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SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title: MECHANICS OF FLUIDS II

Code No.: MCH 302-3

Program: MECHANICAL TECHNOLOGY

Semester: SIXTH

Date: SEPTEMBER 1990

Author: NORMAN TRIPLETT

New: Revision:

APPROVED Chairperson

Date

MECHANICS OF FLUIDS II — MCH 302-3

Course Name — Course Number

PHILOSOPHY/GOALS:

The- study of hydraulics deals with the use and characteristics of liquids The integration of Engineering theory of fluid mechanics with down-to-earth practical aplication is a primary objective. Industry has given the name "Fluid Power" to the field of practical application of fluid mechancis. It is esential that the student end up with a good understanding of the basic theory in order for them to know how fluids can be applied to a specific job.

METHOD OF ASSESSMENT:

1) One week notice for tests.

2) Final mark based on the followin:

   Tests - from manual information, films, practical knowledge
   Labs - hyd. circuits, pelton wheel, francis turbine and centrifugal pump.

3) A final examination will be given to those students who have a final mark below 60% including two or more "I" grades. The result of this final exam will be the final mark assigned . . . . . a "C" or "R"

4) Classes will be lecture, demonstration and lab oriented.

5) All students are expected to be punctual, regular attendees, and conscientious in the work,

6) GRADES: A = 80% & Up -- Consistently Oustanding Achievement
   B = 70% - 79% -- Consistently Above Average Achievement
   C = 60% - 69% -- Average or Acceptable Achievement

TEXT;

Industrial Hydraulic Manual - Vickers-Sperry

REFERENCES:

Fluid Mechanics - Binder (Prentice Hall)

Flow of Fluids - Crane (Tech. Paper 410-C)

COURSE OBJECTIVE:

This course consists of two components, as described below:

SECTION I - HYDRUALICS

The work covered in this component is directed twoard providing the student with a sound understanding of the principles of hydraulics, the components and systems. The Vickers Handbook covers the above and ths theoretical material is supported by (1) labs, (2) circuits produced on hydrulic trainers.

SECTION II - FLUID MECHANICS LAB

A detailed study of the performance characteristics of (1) the centrifuga pump and (2) either the pelton wheel/francis turbine is conducted. The lab is to be written and presented in a form acceptable for grading and will consititute aproximately 35% of the final grade.

FLUID MECHANICS

MCH 302

SECTION I

Topic No,	Suggested Periods	Topic Description	Reference
1	6	FUNDAMENTALS - Pascal's Law - pressure exerted by a column of oil or water - cause of pressure - H.P. equation - frictions in piping, etc.	
2	4	RESERVOIRS & FILTERS & OIL - purpose of reservoirs - design of reservoirs - types of filters - mesh and muron rating - viscosity	
3	5	VANE PUMPS - types of pumps - hydrostatic and hydrodynamic - assembly/disassembly - "round", "square" and "intravane" pumps - volumetric efficiency - malfunctions	
4	6	RELIEF & PRESSURE REDUCING VALVES - operation of relief valve and pressure valve - construction of relief valve and pressure valve - assembly of relief valve and pressure valve - malfunctions of relief valve and pressure valve - high vent spring - venting relief valve	
5	2	DOUBLE & TWO STAGE PUMPS - difference between above pumps - assembly of above pumps - functions of dividing valve into two stage pumps - malfunctions of above pumps	

Topic No.	Suggested Periods	Topic Description	Reference
6	9	DIRECTIONAL CONTROLS - purpose - major classifications - 2 and 4 way valves - adaptation of valves - center condition of 3 position valves - function and operation of DG4, DG3 and DG5 vicker valves - pilot valves - deceleration valves	
7	6	R TYPE VALVES - types of valves and assembly for each type - malfunctions of each type	
8	3	COMBINATION PUMPS - definition - operation and assembly of various types of combination pumps - malfunctions	
9	5	PISTON PUMPS & MOTORS - types - operation - pressure ranges - assembly - malfunction - fixed and variable types - open and closed circuit system	
10	3	FLOW CONTROLS - types - factors affecting flow - applications of flow control valves - malfunctions	
11	4	CIRCUIT LAB - connecting 10 basic circuits on Vickers panel boards	

MECHANICS OF FLUIDS

SECTION I: HYDRUALICS - BASIC INFORMATION

TOPIC I

GENERAL OBJECTIVES:

To have sound understanding of the basic principles of hydraulics.

SPECIFIC OBJECTIVES:

1. To be able to state "Pascal's Law".
2. To be able to state that hydraulics is a means of power transmission.
3. To be able to state that oil is the most commonly used medium as it serves as a lubricant and is practically non-compressible.
4. To be able to state that oil weighs 55 to 58 lbs. per cubic foot.
5. To be able to state that the pressure at the bottom of one foot column of oil is approximately 0.4 psi and to be able to find the pressure at the bottom of any column of oil.
6. To be able to state that there must be a pressure drop across an orifice or restriction to cause flow through it.
7. To be able to state that liquid is pushed, not drawn, into a pump by atmospheric pressure. (14.7 psi).
8. To be able to state that a pump's purpose is to create flow, not pressure and only positive displacement types are used in industrial hydraulics.
9. To be able to state that pressure is caused by resistance to flow.
10. To be able to state that oil takes the course of least resistance.
11. To be able to state that a pressure guage indicates the work load at any given moment. Gauge reading does not include atmospheric pressure.
12. To be able to state that the force exerted by a cylinder is dependent upon pressure applied and piston area. (Area = diameter squared x 0.7854)

SPECIFIC OBJECTIVES - Continued

13. To be able to state that the speed of a piston as a cylinder is dependent upon its size (piston area) and the rate of oil flow into it.

14. To be able to state that the flow velocity through a pipe varies inversely as the square of the inside diameter - i.e. doubling the I.D. increases the area by four times.

15. To be able to state that the friction of a liquid in a pipe varies as the square of the velocity.

16. To be able to find the actual area of a pipe needed to handle a given flow using the formula:

$$\text{Area} = \frac{\text{G.P.M.}}{\text{Velocity (Ft./sec.)}} \times \frac{0.32Q8}{} \quad \text{or Velocity (Ft./sec.)} = \frac{\text{G.P.M.}}{3.117 \times \text{area}}$$

17. To be able to state that in standard pipe, the actual inside diameter is larger than the normal size quoted.

18. To be able to state that steel and copper tubing size indicates the outside diameter.

19. To be able to state that a) single wire braid hose corresponds to tubing in nominal size, i.e., 3/4" tube = #12 hose; b) double wire braid hose has same I.D. as O.D. of tube.

20. To be able to find that H.P. required to move a given volume at a known pressure using formula:

$$\text{H.P.} = \text{G.P.M.} \times \text{Pressure} \times 0.000583$$
$$\text{H.P.} = \frac{\text{G.P.M.} \times \text{P.S.I.}}{1714}$$

21. To be able to list the following relationships:
    1 H.P. = 33000 ft./lbs. per minute
    = 746 watts
    = 42.4 BIU/Min,

22. To be able to list the following formula:
    a) $\text{Torque (in lbs.)} = \frac{63025}{\text{R.P.M.}} \times \text{H.P.}$

    b) $\text{H.P.} = \frac{\text{Torque (in lbs.)}}{63025} \times \text{R.P.M.}$

23. To be able to find the amount of oil reuqired to move a piston through a given distance by multiplying the piston area in inches by the stroke length in inches and divide this by 231 to find the capacity in gallons.

SECTION I

SECTION II: RESERVOIRS, FILTERS, STRAINERS AND OILS

GENERAL OBJECTIVES:

To have a sound understanding of hydraulic reservoirs, filters, strainers and oils.

SPECIFIC OBJECTIVES

1. To be able to state the reservoir should be 2 or 3 times the pump capacity.
2. To be able to state that the air filter should be 5 times the pump volume.
3. To be able to state that the oil temperature should be about 60° to 70 F above room (ambient) temperature in a reservoir.
4. To be able to state the basic requirements of a reservoir construction, breather, baffle Plate, line connections and fillings.
5. To be able to define a) Filter, b) Strainer.
6. To be able to define "Mesh" and "Micron Rating".
7. To be able to state the three positions for filters.
8. To be able to list three types of filtering materials.
9. To be able to list the two types of filter elements.
10. To be able to list the three basic types of filters.
11. To be able to state what three basic properties hydraulic oil must have.
12. To be able to define Viscosity.
13. To be able to state the temperature and cleanliness requirements of hydraulic oil.

SECTION I

TOPIC Ills PUMPS - GENERAL

GENERAL OBJECTIVES;

To have a sound understanding of the types of pumps and their particular design and construction used in industrial hydraulics.

SPECIFIC OBJECTIVES;

1. To be able to list the two types of pumps:

   a) Positive (Hydrostatic)

   b) Non-Positive (Hydrodynamic)

2. To be able to state that industrial hydraulics uses positive displacement pumps, either fixed or variable displacement.

3. To be able to list four types of positive displacement pumps.

4. To be able to correctly disassemble and assemble a Vickers "Round" pump, and reassemble for opposite shaft rotation.

5. To be able to list three items that affect a round pump's delivery.

6. To be able to correctly disassemble a Vicker's "Square" pump and reassemble for opposite shaft rotation,

7. To be able to correctly disassemble and assemble a Vickers "Intravane" pump and reassemble for opposite drive shaft rotation.

8. To be able to difine Volumetric Efficiency.

SECTION I

TOPIC IV: RELIEF VALVES AND PRESSURE REDUCING VALVES

GENERAL OBJECTIVES;

To have a sound understanding of the operation and repair of a balanced piston relief valve and pressure reducing valves.

SPECIFIC OBJECTIVES:

1. To be able to describe the operation of a simple type relief valve.
2. To be able to define "Cracking Pressure".
3. To be able to sketch a balanced piston relief valve and describe the operation of the various components.
4. To be able to describe the construction and operation of a remote control relief valve.
5. To be able to describe the purpose of a vent connection on a relief valve.
6. To be able to define a "High Vent Spring".
7. To be able to describe five malfunctions of a balanced spool relief valve and their remedies.
8. To be able to state the differences between a relief valve and an unloading valve.
9. To be able to disassemble and assemble a Vickers balanced spool relief valve correctly.
10. To be able to sketch a pressure reducing valve (Vicker's design) and describe the operation of the various components.
11. To be able to describe five malfunctions of a pressure reducing valve and state their remedies.
12. To be able to assemble and disassemble a Vickers pressure reducing valve correctly.

SECTION I

TOPIC V: DOUBLE & TWO STAGE PUMPS

GENERAL OBJECTIVES;

To have a thorough understanding of the operation and malfunctions of double and two stage pumps.

SPECIFIC OBJECTIVES;

1. To be able to diagramatically sketch a double pump.
2. To be able to assemble and disassemble a double pump correctly.
3. To be able to state the function of a two stage pump and draw a diagramatic sketch of it.
4. To be able to describe the functions of a dividing valve.
5. To be able to draw a circuit diagram of a two stage pump showing how the dividing valve operates.
6. To be able to state that leakage in small pumps are externally drained because of heat, while the larger ones are internally drained.
7. To be able to state that when adjusting a two stage pump adjust the head bolts in the head end cartridge.

SECTION I

TOPIC VI: DIRECTIONAL CONTROLS

GENERAL OBJECTIVES:

To have a sound understanding of the operation and malfunctions of directional control valves.

SPECIFIC OBJECTIVES:

1. To be able to define control valves.
2. To be able to list five major classifications of directional valves.
3. To be able to define the function of a check valve.
4. To be able to list four types of check valves and their applications.
5. To be able to describe the functions of a 2-way and 4-way valves.
6. To be able to describe the operation of and draw schematics of:
   a) Rotary four-way valves
   b) Spool type two-way valves
   c) Spool type four-way valves,
7. To be able to list five methods of operating directional valves.
8. To be able to state what is meant by "spring centered", "spring offset" and "no spring".
9. To be able to describe or craw schematics to show the following Vicker's center conditions, type 0, type 1, type 2, type 3, type 4 or 8, type 9.
10. To be able to describe the function and operations of the following Vickers valves:
    a) DG4 series
    b) DG3 and DG5 series.
11. To be able to describe where pilot pressure sources are available.
12. To be able to describe the function and operation of a pilot choke$_r$ pilot piston, and a deceleration valve.

SPECIFIC OBJECTIVES - Continued

13. To be able to state the difference between a two land and a three land spool.

14. To be able to state the direction of oil flow inside a two or three land spool directional valve.

15. To be able to state that a pilot valve for a spring centered valve must be a type 6.

16. To be able to comprehend circuit diagrams of various type directional valves.

17. To be able to correctly assemble and disassemble simple type directional valves.

SECTION I

TOPIC VII: "R" TYPE VALVES

GENERAL OBJECTIVES:

To have a sound understanding of the operation and maintenance of Vickers "R" valves.

SPECIFIC OBJECTIVES:

1. To be able to describe the operation of the various components of an "R" valve.
2. To be able to list the five applications an "R" valve can be used in and the component relocation(s) required for each type.
3. To be able to list the main disadvantage of using an "R" valve as a relief valve.
4. To be able to sketch a schematic of a circuit that the "R" valve would be used in for each application listed in objective #2.
5. To be able to correctly assemble and disassemble a Vickers "R" valve and assemble it to suit any of objective #2 requirements.

SECTION I

TOPIC VIII: COMBINATION PUMPS

GENERAL OBJECTIVES;

To have a thorough understanding of the operation and maintenance of combination pumps.

SPECIFIC OBJECTIVES:

1. To be able to define combination pumps.
2. To be able to list the various components of a combination pump.
3. To be able to describe the operation of a type #3 pump during low pressure advance and high pressure low volume advance.
4. To be able to state the problems with the unloading valve section is set too high or too low.
5. To be able to describe the operation of a combination type 33 pump, and type 6 pump.
6. To be able to correctly assemble and disassemble a Vickers type 3 combination pump.

SECTION I

TOPIC IX: PISTON PUMPS & MOTORS

GENERAL OBJECTIVES:

To have a thorough understanding of the operation and maintenance of piston pumps and motors.

SPECIFIC OBJECTIVES:

1. To be able to state the pressure range that piston pumps are used in.
2. To be able to state the two basic types of piston pumps:
   a) Radial
   b) Axial.
3. To be able to state that axial pumps can be bent-axis type or in-line type.
4. To be able to describe the operation of a radial piston pump,
5. To be able to describe the operation of a fixed displacement in-line pump.
6. To be able to describe the operation of a variable displacement in-line pump.
7. To be able to describe the operation of a bent-axis piston pump.
8. To be able to state that most piston pumps and motors have 7 or 9 pistons, to smooth off pressure fluctuation,
9. To be able to state that for variable volume pumps:
   a) Output varies as pump angle
   b) Output varies as shaft speed.
10. To be able to draw a sketch of an open circuit hydraulic system.
11. To be able to draw:
    a) a simple closed circuit system
    b) a simple closed circuit system with replenishing checks
    c) a simple closed circuit system with replenishing checks and across the line relief- valves
    d) a simple closed circuit system with replenishing relief valve.

SPECIFIC OBJECTIVES - Continued

12. To be able to state that piston pumps and motors are externally drained.

13. To be able to state what a H.A.S. drive is and list 4 applications where it can be used.

14. To be able to sketch a valve plate showing the dwell portion and precompression and decompression grooves.

15. To be able to define "Valve plate separation" or "Cylinder block lift" and its cause and solution.

16. To be able to state the difference in valving between a piston pump and motor.

17. To be able to state for a fixed displacement motor:

    a) constant torque
    b) variable speed•

18. To be able to state for a variable displacement motor:

    a) variable torque
    b) variable speed.

19. To be able to describe the operation of pressure compensators on in-line and bent-axis piston pumps and motors.

20. To be able to state that during field repairs of piston pumps and motors, shallow grooves in the valve plate and cylinder block can be removed and new pintle seals (bent-axis) can.be installed.

21. To be able to correctly assemble and disassemble a Vickers in-line piston pump and motor and a Vickers bent-axis pump.

SECTION I

TOPIC X: FLOW CONTROLS

GENERAL OBJECTIVES;

To know the operation and maintenance of flow control valves.

SPECIFIC OBJECTIVES;

1. To be able to list four factors affected the flow of oil.
2. To be able to state that when the work load increases or decreases the size of the opening must adjust according to maintain a fixed flow through an orifice.
3. To be able to list three applications of a flow control valve.
4. To be able to explain the operation and function of a Vickers FRG type (by-pass) flow control valve and its application.
5. To be able to explain the operation and furtction of a Vickers FCG type (restrictor) flow control valve and its application.
6. To be able to state that there must be at least 150 psi pressure drop across a meter valve or the valve will become unstable and stick.
7. To be able to state the disadvantage of a flow control valve used in a Bleed-Off application.
8. To be able to state three applications of each of the following:

   a) Meter-In Circuit
   b) Meter-Out Circuit
   c) Bleed-Off Circuit

SECTION I

TOPIC XIs CIRCUITS AND SUMMARY

GENERAL OBJECTIVES:

To know how to read hydraulic circuit drawings and follow through a troubleshooting procedure.

SPECIFIC OBJECTIVES:

1. To know how to obtain the following information from a hydraulic drawing.

   a) Component list
   b) Operation of total and branch circuits
   c) Valve setting and types

2, To be able to follow through a trouble shooting procedure of given basic hydraulic circuits when adequate information on operating problems is given.

SECTION II

FLUID MECHANICS LABS

CENTRIFUGAL PUMP:

The test set and measuring equipment is designed for engineering students. The students are introduced to concepts of hydraulics; the energy used in moving fluids; the measurement of power and various methods of scientific measurement. The students will be supplied with a set of operating instructions from which the lab will be conducted.

PELTON WHEEL AND FRANCIS TURBINE:

Visible working parts allow the student to view the conservation of energy taking place. Some of the fundamental engineering principles can be demonstrated: measuring flow over a vee notch, measuring shaft HP by Prony Brake, measuring speed with a Tachometer, water HP can be found to be the product of head and flow rate. These are some of the items that can provide the student with a greater understanding for the practical and theoretical side of fluids at rest and in motion.