Engineering Physics: Rotation and Heat Engines

Options and applications · 4 questions · step-by-step answers at the end

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USEFUL EQUATIONS

$T = I\alpha \quad E_k = \tfrac{1}{2}I\omega^2 \quad L = I\omega \quad W = T\theta,\ P = T\omega \quad Q = \Delta U + W$

$\text{efficiency} = W / Q_H \le 1 - T_C / T_H$

Questions

Show your working in the space under each question.

1. An engine takes in 800 J from a 600 K source and rejects 500 J to a 300 K sink each cycle. Find its efficiency and the maximum possible efficiency.

2. A flywheel with moment of inertia 0.50 kg m² starts from rest. A constant torque of 2.0 N m acts for 10 s. Find its angular acceleration, final angular speed, kinetic energy and the number of revolutions made.

3. A motor delivers a torque of 12 N m at 150 rad s⁻¹. Find its power.

4. The loop on an indicator diagram has an area of 450 J, and the engine completes 20 cycles per second. Find the indicated power.

Step-by-step answers

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1. W = 300 J, so efficiency = 300/800 = **37.5%**. Maximum = 1 − 300/600 = **50%**.

2. 1. $\alpha = T/I = 2.0/0.50 =$ **$4.0\ \text{rad s}^{-2}$**.
2. $\omega = \alpha t =$ **$40\ \text{rad s}^{-1}$**.
3. $E_k = \tfrac{1}{2}I\omega^2 = \tfrac{1}{2} \times 0.50 \times 40^2 =$ **400 J**.
4. $\theta = \tfrac{1}{2}\alpha t^2 = 200$ rad = **32 revolutions**. Check: $W = T\theta = 2.0 \times 200 = 400$ J ✓

Answer: $4.0\ \text{rad s}^{-2}$; $40\ \text{rad s}^{-1}$; 400 J; 32 revolutions

3. $P = T\omega =$ **1800 W**.

4. 450 × 20 = **9.0 kW**.