$$P = (\text{MRR})u_s = (5299 \text{ mm}^3/\text{min})(5 \times 0.08 \text{ W min/mm}^3) = 2120 \text{ W}$$

(b) The machining time is

$$t_m = \frac{(\text{depth of cut})_{\text{total}}}{d} t_{mp} + t_s = \frac{0.2 \text{ mm}}{0.015 \text{ mm}} 0.155 \text{ min/pass} + 2(0.155) = 2.38 \text{ min}$$

The time to travel across the part length (or perform one pass) is

$$t_{mp} = (L_p + W_w + L_a)/f_r = (200 + 25 + 8)/1500 = 0.155 \text{ min/pass}$$

2.14 PROBLEMS

Problem 2.1 A 1020 steel bar 150 mm in diameter is turned on a 12 kW lathe at 100 rpm and a 0.5 mm/rev feed. The lathe has a 90% efficiency. What is the maximum depth of cut that can be used with this operation?

Problem 2.2 Estimate the machining time required in rough turning an 800 mm long, annealed 4240 steel round bar of 100 mm in diameter, using a carbide tool. Estimate the time for a ceramic tool.

Problem 2.3 Estimate the machining time required for rough turning the OD and facing the end of a 0.6 m long round bar 1040 steel, 100 mm in diameter using a carbide tool. The depth of cut for both operations is 1 mm. The maximum cutting speed allowed is 70 m/min, with a feed of 0.25 mm/rev.

Problem 2.4 The diameter of a 250 mm long by 95 mm diameter steel rod is being turned down to 90 mm on a lathe. The spindle rotates at 450 rpm, and the feed rate of the tool (traveling at an axial speed) is 250 mm/min. Calculate the cutting speed, material removal rate, time of cut, power required, and the cutting force.

Problem 2.5 A shaft of 1040 steel is grooved to a diameter of 80 mm from 100 mm. The width of the groove is 5 mm. The maximum cutting speed for the cutting tool material is 120 m/min with a feed of 0.25 mm/rev. Determine the chip area, material removal rate, power, and machining time.

Problem 2.6 A 200 mm long taper shaft is generated from 1040 steel 80 mm round bar stock in a lathe. The small diameter is 40 mm. The taper is 10° included angle. The maximum depth of cut for a roughing operation is 4 mm while for a finish cut it is 0.5 to 1 mm. The rapid travel feedrate is 12,000 mm/min, the rough feed is 0.35 mm/rev, and finish feed is 0.1 mm/rev. The suggested cutting speed is 100 m/min. Determine the following:

(a) number of passes from rough to finish part, and
(b) total machining time.

Problem 2.7 One thousand gray cast iron bars 100 mm diameter and 300 mm long must be turned down to 65 mm diameter for 200 mm of their length. The surface finish and accuracy requirements are such that a heavy roughing cut (removing most of the material) followed by a light finishing cut are needed. The available maximum power in the lathe spindle of 2.5 kW

with an efficiency of 85% is used for the roughing cuts. The finish cut is selected at a feed of 0.13 mm, a cutting speed of 90 m/min, and at maximum power. Calculate the total production time in hours for the batch of work. Assume that the time taken to return the tool to the beginning of the cut is 3 sec, the tool index time is 1 sec, and the time taken to load and unload a workpiece is 2 min.

Problem 2.8 A 1 m diameter 6061 aluminum disk with a 300 mm diameter hole in the center is fixtured on the table in a vertical boring machine to perform a facing operation. The cutting tool starts to cut at the outside diameter and it is fed to the center (along its radius) for performing a facing operation. A constant table spindle rpm (rotational frequency) of 70 rpm is used, while the tool is fed at 0.25 mm/rev with a depth of cut of 6 mm. Calculate the following: (1) the machining time and (2) the power consumption at both the beginning and just before the end of the operation.

Problem 2.9 A hole is being drilled in a block of soft steel alloy with a 12 mm drill at 100 m/min cutting speed. The feed is 0.3 mm/rev and the hole depth (not including the drill point) is 25 mm. A standard solid carbide drill is used with a 120° point angle. Calculate the power and torque required drilling the hole and the machining time.

Problem 2.10 Calculate the time to drill a core hole through a cast iron workpiece material with a solid carbide three-flute drill that has a point angle of 120°. The thickness of the part at the drilling location is 50 mm. A drill diameter of 30 mm is used to enlarge a 15 mm hole. The recommended cutting speed for carbide drill is 80 m/min at a feed of 0.12 mm/rev/flute. What are the material removal rate (MRR) and the torque required by the spindle?

Problem 2.11 The hole generated in Problem 2.10 is reamed with a 30.5 mm eight-flute reamer. The feed for the reamer is 0.1 mm/tooth. The recommended cutting speed is 70 m/min. Calculate the machining time and power required to ream the hole.

Problem 2.12 A peripheral (slab) milling operation is being carried out on a 600 mm long, 50 mm wide steel (hardness of about 30 R_c) block at a feed of 0.15 mm/tooth and depth of cut of 10 mm. A 200 mm diameter staggertoothed side cutter is used with 20 inserts, and rotates at 250 rpm. The effective teeth are only one fourth the total number of teeth in the cutter (see Example 2.8). Calculate the material removal rate (MRR), the cutting time, and estimate the power and torque required by the machine tool spindle.

Problem 2.13 Face milling operation is being carried out on a 500 mm long by 50 mm wide rectangular stock of stainless steel material. A 200 mm diameter face milling cutter with 10 inserts is used to clean up the top 2 mm on the surface of the workpiece. The cutting parameters are 200 mm/min feed rate and 200 rpm on the spindle. Calculate the material removal rate (MRR), cutting time, and feed per tooth, and estimate the power required.

Problem 2.14 A face milling operation is being performed on an 80 mm wide aluminum part with a 300 mm diameter cutter. The feed per tooth is 0.2 mm and the depth of cut is 8 mm. The cutter center is offset 20 mm from the workpiece centerline. The cutter has 12 inserts.

(a) Determine the uncut chip thickness.
(b) Indicate in a graph the variation of uncut chip thickness on one tooth over two revolutions of the cutter.

Problem 2.15 Estimate the machining time required in tapping a hole at 20 mm depth with an M12 × 1 mm tap. A high speed steel cutting tap is used at 12 m/min cutting speed. What is the material removal rate?

Problem 2.16 A 100 mm diameter hole is threaded for the first 30 mm depth using a 25 mm diameter solid carbide four-flute thread milling tool with a single row of teeth. The thread pitch is 3 mm. The allowable feed per tooth (chip load) in this case is 0.1 mm/rev., while the cutting speed is 100 m/min. Estimate the machining time.

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