LECTURE 10-HYDRAULIC MOTORS

SELF EVALUATION QUESTIONS AND ANSWERS

1.A rotary vane motor has a displacement volume of 80cm^3/rev and operate at 1750rpm.The system pressure is 7 bar. Calculate the flow rate and the kW power output of the motor.

2.A hydraulic motor has a volumetric displacement of 125 cm^3 and a pressure rating of 150 bars. It receives a theoretical flow of oil of 0.0015 m^3/s from a pump. Find the motor: a) Speed b) theoretical torque c) theoretical power.

3.A hydraulic motor has a displacement of 150 cm^3 and operates with a pressure of 120 bars and a speed of 2500 rpm. The actual flow rate consumed by the motor is 0.0078 m^3/s and the actual torque delivered by the motor is 250 Nm. Find

a. Volumetric efficiency

b. Mechanical efficiency

c. Overall efficiency

d. Power delivered by the motor

4.A motor has a displacement 300 cm^3 and a speed of 200 rpm with a pressure drop of 200 bar. The volumetric efficiency is 90% and the mechanical efficiency is 95%. Determine theoretical and actual a. Discharge b. Torque c.Power

5.A hydraulic motor with a displacement of 475 is used to directly drive a conveyor drum having a diameter of 0.7m. The pressure drop over the motor is 140 bar and the actual flow into the motor is 48 l/min. The overall and mechanical efficiency of the motor are 0.9 and 0.94 respectively. Determine

a. the torque at the conveyor drum

b. the power in kW supplied to the conveyor drum

c. the linear speed of the conveyor belt

Q1Solution

$V_d = 80\dfrac{cm^3}{rev} = 80 \times 10^{-6}\dfrac{m^3}{rev}$

$N = 1750\ RPM$

$P = 7bar = 7 \times 10^5 \dfrac{\text{N}}{\text{m}^2}$

Flow rate

$Q = V_d \times N = 80 \times 10^{-6} = 0.14\ m^3/min$

$Q = 2.333\ LPS$

Power output in kW

$P_o = P \times Q = 700 \times 2.333 \times 10^{-3} = 1.6331kW$

Q2Solution

Theoretical flow rate Q_T = 0.0015 m^3/s

Displacement of motor D_m = $125cm^3$

= $125 \times 10^{-3}\text{m}^3$

Pressure rating P_m = 150 bars

= $150 \times 10^5\ \text{N/m}^3$

a. The motor speed $N = \frac{Q_T}{D_m} = \frac{0.0015}{125 \times 10^{-6}}$

= 12 rev/s

= 12 × 60 = **720 rev/min**

b. Theoretical torque = $\frac{P_m D_m}{2\pi} = \frac{150\times 10^5 \times 125 \times 10^{-6}}{2\pi}$

= 298.4 Nm

c. Theoretical power = $P_m Q_T = 150 \times 10^5 \times 0.0015$

= 22500 W

= 22.5 kW

Q3Solution

Displacement of motor $D_m = 150\ \text{cm}^3$

$= 150 \times 10^{-6}\ \text{cm}^3$

Pressure P_m = 120 bar

$= 120 \times 10^5 \text{N/m}^2$

a. Volumetric efficiency $\eta_v = \frac{Q_T}{Q_A} \times 100$

$= \frac{(D_m N)/60}{Q_A} \times 100$

$= \frac{150\times 10^{-6}\times 2500}{0.00781\times 60} \times 100$

= 80%

b. Mechanical efficiency $\eta_m = \frac{T_A \times 2\pi}{P_m D_m} \times 100$

$= \frac{250\times 2\pi}{120\times 10^5\times 150\times 10^{-6}} \times 100$

= 87%

c. Overall efficiency $\eta_o = \eta_v \times \eta_m$

= 0.8 × 0.87 × 100

= 69.6%

d. Power delivered by the motor = 2πNT/60

$= \frac{2\pi\times 2500\times 100}{60}$

= **65450 W**

Q4Solution

Displacement of motor D_m = 300 cm^3

$= 300 \times 10^{-6} \text{m}^3$

Speed of the motor N = 200 rpm

Pressure drop = 200 bar

$= 200 \times 10^5$ N/m^2

Volumetric efficiency η_v= 90%

= 0.9

Mechanical efficiency η_m= 95%

= 0.95

a. Theoretical discharge Q_T= D_m .N

$= 300 \times 10^{-6} \times 200$

= 0.06 m^3/min

Actual discharge = $\frac{Q_T}{\eta_v}$

$= \frac{0.06}{0.9}$

= 0.0667

b. Theoretical torque $T_T = \frac{P_m D_m}{2\pi}$

$= \frac{200\times10^5\times300\times10^{-6}}{2\pi}$

= 955 Nm

Actual torque $T_A = T_T \times \eta_m$

$= 955\times 0.95$

= 907.3 Nm

c. Theoretical power the motor should deliver $=\frac{P_m Q_T}{60}$

$= \frac{200\times10^5\times.06}{60}$

= 20000 W

= 20 kW

Actual power delivered by the motor = 20×0.95

= 19 Kw

Q5Solution

The pressure drop over the motor P_m= 140 bar

$= 140 \times 10^5$ N/m^2

Displacement of motor D_m = 475 cm^3/rev

$= 475 \text{ x } 10^{-6}$ m^3/rev

Actual flow into the motor Q_A = 48 lit/min

$= 48 \times 10^{-3}$ m^3/min

Mechanical efficiency η_m= 0.94

Overall efficiency η_o= 0.9

a. Mechanical efficiency $\eta_m = \frac{2\pi\, T}{P_m D_m}$

The torque at the conveyor drum T = $\frac{P_m D_m}{2\pi}$ x η_m

$$= \frac{140\times10^5\times475\times10^{-6}\times.94}{2\pi}$$

= 995 Nm

b. Overall efficiency = $\frac{2\pi N\, T}{P_m Q_A}$

Power supplied by the motor to the conveyor drum = $P_m Q_A \eta_o$

$$= \frac{140\times10^5\times48\times10^{-3}\times.9}{60\times1000}$$

= 10.1 kW

c. Power = $\frac{2\pi N\, T}{60\times1000}$

Speed of the hydraulic motor,

$$N = \frac{10.1\times60\times1000}{2\pi\times995}$$

= 97 rpm

Linear speed of the conveyor = $\pi\, D\, n = \pi \times 0.7 \times 97 = \boldsymbol{213 m/min}$