ME3210 Spring 2016 HW5 Solution

8.14

As can be seen in Fig. 8.21 on p. 441, tool life can be almost infinite at very low cutting speeds, but this reason alone would not always justify using low cutting speeds. Low cutting speeds will remove less material in a given time which could be economically undesirable. Lower cutting speeds often also lead to the formation of built-up edge and discontinuous chips. Also, as cutting speed decreases, friction increases and the shear angle decreases, thus generally causing the cutting force to increase.

8.34

8.46

As we can see in Fig. 8.22a on p. 442, high n values are desirable because for the same tool life, we can cut at higher speeds, thus increasing productivity. Conversely, it can also be seen that for the same cutting speed, high n values give longer tool life. Note that as n approaches zero, tool life becomes extremely sensitive to cutting speed, with rapidly decreasing tool life.

8.54

From the Taylor tool-life equation, $VT^n = C$, it can be seen that tool wear increases rapidly with increasing speed. When a tool wears excessively, it causes poor surface finish and higher temperatures. With continual tool replacement, more time is spent indexing or changing tools than is gained through faster cutting. Thus, higher speeds can lead to lower production rates.

8.70

Thread rolling is described in Section 6.3.5. The main advantages of thread rolling over thread cutting are the speeds involved (thread rolling is a very high-production-rate operation). Also, the fact that the threads undergo extensive cold working will lead to stronger work-hardened threads. Cutting continues to be used for making threads because it is a very versatile operation and much more economical for low production runs (since expensive dies are not required). Note that internal threads also can be rolled, but this is not nearly as common as machining and can be a difficult operation to perform.

8.114

We begin with Eq. (8.32) which, for this case, can be rewritten as

$$V_1^a f_1^b = (3V_1)^a f_2^b$$

Rearranging and simplifying this equation, we obtain

$$\frac{f_2}{f_1} = 3^{-a/b}$$

For carbide tools, approximate values are given on in Section 8.2.6 as $a = 0.2$ and $b = 0.125$. Substituting these values, we obtain

$$\frac{f_2}{f_1} = 3^{-(0.2/0.125)} = 0.17$$

Therefore, the feed should be reduced by (1-0.17) = 0.83, or 83%.

8.124

The metal removal rate for drilling is given by Eq. (8.40) on p. 480 as

$$\begin{aligned} \text{MRR} &= \frac{\pi D^2}{4} f N \\ &= \frac{\pi (0.75)^2}{4}(0.005)(300) \\ &= 0.66 \text{ in}^3/\text{min} \end{aligned}$$

If the drill diameter is tripled (that is, it is now 2.25 in.), then the metal removal rate is

$$\begin{aligned}\text{MRR} &= \frac{\pi D^2}{4} f N \\ &= \frac{\pi(2.25)^2}{4}(0.005)(300) \\ &= 5.96 \text{ in}^3/\text{min}\end{aligned}$$

It can be seen that this is a ninefold increase in metal removal rate.

9.41

Many processing methods have their own limited suitability for difficult-to-process workpieces. However, an example of an acceptable answer is:

(a) Ceramics: grinding, ultrasonic machining, chemical machining;

(b) thermoplastics: chemical machining, high-energy-beam machining, water-jet and abrasive-jet machining;

(c) thermosets: grinding, ultrasonic machining, chemical machining, and water-jet and abrasive-jet machining.

9.54

The advanced machining processes which cause thermal damage are obviously those that involve high levels of heat, that is, EDM, laser-beam, and electron-beam machining. The thermal effect can cause the material to develop a heat-affected zone (see Fig. 12.15), thus adversely affecting hardness and ductility. For the various effects of temperature in machining and grinding, see Sections 8.2.6 and 9.4.3, respectively.

9.66

The maximum current density for electrochemical machining is 8 A/mm^2 (see Table 9.4 on p. 554). The area of the hole is

$$A = \frac{\pi D^2}{4} = \frac{\pi(25)^2}{4} = 491 \text{ mm}^2$$

The current is the product of the current density and the cathode area, which is assumed to be the same as the cross-sectional area of the hole. Thus,

$$i = \left(8 \text{ A/mm}^2\right)\left(491 \text{ mm}^2\right) = 3927 \text{ A}$$

Note also that the maximum material removal rate in Table 9.4 (given in terms of penetration rate) is 12 mm/min. Since the depth of the hole is 50 mm, the time required is

$$t = \frac{50 \text{ mm}}{12 \text{ mm/min}} = 4.17 \text{ min}$$

9.79

Note from Table 3.3 on p. 106 that the density of copper is $\rho = 8970$ kg/m^3. The metal removal rate is given by Eq. (9.22) on p. 565 as

$$\text{MRR} = V_f hb = (1500)(25)(1.5)$$

or MRR=56,250 mm^3/min = 56.25×10^{-6} m^3/min. Therefore, we can calculate the rate of mass removal as:

$$\text{Mass MRR} = \rho(\text{MRR}) = (8970)(56.25 \times 10^{-6})$$

or 505 g/min. Therefore, the required power is calculated as

$$P = (505)(1550)\left(\frac{1}{60}\right) = 13,046 \text{ Nm/s}$$

or $P = 13$ kW.