

Thermodynamics
Professor Anand T N C
Department of Mechanical Engineering
Indian Institute of Technology, Madras
Lecture - 21
Tutorial problem – Part 1

(Refer Slide Time: 00:16)



Q1 The tangential force acting on the cutting tool of a lathe when turning a metallic workpiece of 80 mm diameter is 180 N. After 8 minutes of turning the internal energy of the workpiece and chips has increased by 80 kJ. If the frequency of revolution of the workpiece is 250 rev/min estimate the heat transfer from the workpiece and chips in this time.

$F = 180 \text{ N}$
 $r = 40 \text{ mm} = 40 \times 10^{-3} \text{ m}$
 $t = 8 \text{ min} = 8 \times 60 = 480 \text{ s}$
 system = initially rod
 finally machined rod + chips
 $\Delta U = 80 \text{ kJ}$
 $N = 250 \text{ rpm} = 250/60 \text{ rps}$



Figure 1.

Solution of the problem in Fig. 1:

$F = 180 \text{ N}$, $r = 40 \text{ mm} = 0.04 \text{ m}$, $t = 8 \text{ min} = 480 \text{ s}$, $N = 250 \text{ rpm} = 250/60 \text{ rps}$

Initially, the system is only the metallic workpiece. Finally the system is the machined workpiece and the chips.

Torque is acting on the workpiece.

Cutting torque, $T = Fr = 180 \times 0.04 = 7.2 \text{ Nm}$

Work done, $W = T\theta = T(2\pi Nt) = 7.2 \times \left(2\pi \times \frac{250}{60} \times 480\right) = 90.4 \text{ kJ}$

Here, work is done on the system. Hence, $W = -90.4 \text{ kJ}$

Now, $\Delta U = 80 \text{ kJ}$

According to the first law for a process, $\delta Q - \delta W = dU$ (ignoring changes in potential and kinetic energy).

Integrating, $Q - W = \Delta U \rightarrow Q - (-90.4) = 80 \rightarrow Q = -10.4 \text{ kJ}$

Heat transfer is negative. The workpiece gets heated during the turning operation and its temperature increases. Hence, it loses heat to the surroundings.

(Refer Slide Time: 4:31)



$$T = F \times r$$

$$= 180 \text{ N} \times 0.04 \text{ m}$$

$$T = 7.2 \text{ Nm}$$

$$M_2 = T \theta$$

$$M_2 = T \times 2\pi N \times t$$

$$= 7.2 \times 2\pi \times \frac{250}{60} \text{ rpm} \times 480 \text{ s}$$

$$M_2 = -90475 \text{ Nm}$$

$$M_2 = -90.4 \text{ kJ}$$

$$\Delta U = U_2 - U_1 = 80 \text{ kJ}$$

$$dE = \delta Q - \delta W$$

$$dU = \delta Q - \delta W$$

$$\Delta U = Q - W$$

$$80 \text{ kJ} = Q - (-90.4 \text{ kJ})$$

$$Q = 80 - 90.4$$

$$Q = -10.4 \text{ kJ}$$





Q1 The tangential force acting on the cutting tool of a lathe when turning a metallic workpiece of 80 mm diameter is 180 N. After 8 minutes of turning the internal energy of the workpiece and chips has increased by 80 kJ. If the frequency of revolution of the workpiece is 250 rev/min estimate the heat transfer from the workpiece and chips in this time.

$$F = 180 \text{ N}$$

$$r = 40 \text{ mm} = 40 \times 10^{-3} \text{ m}$$

$$t = 8 \text{ min} = 8 \times 60 = 480 \text{ s}$$

system = initially rod
finally machined rod + chips

$$\Delta U = 80 \text{ kJ}$$

$$N = 250 \text{ rpm} = \frac{250}{60} \text{ rpm}$$



