COLLEGE OF ENGINEERING & TECHNOLOGY
Department : MECHANICAL ENGINEERING
Lecturer : Prof. Dr. Ashraf S. Ismail
Course : Hydraulic Systems
Course No. : ME 464 Marks : 40
Date : 8/1/2013 Time : 2 hours

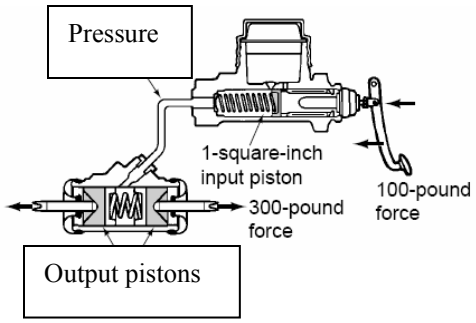
FINAL EXAMINATION PAPER

Question (1)

A- What is the difference between the hydraulic system and the pneumatic system; can we apply Pascal's law to both systems? [3M]

B- Mention two gases commonly used in pneumatic systems, and mention four necessary characteristics for gases used in pneumatic systems. [3M]

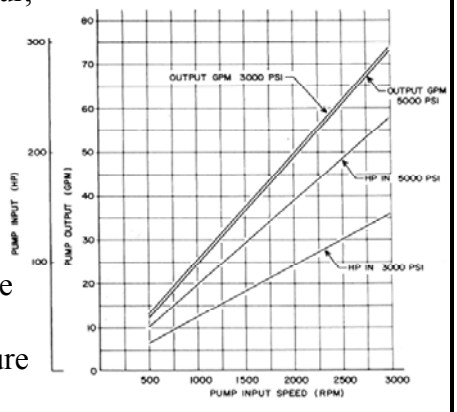
C- The mechanical force exerted on the brake pedal is transferred hydraulically to provide an increased mechanical force at the wheel brake unit, as shown in the figure. Calculate the area of the output pistons. [4M]



Question (2)

A- The external gear pump uses three types of gears, spur, helical, or herringbone gears. Mention the advantages and disadvantages of the three types. [2M]

B- The shown graph gives the pump input horsepower (hp), and pump output flow (gpm) as a function of Pump speed, for pressure levels of 3000 and 5000 psi. The volumetric displacement of the pump is 6 in^3/rev.



i- Calculate the volumetric efficiency at the two pressure levels, at input power of 100 hp. [2M]

ii- Calculate the mechanical efficiency at the two pressure levels, at 2000 rpm. [2M]

C- Find the flow rate in L/s that an axial piston pump delivers at 1000 rpm. The pump has nine 15 mm diameter pistons arranged on a 125 mm diameter piston circle. The offset angle is set at 10° and the volumetric efficiency is 94%. [4M]

Question (3)

A- Draw the symbol and describe briefly the function of the following:

i-Pressure relief valve [1M]

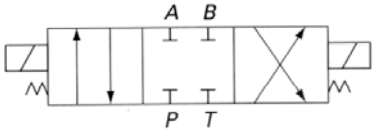
ii-Unloading valve [1M]

iii-Sequence valve [1M]

iv-Pressure reducing valve [1M]

B- A pressure relief valve has a pressure setting of 1000 psi. Compute the power loss across this valve if it returns all the flow back to the tank from a 20 gpm pump. If an unloading valve is used to unload the pump, where the pump discharge pressure during unloading equals 25 psi, how much power is being wasted? [3M]

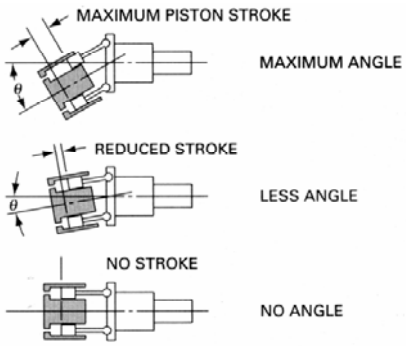
C- Describe the valve shown in figure, and mention four disadvantages for this design.



[3M]

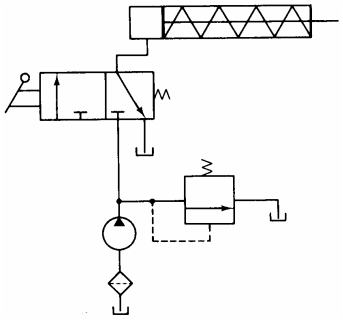
Question (4)

A- For the axial piston motor (bent-axis type) shown in figure, compare between the volumetric displacement, torque capacity, and drive shaft speed in the three cases. [3M]



B- A hydraulic motor has a 82 cm^3 volumetric displacement. If it has a pressure rating of 70 bar and it receives oil from a 0.0006 m^3/s theoretical flow rate pump, find the motor speed, theoretical torque, and theoretical power. [4M]

C- The following circuit used to control a single-acting hydraulic cylinder, redraw the circuit and write the name of the different components and its function in the circuit in brief. [3M]



Units conversion:

in= 2.54 cm

psi= 0.0689 bar

hp= 746 W

gallon= 3.78 litre

litre= 1000 cm^3

Answer Sheet

Question (1)

A- What is the difference between the hydraulic system and the pneumatic system; can we apply Pascal's law to both systems? [3M]

Answer:

Hydraulics uses pressurized liquid, for example, oil or water; pneumatics uses compressed air or other neutral gases. [2M]

Pascal's law applies to gases as well as liquids. [1M]

B- Mention two gases commonly used in pneumatic systems, and mention four necessary characteristics for gases used in pneumatic systems. [3M]

Answer:

Two gases are commonly used in pneumatic systems, Air and Nitrogen. [1M]

Four necessary characteristics for gases used in pneumatic systems: [2M]

1- non-toxic
2- chemically stable
3- free from acids that cause corrosion of system components
4- non-flammable

C- The mechanical force exerted on the brake pedal is transferred hydraulically to provide an increased mechanical force at the wheel brake unit, as shown in the figure. Calculate the area of the output pistons. [4M]

Answer:

Force= 100 lb

P= 100/1 =100 psi

A=300/100 = 3 in^2

Question (2)

A- The external gear pump uses three types of gears, spur, helical, or herringbone gears. Mention the advantages and disadvantages of the three types. [2M]

Answer:

Spur Gears: Noisy at Relatively High Speeds.

Helical Gears: To Reduce Noise and provide Smoother Operation.
Limited to Low-Pressure Applications (< 200 psi) because they develop Excessive End Thrust due to the action of the Helical Gears.

Herringbone Gear: Eliminate this Thrust Action and thus can be used to develop Much Higher Pressures (up to 3000 psi).
Herringbone Gear Pumps operate as Smoothly as Helical Gear Pumps and provide Greater Flow Rates with Much Less Pulsating Action.

B- The shown graph gives the pump input horsepower (hp), and pump output flow (gpm) as a function of Pump speed, for pressure levels of 3000 and 5000 psi. The volumetric displacement of the pump is 6 in^3/rev.
i- Calculate the volumetric efficiency at the two pressure levels, at input power of 100 hp. [2M]
ii- Calculate the mechanical efficiency at the two pressure levels, at 2000 rpm. [2M]

Answer:

i-volumetric Efficiency= Q_A/Q_{th}

$Q_{th} = V_D x RPM$

$V_D = 6\ in^3/rev$

From the graph at 100 hp:

RPM @ 3000 psi=2050

RPM @ 5000 psi=1250

Q_A @ 3000 psi= 51 gpm= $51x3.78x10^{-3}/60 = 0.0032\ m^3/s$

Q_A @ 5000 psi= 30 gpm= $30x3.78x10^{-3}/60 = 0.00189\ m^3/s$

Q_{th} @ 3000 psi =6x2050x$(2.54x10^{-2})^3$/60= 0.0033 m^3/s
Q_{th} @ 5000 psi =6x1250x$(2.54x10^{-2})^3$/60= 0.002 m^3/s
volumetric Efficiency @ 3000 psi =0.0032/0.0033=0.9696
volumetric Efficiency @ 5000 psi =0.00189/0.002=0.945

ii- From the graph at 2000 RPM:
hp @ 3000 psi=98 hp
hp @ 5000 psi=156 hp
Q_{th} @ 3000 psi = Q_{th} @ 5000 psi =6x2000x$(2.54x10^{-2})^3$/60= 0.00327 m^3/s
Mechanical Efficiency @ 3000 psi =P x Q_{th} @ 3000 psi/ hp @ 3000 psi =
=3000x0.0689x10^5x0.00327/98x746
= 0.9245
Mechanical Efficiency @ 5000 psi = P x Q_{th} @ 5000 psi/ hp @ 5000 psi =
=5000x0.0689x10^5x0.00327/156x746
= 0.9679

C- Find the flow rate in L/s that an axial piston pump delivers at 1000 rpm. The pump has nine 15 mm diameter pistons arranged on a 125 mm diameter piston circle. The offset angle is set at 10° and the volumetric efficiency is 94%. [4M]

Answer:
Q_T=DxAxNxY tan θ = 0.125 (3.14 x 0.015^2/4)x1000x9xtan10
= 0.0351 m^3/min

$Q_A = Q_T \eta_v$ = 0.0351 x 0.94 = 0.033 m^3/min

Q_A=0.033x 1/60 x 1/0.001 = 0.55 L/s

Question (3)

A- Draw the symbol and describe briefly the function of the following:

i-Pressure relief valve [1M]

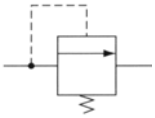
ii-Unloading valve [1M]

iii-Sequence valve [1M]

iv-Pressure reducing valve [1M]

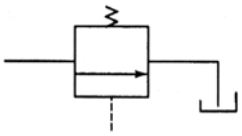
Answer:

i-Pressure relief valve



It is normally a closed valve whose function is to limit Ihe pressure to a specified maximum value by diverting pump flow back to the tank.

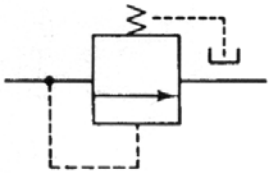
ii-Unloading valve



This valve is used to permit a pump to build pressure to an adjustable pressure setting and then allow it to discharge oil to the tank at essentially zero pressure as long, as pilot pressure is maintained on the valve from a remote source. Hence, the pump has essentially no load and is therefore developing a minimum amount of power.

iii-Sequence valve

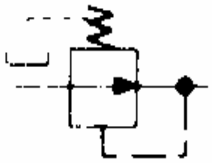
The sequence valve is designed to cause a hydraulic system to operate in a pressure sequence.



iv-Pressure reducing valve

This type of valve (which is normally open) is used to maintain reduced pressures in specified locations of hydraulic systems.

It is actuated by downstream pressure and tends to close as this pressure reaches the valve selling.

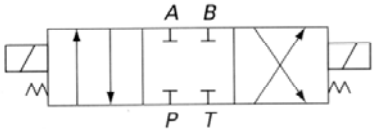


B- A pressure relief valve has a pressure setting of 1000 psi. Compute the power loss across this valve if it returns all the flow back to the tank from a 20 gpm pump. If an unloading valve is used to unload the pump, where the pump discharge pressure during unloading equals 25 psi, how much power is being wasted? [3M]

HP = PQ/1714 = 1000 x 20/1714 = 11.7 HP

HP = PQ/1714 = 25 x 20/1714 = 0.29 HP

C- Describe the valve shown in figure, and mention four disadvantages for this design.



[3M]

Answer:

It is a solenoid-actuated, four-way, three position, spring-centered directional control valve.

The closed-center design forces the pump to produce flow at the high-pressure setting of the pressure relief valve. This:

1-wastes pump power

2-promotes wear

3-shortens pump life

4-the wasted power shows up as heat, which raises the temperature of the oil. This promotes oil oxidation, which increases the acidity of the oil. Such oil tends to corrode the critical metallic parts not only of the pump but also of the actuators and valves. Also affected is the viscosity of the oil. Higher temperature lowers the viscosity, which in turn increases leakage and reduces the lubricity of the oil.

Question (4)

A- For the axial piston motor (bent-axis type) shown in figure, compare between the volumetric displacement, torque capacity, and drive shaft speed in the three cases. [3M]

Answer:

The Volumetric Displacement of the motor varies with the Offset Angle θ. No flow is produced When the Cylinder Block centerline is parallel to the Drive Shaft Centerline.
If the Offset Angle θ is increased, the Torque capacity is increased, but the Drive Shaft speed is decreased.

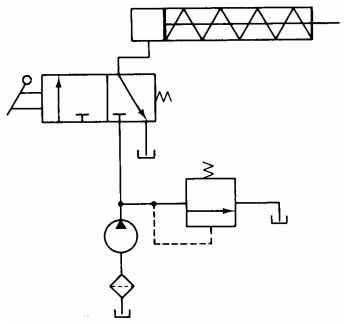
B- A hydraulic motor has a 82 cm^3 volumetric displacement. If it has a pressure rating of 70 bar and it receives oil from a 0.0006 m^3/s theoretical flow rate pump, find the motor speed, theoretical torque, and theoretical power. [4M]

$N = Q_T/V_D = 0.0006/0.000082 = 7.32 rps = 439$ rpm

$T_T = P\ V_D/2\pi = 0.000082 \times 70 \times 10^5/2\pi = 91.4$ N. m

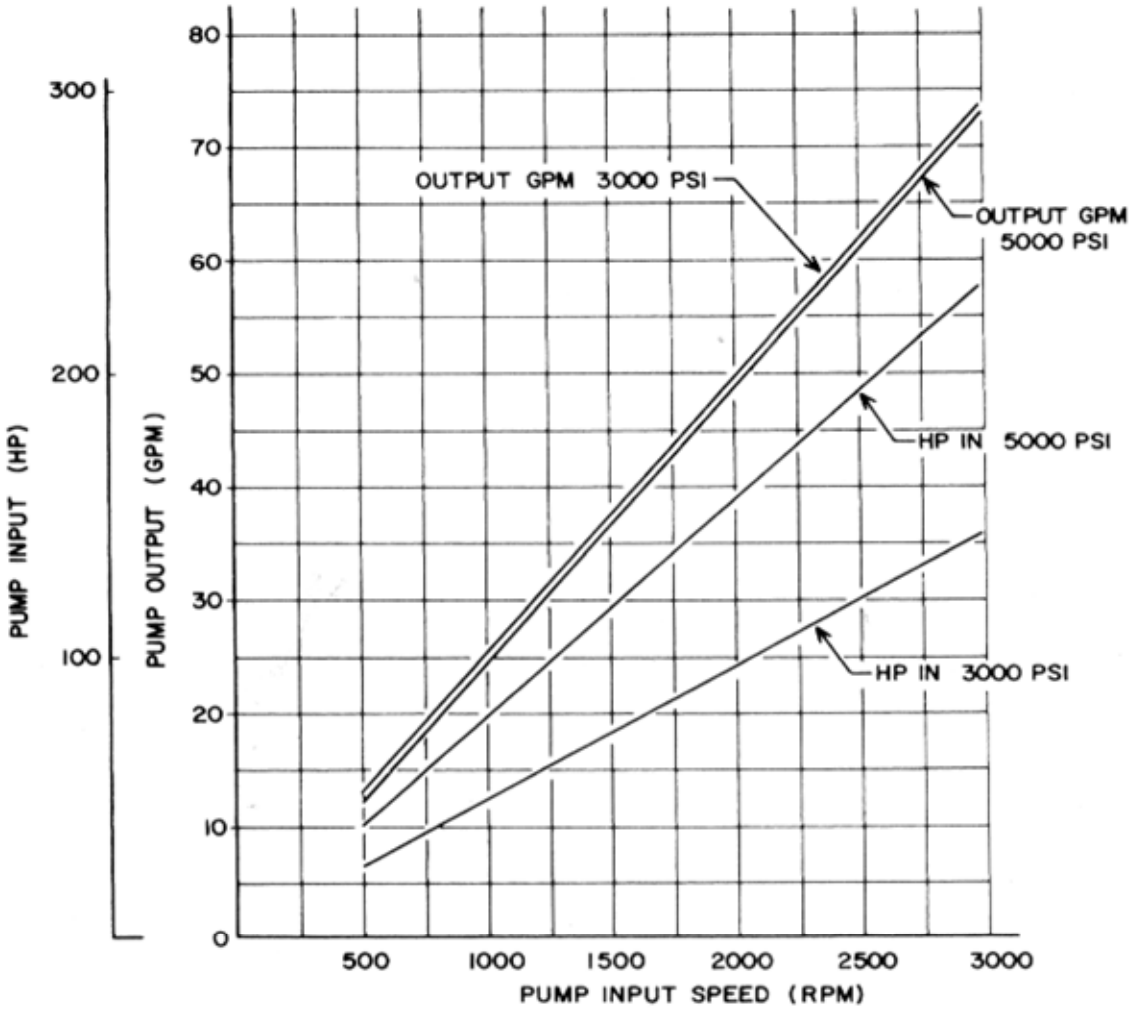
Theoretical power $= T_T \times N = 91.4 \times 7.32 \times 2\pi = 4200$ W

C- The following circuit used to control a single-acting hydraulic cylinder, redraw the circuit and write the name of the different components and its function in the circuit in brief. [3M]



Units conversion:

in= 2.54 cm
psi= 0.0689 bar
hp= 746 W
gallon= 3.78 litre
litre= 1000 cm^3


PUMP INPUT (HP)
300
200
100
PUMP OUTPUT (GPM)
80
70
60
50
40
30
20
10
0
OUTPUT GPM 3000 PSI
OUTPUT GPM 5000 PSI
HP IN 5000 PSI
HP IN 3000 PSI
500
1000
1500
2000
2500
3000
PUMP INPUT SPEED (RPM)