ASSIGNMENT Due on 20-01-2025 Assignments submitted after 3:15 am will not be accepted Answer the short questions

1. What are the parameters of a machining operation that are included within the scope of cutting conditions?
   Parameters of Machining Operations: The parameters included within the scope of cutting conditions in a machining operation are:
   Cutting speed: The speed at which the cutting tool engages the workpiece.
   Feed rate: The distance the tool advances during each revolution or pass.
   Depth of cut: The thickness of the material being removed in a single pass.
2. Explain the difference between roughing and finishing operations in machining.

Roughing operations focus on removing large amounts of material quickly to shape the workpiece, often resulting in a rough surface finish with visible tool marks. They use higher feed rates and cutting depths.

Finishing operations, on the other hand, aim to achieve a smooth surface finish and precise dimensions, using lighter cuts and lower feed rates to refine the workpiece.

3. What is an orthogonal cutting operation?

Orthogonal Cutting Operation: An orthogonal cutting operation is characterized by a cutting tool that engages the workpiece at a constant angle, typically perpendicular to the cutting surface. This type of cutting minimizes friction and allows for easier analysis of forces and chip formation.

4. Identify the two forces that can be measured in the orthogonal metal cutting model.

Forces in Orthogonal Metal Cutting Model: The two primary forces that can be measured in the orthogonal metal cutting model are:

Cutting force: The force required to remove material from the workpiece.

Radial force: The force acting perpendicular to the cutting edge, which can influence tool wear and stability.

5. What is the specific energy in metal machining?

Specific Energy in Metal Machining: Specific energy in metal machining refers to the energy consumed per unit volume of material removed. It is a measure of the efficiency of the machining process and is influenced by factors such as cutting speed, feed rate, and depth of cut.

6. How does a boring operation differ from a turning operation?

Boring vs. Turning Operations:

Boring operations involve enlarging existing holes or creating precise diameters in a workpiece using a single-point cutting tool.

Turning operations, however, involve rotating the workpiece against a stationary cutting tool to shape it into cylindrical forms.

7. What is meant by the designation 12 x 36 inch lathe?

Designation 12 x 36 Inch Lathe: The designation "12 x 36 inch lathe" indicates that the lathe can accommodate workpieces with a maximum diameter of 12 inches and a maximum length of 36 inches. This specification helps users understand the size limitations for machining operations.

8. How does a turret lathe differ from an engine lathe?

A turret lathe is designed for repetitive production runs, featuring multiple tools mounted on a rotating turret for quick changes between operations.

An engine lathe, conversely, is more versatile and typically used for one-off or small batch productions, allowing for manual setup and adjustments.

9. What is the distinguishing feature of a radial drill press?

Distinguishing Feature of a Radial Drill Press: The distinguishing feature of a radial drill press is its arm that can swing around a vertical column, allowing for drilling at various angles and positions without needing to reposition the workpiece itself. This enhances flexibility and accessibility during drilling operations.

Q2. 21.1

21.1 In an orthogonal cutting operation, the tool has a rake angle = 15°. The chip thickness before the cut = 0.30 mm and the cut yields a deformed chip thickness = 0.65 mm. Calculate (a) the shear plane angle and (b) the shear strain for the operation.

Solution: (a) $r = t_o/t_c = 0.30/0.65 = 0.4615$
$\phi = \tan^{-1}(0.4615 \cos 15/(1 - 0.4615 \sin 15)) = \tan^{-1}(0.5062) = \mathbf{26.85°}$

(b) Shear strain $\gamma = \cot 26.85 + \tan(26.85 - 15) = 1.975 + 0.210 = \mathbf{2.185}$

Q3. 21.3

21.3 In an orthogonal cutting operation, the 0.250 in wide tool has a rake angle of 5°. The lathe is set so the chip thickness before the cut is 0.010 in. After the cut, the deformed chip thickness is measured to be 0.027 in. Calculate (a) the shear plane angle and (b) the shear strain for the operation.

Solution: (a) $r = t_o/t_c = 0.010/0.027 = 0.3701$
$\phi = \tan^{-1}(0.3701 \cos 5/(1 - 0.3701 \sin 5)) = \tan^{-1}(0.3813) = \mathbf{20.9°}$

(b) Shear strain $\gamma = \cot 20.9 + \tan(20.9 – 5) = 2.623 + 0.284 = \mathbf{2.907}$

Q4. 21.4

21.4 In a turning operation, spindle speed is set to provide a cutting speed of 1.8 m/s. The feed and depth of cut of cut are 0.30 mm and 2.6 mm, respectively. The tool rake angle is 8°. After the cut, the deformed chip thickness is measured to be 0.49 mm. Determine (a) shear plane angle, (b) shear strain, and (c) material removal rate. Use the orthogonal cutting model as an approximation of the turning process.

Solution: (a) $r = t_o/t_c = 0.30/0.49 = 0.612$
$\phi = \tan^{-1}(0.612 \cos 8/(1 – 0.612 \sin 8)) = \tan^{-1}(0.6628) = \mathbf{33.6°}$

(b) $\gamma = \cot 33.6 + \tan(33.6 - 8) = 1.509 + 0.478 = \mathbf{1.987}$

(c) $R_{MR} = (1.8 \text{ m/s x } 10^3 \text{ mm/m})(0.3)(2.6) = \mathbf{1404\ mm^3/s}$

Q5. 21.5

21.5 The cutting force and thrust force in an orthogonal cutting operation are 1470 N and 1589 N, respectively. The rake angle = 5°, the width of the cut = 5.0 mm, the chip thickness before the cut = 0.6, and the chip thickness ratio = 0.38. Determine (a) the shear strength of the work material and (b) the coefficient of friction in the operation.

Solution: (a) $\phi = \tan^{-1}(0.38 \cos 5/(1 - 0.38 \sin 5)) = \tan^{-1}(0.3916) = 21.38°$
$F_s = 1470 \cos 21.38 – 1589 \sin 21.38 = 789.3$ N
$A_s = (0.6)(5.0)/\sin 21.38 = 3.0/.3646 = 8.23 \text{ mm}^2$
$S = 789.3/8.23 = 95.9 \text{ N/mm}^2 = \mathbf{95.9\ MPa}$

(b) $\phi = 45 + \alpha/2 - \beta/2$; rearranging, $\beta = 2(45) + \alpha - 2\phi$
$\beta = 2(45) + \alpha - 2(\phi) = 90 + 5 – 2(21.38) = 52.24°$
$\mu = \tan 52.24 = \mathbf{1.291}$

Q6. 21.6

21.6 The cutting force and thrust force have been measured in an orthogonal cutting operation to be 300 lb and 291 lb, respectively. The rake angle = 10°, width of cut = 0.200 in, chip thickness before the cut = 0.015, and chip thickness ratio = 0.4. Determine (a) the shear strength of the work material and (b) the coefficient of friction in the operation.

Solution: $\phi = \tan^{-1}(0.4 \cos 10/(1 - 0.4 \sin 10)) = \tan^{-1}(0.4233) = 22.94°$
$F_s = 300 \cos 22.94 - 291 \sin 22.94 = 162.9$ lb.
$A_s = (0.015)(0.2)/\sin 22.94 = 0.0077$ in^2
$S = 162.9/0.0077 =$ **21,167 lb/in^2**
$\beta = 2(45) + \alpha - 2(\phi) = 90 + 10 - 2(22.94) = 54.1°$
$\mu = \tan 54.1 =$ **1.38**

Q7. 21.10

21.10 The shear strength of a certain work material = 50,000 lb/in^2. An orthogonal cutting operation is performed using a tool with a rake angle = 20° at the following cutting conditions: cutting speed = 100 ft/min, chip thickness before the cut = 0.015 in, and width of cut = 0.150 in. The resulting chip thickness ratio = 0.50. Determine (a) the shear plane angle, (b) shear force, (c) cutting force and thrust force, and (d) friction force.

Solution: (a) $\phi = \tan^{-1}(0.5 \cos 20/(1 - 0.5 \sin 20)) = \tan^{-1}(0.5668) =$ **29.5°**

(b) $A_s = (0.015)(0.15)/\sin 29.5 = 0.00456$ in^2.
$F_s = A_s S = 0.00456(50{,}000) =$ **228 lb**

(c) $\beta = 2(45) + \alpha - 2(\phi) = 90 + 20 - 2(29.5) = 50.9°$
$F_c = 228 \cos(50.9 - 20)/\cos(29.5 + 50.9 - 20) =$ **397 lb**
$F_t = 228 \sin(50.9 - 20)/\cos(29.5 + 50.9 - 20) =$ **238 lb**

Q8. 21.19

21.19 In Problem 21.18, compute the lathe power requirements if feed = 0.50 mm/rev.

Solution: This is the same basic problem as the previous, except that a correction must be made for the "size effect." Using Figure 21.14, for $f = 0.50$ mm, correction factor = 0.85.
From Table 21.2, $U = 2.8$ J/mm^3. With the correction factor, $U = 2.8(0.85) = 2.38$ J/mm^3.
$R_{MR} = vfd = (200 \text{ m/min})(10^3 \text{ mm/m})(0.50 \text{ mm})(7.5 \text{ mm}) = 750{,}000 \text{ mm}^3\text{/min} = 12{,}500 \text{ mm}^3\text{/s}$
$P_c = (12{,}500 \text{ mm}^3\text{/s})(2.38 \text{ J/mm}^3) = 29{,}750 \text{ J/s} = 29{,}750 \text{ W} = 29.75 \text{ kW}$
Accounting for mechanical efficiency, $P_g = 29.75/0.90 =$ **33.06 kW**

In a turning operation on stainless steel with hardness = 200 HB, the cutting speed = 200 m/min, feed = 0.25 mm/rev, and depth of cut = 7.5 mm. How much power will the lathe draw in performing this operation if its mechanical efficiency = 90%. Use Table 21.2 to obtain the appropriate specific energy value.

Q9. 21.23

21.23 Suppose the cutting speed in Problems 21.7 and 21.8 is 200 ft/min. From your answers to those problems, find (a) the horsepower consumed in the operation, (b) metal removal rate in in^3/min, (c) unit horsepower (hp-min/in^3), and (d) the specific energy (in-lb/in^3).

Solution: (a) From Problem 21.8, $F_c = 155$ lb. $HP_c = 155(200)/33{,}000 =$ **0.94 hp**

(b) $R_{MR} = vfd = (200 \times 12)(0.012)(0.100) =$ **2.88 in^3/min**

(c) $HP_u = 0.94/2.88 =$ **0.326 hp/(in^3/min)**

(d) $U = 155(200)/2.88 =$ **10,764 ft-lb/in^3 = 129,167 in-lb/in^3**

Q10. 21.26

21.26 Solve Problem 21.25 except that the feed = 0.0075 in/rev and the work material is stainless steel (Brinell Hardness = 240 HB).

Solution: (a) From Table 21.2, HP_u = 1.0 hp/(in^3/min) for stainless steel. Since feed is lower than 0.010 in/rev in the table, a correction factor must be applied from Figure 21.14. For f = 0.0075 in/rev = t_o, correction factor = 1.1.
$HP_c = HP_u \times R_{MR}$
R_{MR} = 400 x 12(0.0075)(0.12) = 4.32 in^3/min
HP_c = 1.1(1.0)(4.32) = **4.75 hp**

(b) HP_g = 5.01/0.83 = **5.73 hp**

Q11. 22.1

22.1 A cylindrical workpart 200 mm in diameter and 700 mm long is to be turned in an engine lathe. Cutting speed = 2.30 m/s, feed = 0.32 mm/rev, and depth of cut = 1.80 mm. Determine (a) cutting time, and (b) metal removal rate.

Solution: (a) $N = v/(\pi D)$ = (2.30 m/s)/0.200π = 3.66 rev/s
$f_r = Nf$ = 6.366(.3) = 1.17 mm/s
$T_m = L/f_r$ = 700/1.17 = 598 s = **9.96 min**

Alternative calculation using Eq. (22.5), T_m = 200(700)π/(2,300 x 0.32) = 597.6 sec = 9.96 min

(b) $R_{MR} = vfd$ = (2.30 m/s)(10^3)(0.32 mm)(1.80 mm) = **1320 mm^3/s**

Q12. 22.2

22.2 In a production turning operation, the foreman has decreed that a single pass must be completed on the cylindrical workpiece in 5.0 min. The piece is 400 mm long and 150 mm in diameter. Using a feed = 0.30 mm/rev and a depth of cut = 4.0 mm, what cutting speed must be used to meet this machining time requirement?

Solution: Starting with Eq. (22.5): $T_m = \pi D_o L/vf$.
Rearranging to determine cutting speed: $v = \pi D_o L/fT_m$
v = π(0.4)(0.15)/(0.30)(10^{-3})(5.0) = 0.1257(10^3) m/min = **125.7 m/min**

Q13. 22.6

22.6 A cylindrical work bar with 4.5 in diameter and 52 in length is chucked in an engine lathe and supported at the opposite end using a live center. A 46.0 in portion of the length is to be turned to a diameter of 4.25 in one pass at a speed of 450 ft/min. The metal removal rate should be 6.75 in^3/min. Determine (a) the required depth of cut, (b) the required feed, and (c) the cutting time.

Solution: (a) depth d = (4.50 - 4.25)/2 = **0.125 in**
(b) $R_{MR} = vfd$; $f = R_{MR}/(12vd)$ = 6.75/(12 x 450 x 0.125) = 0.010 in
f = **0.010 in/rev**

(c) $N = v/\pi D$ = 450 x 12/4.5π = 382 rev/min
f_r = 382(0.010) = 3.82 in/min
T_m = 46/3.82 = **12.04 min**

Q14. 22.8

22.8 The end of a large tubular workpart is to be faced on a NC vertical boring mill. The part has an outside diameter of 38.0 in and an inside diameter of 24.0 in. If the facing operation is performed at a rotational speed of 40.0 rev/min, feed of 0.015 in/rev, and depth of cut of 0.180 in, determine (a) the cutting time to complete the facing operation and the cutting speeds and metal removal rates at the beginning and end of the cut.

Solution: (a) Distance traveled $L = (D_o - D_i)/2 = (38 - 24)/2 = 7.0$ in
$f_r = (40 \text{ rev/min})(0.015 \text{ in/rev}) = 0.60$ in/min
$T_m = 7.0/0.60 =$ **11.67 min**

(b) At $D_o = 38$ in, $N = v/\pi D$, $v = N\pi D = (40 \text{ rev/min})(\pi 38/12) =$ **398 ft/min**
$R_{MR} = vfd = (398 \times 12)(0.015)(0.18) =$ **12.89 in^3/min**

At $D_i = 24$ in, $N = v/\pi D$, $v = N\pi D = (40 \text{ rev/min})(\pi 24/12) =$ **251 ft/min**
$R_{MR} = vfd = (251 \times 12)(0.015)(0.18) =$ **8.14 in^3/min**

Q15. 22.10

22.10 A drilling operation is to be performed with a 12.7 mm diameter twist drill in a steel workpart. The hole is a blind hole at a depth of 60 mm and the point angle is 118°. The cutting speed is 25 m/min and the feed is 0.30 mm/rev. Determine (a) the cutting time to complete the drilling operation, and (b) metal removal rate during the operation, after the drill bit reaches full diameter.

Solution: (a) $N = v/\pi D = 25(10^3) / (12.7\pi) = 626.6$ rev/min
$f_r = Nf = 626.6(0.30) = 188$ mm/min
$A = 0.5D \tan(90 - \theta/2) = 0.5(12.7)\tan(90 - 118/2) = 3.82$ mm
$T_m = (d + A)/f_r = (60 + 3.82)/188 = 0.339$ min

(b) $R_{MR} = 0.25\pi D^2 f_r = 0.25\pi(12.7)^2(188) = 23{,}800$ mm^3/min

Q16. 22.11

22.11 A two-spindle drill simultaneously drills a ½ in hole and a ¾ in hole through a workpiece that is 1.0 inch thick. Both drills are twist drills with point angles of 118°. Cutting speed for the material is 230 ft/min. The rotational speed of each spindle can be set individually. The feed rate for both holes must be set to the same value because the 2 spindles lower at the same rate. The feed rate is set so the total metal removal rate does not exceed 1.50 in^3/min. Determine (a) the maximum feed rate (in/min) that can be used, (b) the individual feeds (in/rev) that result for each hole, and (c) the time required to drill the holes.

Solution: (a) Total $R_{MR} = 1.50 = 0.25\pi D_1^2 f_r + 0.25\pi D_2^2 f_r = 0.25\pi(D_1^2 + D_2^2)f_r$
$1.50 = 0.25\pi(0.5^2 + 0.75^2)f_r = 0.638 f_r$
$f_r = 1.50/0.638 =$ **2.35 in/min**

(b) For 1/2 in hole, $N = v/\pi D = 230/(0.50\pi/12) = 1757$
For 3/4 in hole, $N = v/\pi D = 230/(0.75\pi/12) = 1171$
$f = f_r/N$. For 1/2 hole, $f = 2.35/1757 =$ **0.0013 in/rev**
For 3/4 hole, $f = 2.35/1171 =$ **0.0020 in/rev**

(c) Must use maximum Allowance for the 2 drills.
For 1/2 in hole, $A = 0.5D \tan(90 - \theta/2) = 0.5(0.50)\tan(90 - 118/2) = 0.150$ in
For 3/4 in hole, $A = 0.5D \tan(90 - \theta/2) = 0.5(0.75)\tan(90 - 118/2) = 0.225$ in
$T_m = (t + A)/f_r = (1.00 + 0.225)/2.35 =$ **0.522 min = 31.2 seconds**