Answer on Question #56595, Physics Mechanics Relativity

The flywheel of a large motor in a factory has mass 30 kg and moment of inertia 67.5kg*m^2 about rotation axis. The motor develops a constant torque of 600Nt*m, and the flywheel starts from rest.

(a) What is the angular acceleration of the flywheel?

(b) What is its angular velocity after making 4 revolutions?

(c) How much work is done by the motor during the first 4 revolutions?

(d) What is the average power output of the motor during the first 4 revolutions?

Solution

(a)

$$M = J\varepsilon \tag{1}$$

where $M = 600N \cdot m$ is a constant torque; ε is the angular acceleration of the flywheel; $J = 67.5kg \cdot m^2$ is moment of inertia about rotation axis.

Then

$$\varepsilon = M / J = 600N \cdot m / 67.5kg \cdot m^2 \approx 8.89rad / s^2$$

(b)

Angular velocity:

$$\omega = \omega_0 + \varepsilon t \tag{2}$$

$\omega_0 = 0$ (flywheel starts from rest).

The angle of rotation

$$\varphi = \varphi_0 + \omega_0 t + \frac{1}{2}\varepsilon t^2 \tag{3}$$

where $\omega_0 = 0$ and $\varphi_0 = 0$ (flywheel starts from rest).

4 revolutions $\varphi = 4 \cdot 2\pi$, then from (3)

$$t = \sqrt{16\pi / \varepsilon} = 4\sqrt{\pi / \varepsilon} = 2.38s \tag{4}$$

Angular velocity after making 4 revolutions:

$$\omega = \varepsilon t = \varepsilon 4\sqrt{\pi / \varepsilon} = 4\sqrt{\pi\varepsilon} = 4\sqrt{\pi \cdot 8.89} \approx 21.14 rad / s \tag{5}$$

(c)

The work is done by the motor during the first 4 revolutions:

$$A = \frac{J\omega^2}{2} - \frac{J\omega_0^2}{2} = \frac{J\omega^2}{2} - 0 = \frac{J\omega^2}{2} = \frac{67.5 \cdot 8.89^2}{2} = 2667.33J = 2.67kJ \tag{6}$$

(d)

The average power output of the motor during the first 4 revolutions:

$$\langle P \rangle = \frac{A}{t} = \frac{2667.33}{2.38} = 1120 Watt$$