HYDRAULICS TRAINING AND PROJECT WORK AT BOSCH REXROTH

Authored By-

Ajith Srikanth

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DECLARATION

I, Ajith Srikanth, 2nd year student of B.Tech – Mechatronics, SRM Institute of Science & Technology, Kattankulathur, Chennai humbly declare that this report is based on the learning during my internship at Bosch Rexroth Pvt Ltd, Sanand GIDC, Ahmedabad carried by me and no part of it has been presented previously anywhere.

The report was prepared under the guidance of my mentor Mr. Rupesh Shah (DCIN/SLE5, DCIN SLE6), Bosch Rexroth Pvt Ltd.

It is also declared that this report has been prepared for academic purpose alone and has not been/will not be submitted elsewhere for any other purposes.

Ajith Srikanth
Register No : RA1811018010007
B.Tech Mechatronics - 1st Year completed
SRM Institute of Science and Technology, Kathakulathur, Chennai.

ACKNOWLEDGMENT

This report would not have been possible without the essential and gracious support of my Mentor Mr. Rupesh Shah from Bosch Rexroth Pvt Ltd. His willingness to motivate me contributed tremendously during my internship and project report. I also would like to thank him for showing me valuable guidance during the internship period.

Besides I would like to thank you the Management of Bosch Rexroth Pvt Ltd for providing me good learning environment to complete this project report. It gave me opportunity to learn about the basics of Hydraulics.
I would also like to show my gratitude to Mr. Vignesh Mudalair and Mr. Darsh N Shah for helping throughout the Project.

Finally, I would like to thank my family, friends & mentor for their understanding and support towards completing this report.

ABSTRACT

Mechatronic is a subject which deals with many aspects of engineering which includes the study of hydraulics also. Bosch Rexroth which is specialized in this field gave me an opportunity to study hydraulics which will be a part of my curriculum in my future semester.

This basic study of hydraulics gave me an insight of how my subject is going to be. With plant visits and assistance from my mentor I learned the basic of hydraulics. Both practically and theoretically. I understood the components and working of the hydraulics.
I even understood how to read a hydraulic circuit which includes the study of the symbols. My mentor assigned me a person with whom I could clear my doubts which was helpful. Due to my level of study I was just assigned a basic level of training which is elaborated in this report.

I hope this training course of 3 weeks helps me in my future endeavours and I am grateful everyone who contributed in my study.

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INTRODUCTION

Definition of Hydraulics:

Transmission & control of forces & movements by means of fluids is called hydraulics

Or

Anything which is in affiliation with fluids is called hydraulics.

Basic Physical Terms:

- Force – The product of Mass and acceleration. F=m.a
- Velocity- The distance covered in the given amount of time. V=s/t
- Acceleration- The rate of change of velocity which can either be positive or negative.
- Pressure- The force acting per unit area. P= F/A
- Energy
    - Potential energy- The amount of work Stored is dependent upon the weight force of the object and the height. U=m.g.h
    - Kinetic Energy- The work stored is contained in the movement of the object. K.E=(m.v^2)/2
- Power- The work done per unit time. P=W/t
- Work – Product of distance and the force applied on that body which acts in the direction of the force. W= Fscos⍺ Where ⍺ is the angle between the force and direction of displacement.

Laws to Remember:

- Flow Law- Equal volume flow through a pipe of varying diameter over the same period.
- Law of Conservation energy- The law of conservation of energy is a law of science that states that energy cannot be created or destroyed, but only changed from one form into another or transferred from one object to another.

Some Additional Principles:

- Hydromechanics - The science of the mechanics of water and fluids in general, including hydrostatics or the mathematical theory of fluids in equilibrium, and hydromechanics, the theory of fluids in motion.
- Hydrostatics - Fluid statics or hydrostatics is the branch of fluid mechanics that studies "fluids at rest and the pressure in a fluid or exerted by a fluid on an immersed body".
- Hydrokinetics -
  The branch of hydrodynamics that deals with the laws governing liquids or gases in motion.
- Fluid Power - Fluid power is the use of fluids under pressure to generate, control, and transmit power. Fluid power is subdivided into hydraulics using a liquid such as mineral oil or water, and pneumatics using a gas such as air or other gases.

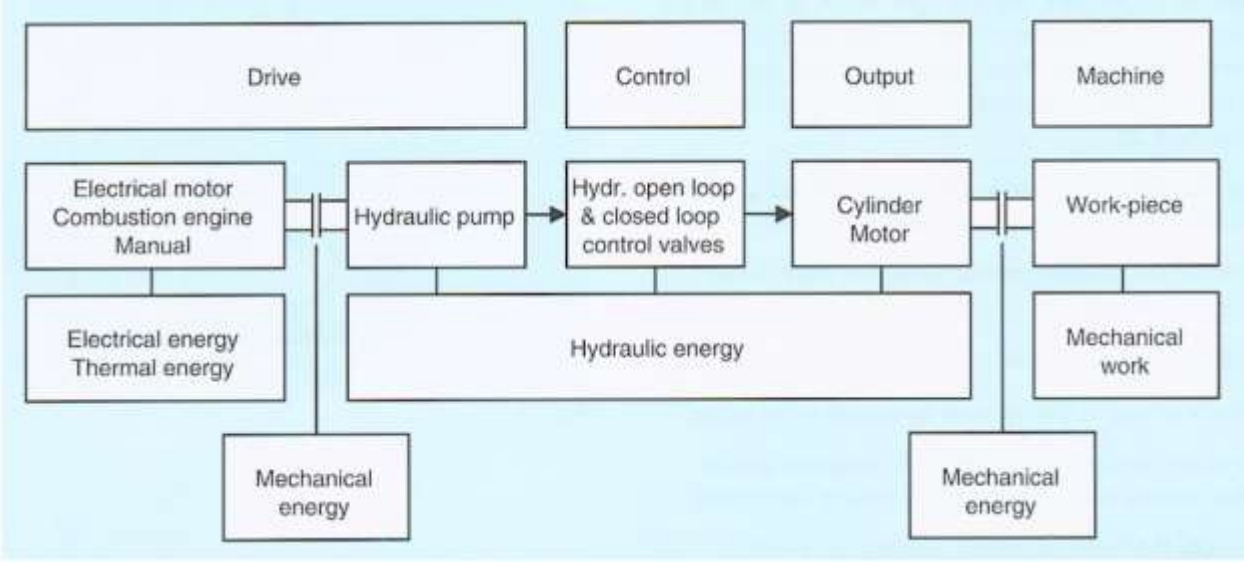
	Hydraulic	Pneumatic	Electrical	Mechanical
Energy source (power input)	E-Motor I. C. engine	E-Motor I. C. engine	Mains (Power line) Battery	E-Motor I. C. engine
Energy transmission	Pipes hoses	Pipes hoses	Cable Shafts etc.	Mech. components, levers, shafts, etc.
Energy carrier	Oil (fluid)	Air	Electricity	Mech. parts
Power density	High powers, high pressures, large forces, small build volume	Low powers, low pressures	Low comparative power/weight ratio E motor : hydr. motor = 1 : 10	High, extent and cost of required parts less favourable than hydraulics
Stepless control (acceleration + deceleration)	Very good both flow and pressure	Fair to good flow and pressure sets electronics	Good – very good Ward-Leonhard	Poor, limited to low powers
Positional accuracy	Good fluid almost incompressible	Poor air is compressible	Good	Very good accurate movement (levers and gears)
Output (form)	Linear (cylinders) rotary (motors)	Linear rotary	Primarily rotary Linear motions using solenoids → small forces → short strokes Linear motors possible	Primarily rotary linear by con-version of rotary motion

Components of a Hydraulic System:

- Hydraulic Pump
- Fluid Tank
- Check Valve
- Pressure Relief Valve
- Hydraulic Cylinders
- Flow Control Valve
- Direction Control Valve
- Filters
- Accumulators
- Power Unit

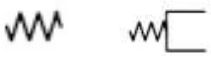
Hydraulics Systems:

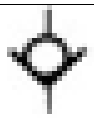
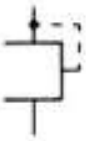
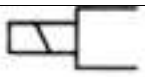
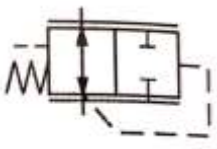
In a hydraulic system, mechanical energy is converted into hydraulic energy and then transferred or processed in a loop and converted back to mechanical energy. Pumps are used to convert energy. The fluid is fed through the pipes, hose and bores within a control block which is known as a manifold block. In addition, some more accessories are added like filters, tanks, coolers, heating elements, accumulators , actuators and measuring instruments. A power unit and the manifold block are the main components.

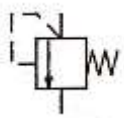
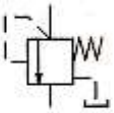
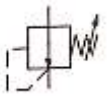
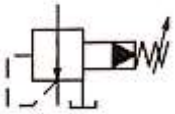
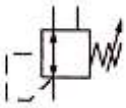
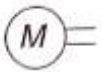
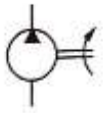
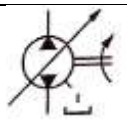


Symbols to DIN ISO 1219:

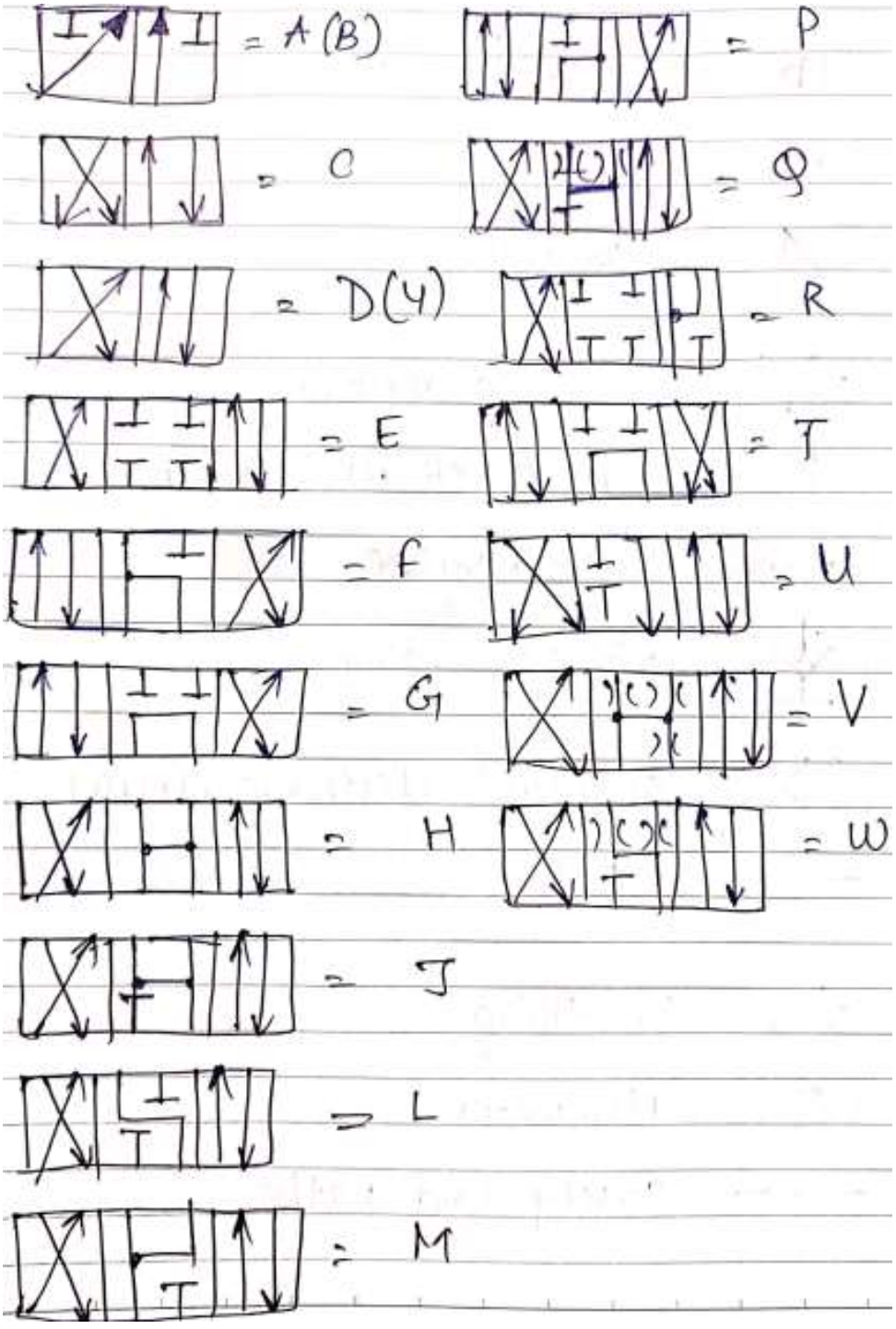
Graphical symbols are used in a hydraulic circuit. Symbols are neither dimensional nor specific for any position. Symbols are used for reading and understanding a circuit diagram which will be dealt later. Some important ISO specified symbols are shown below:

Name/Description	**Symbol**
Continuous line Electrical line or reverse current line; Pressure or Return Line	
Dash Line Control Line or Drain Line or Transition Position	
Diagonal Arrow Adjustable or Variable Motor, Pumps, Springs, Solenoid	
Curved Arrow Rotatory Movement, Direction of Rotation viewed from Shaft end	
Triangle Filled, hydraulic	
Triangle Unfilled, Pneumatic	
Closed Connection	
Test Point	
Temperature Display or Control	
Drive Unit	
Spring	
Throttling	

Check Valve Non-Return Valve / Not Loaded	
Check Valve Spring Loaded	
Internal Control Line	
External Control Line	
Pneumatic/Hydraulic operation	
Thermometer	
Flow Indicator	
Flow meter	
Pressure Indicator	
Single Solenoid	
Flow Control Valve Throttle and Adjustable Valve	
Logic Element	
Shut Off Valve	

Pressure control Valve Pressure relief valve, Directly Operated, Internal Pilot Oil Supply	
Pressure Relief Valve Direct Operated, Internal Pilot Oil Supply, External Drain Pot	
2-way Pressure Reducing Valve Directly Operated; Internal Pilot Oil Supply	
2-way Pressure Reducing Valve Pilot Operated; Internal Pilot Oil Supply, External Oil Return	
3-way Pressure Reducing Valve Directly Operated; Internal Pilot Oil Supply	
Electric Motor	
Hydraulic Pump	
Fixed Displacement Pump 1 Direction Flow and Rotation	
Variable displacement pump 2 Direction Flow, 1 Direction Rotation, Case Drain Port	
3/2 Direction Control Valve 3 Ports,2 Spool,1 Transition; Solenoid Operation, Initial Position Defined By spring	
4/3 Servo Valve	

Some Commonly Used Direction Control Valve:



Hydraulic fluids

A hydraulic fluid or hydraulic liquid is the medium by which power is transferred in hydraulic machinery. Common hydraulic fluids are based on mineral oil or water. Quality and cleanliness of the hydraulic fluid are decisive for the operational safety , efficiency and service life of a system.

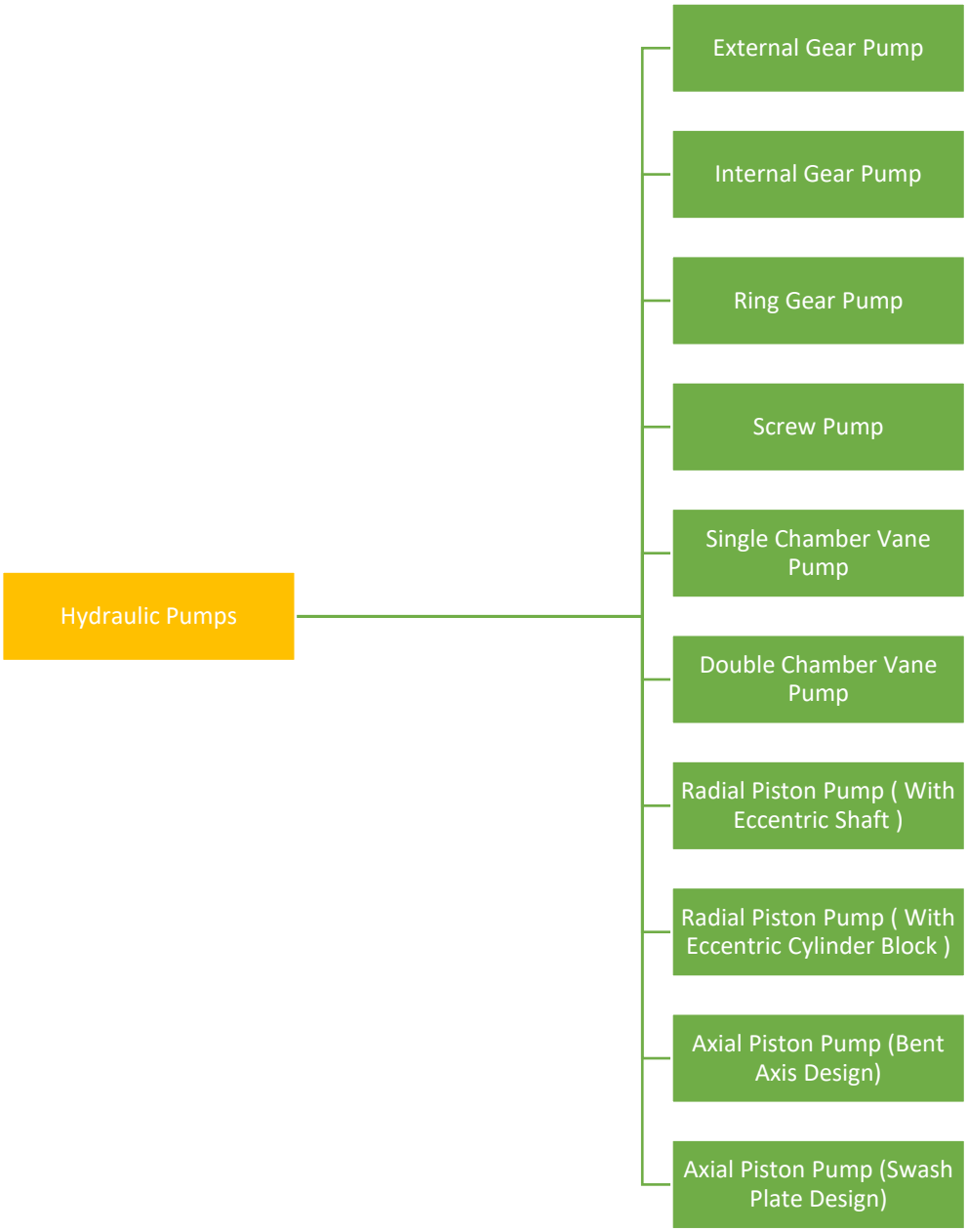
Hydraulic Fluid Requirements:

- Viscosity
- Temperature
- Cost and Availability
- Fire Resistance
- Non-Toxic and Good Dielectric
- Ecologically Accepted
- Non-Hygroscopic
- No Formation of Sticky Substance or Slit
- Stability Against:
    - Shearing
    - Low Compressibility
    - Thermal Loads
    - Thermal Conductivity
    - Oxidation and Corrosion

COMPONENTS

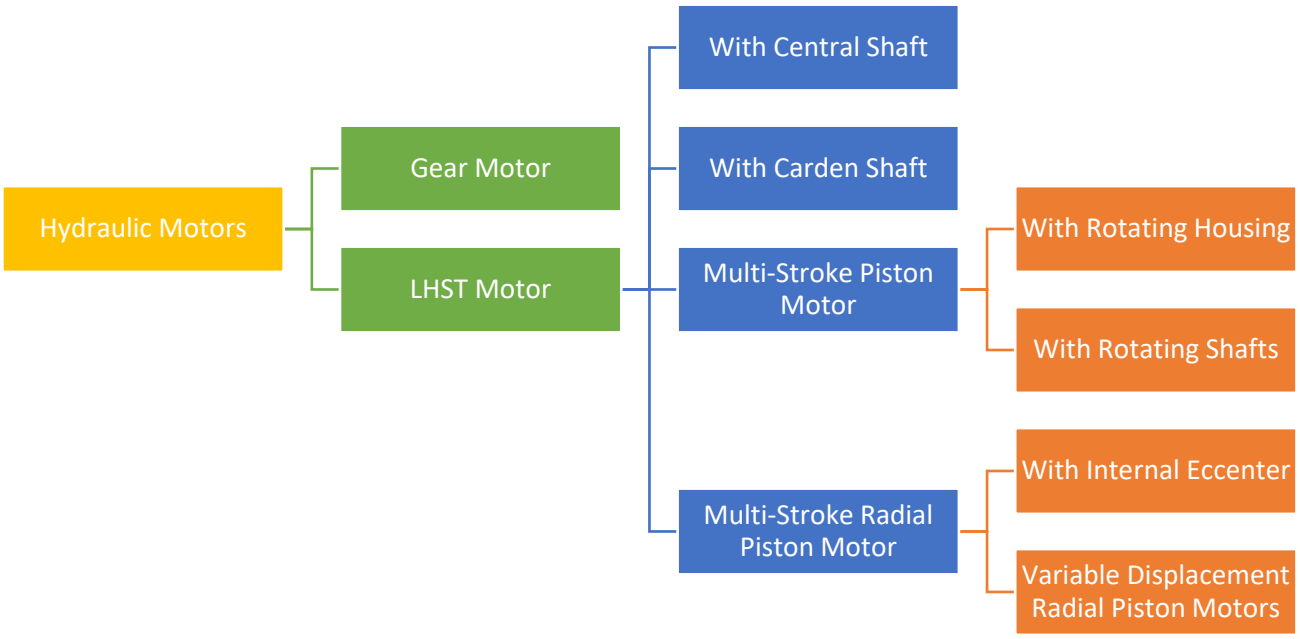
1. Hydraulic Pumps

A hydraulic pump is a mechanical source of power that converts mechanical power into hydraulic energy. It generates flow with enough power to overcome pressure induced by the load at the pump outlet.



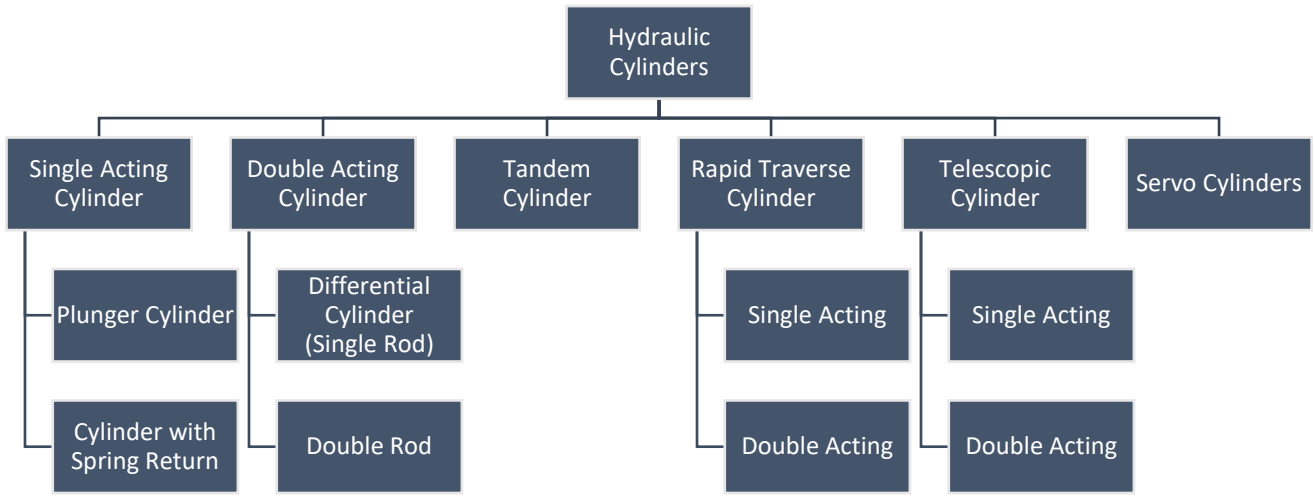
2. Hydraulic Motors

Hydraulic motors are rotary actuators that convert hydraulic, or fluid energy into mechanical power.



3. Hydraulic Cylinders

A hydraulic cylinder is a mechanical actuator that is used to give a unidirectional force through a unidirectional stroke.



4. Hydraulic Accumulators:

A hydraulic accumulator is a pressure storage reservoir in which a non-compressible hydraulic fluid is held under pressure that is applied by an external source.

Function:

- Energy Storage
- Fluid Reserve
- Emergency Operation
- Compensating the Flow
- Maintaining constant Pressure
- Compensation of Oil Leakage

Types of Accumulator with Separating Element:

a) Bladder Accumulator
b) Diaphragm Type accumulator
c) Piston Accumulator

5. Actuators:

They perform a swerving motion across a shaft end when pressurized with hydraulic fluids. The movement is limited and hence the application is also limited.

Types:

- Vane Type
- Single Vane
- Double Vane
- Radial/Tangential Piston Type
- Parallel Piston Type
- Axial Piston Type
- In-Line Piston Part-Turn Actuator
    - With Connecting Rod-Crank Drive
    - With Rack and Pinion Drive

6. Check Valve:

They are used mainly to stop the flow in one direction and to allow free flow in the opposite direction and are also known as non-return valves.

Categories:

- Simple Check Valve
- Pilot Operated Check Valve
    - With Drain Port
    - Without Drain Port
- Double Pilot Operated Valve
    - With Case Drain Port
    - Without Case Drain Port
- Anti-Cavitation Valves (Filling Valves)

7. Directional Control Valves

They are used to start, stop and change the direction of the flow of a pressure medium.

Categories:

- Spool Valves
  - Pilot Operated
  - Directly Operated
- Poppet Valves
  - Pilot Operated
  - Directly Operated

There are 2,3 and 4 port DC valves. They are positional and changed either by pilot operating it or manually operating it. They are changed as in when required by the system.

8. Pressure Control Valves

They are influenced the system pressure in a system or a part of a system in a predetermined manner. This is achieved by changing the size of the throttle opening metering notches.

Categories:

- Pressure Control Valves (Control Task)
- Pressure Switching Valves (Switching Task)
- Pressure Relief Valve
  - Direct Operated
  - Pilot Operated
- Pressure Sequence Valve
  - Direct Operated
  - Pilot Operated
- Pressure Shut Off Valve
- Direct Operated
  - Pilot Operated
- Pressure Reducing Valve
  - Direct Operated
  - 2-Way Pilot Operated
  - 3-Way Pilot Operated

9. Flow Control Valve:

Used to influence the speed of movement of actuators by changing the opening to flow at the throttling point.

Categorised as:

- 2-way Flow Control Valve
- 3-way Flow Control Valve

10. Filtration Technology

Filters are devices which separate solid particles from fluids. They can be of any size. There are different types of filters used for different materials. Even the air is filtered when used in the machinery.

Cause of Contamination:

- ✓ During Production of Components
- ✓ During System Assembly
- ✓ During Operation of System

Filtration Methods:

a) Gravity Filtering
b) Pressure line Filtering
c) Centrifuges
d) Filter Presses
e) Filter Materials

11. Hydraulic Power Units

A Power Unit is the main part of the system. Every unit is diverse due to the different components or different manifold blocks. Every circuit has a different power unit. Hence power units are custom made.

There are :

- ✓ Small Power units
- ✓ Modular Standard Power Units
- ✓ Standard Power Unit
- ✓ Project Power Unit
- ✓ Compact Power Unit

12. Connectors:

A Hydraulic system should be connected to form a hydraulic circuit by the means of suitable connections. Some connectors are listed below:

- ❖ Valves for Pipeline Mounting
- ❖ Valves With threaded Connection and as cartridges
- ❖ Valves for Sub-plate Mounting

STUDY

PLANT VISIT

Processes Involved:

1) The raw material, unfinished product or outsourced products come in through the INWARD and then processed through the either of the lines.
2) *Machining* - Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. Much of modern-day machining is carried out by computer numerical control (CNC), in which computers are used to control the movement and operation of the mills, lathes, and other cutting machines.
3) *Deburring* - Metal must go through an extensive manufacturing process in order to be formed into a serviceable, efficient enclosure. Machining operations commonly employed include grinding, drilling, milling, engraving, and turning. These procedures may leave behind burrs, of which there are three types: Poisson, rollover, and breakout. Removing these unwanted imperfections is a process called deburring.
4) *Chamfering(Optional)* - Chamfering removes the burrs and sharp edges, and thus makes the handling safe. Chamfering can be done by a form tool having angle equal to chamfer which is generally kept at 45°.
5) *Honing* - Honing is an abrasive machining process that produces a precision surface on a metal workpiece by scrubbing an abrasive stone against it along a controlled path.
6) *Washing* - Cleaning of the metal workpiece. Removing all the impurities is known as washing.
7) *Water base painting(Optional)* - Water based paints contain microscopic plastic particles of binder, filler and pigment, dissolved in water.
8) *Paint Booth* - Painting the metallic workpiece to prevent it from corrosion and other harms. This plant colours them to blue and different colours are available as per the customers' requirements.
9) *Inspection* - inspection involves the measurements, tests, and gauges applied to certain characteristics in regard to an object or activity. The results are usually compared to specified requirements and standards for determining whether the item or activity is in line with these targets, often with a Standard Inspection Procedure in place to ensure consistent checking.
10) *Packing* - Preparation of product or commodity for proper storage and/or transportation. It may entail blocking, bracing, cushioning, marking, sealing, strapping, weather proofing, wrapping, etc.
11) The finished product after packing is sent to the OUTBOUND where with the bill of the material the shipment is loaded.

Manufacturing Operation:

Production Area 1

- WE6 (Direction Control Valve)
    - Directional valves type WE are solenoid operated directional spool valves. They control the start, stop, and direction of a flow.
    - They consist of housing; one or two solenoids; control spool; and no, one, or two return springs.
    - 6mm Nominal Gauge is the Size.

Production in Area 2

- Modular 6
    - Z2S6
        - Pilot operated check valves in a sandwich plate design.
        - They provide line contact closure in one or two actuator ports, even during idle periods. Piloted to open, utilizing a pressure signal from the opposite actuator port provides a self-contained function.
        - 6mm is the Size.
    - Z2FS6
        - Double throttle/check sandwich type valves.
        - They restrict flow to or from actuator ports of a directional valve. Two throttle/check valves, symmetrically arranged in the housing, restrict flow with adjustable throttles in one direction while providing free flow in the opposite direction.
        - 6mm is the Size.
    - ZDR6 DA/DP
        - 3-way direct operated pressure reducing -relieving valves. They maintain a “reduced” pressure in a branch circuit and permit “relieving” pressure spike occurrences in the reduced branch circuit.
        - 10mm is the Size

Production in Area 3

- NG16 / NG25
    - Cartridge valve with various options
    - Control cover in various variants for realization of selected functions
    - Electric monitoring of the spool position
    - Nominal gauge of size 16mm and 25mm respectively.
- NG22
    - A solenoid operated directional spool valves.
    - They control the start, stop, and direction of a flow. These pilots operated directional valves consist of a pilot control valve and main stage with spring or hydraulic centering options.
    - Nominal gauge of size 22mm

Production in Area 4

- Modular 10
    - Z2FS10
        - Double throttle/check sandwich type valves.
        - They restrict flow to or from actuator ports of a directional valve. Two throttle/check valves, symmetrically arranged in the housing, restrict flow with adjustable throttles in one direction while providing free flow in the opposite direction.
        - 10mm is the Size.
    - Z2S10
        - Pilot operated check valves in a sandwich plate design.
        - They provide line contact closure in one or two actuator ports, even during idle periods. Piloted to open, utilizing a pressure signal from the opposite actuator port provides a self-contained function.
        - 10mm is the Size.
    - ZDR10
        - 3-way direct operated pressure reducing -relieving valves. They maintain a “reduced” pressure in a branch circuit and permit “relieving” pressure spike occurrences in the reduced branch circuit.
        - 10mm is the Size

Production in Area 5

- DB 10/20/30
    - Pilot operated pressure relief valves. They are used for the limitation of the operating pressure.
    - Pressure relief valves basically consist of a main valve with main spool insert and pilot valve with pressure adjustment elements.
- DR 20
    - A direct operated pressure reducing valve in 3-way design, i.e. with pressure limitation of the secondary circuit.
- Manifold Block Machining

Cylinder

- Cylinders are used in Hydraulic presses, cranes, forges, packing machines, agricultural machines, construction vehicles, and marine equipment.
- They’re essential to the operation of excavators, loaders, balers, telehandlers, man-lifts, drill-rigs, and dump trucks—not to mention operating booms, arms, lifts, platforms, and buckets.
- Hydraulic cylinders are the most effective and efficient method of pushing, pulling, lifting and lowering.

Power Unit & Manifold (PM)

- A hydraulic manifold is a component that regulates fluid flow between pumps and actuators and other components in a hydraulic system.
- A hydraulic manifold distributes hydraulic oil throughout a circuit. The flow of pressurized oil is regulated by hydraulic valves installed within the manifold and directed through hoses to work device, such as a hydraulic motor or a cylinder.
- Every Manifold block is different due to different circuits hence they are custom made.

Assembly Line

- An assembly line is a manufacturing process in which parts are added as the semi-finished assembly moves from workstation to workstation where the parts are added in sequence until the final assembly is produced.

Some Important Aspects of the factory:

The supply for the hydraulic fluid throughout the factory for the testing of the immoveable components is done by a common tank.

Scrap Bay is where the metallic, wooden and other unwanted machinery parts are sent to for selling to the scrap dealers.

Testing Area:

There is a Valve Testing Area when large machinery is tested with proper computerised calculations and for this the Mother Tank doesn't provide the fluid since it has its own fluids tank.

There is also a Hydraulic Cylinder Testing Area where with computerized machinery the cylinders are checked before installing. It's an authorised area and can only be entered either permission from higher officials.

PRESS BRAKE

A Press Brake is a machine tool for banding sheets and plate material most commonly sheet metals. It forms predetermined bends by clamping the workpiece between a matching pun and die.

There are 4 types namely:

- Mechanical Press Brake
- Servo-Electrical Press Brake
- Pneumatic Press Brake
- Hydraulic Press Brake

They can also be categorized as:

- Manual Press Brake
- Hydraulic Press Brake
- CNC Press Brake

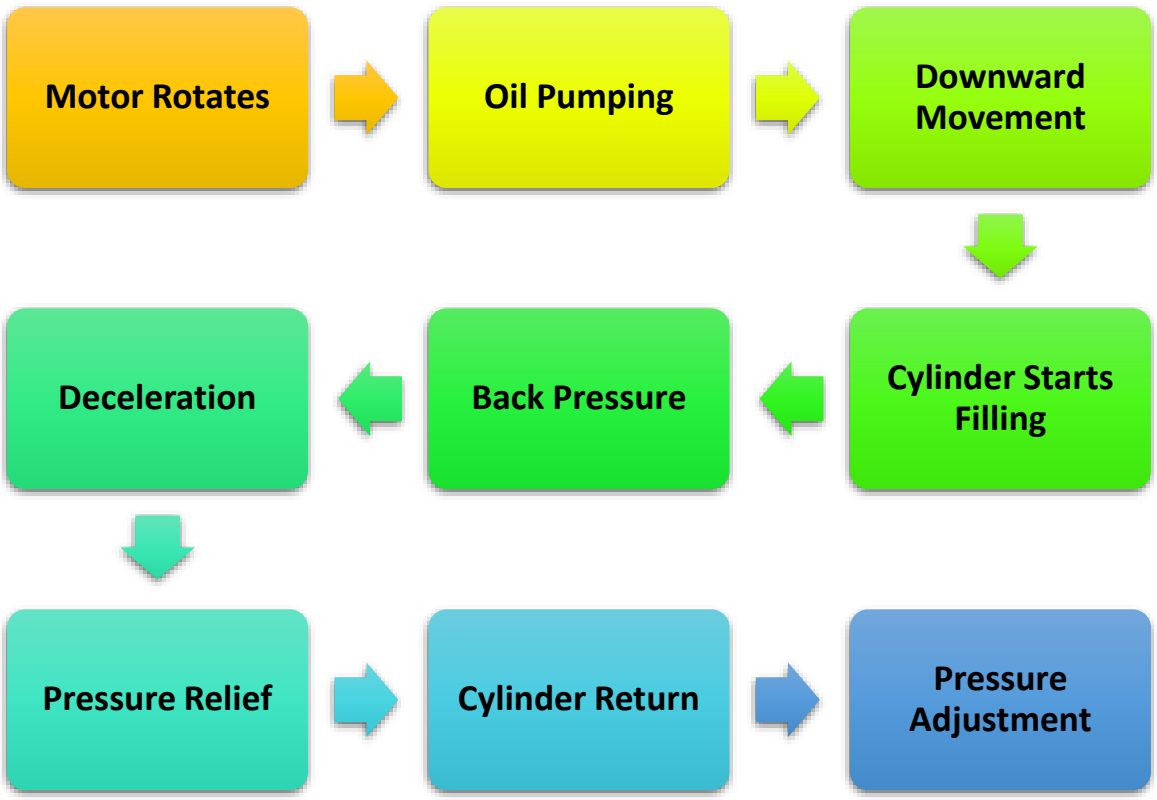
Working Principle:

The sheet needs to be fixed at the top punch and bottom die on the worktable. The relative motion of the worktable driven by hydraulic transmission as well as the shape of the punch and die to achieve the bending formation for the sheet metal material.

Components of Hydraulic Press Brake:

1) Hydraulic Oil Cylinder
2) Slider
3) Stage Die
4) Top Punch
5) Back Gauge
6) Front Support
7) Bottom Die
8) Convex Workbench
9) Hydraulic Systems
10) Workbench
11) Feedback Arm
12) CNC Controls
13) Electrical Cabinets
14) Machine Frame
15) Protection Guard
16) Hydraulic Servo Systems

Process:

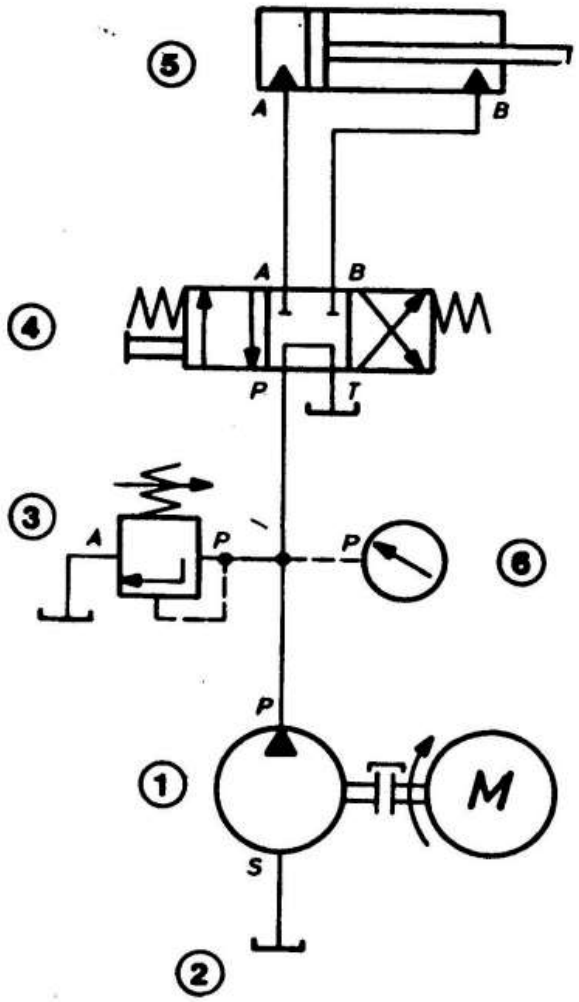


Difference Between CNC and Mechanical press Brake

CNC Press Brake	Mechanical Press Brake
Once sheet is inserted all work is automatic there is no need of manual involvement.	Bending is manual and requires labour at every bending.
The data is fed for bending angle is directly control by folding angle which has no relationship with the thickness.	Bending angle is controlled by controlling the pressure amount of the top punch depends upon material thickness.
Since the relative motion between material and tool is avoided it can be used for a long time.	Since there is a relative motion between punch and die the tooling is worn out and needs to be maintained.
Full electrical drive design reduces maintenance and achieves bending precision.	Use of hydraulic drive results in more maintenance work and affects environment.

CIRCUITS AND READING

Simple Hydraulic Circuit:



Components of the Circuit:

1) Fixed Displacement Pump with Electrical Motor
2) Fluid Tank
3) Variable Pressure Relief Valve Directly Operated
4) 4/3 Direction Control Valve with Spring Retraction (DC Valve)
5) Double acting single Rod Cylinder
6) Pressure Gauge

Reading the Circuit:

A,B,P & T are 4 Ports of DC Valve 3 spool positions. The pump forces the fluid towards the cylinder. When the pressure increases at the P point the relief valve opens leading the fluid into the tank. This is indicated by the Pressure Gauge.

During a normal process, the fluid flows through P port with either go through the right or left spool configuration. The arrow direction in the DC valve depicts the flow of the fluid. The configuration given in the figure is a null configuration which means no fluid flows to the cylinder. Port T has a tank at its end in this configuration. All fluid flowing will flow into this tank.

REFERENCES

Books:

Hydraulics, Basic Principles and Components
The Hydraulic Trainer, Volume 1
Didactic from Rexroth

Links:

https://www.mobilehydraulictips.com/
https://www.wikipedia.org/
https://www.boschrexroth.com/
https://www.britannica.com/science/hydraulics
https://www.hydraulicspneumatics.com/