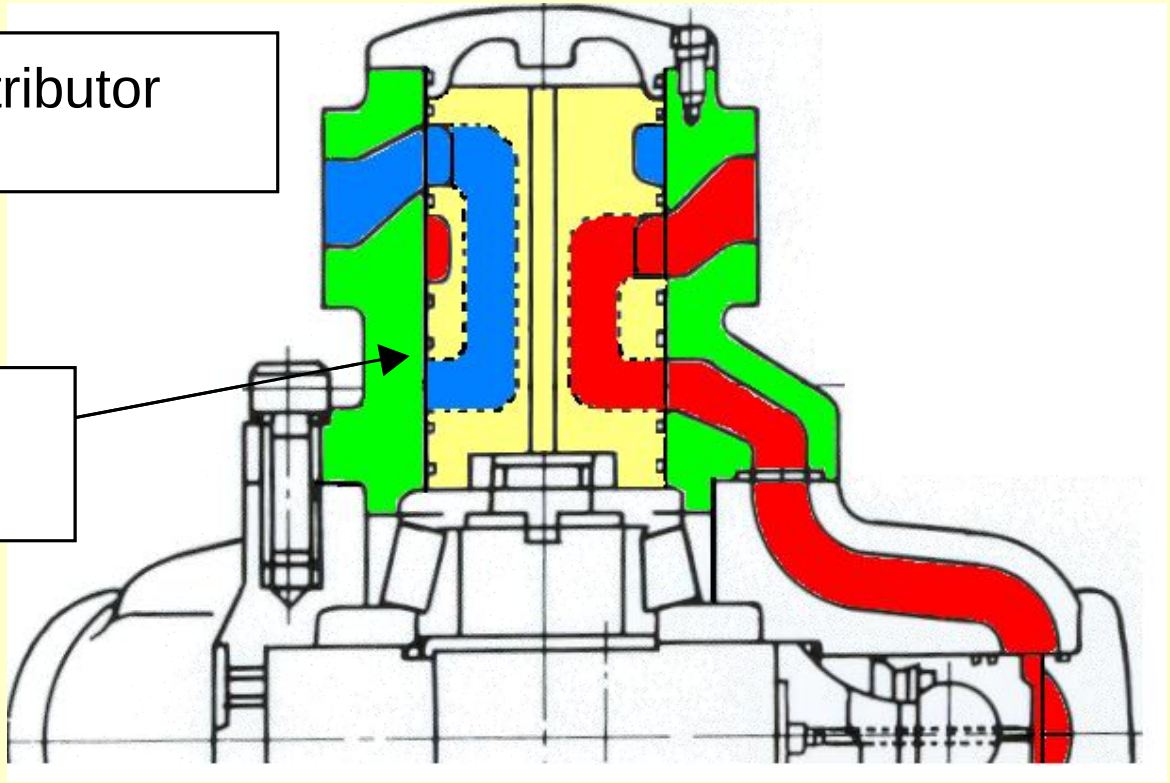


# HYDRAULIC MOTORS

## RADIAL PISTON MOTORS

Radial type distributor

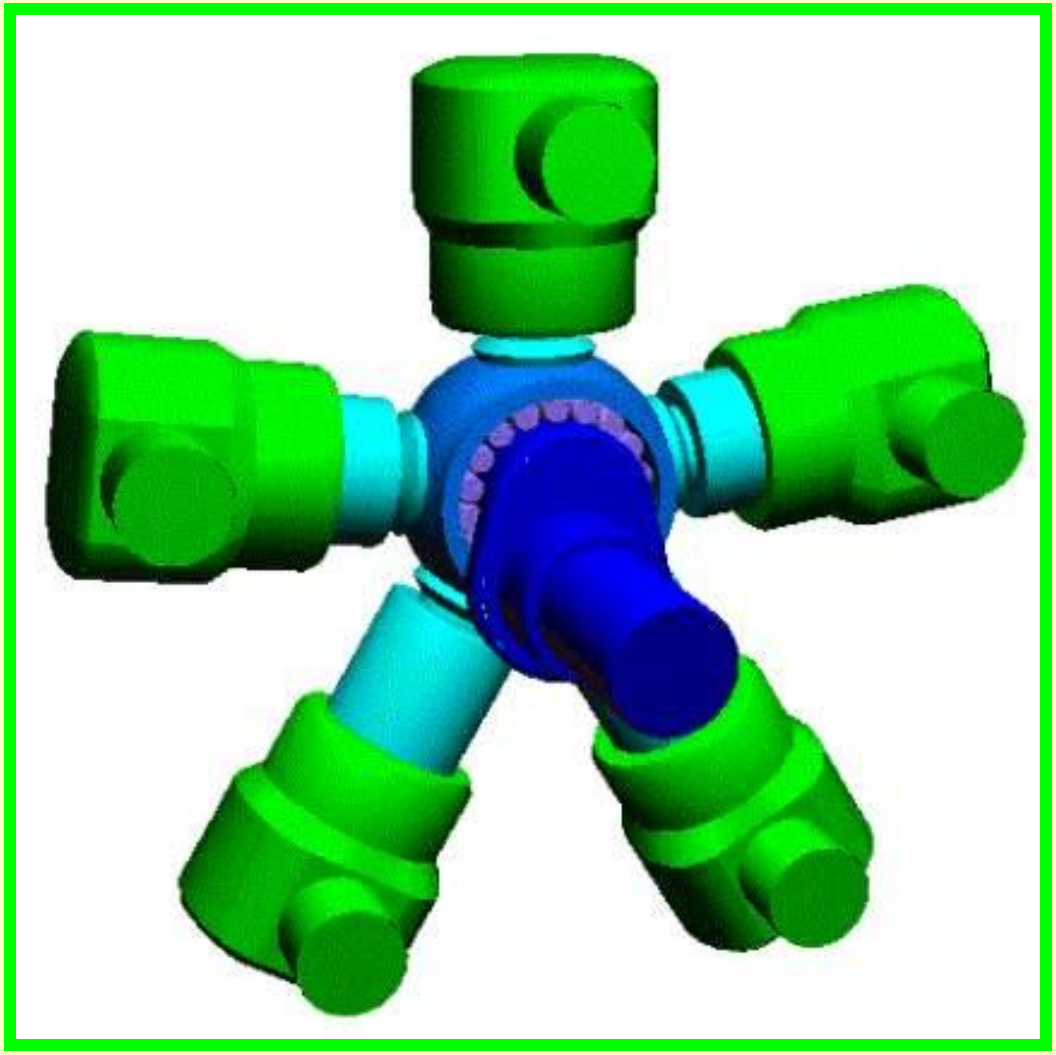
Small clearance



# HYDRAULIC MOTORS

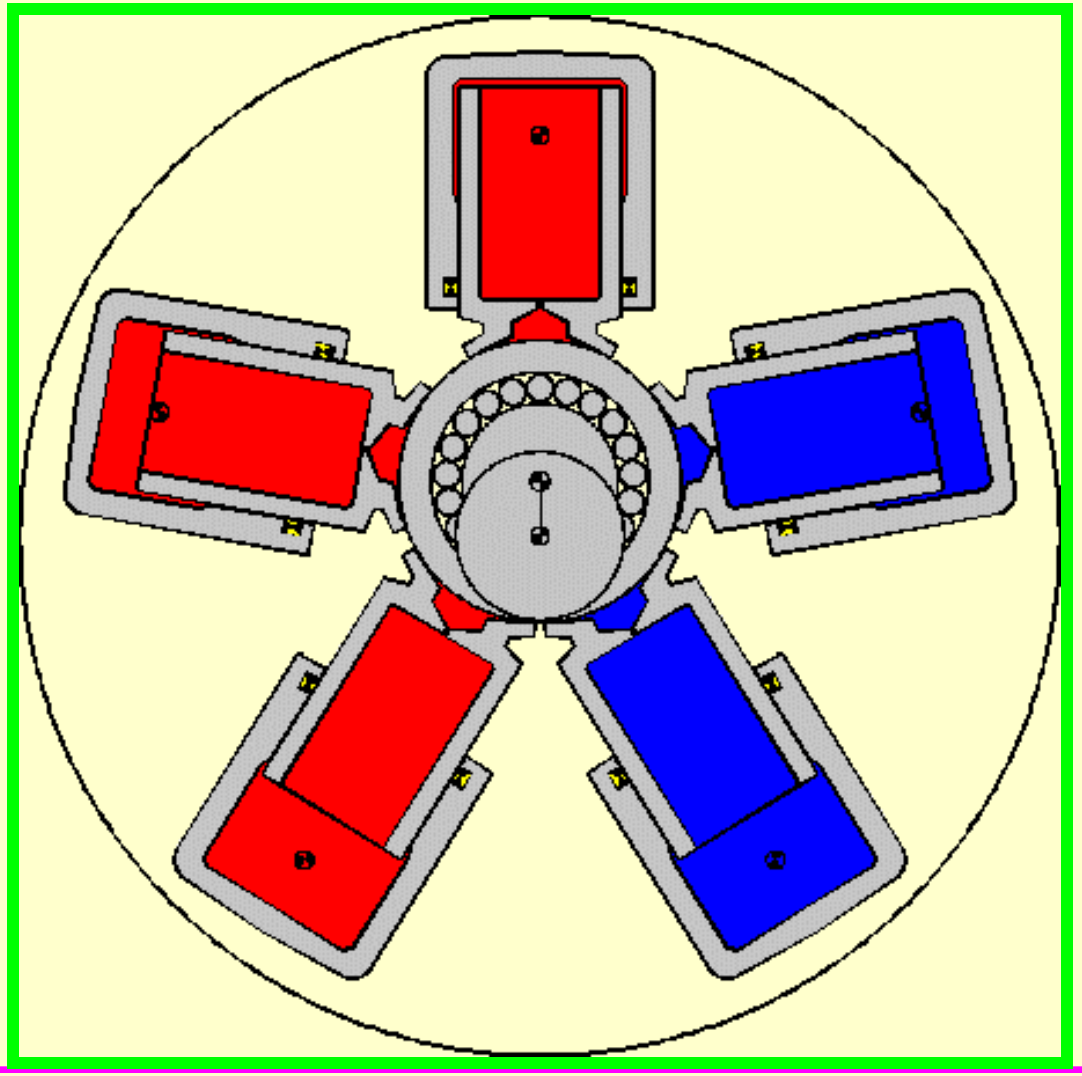
## RADIAL PISTON MOTORS

- Swivelling Cylinder
- Double Piston Support bearing.



# HYDRAULIC MOTORS

- **RADIAL PISTON MOTORS**



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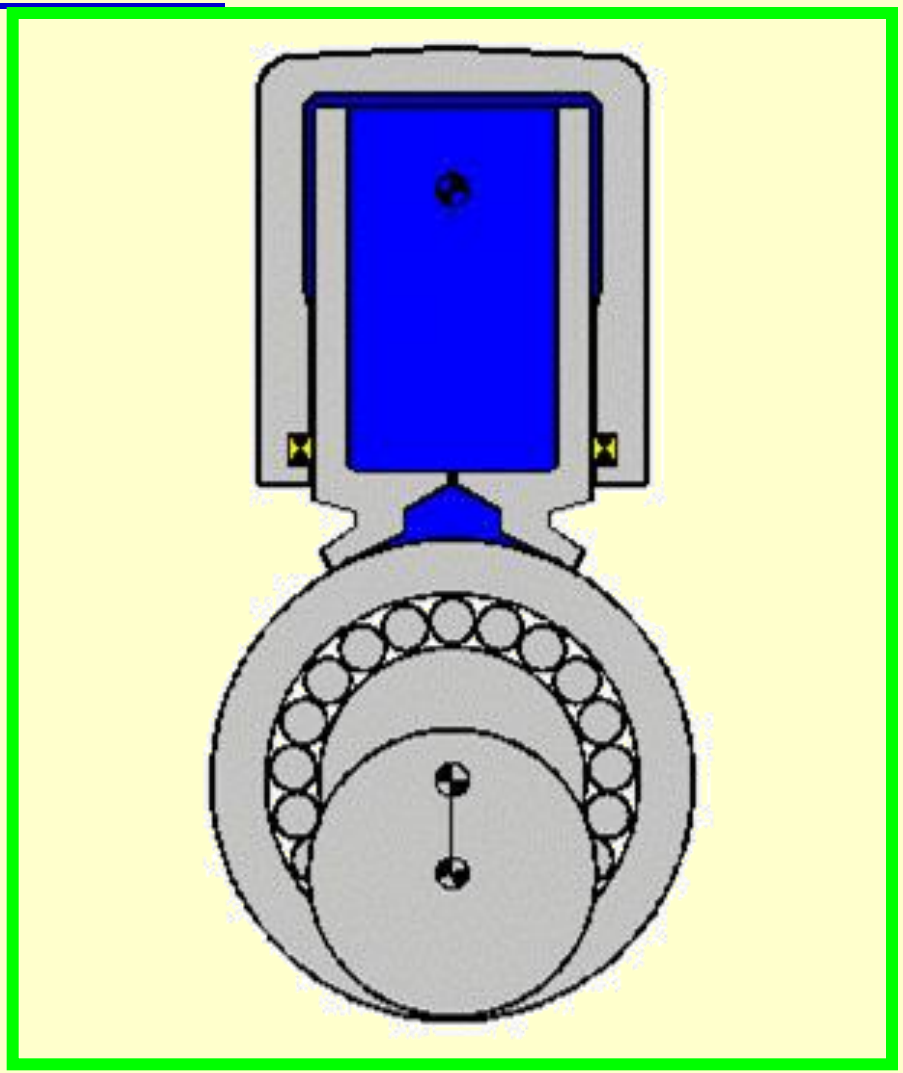
- **RADIAL PISTON MOTORS**



# HYDRAULIC MOTORS

## MOTOR RATINGS

The rating of hydraulic motors are done based on the following operating parameters :

- Displacement
- Torque capacity
- Speed
- Operating Pressure

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- Displacement : of a hydraulic motor is defined as the amount of fluid required to turn the motor shaft by one revolution.

# HYDRAULIC MOTORS

## MOTOR RATINGS

- Torque : Torque is the turning force developed at the motor shaft due to its rotation. The value of Torque increases with an increase in operating pressure, and decreases when the pressure decreases.

- Speed : The speed of a hydraulic motor depends on its displacement and the flow rate to it.

- Operating Pressure : The pressure required by a hydraulic motor depends on the torque requirement and its displacement

# HYDRAULIC MOTORS

## MOTOR SELECTION

**OUTPUT PARAMETERS :**

- SPEED ( RPM )
- TORQUE ( KG - M )

**MOTOR PARAMETER :**

- DISPLACEMENT ( CC / REV. )

**HYD. PARAMETERS :**

- FLOW ( LPM )
- PRESSURE ( BAR )

**TORQUE :**

$$\frac{\text{DISPLACEMENT} \times \text{PR.} \times \eta_m}{628}$$

**SPEED :**

$$\frac{\text{FLOW} \times 1000}{\text{DISPLACEMENT}} \times \eta_v$$

# HYDRAULIC MOTORS

## EFFECT ON HYDRAULIC MOTOR DURING CHANGE IN HYD. SETTINGS UNDER CONSTANT LOAD CONDITION

| CHANGE | SPEED | EFFECT ON OPERATING PRESSURE | TORQUE AVAILABILITY |
|---|---|---|---|
| Increase pressure setting | No Effect | No Effect | Increases |
| Decrease pressure setting | No Effect | No Effect | Decreases |
| Increase flow | Increases | No Effect | No Effect |
| Decrease flow | Decreases | No Effect | No Effect |
| Increase displacement (Size) | Decreases | Decreases | Increases |
| Decrease displacement (Size) | Increases | Increases | Decreases |

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https://en.wikipedia.org/wiki/Hydraulic_motor#Radial_piston_motors