Hydraulics & Pneumatics

Chapter 1: Hydraulics (Pump Examples)

by

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Example 1

- Calculate the volumetric displacement for a gear pump. Given the inside diameter, outside diameter and the gear width is 40 mm, 65 mm and 20 mm respectively.

Example 1: Solution

- $D_i = 40 \times 10^{-3}$ m
- $D_o = 65 \times 10^{-3}$ m
- $L = 20 \times 10^{-3}$ m

$$V_D = \frac{\pi}{4}(D_o^2 - D_i^2)L$$

$$V_D = \pi/4\ ((65 \times 10^{-3})^2 - (40 \times 10^{-3})^2) \times 20 \times 10^{-3}$$

$$V_D = 4.124e\text{-}5\ m^3/rev$$

Example 2

- A geometrical volume for an ideal gear pump is 12.5 cm^3. This pump delivers the fluid at 16 MPa and run at 1800 rpm. The pump inlet pressure is 200 kPa. Calculate:
  - Pump flow rate, Q_t
  - Fluid power increment, ΔN
  - Output hydraulic power, N_{out},
  - Driving torque, T_t

Example 2: Solution

$Q_t = V_g n = 12.5\text{x}10^{-6} \text{ x } (1800/60) = 3.75\text{x}10^{-4} \text{ m}^3/\text{s}$

$\Delta N = Q_t \Delta P = 37.5\text{x}10^{-5}\text{x}(16\text{x}10^6 - 2\text{x}10^5)$

$= 5925 \text{ W}$

$N_{out} = Q_t P = 37.5\text{x}10^{-5}\text{x } 16\text{x}10^6 = 6000 \text{ W}$

$T_t = (Vg/2\pi)\ \Delta P = (12.5\text{x}10^{-6}/2\pi) \text{ x}(16\text{x}10^6 - 2\text{x}10^5)$

$= 31.4 \text{ Nm}$

Example 3

- A leakage of oil from a pump is 6% at 230 bar. Calculate the total efficiency if the flow rate at 0 bar is 10 dm^3min^{-1} and the motor efficiency is 75%.
- Solution:

$Q\ (P = 0\ bar) = 10\ dm^3min^{-1}$

$Q\ (P = 230\ bar) = 10 \times 0.94 = 9.4\ dm^3min^{-1}$

$\eta_{motor} = 0.75,\ \eta_{vol} = 9.4/10 = 0.94$

Therefore

$\eta_{tot} = \eta_{motor} \times \eta_{vol} = 0.705\ (= 70.5\ \%)$

Example 4

- A displacement volume for a positive displacement pump is 100 cm^3. The pump flow rate is 0.0015 m^3/s at 1000 rpm and 70 bars. If the input torque of the pump motor is 120 Nm, calculate:

a) Overall efficiency of the pump?

b) Theoretical torque required to operate the pump?

Example 4: Solution

- a) From $Q_T = V \times n$,

Given $V = 100\ cm^3/rev$

$= 0.0001\ m^3/rev$

$Q_T = V \times n$

$= 0.0001\ m^3/rev \times (1000/60\ revs^{-1})$

$= 0.00167\ m^3/s$

Example 4: Solution

- Solve volumetric efficiency

$\eta_{vol} = Q_A/Q_T$

$= 0.0015/0.00167 = 0.898 = 89.8\%$

Solve mechanical efficiency

$\eta_m = PQ_T/T_A N$

$= (70 \times 10^5)(0.00167)/(120)(1000 \times (2\pi/60))$

$= 0.93 = 93\%$

Therefore, $\eta_{tot} = 0.93 \times 0.898 = 0.835 = 83.5\%$

Example 4: Solution

- b) $\eta_m = T_T/T_A$

  $T_T = \eta_m \times T_A = 0.93 \times 120 = 112\ Nm$