ME338 – S3 Quiz 2 Time: 40 min

Q1: 50 pieces of discs (outer diameter 100 cm, inner diameter: 8 cm) are to be faced on a vertical-boring machine with a feed of 0.25 mm and depth of cut of 5 mm. The machine has an automatic control device by which the cutting speed is continuously adjusted to allow maximum power utilization at the cutting tool of 3 kW. However, the maximum rotational frequency of the spindle is limited to 0.7 s^{-1}. If the specific cutting energy for the work material is 2.27 GJ/m^3 and it takes 600 s to unload a machined disc, load an unmachined disc, and return the tool to the beginning of the cut, calculate the total production time for the batch, in minutes. [10]

Q2: In a slab-milling operation, the cutter has 20 teeth and is 100 mm in diameter. The rotational frequency of the cutter is 5 s^{-1}, the workpiece feed speed is 1.3 mm/s, the depth of cut is 6 mm, and the width of the workpiece is 50 mm. The relationship between the maximum undeformed chip thickness (t_o) and the specific cutting energy U in gigajoules per cubic meter (GJ/m^3), for the work material is:

$$U = 1.4\left[1 + \frac{1.25 \times 10^{-6}}{t_0}\right]$$

Estimate:

a. The maximum metal removal rate [5]

b. The maximum power, in kilowatts (kW), required at the cutter [5]

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Solution:

Q14)

$N = 20$ (teeth) $\qquad a_p = 50\ mm$

$d_t = 100\ mm \qquad a_e = 6\ mm$

$n = 5\ s^{-1}$

$v_f = 1.3\ mm/s \qquad p_s = 1.4\left[1 + \frac{25 \times 10^{-6}}{a_{c,max}}\right] \frac{GJ}{m^3}$

a) $Z_w = a_p\, a_e\, v_f = 50 \times 6 \times 1.3 = 390\ mm^3/s$

b) $a_{c,avg} = a_f \sqrt{\frac{a_e}{d_t}}$; $a_{c,max} = \frac{2 v_f}{Nn}\sqrt{\frac{a_e}{d_t}}$

(v_f/Nn)

$$a_{c,max} = \frac{2 \times 1.3}{20 \times 5}\sqrt{6/100} = 6.37 \times 10^{-3}\ mm$$

$$= 6.37 \times 10^{-6}\ m$$

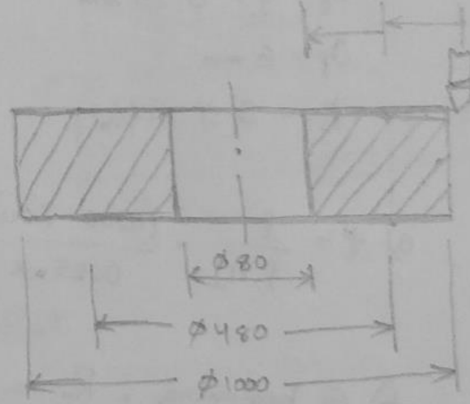
c) $P_{m,max} = p_s \cdot Z_{w,max} = 1.4\left[1 + \frac{25 \times 10^{-6}}{6.37 \times 10^{-6}}\right] \times 10^6 \frac{KJ}{m^3} \times \left[390 \times 10^{-9}\ m^3/s\right] = 2.69\ kW$

Q6)

$a_f = f = 0.25\ mm \qquad n_w = 0.7\ rad/s$

$a_p = 5\ mm \qquad p_s = 2.27\ GJ/m^3$

$P_m = 3\ kW \qquad t_{lu} = 600\ s$



$$(P_m)_{max} = p_s \cdot Z_{w,max} = p_s\, a_f\, a_p\, \pi\, n_w\, d_{max}$$

$$(3\ kW) = \left(2.27 \times 10^6 \frac{KJ}{m^3}\right)\left(0.25 \times 10^{-3} m\right)\left(5 \times 10^{-3} m\right)\left(\pi \times 0.7\ s^{-1} \times d_{max}\right)$$

$$d_{max} = 0.481\ m$$

∴ Upto 0.481 m of diameter, $(n_w)_{max} = 0.7\ s^{-1}$ can be maintained.

If facing is done for diameter $> 0.481\ m$, n_w will be $< 0.7\ s^{-1}$

So find 'n_w' at 1000 mm of diameter (which is > 0.481 m of dia)

$$(n_w d)_{@481\,mm} = (n_w d)_{@1000\,mm} \qquad \left[\because P_m \text{ is constant}\right]$$

$$\therefore n_{w@1000\,mm} = \frac{0.481\text{ m} \times 0.7\text{ s}^{-1}}{1\text{ m}} = 0.3365\text{ s}^{-1}$$

$(n_w)_{avg}$ between diameters 1000 mm & 481 mm is $\frac{0.7 + 0.3365}{2} = 0.52\text{ s}^{-1}$

$$t_{s\text{-}m} = \frac{(1000-481)/2}{(0.52)(0.25)} = 1996.15\text{ s} \qquad (\text{start to max. dia})$$

$$t_{m\text{-}e} = \frac{(481-80)/2}{(0.7)(0.25)} = 1145.7\text{ s} \qquad (\text{max dia to end})$$

$$T = (t_{s\text{-}m} + t_{m\text{-}e} + t_{u,l})\,50 = 3741.86 \times 50 = 187.1 \text{ kiloseconds.}$$