

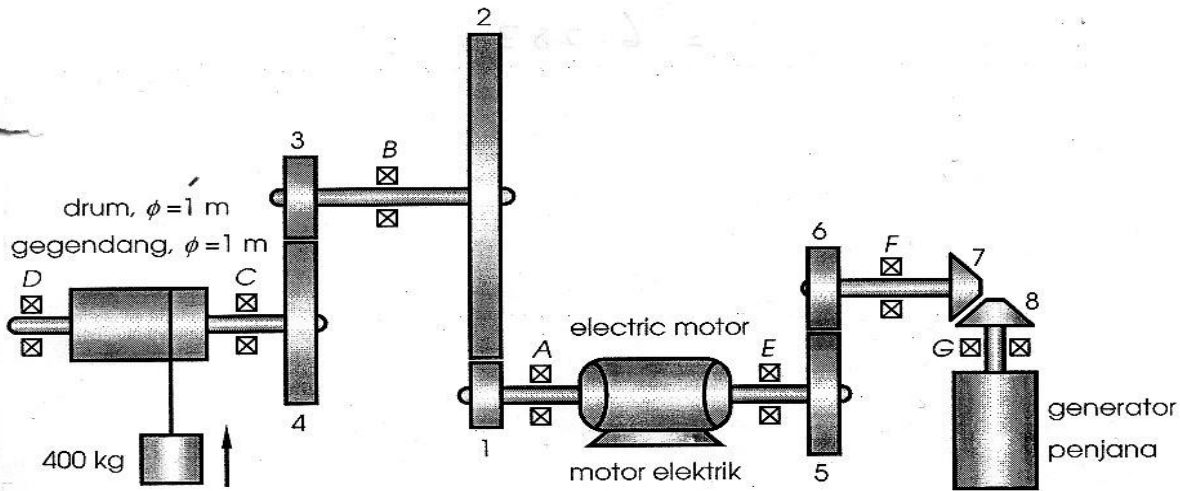
UNIVERSITI TEKNOLOGI MALAYSIA
 FACULTY OF MECHANICAL ENGINEERING
 DEPARTMENT OF APPLIED MECHANICS

TEST 1 SME2223/ SMJ3203 MECHANICS OF MACHINES & VIBRATION SEMESTER II SESSION 2008/2009

QUESTION 1

An electric motor is used to drive the drum of a lifting machine and a generator by means of a compound gear train as shown. The power of the motor is 30 kW at a rotational speed of 600 rpm and an angular acceleration of 2 rad/s². Find

- a. The power produced at the generator.
- b. The overall power transmission efficiency of the gear system.



No of teeth	Equivalent mass moment of inertia (kg·m ²)	bearing friction torque (N·m)	gear mesh efficiency
$t_1 = 40$	$I_{motor} = 5$	$A = E = 5$	$\eta_{12} = 90\%$
$t_2 = 200$	$I_{23} = 20$	$B = 10$	$\eta_{34} = 90\%$
$t_3 = 50$	$I_{drum} = 100$	$C = D = 5$	$\eta_{56} = 90\%$
$t_4 = 100$	$I_{67} = 5$	$F = 5$	$\eta_{78} = 90\%$
$t_5 = 75$	$I_{generator} = 10$	$G = 10$	
$t_6 = 50$			
$t_7 = 40$			
$t_8 = 40$			

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$$\frac{20}{24} = \frac{6.67}{7}$$

No. Kad Pengenalan.....

No. Soalan.....

Muka surat.....

Jangan tulis apa-apa di kedua-dua belah garisan

$$n_{12} = \frac{t_1}{t_2} = \frac{40}{200} = \frac{1}{5}$$

$$n_{34} = \frac{t_3}{t_4} = \frac{50}{100} = \frac{1}{2}$$

$$n_{56} = \frac{75}{50} \cdot \frac{t_5}{t_6} = \frac{75}{50} = 1\frac{1}{2}$$

$$n_{78} = \frac{t_7}{t_8} = \frac{40}{40} = 1$$

given: -

$$P_{in} = 30 \text{ kW}$$

$$N = 600 \text{ rpm}$$

$$\alpha_{in} = 2 \text{ rad/s}^2$$

$$\omega_{in} = \frac{2\pi N (600)}{60}$$

$$= 62.83 \text{ rad/s}$$

$$T_{in} = T_{out\ drum/in} + T_{out\ gen/in} + T_{fric/in} + T_{inertia/in}$$

$$T_{fric/in} = \frac{A + E + B(n_{12})}{\eta} + \frac{C + D(n_{12} n_{34})}{\eta \eta} + \frac{F(n_{56})}{\eta} + \frac{G(n_{56} n_{78})}{\eta \eta}$$

$$= 10 + 10 \left(\frac{1}{5} \right) + 10 \left(\frac{1}{5} \cdot \frac{1}{2} \right) + 5 \left(1\frac{1}{2} \right) + 10 \left(1\frac{1}{2} \cdot 1 \right)$$

$$= 10 + 2.22 + 1.23 + 8.33 + 18.52$$

$$= 40.299 \text{ Nm}$$

$$T_{iner/in} = I_{eq/in} \alpha_{in}$$

$$I_{eq/in} = I_{motor} + I_{23} \left(\frac{n_{12}^2}{\eta} \right) + I_{drum} \left(\frac{n_{12}^2 n_{34}^2}{\eta \eta} \right) + I_{G7} \left(\frac{n_{56}^2}{\eta} \right) + I_{gen} \left(\frac{n_{56}^2 n_{78}^2}{\eta \eta} \right)$$

$$= 5 + 20 \left(\frac{1}{5}^2 \right) + 100 \left(\frac{1}{5}^2 \cdot \frac{1}{2}^2 \right) + 5 \left(1\frac{1}{2}^2 \right) + 10 \left(1\frac{1}{2}^2 \cdot 1^2 \right)$$

$$= 5 + 0.89 + 1.23 + 12.5 + 27.78$$

$$= 47.4 \text{ kg m}^2$$

$$\therefore \alpha_{in} = 2 \text{ rad/s}^2$$

$$\therefore T_{inertia/in} = 47.4 (2) = 94.8 \text{ Nm}$$



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Jangan tulis apa-apa di kedua-dua belah garisan

$$T_{in} = \frac{P_{in}}{\omega_{in}}$$

$$T_{in} = \frac{30 \times 10^3 (60)}{2\pi (600)}$$

$$T_{in} = 477.46 \text{ Nm.}$$

$$T_{out \text{ drum/in}} = T_{out} \frac{n_2 n_3}{n_1 n_4}$$

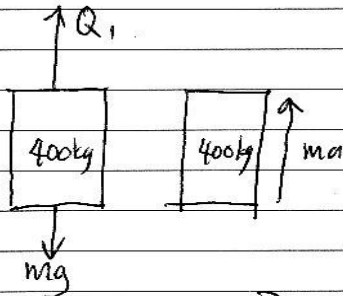
drum ..

$$\frac{\omega_{out}}{\alpha_{in}} = \frac{\omega_{out}}{\omega_{in}} = n.$$

$$\omega_{out \text{ drum}} = \alpha_{in} n.$$

$$= 2 (n_2 n_3)$$

$$\omega_{out \text{ drum}} = 0.2 \text{ rad/s}^2$$



$$\Sigma F = ma.$$

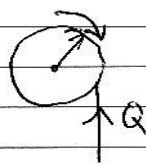
$$Q_1 - 400g = 400(a).$$

$$Q_1 = 3964 \text{ Nm.}$$

$$a = \alpha r.$$

$$a = 0.2(0.5)$$

$$a = 0.1 \text{ m/s}^2$$



$$+\vee \quad T_{drum} - Qr = 0. \checkmark$$

$$T_{drum} = Qr$$

$$T_{drum} = 1982 \text{ Nm.}$$

$$\therefore T_{out \text{ drum/in}} = 1982 \left(\frac{1/5 \cdot 1/2}{0.81} \right)$$

$$= 244.69 \text{ Nm.}$$

$$T_{in} = T_{out \text{ drum/in}} + T_{out \text{ gen/in}} + T_{fric/in} + T_{iner/in}.$$

$$T_{out \text{ gen/in}} = 477.46 - 244.69 - 40.299 - 94.8.$$

$$T_{out \text{ gen/in}} = 97.669 \text{ Nm.} \checkmark$$



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Muka surat.....

Jangan tulis apa-apa di kedua-dua belah garisan

$$T_{out\ gen/in} = T_{out\ gen} \frac{n_{56} n_{78}}{n_n n_n}$$

$$T_{out\ gen} = \frac{97.669}{1.85}$$

$$T_{out\ gen} = 52.74\ Nm \quad \checkmark$$

a) P at generator.

$$\frac{\omega_{out}}{\omega_{in}} = \frac{W_{out}}{W_{in}} = \eta$$

$$W_{out\ gen} = W_{in} \frac{n_{56} n_{78}}{n_n n_n}$$

$$W_{out\ gen} = 62.83 \left(1\frac{1}{2} \cdot 1\right)$$

$$W_{out\ gen} = 94.25\ rad/s \quad \checkmark$$

$$P_{gen} = \frac{T_{out\ gen} \omega_{out}}{\omega_{in}}$$

$$P_{gen} = 9.21\ kW$$

should be " T_{gen} ", Not " $T_{gen/i}$ "

b) $\eta_{overall} = \frac{P_{out\ drum} + P_{out\ gen}}{P_{in}}$

$$= \frac{T_{out\ drum} \left(\frac{n_{12} n_{34}}{n_n n_n}\right) \omega_{in} + T_{out\ gen} \left(\frac{n_{56} n_{78}}{n_n n_n}\right) \omega_{in}}{T_{in} \omega_{in}}$$

$$= \frac{244.69 + 97.669}{477.46} \quad \checkmark$$

$$= 0.72 \text{ @ } 72\% \quad \checkmark$$