LECTURE 30 to 31 – ACCESSORIES USED IN FLUID POWER SYSTEMS

SELF EVALUATION QUESTIONS AND ANSWERS

1. Determine the Beta ratio of a filter when , during test operation, 20000 particles greater than 10 μm enter the filter and 2000 of these particles pass through the filter. What is the beta efficiency.

2. The pressure drop across a sticking control valve is observed to be 80 bar if the fluid has a specific gravity of 0.9 and a flow rate of 0.2 LPS, estimate the rise in temperature of fluid that can be attributed to the control valve.

3 Oil at 50℃ and 70 bar is flowing through a pressure relief valve at 40 LPM. What is the downstream oil temperature?

4. **Hydraulic machine has the following duty cycle. Idle at 15 bar for 30 seconds. Clamp work piece at 100 bar for 5 seconds. Approach at 15 bar for 2 seconds, perform work at 300 bar for 3 seconds, declamp , return at 15 bar for 2 seconds. The pump flow is 100 LPM. Total surface area of the oil reservoir is 2.5 m^2. Hydraulic pipe line is 25 mm in diameter and 2500 mm long. Calculate the netw wasted energy that needs to be dissicpated and recommend a suitable heat exchanger if necessary. Room temperature is 20 ℃. Volumetric efficiency of pump =0.85. density of the oil used = 806 kg/m^3.**

5. **A hydraulic pump operates at 70 bars and delivers oil at 0.00126 m^3/s to a hydraulic actuator. Oil discharges through pressure relief valve (PRV) during 50 % of the cycle time. The pump has an overall efficiency of 85 % and 10 % of power is lost due to frictional pressure losses in the hydraulic lines. What heat exchanger rating is required to dissipate all the generated heat.**

6. What would be size an adequate size of reservoir for a hydraulic system using 0.001 m^3/s pump?

7. A pump delievers oil to a hydraulic motor at 10 LPM at a pressure of 15 MPa. If the motor delivers 2kW and 70% of the power loss is due to internal leakage , which heats the oil, calculate the heat generation rate in kJ/min.

Q1 Solution

$$\text{BetaRatio} = \frac{\text{No of upstream particles of size } > N\ \mu\text{m}}{\text{No of downstream paricles of size} > N\ \mu\text{m}} = \frac{20000}{200} = 100$$

Beta Efficiency = $\frac{\text{No of upstream particles} - \text{No of downstream particles}}{\text{Noofupstreamparicles}} = \frac{20000-2000}{20000} = 90\%$

Beta Efficiency = 1 - $\frac{1}{\text{BetaRatio}} = 1 - \frac{1}{100} = 90\ \%$

Q2 Solution: The heat generated by the pressure drop across the control valve is

Heat loss generated = 80 x 10^5x0.2 x10^{-3} = 1600 Watts/s

The mass flow rate of fluid through the valve is computed from

Mass flow rate kg/s, = 900kg/m^3x 0.20 x$10^{-3}$$m^3/sec$ = 0.18 kg/s

Solving for the temperature rise in °C of the fluid

$$Temperature\ incrase\ (°C) = \frac{Heat\ generated\ (kW)}{oil\ specifica\ weight\ \left({}^{kJ}/_{kg°C}\right) x\ Oil\ flow\ rate\ ({}^{kg}/_{s})}$$

$$= \frac{1600}{0.18x1.8x1000} = 4.94\ °C$$

Q3 Solution

First calculate the power lost/wasted

Power Lost = P (bar) × Q (LPM) = (70 x10^5 N/m^2) (40x10^{-3} m^3/min) x1/60(seconds) = 4370 watts = 4.67 kW

Next calculate the oil flow-rate in units of kg/second and the temperature increase:

Oil flow-rate (kg/s) = 895 × oil flow-rate (m^3/s) = 895x40x10^{-3}/60 = 0.596 kg/s

Temperature (°C) = $\frac{\text{heat-generation rate (kW)}}{\text{Oil specific heat}\left(\frac{\text{kJ}}{\text{kg}}°\text{C}\right)\text{x oil flow-rate (kg/s)}} = \frac{4.67}{1.8\text{x}0.596} = 4.35°\text{C}$

Downstream oil temperature = 50+4.35 =54.35°C

Q4 Solution

Power dissipated in kW

$$\frac{P \times Q}{600 \times \eta} = \frac{15 \times 100}{600 \times 0.85} = 2.94\ \text{kW}$$

Energy consumed during 30 seconds.

$$\frac{2.94 \times 30}{3600} = 0.0245\ kWh$$

Power dissipated during clamping

$$\frac{100 \times 100}{600 \times 0.85} = 19.6\ kW$$

Since clamping takes place in 5 seconds, energy consumed is

$$\frac{19.6 \times 5}{3600} = 0.027\ kWh$$

Power dissipated during approach

$$\frac{100 \times 15}{600 \times 0.85} = 2.94\ kW$$

Since approach takes place in 2 seconds, energy consumed is

$$\frac{2.94 \times 2}{3600} = 0.001\ kWh$$

Power dissipated during Forward (work)

$$\frac{100 \times 300}{600 \times 0.85} = 58.8\ kW$$

Since work takes place in3 seconds, energy consumed is

$$\frac{58.8 \times 3}{3600} = 0.049\ kWh$$

Power dissipated during retrun

$$\frac{100 \times 15}{600 \times 0.85} = 2.94\ kW$$

Since return takes place in 2 seconds, energy consumed is

$$\frac{2.94 \times 2}{3600} = 0.001\ kWh$$

Total power dissipated in 42 seconds = 0.058 kWh = $\frac{0.058\times3600}{42} = 5\ kW$

Mass flow rate = 860× 0.001=0.86 kg/second

Temperature (°C) = $\frac{\text{heat}-\text{generation rate (kW)}}{\text{Oil specific heat}\left(\frac{\text{kJ}}{\text{kg}}\text{°C}\right)\text{x oil flow}-\text{rate (kg/s)}} = \frac{5}{1.8\text{x}0.86} = 3.22\ \text{°C}$

Temperature rise is small, therfore there is no need for a heat exchanger.

Q5 Solution

$$\text{Pump power loss} = \text{pump power input} - \text{pump power output}$$

$$\text{Pump power loss} = \frac{\text{Power output}}{\text{overall efficiency}} - \text{power output}$$

$$\text{Pump power loss} = \left\{\frac{1}{\eta_0} - 1\right\}\text{pump power output}$$

$$\text{Pump power loss} = \left\{\frac{1}{85} - 1\right\} \times \left(\frac{70 \times 10^5 \times 0.00126}{1000}\right) = 1.56\ \text{kW}$$

$$\text{Pump average loss} = \{0.50\} \times \left(\frac{70 \times 10^5 \times 0.00126}{1000}\right) = 4.41\ \text{kW}$$

$$\text{lineaverageloss} = \{0.50\} \times 0.10 \times \left(\frac{70 \times 10^5 \times 0.001260}{1000}\right) = 0.44\ \text{kW}$$

Total loss = 1.56+4.41+0.44=6.41 kW

Select heat exchanger rating of 6.41 kW

Q6 Solution

Size of the reservoir = 3 to 4 times the capacity of pump = 4× $capacity\ of\ pump\ (LPM)$

$$4 \times\ 0.001 = 4 \times 60\ (LPM) = 240\ L\ tank\ is\ required$$

Q7 Solution

Pump power $= \frac{0.01}{60} \times 150000 = 2.5 \text{ kW}$

Motor delivers 2 kw ,therfore loss is 0.5 kW

$\text{power loss due to leakage} = 0.7 \times 0.5 = 0.35\text{kW}$

$\text{power loss due to leakage} = 0.35 \times 60 = 21 \text{ kJ/min}$