

**PRAIRIE VIEW A&M UNIVERSITY
ROY G. PERRY COLLEGE OF ENGINEERING
DEPARTMENT OF MECHANICAL ENGINEERING
MCEG 3303 - Manufacturing Processes
FALL 2021**

- I. COURSE DESCRIPTION IN ABET FORMAT**
- II. ASSESSMENT RESULTS FOR CURRENT AND PAST THREE PERIODS**
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 - Original Test Questions & Master Solution/grading scheme used**
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 - Above Average (Graded original work)**
 - Average (Graded original work)**
 - Below Average (Graded original work)**
- IV. QUIZZES**
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 - Above Average (Graded original work)**
 - Average (Graded original work)**
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 - Average (Graded original work)**
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 - Project Problem Statement and Grading Scheme**
 - Above Average (Graded original work)**
 - Average (Graded original work)**
 - Below Average (Graded original work)**

[Include any other evaluation used and omit any method above method (Test, Quizzes, Homework, Laboratory and Project reports) that was not used]

Course Description in ABET Format

1. Course number and name:	MCEG 3303 MANUFACTURING PROCESSES
2. Credits and contact hours:	3 credit hours; 3 contact hours * Subject Area: Engineering Topics
3. Instructor's or course coordinator's name:	Dr. Lai Jiang
4. Text book:	
Title:	Fundamentals of Modern Manufacturing: Materials, Processes, and Systems
Author:	Groover, Mikell P.
Publisher, Year & Edition:	John Wiley & Sons Inc., New York, NY. 2016, 6 th Edition
a. Other Supplemental material	N/A
5. Specific course information	
a. Brief description of the content of the course (catalog description)	This course provides the concepts for the conversion of materials into products. It includes measurement and quality assurance, and processes of casting, forming, material removal, and joining. In addition, it involves the study of computer numerical control machines, manufacturing systems, and automation.
b. Prerequisites or Co-requisites	MCEG 2303, Materials Science and Engineering MCEG 3103, Manufacturing Processes Lab
c. ** Indicate whether a required, elective, or selected elective (as per definition provided) course in the program	Required
6. a. Specific goals for the course specific outcomes of instruction (e.g., The student will be able to explain the significance of current research about a particular topic.) <i>Students will be able to:</i>	b. Explicitly indicate which of the student outcomes listed in Criterion 3 or any other outcomes are addressed by the course. <i>The specific goals for the course specific outcomes listed on the left column will address the following student learning outcomes:</i>
1. Apply knowledge of different skills and techniques in the manufacturing of engineering products.	Outcome 2 An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factor (including use of the techniques, skills, and modern engineering tools necessary for engineering practice).
2. Analyze operational procedures required to manufacture a part.	

3. Use manufacturing literature and consult databases.

Outcome 4

An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

7 Brief list of topics to be covered

Introduction, Manufacturing Processes	(3 hours)
Mechanical Properties of Materials	(3 hours)
Dimensions, Surfaces, and their Measurement	(1.5 hours)
Metal Machining	(3 hours)
Machining Operations and Machine Tools	(3 hours)
Cutting-tool Technology	(3 hours)
NC Codes for CNC Milling	(3 hours)
Shaping Processes for Plastics	(3 Hours)
Rapid Prototyping	(3 hours)
Bulk Deformation Processes in Metal Working	(4.5 hours)
Sheet Metalworking	(3 hours)

* For all Engineering programs, indicate subject area from the following: **Math, Basic science, Engineering topic or Other**

** **Required** courses are required of all students in the program, **elective** courses (often referred to as open or free electives) are optional for students, and **selected elective** courses are those for which students must take one or more courses from a specified group

II ASSESSMENT RESULTS FOR CURRENT AND PAST THREE PERIODS

Program Outcomes Assessed in this course

Outcome 2:

An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global cultural, social, environmental, and economic factor.

Outcome 4:

An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.

Assessment Summary of Class Semester Averages for Outcomes (Should be provided for Spring 2020 through Fall 2021 Assessment Period)

Outcomes	2	4
Semester	Semester Class Average (%)	Semester Class Average (%)
Fall 2021		76.4
Spring 2021	70.9	
Spring 2020		66.4
Comments on Trend of Data (Improving or deteriorating)	The average for this outcome has been above 70% in the evaluation period.	The low average of this outcome was mainly due to the COVID-19 pandemic and the online education mode. The instructor emphasized the importance of technical writing skills and also how the project reports' grades can improve their overall grades. The problem has been be fixed, with the performance from Fall 2021 significantly improved.

*Expected Semester Class Average = 70% (or as defined by the program)

Ideal Semester Class Average = 75% (or as defined by the program)

End of Semester Course Assessment Reports Fall 2021 and Last Three Assessment Periods.

Each summary contains the following Information

1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class and the **two previous times course was assessed**.
- The acceptable class average for the class in each outcome area as set by your department.
- Percentage of students who scored below the expected average in each outcome.

2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve. Be creative.**

5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

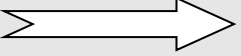
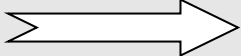
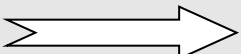
5. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer NO.

Table 2.1 END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT
MCEG 3303-Y01 MANUFACTURING PROCESSES
FALL 2021 SEMESTER

Report Prepared by: Dr. Lai Jiang

Report Date: Dec. 12, 2021

Semester	Analysis Type	Number of Students	Outcome 2 An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global cultural, social, environmental, and economic factor.			Outcome 4 An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgements, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.		
			Expected Average	Class Average	% Students Above Expected Average	Expected Average	Class Average	% Students Above Expected Average
Fall 2021	Direct	9				70	76.4	77.8
Spring 2021	Direct	19	70	70.9	37			
Spring 2020	Direct	25				70	66.4	45.5
Implementation Summary			1. Detailed Class slides were prepared from the textbook and made available through eCourses. 2. Similar example problems were solved in the lecture.			1. Related course materials were posted on eCourses. 2. Detailed project requirements were covered in class.		
Perceived Problems			1. The students' ability in understanding and utilizing the knowledge learned in class needs to be improved. 2. Some students can come up with a good design idea or topic, but cannot express those in a clear and logical manner.			1. Students had problems with the typical essay formats. 2. Students had problems with the citation format.		
Plans for Addressing Problems			1. Further enforce class attendances and make sure more students can practice with example problems. 2. Give students more design examples so they could refer to a good one and then proceed with their own design.			An example essay will be provided to students as a reference in following the right format.		
Overall Trend over Periods			Class average is above the expected average, but the % of students above expected average is too low.			There was a huge improvement in the students' performance comparing to the evaluation results obtained from Spring 2020.		
Were Expectations Met?	Average ≥ 70%? and ≥ 70% students above avg.?		NO			YES		

**MANUFACTURING PROCESSES
FALL 2021**

Title of Assignment: Midterm Exam

TOPICS COVERED

Chapter 1. Introduction

Chapter 3. Mechanical Properties of Materials

Chapter 5. Dimensions, Surfaces, and their Measurement

Chapter 10. Fundamentals of Metal Casting

Chapter 20. Metal Machining

Chapter 21. Machining Operations and Machine Tools

Chapter 22. Cutting-tool Technology

PRAIRIE VIEW A&M UNIVERSITY

Student Name (print): Solu

Total Grade:

Midterm Exam

MCEG 3303 – Y01

Fall 2021

11:00 am - 12:20 pm, 10/12/2021

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- By writing your name on the cover page you agree to all the articles mentioned above.

Part I: Short-answer Problems (10 questions, 62 pts)

1. (6 pts) What are the differences between consumer goods and capital goods? Give an example for each type of goods.

Ch. 1 Consumer goods: products purchased and used directly by consumers
toys.

Capital goods: those purchased by companies to produce goods and/or
provide services: aircraft, trains.

2. (6 pts) What are the differences between a "net shape" process and a "near net shape" process? Give an example for each process.

Ch. 1 Net shape processes: little or no waste of starting material and
no machining is required; milling, drilling, turning, investment cast

Near net shape processes: When additional machining is required

Sand casting. (1)

Ch. 5 3. (5 pts) The shaft $\varnothing 4^{+0.01}_{-0.01}$ and the hole $\varnothing 4^{+0.03}_{+0.00}$ are mating components. Determine what tolerance zone it is. Show your calculation process.

Clearance fit? $(4 + 0.00) - (4 + 0.01) = -0.01 < 0 \Rightarrow \text{No}$

Inter. fit? $(4 - 0.01) - (4 + 0.03) = -0.04 < 0 \Rightarrow \text{No}$

Transition fit? $(4 + 0.00) - (4 + 0.01) = -0.01 < 0$
 $(4 - 0.01) - (4 + 0.03) = -0.04 < 0 \Rightarrow \text{Yes.}$ (4)

Ch. 5 4. (6 pts) What are the four elements of surface texture? How can you separate waviness from roughness deviations when calculate the surface roughness?

Roughness, waviness, lay, flaws (4)

Set the cutoff length shorter than the waviness (2)

ch. 20

5. (6 pts) What are the different types of chips in actual chip formation? Under what situation will a BUE be formed?

1. Discontinuous chip, Continuous chip, Continuous chip w/ BUE,
2. serrated chip (4)
3. Ductile material, low to medium cutting speeds (2)
4. Serrated chip

ch. 21

6. (7 pts) Describe all the difference between "up milling" and "down milling". Also, which process is preferred in manufacturing and why?

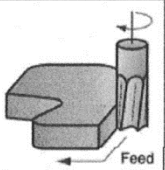
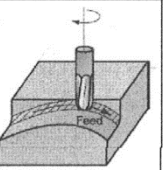
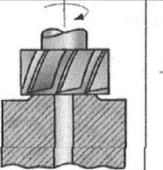
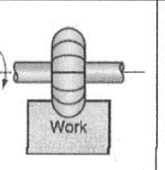
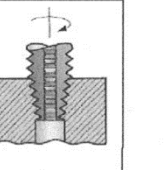
Up milling: milling "against the feed", longer chip - longer cutter engaged time, shorter tool life. (3)

Down milling: milling "with the feed" - shorter chip, shorter cutter engaged time, longer tool life, better surface finish. (3)

Down milling is preferred (1)

7. (10 pts) Specify the **classifications** of the following machining operations ("forming" or "generating" or "both").

ch. 21

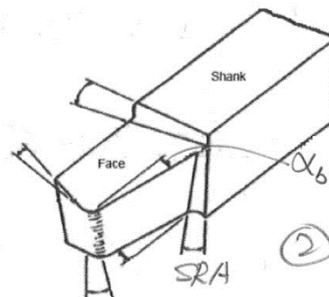
Picture of operation					
Classification of Machining	generating	generating	forming	forming	forming

8. (6 pts) Mark the locations of SR_A and α_b in the following 3D cutting tool figure. Also, describe the main functions of these two angles.

ch. 22

α_b : determine the direction of chip flow across the rake face (2)

SR_A : determine the amount of clearance between the tool and the freshly cut work surface (2)



Ch. 10

9. (4 pts) Why is the sprue in a sand-casting mold tapered? What will happen if it is not tapered?

To keep the volume flow rate constant ($Q = v \cdot A$) ②

If the cross section is fixed, air entrapment in liquid metal ②

Ch. 10
~ 11

10. (6 pts) What are the differences between expendable mold casting and permanent mold casting? Name an example process under each category.

Expendable: The mold must be destroyed to remove the casting

E.g. sand casting

Permanent: The mold can be reused to produce many castings

E.g. die casting, centrifugal casting.

Part II: Comprehensive Calculations and Design (2 problems, 38 pts)

1. (18 pts) An aluminum (tensile strength of 10,000 lb/in² and a shear strength of 30,000 lb/in²) bar with diameter = 5 in is reduced in a turning operation at a cutting speed of 250 ft/min. Feed = 0.01 in/rev and depth of cut = 0.15 in. The rake angle on the tool in the direction of chip flow = 10°. The cutting conditions result in a chip ratio of 0.45. Using the orthogonal model as an approximation of turning, determine (a) shear plane angle, (b) shear force, (c) cutting force and feed force, and (d) coefficient of friction between the tool and chip.

$$(a) \phi = \tan^{-1} \left(\frac{r \cdot \cos \alpha}{1 - r \cdot \cos \alpha} \right) = \tan^{-1} \left(\frac{0.52 \cdot \cos 13^\circ}{1 - 0.52 \cdot \cos 13^\circ} \right) = 29.8^\circ \quad (3)$$

$$(b) A_s = \frac{f_d \cdot w}{\sin \phi} = \frac{0.11 \times 0.12}{\sin 29.8^\circ} = 0.00265 \text{ in}^2 \quad (3)$$

$$F_s = A_s \cdot S = 0.00265 \times 45,000 = 119.3 \text{ lbf} \quad (2)$$

$$(c) \beta = 2 \times (45) + \alpha - 2\phi = 90 + 10 - 2 \times 29.8 = 43.3^\circ \quad (2)$$

$$F_c = \frac{F_s \cdot \cos(\beta - \alpha)}{\cos(\phi + \beta - \alpha)} = \frac{119.3 \cdot \cos(43.3^\circ - 13^\circ)}{\cos(29.8^\circ + 43.3^\circ - 13^\circ)} \quad (3)$$
$$= 207 \text{ lbf}$$

$$F_f = \frac{F_s \cdot \sin(\beta - \alpha)}{\cos(\phi + \beta - \alpha)} = \frac{119.3 \cdot \sin(43.3^\circ - 13^\circ)}{\cos(29.8^\circ + 43.3^\circ - 13^\circ)} \quad (3)$$
$$= 121 \text{ lbf}$$

$$(d) \mu = \tan \beta = \tan 43.3^\circ = 0.942 \quad (2)$$

2. (20 pts) Horizontal true centrifugal casting is used to make steel rings with length = 10 cm, outside diameter = 50 cm, and inside diameter = 45 cm. The density of cast iron = 7.0 g/cm³. (a) Determine the rotational speed that will provide a G-factor = 60. (b) Assume the ring is made from cast iron instead of steel. If the rotational speed computed in part (a) were used, determine the G-factor. (c) Determine the volume of molten metal that must be poured into the mold, given that the liquid shrinkage is 0.5%, solidification shrinkage = 3%, and solid contraction after freezing = 7.2%. (d) Pressure on the internal wall of the mold due to the centrifugal force if the density of steel is 7.87 g/cm³.

$$(a) N = \frac{30}{\pi} \cdot \sqrt{\frac{2g \cdot GF}{D}} = \frac{30}{\pi} \cdot \sqrt{\frac{2 \times 981 \times 60}{65}} = 406.4 \text{ rev/min} \quad (3)$$

$$(b) N = 406.4 \text{ rev/min} \quad (2)$$

$$(c) A = \pi \cdot D_o \cdot L = \pi \cdot 65 \cdot 5 = 1021 \text{ cm}^2 = 0.1021 \text{ m}^2 \quad (2)$$

$$V = \pi(R_o^2 - R_i^2) \cdot L = \pi \left[\left(\frac{65}{2}\right)^2 - \left(\frac{60}{2}\right)^2 \right] \times 5 = 2454.4 \text{ cm}^3 \quad (2)$$

$$\rho = 7.87 \text{ g/cm}^3$$

$$m = \rho V = 7.87 \times 2454.4 = 19,315.9 \text{ g} = 19.316 \text{ kg} \quad (2)$$

$$v = \pi D N = \pi \times \frac{65+60}{2} \times 406.4$$

$$= 79,796.45 \text{ cm/min} = 1329.9 \text{ cm/s} = 13.299 \text{ m/s} \quad (2)$$

$$F = \frac{m \cdot v^2}{R} = \frac{19.316 \times 13.299^2}{\frac{(65+60)}{4} / 100} = 10,932 \text{ N} \quad (2)$$

$$P = \frac{F}{A} = \frac{10932}{0.1021} = 107,079 \text{ Pa} \quad (2)$$

$$(d) V_o = \frac{V}{(1-0.005)(1-0.03)(1-0.072)} = \frac{2454.4}{0.8957} = 2740.2 \text{ cm}^3 \quad (3)$$

ABOVE AVERAGE

88

PRAIRIE VIEW A&M UNIVERSITY

Total Grade:

66

Student Name (print):

Ifeanyi Amushie

Midterm Exam

MCEG 3303 – Y01

Fall 2021

11:00 am - 12:20 pm, 10/12/2021

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Part I: Short-answer Problems (10 questions, 62 pts)

1. (6 pts) What are the differences between consumer goods and capital goods? Give an example for each of type of goods.

Consumer goods are products purchased + used directly by the consumer while capital goods are purchased by companies + used to produce goods + provide services.

Consumer Goods: cars

Capital Goods: trains

+6

chapter 1

2. (6 pts) What are the differences between a "net shape" process and a "near net shape" process? Give an example for each process.

Net Shape Processes have little to no waste from the starting material with no machining being required, while Near Net Shape Processes require additional machining.

Net Shape: Property-Enhancing Process

Near Net Shape: Material Removal Process

+4

chapter 5

3. (5 pts) The shaft $\varnothing 4^{+0.01}_{-0.01}$ and the hole $\varnothing 4^{+0.03}_{+0.00}$ are mating components. Determine what tolerance zone it is. Show your calculation process.

Transition Fit: accurate with slight clearance

+2

chapter 5

4. (6 pts) What are the four elements of surface texture? How can you separate waviness from roughness deviations when calculate the surface roughness?

Roughness, Waviness, Lay, + Flaws

+4

Chapter
20

5. (8 pts) What are the different types of chips in actual chip formation? Under what situation will a BUE be formed?

Discontinuous Chip, Continuous Chip, Continuous Chip with Built-Up Edge, + Serrated Chip (BUE)

BUE chips are formed when Ductile materials are cut with low-to-medium cutting speed where tool-chip friction causes portions of the chip to adhere to rake face

+6

Chapter
21

6. (7 pts) Describe all the difference between "up milling" and "down milling". Also, which process is preferred in manufacturing and why?

Up milling involves milling against the feed, while Down milling involves milling with the feed.

Down milling is preferred because it creates shorter chips, shorter cutting times, and leads to longer tool life as well as better surface finishes.

+7

Chapter
21

7. (10 pts) Specify the **classifications** of the following machining operations ("forming" or "generating" or "both").

Picture of operation					
Classification of Machining	Generating	Generating	Forming	Forming	Forming

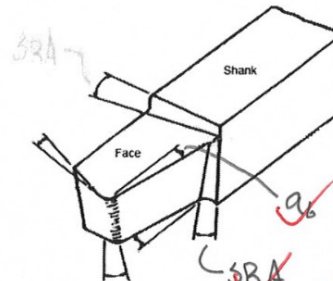
+10

Chapter
22

8. (6 pts) Mark the locations of SR_A and α_b in the following 3D cutting tool figure. Also, describe the main functions of these two angles.

SR_A (Side Relief Angle): determine the amount of clearance between the tool + the freshly cut work surface

α_b (Back Rake Angle): determine the direction of chip flow across the rake face



+6

9. (4 pts) Why is the sprue in a sand-casting mold tapered? What will happen if it is not tapered?

To minimize splash + turbulence as the ~~metal~~ flows into the mold. The metal will create air bubble as it is poured into the mold and splash everywhere

+2

10. (6 pts) What are the differences between expendable mold casting and permanent mold casting? Name an example process under each category.

In Expendable mold casting the mold is sacrificed in order to remove the part, while in Permanent mold casting the mold is made of metal and can be reused

Expendable Mold Casting: Sand Casting

Permanent Mold Casting: Die Casting

+6

Part II: Comprehensive Calculations and Design (2 problems, 38 pts)

1. (18 pts) An aluminum (tensile strength of 10,000 lb/in² and a shear strength of 30,000 lb/in²) bar with diameter = 5 in is reduced in a turning operation at a cutting speed of 250 ft/min. Feed = 0.01 in/rev and depth of cut = 0.15 in. The rake angle on the tool in the direction of chip flow = 10°. The cutting conditions result in a chip ratio of 0.45. Using the orthogonal model as an approximation of turning, determine (a) shear plane angle, (b) shear force, (c) cutting force and feed force, and (d) coefficient of friction between the tool and chip.

$$t_o = .01 \text{ in/rev}$$

$$r = \text{chip ratio} = .45$$

$$t_c = \text{chip thickness after cutting} \\ = \frac{t_o}{r} = \frac{.01}{.45} = .022 \text{ in}$$

a) ϕ = shear plane angle
 $\phi = \tan^{-1} \left(\frac{r \cos \alpha}{1 - r \sin \alpha} \right) \rightarrow \alpha = 10^\circ$
 $= \tan^{-1} \left(\frac{.45 \cos(10)}{1 - .45 \sin(10)} \right)$
 $= 25.68^\circ$ +3

b) $A_s = \frac{t_o (d)}{\sin \phi}$
 $= \frac{.01 (5)}{\sin(25.68)} = .1154$ +2

$$F_s = \text{Shear Force}$$

$$= A_s S$$

$$= .1154 (30000) = 3461.516$$
 +2

c) $F_c = \text{cutting force} \rightarrow \beta = 2(45 + \phi - \alpha)$
 $= \frac{F_s \cos(\beta - \alpha)}{\cos(\phi + \beta - \alpha)} = 48.64^\circ$ +2
 $= \frac{3461.5 \cos(48.64 - 10)}{\cos(25.68 + 48.64 - 10)}$ 2700.7
 $= 6254.216$ +3

d)

2. (20 pts) Horizontal true centrifugal casting is used to make steel rings with length = 10 cm, outside diameter = 50 cm, and inside diameter = 45 cm. The density of cast iron = 7.0 g/cm³. (a) Determine the rotational speed that will provide a G-factor = 60. (b) Assume the ring is made from cast iron instead of steel. If the rotational speed computed in part (a) were used, determine the G-factor. (c) Determine the volume of molten metal that must be poured into the mold, given that the liquid shrinkage is 0.5%, solidification shrinkage = 3%, and solid contraction after freezing = 7.2%. (d) Pressure on the internal wall of the mold due to the centrifugal force if the density of steel is 7.87 g/cm³.

$$a) N = \frac{30}{\pi} \sqrt{\frac{20^2}{R_i^2 + R_o^2}}$$

$$b) GF = \frac{v^2}{R_o} \quad +1$$

$$v = \frac{\pi R N}{30}$$

c)

AVERAGE

PRAIRIE VIEW A&M UNIVERSITY

Total Grade:

39.5

Student Name (print):

Devan Mitchell

Midterm Exam

MCEG 3303 – Y01

Fall 2021

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Part I: Short-answer Problems (10 questions, 62 pts)

1. (6 pts) What are the differences between consumer goods and capital goods? Give an example for each of type of goods.

Consumer goods is for the public / capital goods are for like companies
Ex consumer - cars, toys, TVs
Capital - Aircraft, trains

+6

2. (6 pts) What are the differences between a "net shape" process and a "near net shape" process? Give an example for each process.

Net Shape - little or no waste of the starting material.. Ex: molding

Near net shape - when additional machining is required
example?

+5

3. (5 pts) The shaft $\varnothing 4^{+0.01}_{-0.01}$ and the hole $\varnothing 4^{+0.03}_{+0.00}$ are mating components. Determine what tolerance zone it is. Show your calculation process.

Believe it would be in the transition fit tolerance zone due to the shaft being small enough and having enough clearance to enter the hole

+2

4. (6 pts) What are the four elements of surface texture? How can you separate waviness from roughness deviations when calculate the surface roughness?

Roughness, waviness, lay, Flaws. Waviness is the deviation of much larger spacing; where when you are calculating the surface roughness is based on characteristic

+4

5. (8 pts) What are the different types of chips in actual chip formation? Under what situation will a BUE be formed?

Discontinuous chip, Continuous chip, Continuous chip with Built-up edge, serrated chip. BUE is formed when particles are left on the new surface

+4

6. (7 pts) Describe all the difference between "up milling" and "down milling". Also, which process is preferred in manufacturing and why?

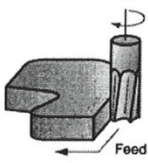
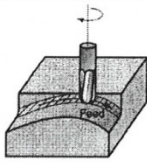
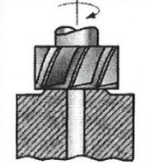
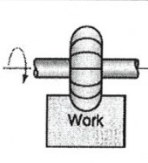
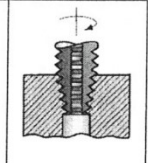
up milling: "against the feed" - longer chip, longer cutter engaged time, shorter tool life

down milling: "with the feed" - shorter chip, shorter cutter engaged time, longer tool life

+7

manufacturing prefer down milling because shorter time

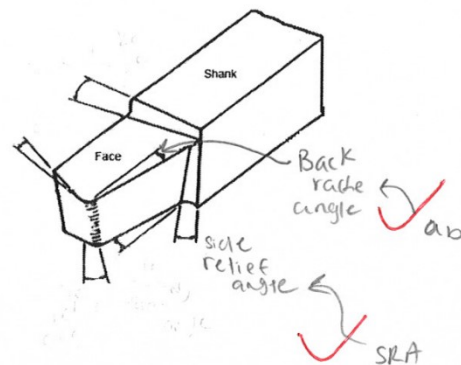
7. (10 pts) Specify the **classifications** of the following machining operations ("**forming**" or "**generating**" or "**both**").

Picture of operation					
Classification of Machining	forming	forming	generating	generating	Both

8. (6 pts) Mark the locations of SRA and α_b in the following 3D cutting tool figure. Also, describe the main functions of these two angles.

-determine the direction of chip flow across the rake face

+4.5



9. (4 pts) Why is the sprue in a sand-casting mold tapered? What will happen if it is not tapered?

In order to keep volume flow rate constant,
if not tapered / constant this can cause air
entrapment in liquid metal

+4

10. (6 pts) What are the differences between expendable mold casting and permanent mold casting? Name an example process under each category.

Expendable : mold is sacrificed to remove part

Permanent : mold is made of metal and can be
reused

+3

Part II: Comprehensive Calculations and Design (2 problems, 38 pts)

1. (18 pts) An aluminum (tensile strength of $10,000 \text{ lb/in}^2$ and a shear strength of $30,000 \text{ lb/in}^2$) bar with diameter = 5 in is reduced in a turning operation at a cutting speed of 250 ft/min . Feed = 0.01 in/rev and depth of cut = 0.15 in . The rake angle on the tool in the direction of chip flow = 10° . The cutting conditions result in a chip ratio of 0.45 . Using the orthogonal model as an approximation of turning, determine (a) shear plane angle, (b) shear force, (c) cutting force and feed force, and (d) coefficient of friction between the tool and chip.

2. (20 pts) Horizontal true centrifugal casting is used to make steel rings with length = 10 cm, outside diameter = 50 cm, and inside diameter = 45 cm. The density of cast iron = 7.0 g/cm^3 . (a) Determine the rotational speed that will provide a G-factor = 60. (b) Assume the ring is made from cast iron instead of steel. If the rotational speed computed in part (a) were used, determine the G-factor. (c) Determine the volume of molten metal that must be poured into the mold, given that the liquid shrinkage is 0.5%, solidification shrinkage = 3%, and solid contraction after freezing = 7.2%. (d) Pressure on the internal wall of the mold due to the centrifugal force if the density of steel is 7.87 g/cm^3 .

BELOW AVERAGE

PRAIRIE VIEW A&M UNIVERSITY

Total Grade: 28

Student Name (print): Caleb Tarver

Midterm Exam

MCEG 3303 – Y01

Fall 2021

11:00 am - 12:20 pm, 10/12/2021

Instructions:

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- By writing your name on the cover page you agree to all the articles mentioned above.

Part I: Short-answer Problems (10 questions, 62 pts)

1. (6 pts) What are the differences between consumer goods and capital goods? Give an example for each of type of goods.

The difference between consumer goods and capital goods is that consumer goods are not created or sold for the development of other things.
 a Basketball ← consumer
 and
 lathe ← capital goods

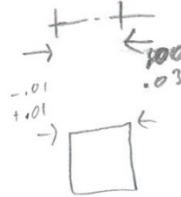
+3

2. (6 pts) What are the differences between a “net shape” process and a “near net shape” process? Give an example for each process.

Net shape is less precise than near shape

3. (5 pts) The shaft $\phi 4^{+0.01}_{-0.01}$ and the hole $\phi 4^{+0.03}_{+0.00}$ are mating components. Determine what tolerance zone it is. Show your calculation process.

Transition Fit
 because it is tight and has a slight clearance



$$\begin{array}{r} .01 \\ - .00 \\ \hline .01 \end{array} \text{ Part the opening of hole}$$

+2

4. (6 pts) What are the four elements of surface texture? How can you separate waviness from roughness deviations when calculate the surface roughness?

Roughness
 Waviness
 Lay
 Flaws

+4

Waviness and roughness can be separated because roughness is a material characteristic and much smaller / finely spaced

X 1

5. (8 pts) What are the different types of chips in actual chip formation? Under what situation will a BUE be formed?

Discontinuous
Continuous
Continuous chip with (BUE)
Serrated

It would need to be a ductile material, low to medium cutting speed, tool friction causes portions to adhere to rake.

+6

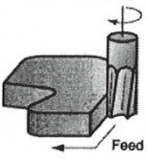
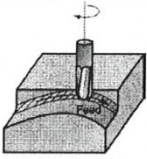
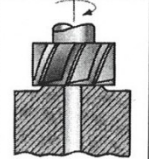
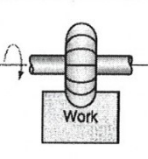
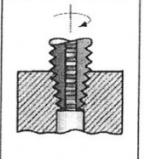
6. (7 pts) Describe all the difference between "up milling" and "down milling". Also, which process is preferred in manufacturing and why?

Up milling - longer chip, longer cutter engaged time, shorter tool life
"milling against the feed"

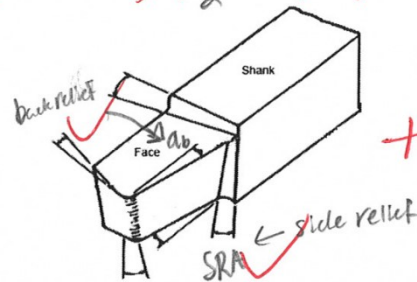
Down milling - milling "with the feed"
- shorter chip, shorter cutter engaged time, longer tool life, better finish

+6

7. (10 pts) Specify the **classifications** of the following machining operations ("forming" or "generating" or "both").

Picture of operation					
Classification of Machining	Profile Milling Forming	Surface Contouring Forming	Spot Facing generating	Form Milling generating	Tapping forming

8. (6 pts) Mark the locations of SRA and α_b in the following 3D cutting tool figure. Also, describe the main functions of these two angles.



+3

9. (4 pts) Why is the sprue in a sand-casting mold tapered? What will happen if it is not tapered?

The part will not come out well

10. (6 pts) What are the differences between expendable mold casting and permanent mold casting? Name an example process under each category.

Expendable - mold process: mold is sacrificed to remove part ✓
Permanent - mold - mold is made of metal and can be reused ✓

+3

Part II: Comprehensive Calculations and Design (2 problems, 38 pts)

1. (18 pts) An aluminum (tensile strength of 10,000 lb/in² and a shear strength of 30,000 lb/in²) bar with diameter = 5 in is reduced in a turning operation at a cutting speed of 250 ft/min. Feed = 0.01 in/rev and depth of cut = 0.15 in. The rake angle on the tool in the direction of chip flow = 10°. The cutting conditions result in a chip ratio of 0.45. Using the orthogonal model as an approximation of turning, determine (a) shear plane angle, (b) shear force, (c) cutting force and feed force, and (d) coefficient of friction between the tool and chip.

$$\bar{L} = \frac{F_s}{K_s}$$

$$45^\circ + \frac{\alpha}{2} + \frac{\beta}{2}$$

$$\phi = 45 + \frac{10^\circ}{2} - \frac{\beta}{2} \quad +1$$

2. (20 pts) Horizontal true centrifugal casting is used to make steel rings with length = 10 cm, outside diameter = 50 cm, and inside diameter = 45 cm. The density of cast iron = 7.0 g/cm^3 . (a) Determine the rotational speed that will provide a G-factor = 60. (b) Assume the ring is made from cast iron instead of steel. If the rotational speed computed in part (a) were used, determine the G-factor. (c) Determine the volume of molten metal that must be poured into the mold, given that the liquid shrinkage is 0.5%, solidification shrinkage = 3%, and solid contraction after freezing = 7.2%. (d) Pressure on the internal wall of the mold due to the centrifugal force if the density of steel is 7.87 g/cm^3 .

MANUFACTURING PROCESSES
Fall 2021

Title of Assignment: Final Exam

TOPICS COVERED IN FINAL EXAM

The Final Exam covered the following topics:

Chapter 11. Metal Casting and its Processes

NC Codes for CNC Milling

Chapters 9 & 14. Composite Materials and its Solidification Processes

Chapter 18. Bulk Deformation Processes in Metal Working

Chapter 19. Sheet Metalworking

Chapter 32. Rapid Prototyping

PRAIRIE VIEW A&M UNIVERSITY

Student Name (print): Solu

Total Grade:

Final Exam

MCEG 3303 – Y01
Manufacturing Processes
Fall 2021
11:00 am - 12:20 pm, 11/30/2021

Instructions:

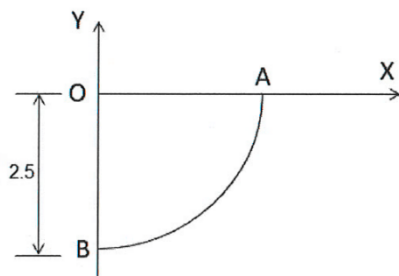
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- By writing your name on the cover page you agree to all the articles mentioned above.

Part I: Short-answer Problems (10 problems, 68 pts)

1. (7 pts) Specify the detailed meaning of the following CNC codes:

M03 S2000	Turn the spindle on CW at 2000 rpm
G43 H02	Activate tool length offset indicated by H02
T03 M06	Change the tool to Tool #3.
G91	Activate incremental coordinates

2. (7 pts) Write one block of code under both G90 and G91 conditions to cut an arc from point A (current location) to point B at a cutting speed of 3.0 in/min. Neither header nor footer is required, but the IJK method is required.



Under

G90: N010 G02 X0.0 Y-2.5 I-2.5 J0.0 F3.0

Under

G91: N010 G02 X-2.5 Y-2.5 I-2.5 J0.0 F3.0

3. (7 pts) What are the differences between hot-chamber die casting and cold-chamber die casting? Which of them can deal with metals with higher melting points? And why?

- ② Hot-chamber die casting: Metal is melted in a container, and a piston injects liquid metal under high pressure into the die.
- ② Cold-chamber die casting: Molten metal is poured into unheated chamber from external melting container, and a piston injects metal under high pressure (14 ~ 140 MPa) into die cavity.
- ① Cold-chamber die casting, because the chamber is not immersed into the molten metal. ②

4. (11 pts) What are the different types of starting materials used in rapid prototyping? Classify all additive manufacturing processes introduced in this course based on their starting materials types.

- Liquid-based: SL or SLA, and MP SL. *Mask projection Stereolithography (DLP)*
- Powder-based: SLS, 3DP
- Molten material: FDM, DDM
- Solid sheets: LDM.

5. (6 pts) What are the two different types of plastic materials? What is their difference?

1. Thermoplastics: ②

- Chemical structure remain unchanged during heating and shaping

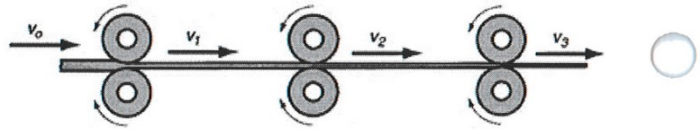
2. Thermosets: ②

- Undergo a curing process during heating and shaping, causing a permanent change in molecular structure, called cross-linking
- Once cured, they cannot be re-melted.

6. (6 pts) What is "die swell" in plastic extrusion? How do you cancel its effects while making round or square profiled parts?

- ② Die swell in extrusion - hot plastic expands when exiting the die opening (memory)
- ② Round profile: use an extrusion die with an orifice of a smaller diameter.
- ② Square profile: use an extrusion die with a diamond-shaped orifice.

7. (4 pts) What is the relationship among v_0 , v_1 , v_2 , and v_3 of the metal part being rolled on a tandem rolling mill? And why?



② $v_0 < v_1 < v_2 < v_3$

② Because the volume passing the cross-section of the gaps between each roller pair during a given time period are the same.

8. (7 pts) What are the different forging types introduced in this course? What are the functions of flash generated in forging?

③ Open-die forging, impression-die forging, and flashless forging.

Functions:

- (1) As flash forms, friction stops more metal from flowing into gap, constraining metal to fill die cavity.
- (2) In hot forging, metal flow is further restricted by the quick cooling down of thin flash against die plates.

9. (8 pts) What are the different types of extrusion processes introduced in this course? List three benefits for each type.

- ① • Hot extrusion = prior heating of billet to above its recrystallization temperature.
 - Reduces strength and increases ductility of the metal.
 - Allows more size reductions and more complex shapes.
 - Reduce ram force, increases ram speed.
- ② • Cold extrusion generally used to produce discrete parts.
 - Increase strength due to strain hardening.
 - Close tolerance - Improve surface finish - Absence of oxide layers.

10. (5 pts) What are the different tube bending processes introduced in this tube? What are the minimum bending radii required if a mandrel is or is not used? - High production rates.

Stretch bending, draw bending, compression bending.

Min. $R = 1.5D$ if a mandrel is used,
 $R = 3.0D$ if not.

Part II: Comprehensive Calculations (2 problems, 32 pts)

1. (12 pts) Continuous tubing is produced in a plastic extrusion operation through a die orifice whose outside diameter = 3 in and inside diameter = 2.4 in. The extruder barrel diameter = 6 in and length = 12 ft. The screw rotates at 30 rev/min; it has a channel depth = 0.2 in and flight angle = 15° . The head pressure has a value of 800 lb/in^2 and the viscosity of the polymer melt is $80 \times 10^{-4} \text{ lb-sec/in}^2$. A die swell ratio of 1.3 is observed in the extrudate. Under these conditions, determine: (a) the outside and inside diameters of the final tubing, (b) the resulting flow rate of plastic melt in the extruder and, (c) the production rate in length of tube.

$$(a) D_{ox} = D_{od} \cdot r_s = 3 \times 1.3 = 3.9 \text{ in.} \quad (1)$$

$$D_{ix} = D_{id} \cdot r_s = 2.4 \times 1.3 = 3.12 \text{ in} \quad (1)$$

$$(b) Q_d = 0.5 \pi^2 D^2 N \cdot d_c \cdot \sin A \cdot \cos A \\ = 0.5 \cdot \pi^2 \cdot 6^2 \cdot (30/60) \cdot 0.2 \cdot \sin 15^\circ \cdot \cos 15^\circ \\ = 4.441 \text{ in}^3/\text{sec} \quad (2)$$

$$Q_b = \frac{\pi \cdot D \cdot d_c^3 \cdot \sin^2 A}{12 \eta L} \\ = \frac{800 \pi \cdot 6 \cdot 0.2^3 \cdot \sin^2 15^\circ}{12 \times 80 \times 10^{-4} \times 12 \times 12} = 0.585 \text{ in}^3/\text{sec} \quad (2)$$

$$Q_x = Q_d - Q_b \\ = 4.441 - 0.585 = 3.856 \text{ in}^3/\text{sec} \quad (2)$$

$$(c) A_x = \frac{\pi}{4} (D_{ox}^2 - D_{ix}^2) \\ = \frac{\pi}{4} (3.9^2 - 3.12^2) = 4.301 \text{ in}^2 \quad (2)$$

$$V_x = \frac{Q_x}{A_x} = \frac{3.856}{4.301} = 0.897 \text{ in/sec} \\ = 53.792 \text{ in/min.} \\ = 4.483 \text{ ft/min.}$$

2. (20 pts) An indirect extrusion operation is performed on an aluminum billet with diameter = 3 in and length = 12 in. Final shape after extrusion is a rectangular cross section that is 1 in by 0.5 in. The aluminum has a strength coefficient = 26,000 lb/in² and strain-hardening exponent = 0.2. In the Johnson extrusion strain equation, $a = 0.8$ and $b = 1.3$. (a) Compute the extrusion ratio, true strain, and extrusion strain. (b) What is the shape factor of the extrudate? (c) If the butt left in the container at the end of the stroke is 0.5 in long, what is the length of the extruded section? (d) Determine the ram pressure in the process.

$$(a) A_0 = \frac{\pi}{4} \cdot D_0^2 = \frac{\pi}{4} \cdot 3^2 = 7.069 \text{ in}^2 \quad (1)$$

$$A_f = ab = 1 \times 0.5 = 0.5 \text{ in}^2 \quad (1)$$

$$r_x = \frac{A_0}{A_f} = \frac{7.069}{0.5} = 14.14 \quad (1)$$

$$\epsilon = \ln r_x = \ln 14.14 = 2.649 \quad (2)$$

$$\epsilon_x = a + b \ln r_x = 0.8 + 1.3 \times 2.649 = 4.243 \quad (2)$$

$$(b) C_x = (1 + 0.5) \times 2 = 3 \text{ in} \quad (1)$$

$$A_f = \pi R^2 \Rightarrow R = \sqrt{\frac{A_f}{\pi}} = \sqrt{\frac{0.5}{\pi}} = 0.3989$$

$$C_c = 2\pi R = 2\pi \cdot 0.3989 = 2.506 \text{ in} \quad (2)$$

$$K_x = 0.98 + 0.02 \left(\frac{C_x}{C_c} \right)^{2.25} = 0.98 + 0.02 \cdot \left(\frac{3}{2.506} \right)^{2.25} = 1.010 \quad (2)$$

$$(c) V_0 = \frac{\pi}{4} D_0^2 \cdot L_0 = \frac{\pi}{4} \times 3^2 \times 12 = 84.8 \text{ in}^3 \quad (1)$$

$$V_L = \frac{\pi}{4} D_0^2 \cdot L_L = \frac{\pi}{4} \times 3^2 \times 0.5 = 3.5 \text{ in}^3 \quad (1)$$

$$L_E = \frac{V_0 - V_L}{A_f} = \frac{84.8 - 3.5}{0.5} = 162.5 \text{ in} \quad (2)$$

$$(d) \bar{Y}_f = \frac{K \cdot \epsilon^n}{1+n} = \frac{26000 \times 2.649^{0.2}}{1+0.2} = 26,327.4 \text{ lb/in}^2 \quad (2)$$

$$p = K_x \cdot \bar{Y}_f \cdot \epsilon_x$$

$$= 1.010 \times 26,327.4 \times 4.243$$

$$= 112,824.4 \text{ psi} \quad (2)$$

ABOVE AVERAGE

PRAIRIE VIEW A&M UNIVERSITY

Student Name (print): Ifeanyi Amushie

Total Grade: 83

Final Exam

62.5

MCEG 3303 – Y01
Manufacturing Processes
Fall 2021
11:00 am - 12:20 pm, 11/30/2021

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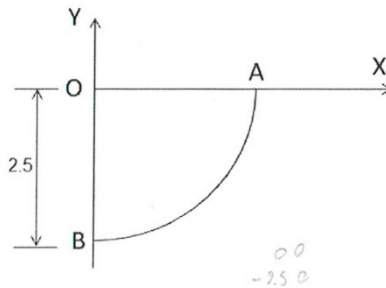
Part I: Short-answer Problems (10 problems, 68 pts)

1. (7 pts) Specify the detailed meaning of the following CNC codes:

M03 S2000	Turns the spindle on (CW) to 2000 RPM
G43 H02	Changes tool height + length offset
T03 M06	Change the tool to Tool # 3
G91	Changes all commands to incremental

+7

2. (7 pts) Write one block of code under both G90 and G91 conditions to cut an arc from point A (current location) to point B at a cutting speed of 3.0 in/min. Neither header nor footer is required, but the IJK method is required.



Under

G90: ~~G02~~ X0.0 Y-2.5 I-2.5 J0.0

Under

G91: ~~G02~~ X0.0 Y-2.5 I-2.5 J0.0

+4.5

chapter
11
SI: de 25

3. (7 pts) What are the differences between hot-chamber die casting and cold-chamber die casting? Which of them can deal with metals with higher melting points? And why?

Cold Chamber casting has molten metal injected into an unheated chamber while the hot chamber casting does the opposite.

Cold Chamber casting can deal with metals with higher melting points because the chamber won't reach the higher temps as fast allowing it to not break

+6

4. (11 pts) What are the different types of starting materials used in rapid prototyping? Classify all additive manufacturing processes introduced in this course based on their starting materials types.

Liquid Polymers, Powders, Molten Materials, + Solid Sheets.

Liquid Polymers: Stereolithography + Mask Projection Stereolithography

Powder-based: Selective laser sintering + three-dimensional printing

Molten Material: Fused deposition modeling + droplet deposition manufacturing

Solid Sheets: Laminated object manufacturing

+11

5. (6 pts) What are the two different types of plastic materials? What is their difference?

Thermoplastics + Thermosets

Thermoplastics experience no change in their chemical structure while heating, while thermosets undergo permanent change to their molecular structure when heated

+6

chapter
13

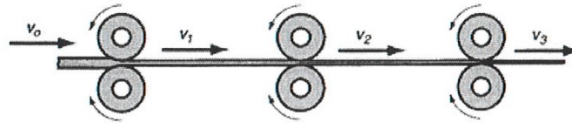
6. (6 pts) What is "die swell" in plastic extrusion? How do you cancel its effects while making round or square profiled parts?

A die swell is when hot plastics expand when exiting the die opening

+2

chapter
18

7. (4 pts) What is the relationship among v_0 , v_1 , v_2 , and v_3 of the metal part being rolled on a tandem rolling mill? And why?



$$\begin{aligned} v_1 &= \frac{1}{2} v_0 \\ v_2 &= \frac{1}{2} v_1 \\ v_3 &= \frac{1}{2} v_2 \end{aligned}$$

8. (7 pts) What are the different forging types introduced in this course? What are the functions of flash generated in forging?

Open-die Forging, Impression-die Forging, Flashless Forging

- As flash forms, friction stops more metal from flowing into gap constraining metal to fill die cavity

- In hot forging, metal flow is further restricted by the quick cooling down of thin flash against die plates

+ 7

chapter
18 slide
25

9. (8 pts) What are the different types of extrusion processes introduced in this course? List three benefits for each type.

Hot Extrusion: Allows more complex shapes, increases ductility of metal, allows more size reduction

Cold Extrusion: Improved surface finish, high production rates, absence of oxide layers

Direct Extrusion:

Indirect Extrusion

+ 8

10. (5 pts) What are the different tube bending processes introduced in this tube? What are the minimum bending radii required if a mandrel is or is not used?

Stretch Forming

Roll bending + forming

Spinning

High energy rate forming

+ 1

Part II: Comprehensive Calculations (2 problems, 32 pts)

1. (12 pts) Continuous tubing is produced in a plastic extrusion operation through a die orifice whose outside diameter = 3 in and inside diameter = 2.4 in. The extruder barrel diameter = 6 in and length = 12 ft. The screw rotates at 30 rev/min; it has a channel depth = 0.2 in and flight angle = 15° . The head pressure has a value of 800 lb/in^2 and the viscosity of the polymer melt is $80 \times 10^{-4} \text{ lb-sec/in}^2$. A die swell ratio of 1.3 is observed in the extrudate. Under these conditions, determine: (a) the outside and inside diameters of the final tubing, (b) the resulting flow rate of plastic melt in the extruder and, (c) the production rate in length of tube.

Flow rate

$$Q_d = .5 \pi^2 D^2 N d_c \sin A \cos A$$

$$.5 \pi^2 (6)^2 (30) (.2) \sin(15) \cos(15)$$

$$= 84.82$$

$$Q_b = \frac{P \pi D d_c^3 \sin^2 A}{12 \eta L}$$

$$= \frac{(800) \pi (6) (.2)^3 \sin^2(15)}{12 (80 \times 10^{-4}) (12 \times 12)}$$

$$= ?$$

$$Q_x = Q_d - Q_b$$

$$a) 1.3 = \frac{3}{d_o} \quad d_o = 2.31$$

$$1.3 = \frac{2.4}{d_i} \quad d_i = 1.85$$

+3

2. (20 pts) An indirect extrusion operation is performed on an aluminum billet with diameter = 3 in and length = 12 in. Final shape after extrusion is a rectangular cross section that is 1 in by 0.5 in. The aluminum has a strength coefficient = 26,000 lb/in² and strain-hardening exponent = 0.2. In the Johnson extrusion strain equation, $a = 0.8$ and $b = 1.3$. (a) Compute the extrusion ratio, true strain, and extrusion strain. (b) What is the shape factor of the extrudate? (c) If the butt left in the container at the end of the stroke is 0.5 in long, what is the length of the extruded section? (d) Determine the ram pressure in the process.



$$A_i = \frac{\pi D^2}{4} = \frac{\pi 3^2}{4} = 7.07 \text{ in}^2$$

$$A_f = l \times w = 1 \times .5 = .5 \text{ in}^2$$

$$\text{extrusion ratio} = \frac{A_i}{A_f} = \frac{7.07}{.5} = 14.14$$

true strain

$$\epsilon = \ln \left(\frac{\text{extrusion}}{\text{ratio}} \right) = \ln(14.14) = 2.65$$

extrusion strain

$$\epsilon_x = a + b \ln \left(\frac{\text{extrusion}}{\text{ratio}} \right) = .8 + 1.3 \ln(14.14) = 4.24$$

(+7)

AVERAGE

PRAIRIE VIEW A&M UNIVERSITY

Student Name (print): Christopher Munk

Total Grade: 69

Final Exam

42.5

MCEG 3303 – Y01
Manufacturing Processes
Fall 2021
11:00 am - 12:20 pm, 11/30/2021

Instructions:

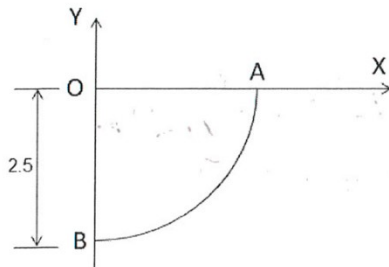
- Please stay on this page until you are asked to start the exam.
- Only the **assigned textbook and printed lecture slides** could be used in the exam. Any other types of written materials, such as homework, quizzes, and handouts from another course are not allowed.
- Make sure to write your answers clearly. Any unreadable answers will result in zero credit.
- Cell phones, iPads, smart watches, and any other electronic devices should be **turned off and put away** during the exam. Only pens, pencils, rulers, erasers and calculators could be used.
- You are not allowed to leave the classroom during the exam without the permission of the instructor.
- Academic dishonesty of any sort (plagiarism, cheating, fabrication or facilitation) is prohibited under any circumstance. Any detected actions of dishonesty will cause a 0 credit of the exam directly.
- By writing your name on the cover page you agree to all the articles mentioned above.

Part I: Short-answer Problems (10 problems, 68 pts)

1. (7 pts) Specify the detailed meaning of the following CNC codes:

M03 S2000	Spindle ON clockwise Spindle Speed designation
G43 H02	tool length off set + enable
T03 M06	tool designation tool change
G91	Makes all subsequent demands incremental

2. (7 pts) Write one block of code under both G90 and G91 conditions to cut an arc from point A (current location) to point B at a cutting speed of 3.0 in/min. Neither header nor footer is required, but the IJK method is required.



Under G90: N100 G90 X0.0 Y2.5

Under G91: N110 G91 X0.0 Y2.5

3. (7 pts) What are the differences between hot-chamber die casting and cold-chamber die casting? Which of them can deal with metals with higher melting points? And why?

In hot chamber die casting:
Plunger forces metal in chamber to flow into the die maintaining pressure during cooling & solidification. ventholes are made. Plunger is withdrawn die opened and cycle has high production rate.

Cold chamber die casting has higher melting point. It is poured in unheated chamber from external container. Pressure ejects metal under high pressure.

4. (11 pts) What are the different types of starting materials used in rapid prototyping? Classify all additive manufacturing processes introduced in this course based on their starting materials types.

liquids polymers
powders sintered
molten materials

Solid sheets

additive manufacturing process covered is liquid based
stereolithography, powder based (selective laser sintering SLS) molten materials
FDM & DPM, Solid sheets (LOM) & 3D printing

5. (6 pts) What are the two different types of plastic materials? What is their difference?

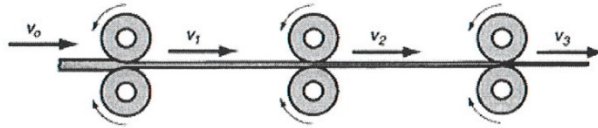
Thermoplastics - chemical structure remains unchanged during heating

Thermosets - undergo curing process during heating & shaping, causes permanent change in molecular structure

6. (6 pts) What is "die swell" in plastic extrusion? How do you cancel its effects while making round or square profiled parts?

This is used for hollowing and shaping plastic products

7. (4 pts) What is the relationship among v_0 , v_1 , v_2 , and v_3 of the metal part being rolled on a tandem rolling mill? And why?



v_0 shows direction
 v_1 moves clockwise
 v_2 moves clockwise
 $v_3 =$ clockwise this is to move v_0 in forward direction

8. (7 pts) What are the different forging types introduced in this course? What are the functions of flash generated in forging?

Open die forging -
 work compressed between 2 flat dies along metal
 to flow laterally
 impression die - contains cavity or impression
 that is imparted to workpiece

+2

9. (8 pts) What are the different types of extrusion processes introduced in this course? List three benefits for each type.

There is direct vs indirect
 hot vs cold direct advantage variety of shapes in
 hot extrusion Close tolerances in cold extrusion
 in hot extrusion Allows more size reduction, run speed
 Cold high production rate, absence of oxide layers
 direct gives perfect hollow shapes/multiple shapes

+5

+7

10. (5 pts) What are the different tube bending processes introduced in this tube? What are the minimum bending radii required if a mandrel is or is not used?

There multiple ways of bending tubes: Compression, Draw
 minimum bending radii is $R = 3.0D$ if not used
 $R = 1.5D$ if mandrel used

+4

Part II: Comprehensive Calculations (2 problems, 32 pts)

1. (12 pts) Continuous tubing is produced in a plastic extrusion operation through a die orifice whose outside diameter = 3 in and inside diameter = 2.4 in. The extruder barrel diameter = 6 in and length = 12 ft. The screw rotates at 30 rev/min; it has a channel depth = 0.2 in and flight angle = 15° . The head pressure has a value of 800 lb/in² and the viscosity of the polymer melt is 80×10^{-4} lb-sec/in². A die swell ratio of 1.3 is observed in the extrudate. Under these conditions, determine: (a) the outside and inside diameters of the final tubing, (b) the resulting flow rate of plastic melt in the extruder and, (c) the production rate in length of tube.

$$T_{wall} \frac{A_{wall}}{V_D} + T_R$$

0

2. (20 pts) An indirect extrusion operation is performed on an aluminum billet with diameter = 3 in and length = 12 in. Final shape after extrusion is a rectangular cross section that is 1 in by 0.5 in. The aluminum has a strength coefficient = 26,000 lb/in² and strain-hardening exponent = 0.2. In the Johnson extrusion strain equation, $a = 0.8$ and $b = 1.3$. (a) Compute the extrusion ratio, true strain, and extrusion strain. (b) What is the shape factor of the extrudate? (c) If the butt left in the container at the end of the stroke is 0.5 in long, what is the length of the extruded section? (d) Determine the ram pressure in the process.

$$r = \frac{A_0}{A_f} = \frac{3^2}{1 \times 0.5} = 0.8515 \text{ in}^2$$

ram pressure

$$P = Y_F \left(E \epsilon + \frac{2L}{D} \right)$$

$$Y_F = \frac{K E^n}{1+n} \quad +1$$

True strain

$$E = a + b \ln(r) \quad +1$$

$$(0.8 + 1.3 \ln(0.8515))$$

$$2.11 \ln(0.8515) = 2.92$$

$$P = 0.25 \left(2.92 + \frac{2(12)}{3} \right)$$

$$0.25 \left(2.92 + 8 \right) = 2.73$$

(+2)

BELOW AVERAGE

PRAIRIE VIEW A&M UNIVERSITY

Student Name (print): John Agboela

Total Grade: 46

Final Exam

18.

MCEG 3303 – Y01
Manufacturing Processes
Fall 2021
11:00 am - 12:20 pm, 11/30/2021

Instructions:

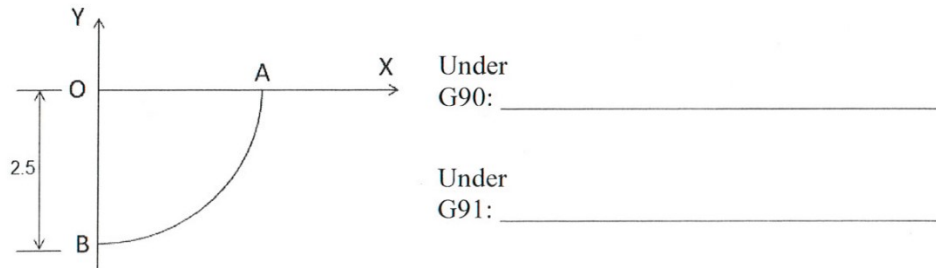
- Please stay on this page until you are asked to start the exam.
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- Make sure to write your answers clearly. Any unreadable answers will result in zero credit.
- Cell phones, iPads, smart watches, and any other electronic devices should be **turned off and put away** during the exam. Only pens, pencils, rulers, erasers and calculators could be used.
- You are not allowed to leave the classroom during the exam without the permission of the instructor.
- Academic dishonesty of any sort (plagiarism, cheating, fabrication or facilitation) is prohibited under any circumstance. Any detected actions of dishonesty will cause a 0 credit of the exam directly.
- By writing your name on the cover page you agree to all the articles mentioned above.

Part I: Short-answer Problems (10 problems, 68 pts)

1. (7 pts) Specify the detailed meaning of the following CNC codes:

M03 S2000	
G43 H02	
T03 M06	
G91	

2. (7 pts) Write one block of code under both G90 and G91 conditions to cut an arc from point A (current location) to point B at a cutting speed of 3.0 in/min. Neither header nor footer is required, but the IJK method is required.



3. (7 pts) What are the differences between hot-chamber die casting and cold-chamber die casting? Which of them can deal with metals with higher melting points? And why?

FD

4. (11 pts) What are the different types of starting materials used in rapid prototyping?
Classify all additive manufacturing processes introduced in this course based on their starting materials types.

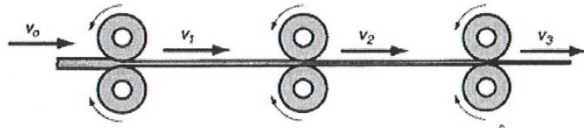
Traditional method → machining, requires significant lead times - weeks depending on part complexity and difficulty
Liquid Polymers → Cured layer by layer into solid polymers
Powders sintered or bonded layer by layer
molten materials solidified Cold welded layer by layer
Solid sheets bonded to create the solid part +4

5. (6 pts) What are the two different types of plastic materials? What is their difference?

* Thermoplastics
Chemical structure remains unchanged during heating and shaping while
* Thermosets
undergo a curing process during heating and shaping causing a permanent change in molecular structure called cross-linking +6

6. (6 pts) What is "die swell" in plastic extrusion? How do you cancel its effects while making round or square profiled parts?

7. (4 pts) What is the relationship among v_0 , v_1 , v_2 , and v_3 of the metal part being rolled on a tandem rolling mill? And why?



The relationship among v_0 , v_1 , v_2 and v_3 of the metal part being rolled are ~~are~~ $v_0 = v_1 = v_2 = v_3$

8. (7 pts) What are the different forging types introduced in this course? What are the functions of flash generated in forging?

Open die ~~forging~~

Impression ~~die forging~~

Flashless ~~forging~~

+3

Work is completely constrained in die, no excess flash is created. Compression of work in punch and die tooling whose cavity does not allow for flash

9. (8 pts) What are the different types of extrusion processes introduced in this course?

List three benefits for each type.

Direct ~~and~~ indirect

Hot vs cold

Hot - Allows more size reductions of complex shapes

- Reduces ram force, increases ram speed

- Reduces strength and increase ductility of the metal

+5

10. (5 pts) What are the different tube bending processes introduced in this tube? What are the minimum bending radii required if a mandrel is or is not used?

Part II: Comprehensive Calculations (2 problems, 32 pts)

1. (12 pts) Continuous tubing is produced in a plastic extrusion operation through a die orifice whose outside diameter = 3 in and inside diameter = 2.4 in. The extruder barrel diameter = 6 in and length = 12 ft. The screw rotates at 30 rev/min; it has a channel depth = 0.2 in and flight angle = 15° . The head pressure has a value of 800 lb/in^2 and the viscosity of the polymer melt is $80 \times 10^{-4} \text{ lb-sec/in}^2$. A die swell ratio of 1.3 is observed in the extrudate. Under these conditions, determine: (a) the outside and inside diameters of the final tubing, (b) the resulting flow rate of plastic melt in the extruder and, (c) the production rate in length of tube.

$$d_o = 3 \text{ in}$$

$$\text{in dia} = 2.4 \text{ in}$$

$$\text{extru diam} = 6 \text{ in}$$

$$L = 12 \text{ ft}$$

$$\text{rotate} = 30 \text{ rev/min} = \text{depth} = 0.2$$

$$P_1 = 800 \text{ lb/in}^2$$

$$\mu = 80 \times 10^{-4} \text{ lb-sec/in}^2$$

$$r = 1.3$$

$$\tan \theta = \frac{P}{\pi D}$$

$$\tan^{-1} ($$

0.

2. (20 pts) An indirect extrusion operation is performed on an aluminum billet with diameter = 3 in and length = 12 in. Final shape after extrusion is a rectangular cross section that is 1 in by 0.5 in. The aluminum has a strength coefficient = 26,000 lb/in² and strain-hardening exponent = 0.2. In the Johnson extrusion strain equation, $a = 0.8$ and $b = 1.3$. (a) Compute the extrusion ratio, true strain, and extrusion strain. (b) What is the shape factor of the extrudate? (c) If the butt left in the container at the end of the stroke is 0.5 in long, what is the length of the extruded section? (d) Determine the ram pressure in the process.

**MANUFACTURING PROCESSES
FALL 2021**

Title of Assignment: Quiz 1

TOPICS COVERED IN QUIZ 1

Chapters 1, 3, 5

Quiz 1 Solutions

1. What are the definitions of the three classifications of manufacturing industries? Give an example of each of them.

Primary Industries: cultivate and exploit natural resources

ex) Agriculture

Secondary Industries: take the outputs of the primary industries and convert them into consumer goods

ex) Electronics manufacturing

Tertiary Industries: constitute the service sector

ex) Banking services

2. What are the different plant layouts introduced in this course? What production quantities can they be implemented, respectively?

Fixed-position plant layout: good for low production quantity

Processes plant layout: good for medium to high production quantities

Cellular plant layout: good for medium to high production quantities

Product plant layout: good for high production quantity

3. What is the definition of the viscosity of a fluid? And how to you determine whether a fluid is Newtonian?

Viscosity is the fluid's resistance to flow. It is a measure of internal friction when velocity gradients are present in the fluid.

When the fluid's viscosity is a constant.

4. What is tolerance stack-up? How to you avoid this phenomenon in creating an engineering drawing?

The cumulative effect of individual tolerances on specified dimensions. Using *Baseline dimensioning* minimizes large tolerance stack-up

ABOVE AVERAGE

Quiz 1 Results for Aniya Facion

Score for this attempt: **38.5** out of 40

Submitted Sep 17 at 11:32pm

This attempt took 19 minutes.

Question 1

Question Score / 10 pts

What are the definitions of the three classifications of manufacturing industries? Give an example of each of them.

Your Answer:

The three classifications of manufacturing industries are: Primary, Secondary and Tertiary.

Primary are things that are farmed or mined, like fishing and quarries. Secondary are things you can buy commercially or good for commercial use, like electronics and textiles. Lastly, tertiary are services, like education and tourism.

Question 2

Question Score / 10 pts

What are the different plant layouts introduced in this course? What production quantities can they be implemented, respectively?

Your Answer:

There are 4 types of plant layouts introduced in this course. Fixed-position plant layout, this implement slow production of 1~100/yr. Process plant layouts and cellular plant layouts and applications that can be used for medium production of 100~10,000/yr. Production plant layout is implied when a high production rate of 10,000~1,000,000 and up/yr is the goal.

Question 3

Question Score / 10 pts

What is the definition of the viscosity of a fluid? And how to you determine whether a fluid is Newtonian?

Your Answer:

Viscosity is a measure of internal frictions when velocity gradients are present in the fluid. When a fluid is not affected by its flow rate and remains constant, that it is Newtonian.

Question 4

Question Score / 10 pts

What is tolerance stack-up? How to you avoid this phenomenon in creating an

engineering drawing?

Your Answer:

Tolerance stack up is the combined effect of individual tolerances on specified dimensions. To help avoid this, baseline dimensioning minimizes the chance of large tolerance stack-ups.

AVERAGE

Quiz 1 Results for Rickya Jones

Score for this attempt: **27.5** out of 40

Submitted Sep 17 at 10:53pm

This attempt took 20 minutes.

Question 1

Question Score / 10 pts

What are the definitions of the three classifications of manufacturing industries? Give an example of each of them.

Your Answer:

Primary Industry: Cultivate and exploit natural resources

Example: Mining

Secondary Industry: Take the outputs of the primary industry and convert them into consumer and capital good

Example: Wood and Furniture

Tertiary Industry: Service Industry

Example: Real Estate

Question 2

Question Score / 10 pts

What are the different plant layouts introduced in this course? What production quantities can they be implemented, respectively?

Your Answer:

Process Plant Layout: They have a batch production. This means that they do medium to hard product variety and require setups between batches.

Cellular Plant Layout: They have cellular manufacturing. This means that they do soft product variety and do not need setups because the worker cells are organized to process parts between different part styles.

Question 3

Question Score / 10 pts

What is the definition of the viscosity of a fluid? And how to you determine whether a fluid is Newtonian?

Your Answer:

Viscosity: Fluid's resistance to flow

You can determine if a fluid is Newtonian if the viscosity is constant.

Question 4

Question Score / 10 pts

What is tolerance stack-up? How to you avoid this phenomenon in creating an engineering drawing?

Your Answer:

Tolerance Stack-up: The cumulative effect of individual tolerances on specified dimensions

BELOW AVERAGE

Quiz 1 Results for Devan Mitchell

Score for this attempt: **23** out of 40

Submitted Sep 19 at 10:04am

This attempt took 17 minutes.

Question 1

Question Score / 10 pts

What are the definitions of the three classifications of manufacturing industries? Give an example of each of them.

Your Answer:

Primary: Mining, Agriculture

Secondary: Converting the output of primary industries into consumer and capital goods

Tertiary: Service industry

Question 2

Question Score / 10 pts

What are the different plant layouts introduced in this course? What production quantities can they be implemented, respectively?

Your Answer:

I am not sure what the question means but I would assume that it is referring to real plant life as you introduce in the lecture on the first class meeting as in cutting wood down and taking it through the manufacturing process to make a wood table so it could also do the same about wheat and taking it through the manufacturing process and making bread for consumers

Question 3

Question Score / 10 pts

What is the definition of the viscosity of a fluid? And how to you determine whether a fluid is Newtonian?

Your Answer:

Viscosity: Measurement of the shear stress of a fluid. You know a fluid is Newtonian fluid because the viscosity is not affected by the shear rate

Question 4

Question Score / 10 pts

What is tolerance stack-up? How to you avoid this phenomenon in creating an

engineering drawing?

Your Answer:

Tolerance stack-up is the process of adding tolerances together before manufacturing in order to understand their cumulative effect on part production. Also, you can use Baseline dimensioning to prevent excessive tolerance stack

MANUFACTURING PROCESSES
Fall 2021

Title of Assignment: Quiz 2

TOPICS COVERED

Chapters 20, 21

Quiz 2 Solutions

1. Please list the names of the three most important machining operations. What classifications of cutting tools do they use, respectively?

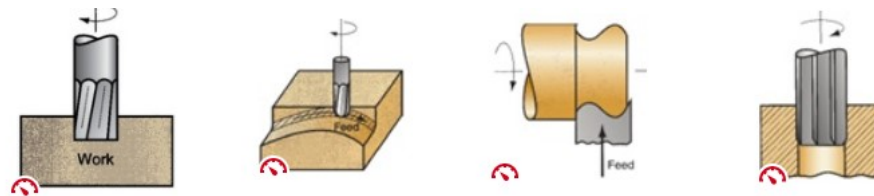
- Turning: Single-Point Tools
- Drilling: Multiple Cutting Edge Tools
- Milling: Multiple Cutting Edge Tools

2. In the orthogonal cutting model, what are the equivalent parameters of cutting feed and cutting depth in a turning operation, respectively?

Chip thickness before cut and Width of cut.

3.

Picture of Machining Process



Name of the machining process	End milling	Surface contouring	Form turning	Reaming
-------------------------------	-------------	--------------------	--------------	---------

4. How can external threads be produced? List three different methods.

- Single-point thread cutting (lathe)
- Threading dies
- Self-opening threading dies
- Thread milling
- Thread rolling

ABOVE AVERAGE

Quiz 2 Results for Aniya Facion

Score for this quiz: 40 out of 40

Submitted Oct 1 at 11:43pm

This attempt took 15 minutes.

Question 1

Question Score / 10 pts

Please list the names of the three most important machining operations. What classifications of cutting tools do they use, respectively?

Your Answer:

There are three important machining operations:

1) Turning- This is a single point cutting tool that removes materials from a rotating workpart to form a cylindrical shape.

2) Drilling- This is used to create a round hole, usually by means of a rotating tool (drill bit) with two cutting edges.

3) Milling- This is when rotating multiple-cutting-edge tools are moved across work to cut a plane or straight surface. There are two forms.

Question 2

Question Score / 10 pts

In the orthogonal cutting model, what are the equivalent parameters of cutting feed and cutting depth in a turning operation, respectively?

Your Answer:

Feed (f) = Chip thickness before cut (t_o)

Depth (d) = Width of cut (w)

Question 3

Question Score / 10 pts

Picture of
Machining
Process

Name of the machining Process 1. _____ 2. _____ 3. _____ 4. _____

Your Answer:

1) End Milling

2) Surface Contouring

3) Form turning

4) Reaming

Question 4

Question Score / 10 pts

How can external threads be produced? List three different methods.

Your Answer:

External threads can be produced by:

1) Self-opening threading dies

2) Threading die

3) Single-point thread cutting tool (Lathe)

AVERAGE

Quiz 2 Results for Caleb Tarver

Score for this quiz: 27.5 out of 40

Submitted Oct 1 at 11:49pm

This attempt took 17 minutes.

Question 1

Question Score / 10 pts

Please list the names of the three most important machining operations. What classifications of cutting tools do they use, respectively?

Your Answer:

Turning - Single point tools

Drilling- Multiple Cutting edge tools

Milling - Multiple cutting edge tools

Question 2

Question Score / 10 pts

In the orthogonal cutting model, what are the equivalent parameters of cutting feed and cutting depth in a turning operation, respectively?

Your Answer:

secondary motion

penetration of tool below original work surface

Question 3

Question Score / 10 pts

Picture of
Machining
Process

Name of the
machining
Process

1. _____ 2. _____ 3. _____ 4. _____

Your Answer:

1. Conventional face milling
2. Surface contouring
3. Form turning
4. reaming

Question 4

Question Score / 10 pts

How can external threads be produced? List three different methods.

Your Answer:

Single-point thread cutting (lathe)

Threading die

Thread milling

BELOW AVERAGE

Quiz 2 Results for Nassr Jawad

Score for this quiz: 20 out of 40

Submitted Oct 1 at 6:14pm

This attempt took 20 minutes.

Question 1

Question Score / 10 pts

Please list the names of the three most important machining operations. What classifications of cutting tools do they use, respectively?

Your Answer:

1-turning

2-drilling

3-milling

Turning uses single point tools

Drilling and milling use rotating multiple cutting edge tools

Question 2

Question Score / 10 pts

In the orthogonal cutting model, what are the equivalent parameters of cutting feed and cutting depth in a turning operation, respectively?

Your Answer:

cutting feed = f

depth = d

Question 3

Question Score / 10 pts

Picture of
Machining
Process

Name of the
machining
Process

1. _____ 2. _____ 3. _____ 4. _____

Your Answer:

1-

2-mill

3-chamferring

4-turning

Question 4

Question Score / 10 pts

How can external threads be produced? List three different methods.

Your Answer:

External threads are made with the help of a threading die or die-stock

methods are:

Single point thread cutting (lathe)

Threading die

Self opening threading dies

**MANUFACTURING PROCESSES
FALL 2021**

Title of Assignment: Quiz 3

TOPICS COVERED

Chapters 22, 10, 11

Quiz 3 Solutions

1. What are the different tool wear regions in the service life of a cutting tool? And what are the different factors that accelerate the wear rate of a cutting tool?

- Break-in Period: sharp cutting edge wears rapidly at the beginning of its use (first few minutes)
- Steady-state Wear Region: tool wear occurs at a fairly uniform rate
- Failure Region: wear rate begins to accelerate again

Factors increase the wear rate:

- Increased hardness of work materials
- Increased cutting speed (most important)
- Increased cutting feed
- Increased cutting depth

2. What are the two main categories of metal casting processes, and how are they different from each other? Give an example casting process for each category.

Expendable mold processes – the mold must be destroyed to remove the casting: sand casting, shell molding, investment casting, etc.

Permanent mold processes – the mold can be reused to produce many castings: die casting, centrifugal casting, etc.

3. What is a riser in a sand mold? How can you classify risers in two different ways?

Reservoir in the mold which is a source of liquid metal to compensate for shrinkage of the part during solidification. Sider riser and top riser or open riser and blind riser.

4. What are the different types of molds used in sand casting? What are their characteristics, respectively?

Green-sand mold, dry-sand mold, and skin-dried mold.

ABOVE AVERAGE

Quiz 3 Results for Nassr Jawad

Score for this quiz: 40 out of 40

Submitted Oct 15 at 1:51pm

This attempt took 19 minutes.

Question 1

Question Score / 10 pts

What are the different tool wear regions in the service life of a cutting tool? And what are the different factors that accelerate the wear rate of a cutting tool?

Your Answer:

1-Break in Period

2-Steady state Wear Region

3-Failure Region

The Factors that increase the wear rate

-Increased hardness of work materials

-Increased cutting speed (most

-Increased cutting feed

-Increased cutting depth

Question 2

Question Score / 10 pts

What are the two main categories of metal casting processes, and how are they different from each other? Give an example casting process for each category.

Your Answer:

1-Expendable mold processes: mold is sacrificed to remove part

eg: shell modeling

2-Permanent mold processes: mold is made of metal and can be reused

eg: Die casting

Question 3

Question Score / 10 pts

What is a riser in a sand mold? How can you classify risers in two different ways?

Your Answer:

Riser: is a Reservoir in the mold which is a source of liquid metal to compensate for shrinkage of the part during solidification

classify riser

Side riser: Attached to the side of casting through a channel

Top riser: Connected to the top surface of the casting

or

Open riser: Exposed to the outside at the top surface of cope

Blind riser: Entirely enclosed within the mold.

Question 4

Question Score / 10 pts

What are the different types of mold used in sand casting? What are their characteristics, respectively?

Your Answer:

1- Green sand mold: its characteristic

a mixture of sand, clay, and water

“Green” means mold contains moisture at the time of pouring

Moisture causes defects in some castings

2- Dry sand mold: its characteristic

organic binders rather than clay

Mold is baked in the oven to improve strength

More expensive, reduced production rate

3- Skin dried mold: its characteristic

drying mold cavity surface of a
green sand mold to a depth of 10 ~ 25 mm, using torches
or heating lamps

AVERAGE

Quiz 3 Results for Devan Mitchell

Score for this quiz: 32 out of 40

Submitted Oct 15 at 8:59pm

This attempt took 14 minutes.

Question 1

Question Score / 10 pts

What are the different tool wear regions in the service life of a cutting tool? And what are the different factors that accelerate the wear rate of a cutting tool?

Your Answer:

Break-in Period: Sharp cutting edge wears rapidly at the beginning of its use

Steady-state Wear Region: Tool wear occurs at a fairly uniform rate

Failure Region: Wear rate begins to accelerate again (Temperature Failure)

Question 2

Question Score / 10 pts

What are the two main categories of metal casting processes, and how are they different from each other? Give an example casting process for each category.

Your Answer:

Expendable Mold Processes- The mold must be destroyed to remove the casting. Ex. sand, plaster

Permanent Mold Processes- The mold can be reused to produce many casting. Ex. a ceramic refractory material

Question 3

Question Score / 10 pts

What is a riser in a sand mold? How can you classify risers in two different ways?

Your Answer:

The riser must be designed to freeze after the main casting in order to satisfy its function:

Side (Attached to the side of casting through a channel) or Top (Connected to the top surface of the casting) Riser or Open (Exposed to the outside at the top surface of cope) or Blind (Entirely enclosed within the mold) Risers

Question 4

Question Score / 10 pts

What are the different types of mold used in sand casting? What are their characteristics, respectively?
Your Answer:

Green-sand mold: a mixture of sand, clay, and water

Dry-sand mold: organic binders rather than clay

Skin-dried mold: drying mold cavity surface of a green-sand mold to a depth of 10 ~ 25 mm, using torches or heating lamps

BELOW AVERAGE

Quiz 3 Results for Idris Agboola

Score for this quiz: 22 out of 40

Submitted Oct 15 at 9:52pm

This attempt took 20 minutes.

Question 1

Question Score / 10 pts

What are the different tool wear regions in the service life of a cutting tool? And what are the different factors that accelerate the wear rate of a cutting tool?

Your Answer:

- Crater wear – occurs on top rake face
- Flank wear – occurs on side of tool (flank or relief face)

Break-in Period: sharp cutting edge wears rapidly at the beginning of its use (first few minutes)

- Steady-state Wear Region: tool wear occurs at a fairly uniform rate
- Failure Region: wear rate begins to accelerate again
- Tool finally fails by temperature fail

Question 2

Question Score / 10 pts

What are the two main categories of metal casting processes, and how are they different from each other? Give an example casting process for each category.

Your Answer:

1. Expendable-mold processes: mold is sacrificed to remove part

- Advantage: more complex shapes are possible
- Disadvantage: production rates often limited by the time to make mold rather than casting itself

2. Permanent-mold processes: mold is made of metal and can be reused

- Advantage: higher production rates
- Disadvantage: geometries are limited by the need to open the mold

Question 3

Question Score / 10 pts

What is a riser in a sand mold? How can you classify risers in two different ways?

Your Answer:

Reservoir in the mold which is a source of liquid metal to compensate for shrinkage of the part during solidification.

Side riser: Attached to the side of casting through a channel

- Top riser: Connected to the top surface of the casting

OR

- Open riser: Exposed to the outside at the top surface of cope
- Blind riser: Entirely enclosed within the mold

Question 4

Question Score / 10 pts

What are the different types of mold used in sand casting? What are their characteristics, respectively?

Your Answer:

- Cope = upper half of mold
- Drag = bottom half

**MANUFACTURING PROCESSES
FALL 2021**

Title of Assignment: Quiz 4

TOPICS COVERED

NC programing, Chapter 13

Quiz 4 Solutions

1. Write a block of CNC code to cut a 90° counterclockwise arc from Point A (-5, 0) to Point B (0, 5) at the feed rate of 10 in/min with a radius of 5 in.

N010 G03 X0.0 Y5.0 R5.0 F10.0

2. What is the difference between G90 and G91 in CNC programming?

G90 is absolute coordinates and G91 is incremental coordinates

3. What are the manufacturing processes introduced in this course that can be used for making thermoset plastic products?

Compression molding, transfer molding, and rotational molding.

4. What are the functions of the clamping unit of a molding machine?

- 1) Holds two halves of mold in proper alignment with each other
- 2) Keeps mold closed during injection by applying a clamping force sufficient to resist injection force
- 3) Opens and closes mold at appropriate times in molding cycles

ABOVE AVERAGE

Quiz 3 Results for Nassr Jawad

Score for this quiz: 40 out of 40

Submitted Oct 15 at 1:51pm

This attempt took 19 minutes.

Question 1

Question Score / 10 pts

What are the different tool wear regions in the service life of a cutting tool? And what are the different factors that accelerate the wear rate of a cutting tool?

Your Answer:

1-Break in Period

2-Steady state Wear Region

3-Failure Region

The Factors that increase the wear rate

-Increased hardness of work materials

-Increased cutting speed (most

-Increased cutting feed

-Increased cutting depth

Question 2

Question Score / 10 pts

What are the two main categories of metal casting processes, and how are they different from each other? Give an example casting process for each category.

Your Answer:

1-Expendable mold processes: mold is sacrificed to remove part

eg: shell modeling

2-Permanent mold processes: mold is made of metal and can be reused

eg: Die casting

Question 3

Question Score / 10 pts

What is a riser in a sand mold? How can you classify risers in two different ways?

Your Answer:

Riser: is a Reservoir in the mold which is a source of liquid metal to compensate for shrinkage of the part during solidification

classify riser

Side riser: Attached to the side of casting through a channel

Top riser: Connected to the top surface of the casting

or

Open riser: Exposed to the outside at the top surface of cope

Blind riser: Entirely enclosed within the mold.

Question 4

Question Score / 10 pts

What are the different types of mold used in sand casting? What are their characteristics, respectively?

Your Answer:

1- Green sand mold: its characteristic

a mixture of sand, clay, and water

“Green” means mold contains moisture at the time of pouring

Moisture causes defects in some castings

2- Dry sand mold: its characteristic

organic binders rather than clay

Mold is baked in the oven to improve strength

More expensive, reduced production rate

3- Skin dried mold: its characteristic

drying mold cavity surface of a
green sand mold to a depth of 10 ~ 25 mm, using torches
or heating lamps

AVERAGE

Quiz 4 Results for Devan Mitchell

Score for this quiz: 27 out of 40

Submitted Nov 5 at 11:54pm

This attempt took 11 minutes.

Question 1

Question Score / 10 pts

Write a block of CNC code to cut a 90° counterclockwise arc from Point A (-5, 0) to Point B (0, 5) at the feed rate of 10 in/min with a radius of 5 in.

Your Answer:

N010 G03 X-5.0 Y0.0 I0.0 J5.0 F10

Question 2

Question Score / 10 pts

What is the difference between G90 and G91 in CNC programming?

Your Answer:

G90: absolute position command each dimension or the move is referenced from a fixed point, known as absolute zero

G91: makes all subsequent commands incremental

Question 3

Question Score / 10 pts

What are the manufacturing processes introduced in this course that can be used for making thermoset plastic products?

Your Answer:

Compression Molding and Rotational Molding

Question 4

Question Score / 10 pts

What are the functions of the clamping unit of a molding machine?

Your Answer:

1. Holds

2. Keeps mold closed

3. Opens and closes mold

BELOW AVERAGE

Quiz 4 Results for Christopher Nweke

Score for this quiz: 22 out of 40

Submitted Nov 5 at 8:48pm

This attempt took 20 minutes.

Question 1

Question Score / 10 pts

Write a block of CNC code to cut a 90° counterclockwise arc from Point A (-5, 0) to Point B (0, 5) at the feed rate of 10 in/min with a radius of 5 in.

Your Answer:

N05 G03 X-5. Y0 Z10 R6

N10 G01 X0 . 5y

Question 2

Question Score / 10 pts

What is the difference between G90 and G91 in CNC programming?

Your Answer:

G90 – In the absolute position command, each dimension or move is referenced from a fixed point, known as ABSOLUTE ZERO (part zero). Absolute zero is usually set at the corner edge of a part, or at the center of a square or round part, or

or an
existing bore

♦ G91 – makes all subsequent commands incremental

Question 3

Question Score / 10 pts

What are the manufacturing processes introduced in this course that can be used for making thermoset plastic products?

Your Answer:

Injection Molding or curing induced by heat

Question 4

Question Score / 10 pts

What are the functions of the clamping unit of a molding machine?

Your Answer:

Hold or close a mold build force open mold and eject the parts.

**MANUFACTURING PROCESSES
FALL 2021**

Title of Assignment: Quiz 5

TOPICS COVERED

Chapters 32, 18

Quiz 5 Solutions

1. What are the three basic channel modes for rapid prototyping? List the names of 3D printing technologies introduced in this chapter that use the basic channel mode which takes the shortest time for creating one single layer.

- (a) Moving-point or moving-spot
- (b) Moving-line consisting of a linear array of spots that sweeps across the entire layer in one translational motion
- (c) Layer mode – uses a mask projection system, entire layer is created at the same time

Mask Projection Stereolithography (MPSL), Laminated Object Manufacturing (LOM)

2. What factors are related to the time a Selective Laser Sintering (SLS) 3D printer takes to finish a single layer? List all of them.

- A_i = prototype cross-sectional area of layer i ;
- v = speed of the moving spot on the surface;
- D = diameter of moving spot (assumed circular);
- T_r = repositioning and recoating time between layers.

3. What are the ways to reduce BOTH the rolling force and power in metal rolling processes?

- 1) Use hot rolling instead of cold rolling to reduce strength and strain hardening (K and n)
- 2) Reduce draft d in each pass
- 3) Use smaller roll radius R

4. What are the different types of metal extrusion process based on the metal flow direction? What are the differences between them?

Direct Extrusion (Forward Extrusion): A ram forces the metal billet to flow through the die opening, and there is significant friction between work surface and container walls.

Indirect Extrusion (Backward Extrusion, Reverse Extrusion): Die mounted to the ram, with lower ram force, no friction at the container walls.

ABOVE AVERAGE

Quiz 5 Results for Nassr Jawad

Score for this quiz: 27 out of 40

Submitted Nov 19 at 3:08pm

This attempt took 20 minutes.

Question 1

Question Score / 10 pts

What are the three basic channel modes for rapid prototyping? List the names of 3D printing technologies introduced in this chapter that use the basic channel mode which takes the shortest time for creating one single layer.

Your Answer:

The three basic channel modes are:

(a)

Moving point or moving spot , e.g. laser or electron spot

(b)

Moving line consisting of a linear array of spots that sweeps across the entire layer in one translational motion

(c)

Layer mode uses a mask projection system , entire layer is created at the same time

Powder

based: Three Dimensional

Printing (3DP)

Molten Material: Fused Deposition

Modeling (FDM)

Molten Material: Droplet

Deposition Manufacturing (DDM)

Solid sheets: Laminated Object

Manufacturing (LOM)

Question 2

Question Score / 10 pts

What factors are related to the time a Selective Laser Sintering (SLS) 3D printer takes to finish a single layer? List all of them.

Your Answer:

Time to complete a single layer in processes that use a moving line channel mode in s (sec):

$$T_i = Ls/vs + T_r$$

where

L s = length of the sweep, mm (

v

s = velocity of moving line, mm/s (in/

Time to complete a single layer in processes that use a layer channel mode in s (sec):

T

$$i = T_{ex} + T_r$$

where

T_{ex} = exposure time for one layer, s (sec)

Question 3

Question Score / 10 pts

What are the ways to reduce BOTH the rolling force and power in metal rolling processes?

Your Answer:

1)

Use hot rolling instead of cold rolling to reduce the strength and strain hardening (K and n

2)

Reduce draft d in each pass

3)

Use smaller roll radius R

4)

Use lower rolling speed N to reduce power

Question 4

Question Score / 10 pts

What are the different types of metal extrusion process based on the metal flow direction? What are the differences between them?

Your Answer:

Direct vs. Indirect

Hot vs. Cold

Direct: A ram forces the metal billet to flow through the die opening

As ram approaches die opening, a small portion of the billet remains (cannot be forced through the die)

This portion, called the butt, must be separated from the extrudate by cutting it off just beyond the die exit

Significant friction between the work surface and container walls

Indirect: Die mounted to the ram

Lower ram force, no friction at the container walls

Limitations

Lower rigidity of hollow ram

Difficulty in supporting the extruded product as it exits die

Hot Extrusion: prior heating of billet to above its recrystallization temperature

Reduces strength and increases the ductility of the metal

Allows more size reductions and more complex shapes

Reduces ram force, increases ram speed

Cold Extrusion: generally used to produce discrete parts

Increase strength due to strain hardening

Close tolerance

Improved surface finish

Absence of oxide layers

High production rates

AVERAGE

Quiz 5 Results for Aniya Facion

Score for this quiz: 22 out of 40

Submitted Nov 19 at 7:45pm

This attempt took 18 minutes.

Question 1

Question Score / 10 pts

What are the three basic channel modes for rapid prototyping? List the names of 3D printing technologies introduced in this chapter that use the basic channel mode which takes the shortest time for creating one single layer.

Your Answer:

The three basic channeling modes are:

1. Moving-Point or Moving Spot: This one takes the most time
2. Moving-line
3. Layer mode: This mode is the one that takes the shortest time to finish a single layer.

Question 2

Question Score / 10 pts

What factors are related to the time a Selective Laser Sintering (SLS) 3D printer takes to finish a single layer? List all of them.

Your Answer:

1. Powder based, which allows for no needs to remove excess supports as the powder helps support the model being formed
2. Laser etching, this allows the powder to be formed easily layer by layer with quick precision. Instead of relying on a machine to carefully place everything.
3. Easily reusable and lack of lost resources

Question 3

Question Score / 10 pts

What are the ways to reduce BOTH the rolling force and power in metal rolling processes?

Your Answer:

1. Use hot rolling to reduce strength and strain hardening (K and n)
2. Reduce draft (d) in each pass
3. Use smaller roll radius (R)

4. Use lower rolling speed (N) to reduce power

Question 4

Question Score / 10 pts

What are the different types of metal extrusion process based on the metal flow direction? What are the differences between them?

Your Answer:

There are 2 types of 'vs.' extruding that can be done.

Direct vs Indirect:

- Direct extruding means that a ram will force a metal billet through a die opening. Significant friction occurs and the butt must be separated beyond the exit die.
- Indirect extruding means that a rod is ram into the metal cause it to form around the ram itself.

Hot vs Cold:

- Hot extrusion causes a reduction in strength while increasing ductility, it allows for more size reductions and more complex shapes, and when coupled with Direct Extrusion, reduces ram force and increases ram speed.
- Cold extrusions cause an increase in strength, improves the finished, close tolerance, is absence of oxide layers, and has high production rates.

BELOW AVERAGE

Quiz 5 Results for Christopher Nweke

Score for this quiz: 16 out of 40

Submitted Nov 19 at 11:53pm

This attempt took 20 minutes.

Question 1

Question Score / 10 pts

What are the three basic channel modes for rapid prototyping? List the names of 3D printing technologies introduced in this chapter that use the basic channel mode which takes the shortest time for creating one single layer.

Your Answer:

- a) Moving-point or moving-spot, e.g. laser or electron spot
- (b) Moving-line consisting of a linear array of spots that sweeps across the entire layer in one translational motion
- (c) Layer mode – uses a mask projection system, entire layer is created at the same time

3d printed tech introduced in chapter is Powder-based: Three Dimensional Printing (3DP)

Question 2

Question Score / 10 pts

What factors are related to the time a Selective Laser Sintering (SLS) 3D printer takes to finish a single layer? List all of them.

Your Answer:

- after each layer is completed, a new layer of loose powders is spread across the surface
- In areas not sintered, the powders are loose and can be removed away from completed part

Layer thickness: 0.075 ~ 0.50 mm (0.003 ~ 0.020 in)

- Versatile materials: polymers, metals, and ceramics (less expensive)

Question 3

Question Score / 10 pts

What are the ways to reduce BOTH the rolling force and power in metal rolling processes?

Your Answer:

Large forces and power are required in rolling, to reduce them:

- 1) Use hot rolling instead of cold rolling to reduce the strength and strain hardening (K and n)
- 2) Reduce draft d in each pass
- 3) Use smaller roll radius R
- 4) Use lower rolling speed N to reduce power

Question 4

Question Score / 10 pts

What are the different types of metal extrusion process based on the metal flow direction? What are the differences between them?

Your Answer:

direct extrusion

hydrostatic extrusion

cold Extrusion: generally used to produce discrete parts

- Increase strength due to strain hardening
- Close tolerance
- Improved surface finish
- Absence of oxide layers
- High production rates

Hot Extrusion: prior heating of billet to above its recrystallization temperature

- Reduces strength and increases ductility of the metal
- Allows more size reductions and more complex shapes

Extrusion Strain (Johnson Strain Eqn.):

$$\epsilon_x = a + b \ln r_x$$

where a and b = empirical constants for a given die angle

- Reduces ram force, increases ram speed

**MANUFACTURING PROCESSES
FALL 2021**

HOMEWORK 1

TOPICS COVERED

Chapters 1, 3

Homework 1 Solutions

1.7 A production machine operates in a semi-automatic cycle but a worker must tend the machine 100% of the time to load parts. Unloading is accomplished automatically. The worker's cost rate = \$27/hr including applicable labor overhead rate. The equipment cost rate of the machine = \$18.00/hr including applicable overhead costs. Cost of the starting parts = \$0.15/pc. The job runs several months so the effect of setup can be ignored. Each cycle, the actual process time = 24 sec, and time to load the part = 6 sec. Automatic unloading takes 3 sec. A proposal has been made to install an automatic parts-loading device on the machine. The device would cost \$36,000 and would reduce the part loading time to 3 sec each cycle. Its expected life = 4 years. The device would also relieve the worker from full-time attention to the machine. Instead, the worker could tend four machines, effectively reducing the labor cost to 25% of its current rate for each machine. The operation runs 250 days per year, eight hours per day. Assume availability = 100% and scrap rate = 0. Determine the cost per part produced (a) without the parts loading device and (b) with the parts loading device installed. (c) How many days of production are required to pay for the automatic loading device? In other words find the breakeven point.

Solution: (a) Equipment cost rate $C_{eq} = 18/60 = \$0.30/\text{min}$

Labor cost rate $C_L = 27/60 = \$0.45/\text{min}$

Without the loading device, $C_{pc} = 0.15 + (0.45 + 0.30)(24 + 6 + 3)/60 = \mathbf{\$0.563/\text{pc}}$

(b) Cost rate of the device = $36,000/(60 \times 4 \times 2000) = \$0.075/\text{min} = \$4.50/\text{hr}$

With the loading device, $C_{pc} = 0.15 + (0.45/4 + 0.30 + 0.075)(24 + 3 + 3)/60 = \mathbf{\$0.394/\text{pc}}$

(c) Without the device, $T_c = 24 + 6 + 3 = 33 \text{ sec} = 0.55 \text{ min}$ and $C_{pc} = 0.563/\text{pc}$

$R_p = R_c = 60/0.55 = 109.1 \text{ pc/hr} = 872 \text{ pc/day}$

With the device, $T_c = 24 + 3 + 3 = 30 \text{ sec} = 0.50 \text{ min}$ and $C_{pc} = 0.394/\text{pc}$

At 100% reliability and no setup time, $R_p = R_c = 60/0.50 = 120.0 \text{ pc/hr} = 960 \text{ pc/day}$

Let D = number of days of production at which the two alternatives are equivalent.

$872(0.563)D = 36,000 + 960(0.394)D$

$490.9D = 36,000 + 378.2D$

$(490.9 - 378.2)D = 112.7D = 36,000 \quad D = 319.5 \text{ round to } \mathbf{320 \text{ days}}$

1.12 A high-production operation was studied during an 80-hr period. During that time, a total of seven equipment breakdowns occurred for a total lost production time of 3.8 hr, and the operation produced 38 defective products. No setups were performed during the period. The operation cycle consists of a processing time of 2.14 min, a part handling time of 0.65 min, and a tool change is required every 25 parts, which takes 1.50 min. Determine (a) hourly production rate of acceptable parts and (b) scrap rate during the period.

Solution: (a) Cycle time of the unit operation $T_c = 2.14 + 0.65 + 1.50/25 = 2.85 \text{ min}$

Hours of production during 80 hours = $80 - 3.8 = 76.2 \text{ hr}$

Total number of parts produced = $76.2(60)/2.85 = 1604 \text{ pc}$

Number of acceptable parts produced = $1604 - 38 = 1566 \text{ pc}$

Production rate of acceptable parts $R_p = 1566/80 = \mathbf{19.58 \text{ pc/hr}}$

(b) Scrap rate $q = 38/1566 = 0.0243 = \mathbf{2.43\%}$

3.3 (SI Units) During a tensile test in which the starting gage length = 100.0 mm and cross-sectional area = 150 mm². During testing, the following force and gage length data are collected: (1) 17,790

N at 100.2 mm, (2) 23,040 N at 103.5 mm, (3) 27,370 N at 110.5 mm, (4) 28,910 N at 122.0 mm, (5) 27,400 N at 130.0 mm, and (6) 20,460 N at 135.1 mm. The final data point (6) occurred immediately prior to failure. Yielding occurred at a load of 19,390 N (0.2% offset value), and the maximum load (4) was 28,960 N. (a) Plot the engineering stress strain curve. Determine (b) yield strength, (c) modulus of elasticity, (d) tensile strength, and (e) percent elongation.

Solution: (a) Student exercise.

- (b) Yield strength = load at yielding divided by original area: $Y = 19,390/150 = \mathbf{129.3 \text{ MPa}}$
- (c) The first data point (1) occurred prior to yielding. Modulus of elasticity $E = s/e$
 Engineering strain $e = (100.2 - 100)/100 = 0.002$; engineering stress = $17,790/150 = 118.6 \text{ MPa}$. $E = 118.6/0.002 = \mathbf{59,300 \text{ MPa}}$
- (d) Tensile strength = maximum load divided by A_o : $TS = 28,960/150 = \mathbf{193.1 \text{ MPa}}$
- (e) Percent elongation $EL = (135.10 - 100)/100 = 0.351 = \mathbf{35.1\%}$

3.10 (SI Units) Given that the flow curve strain-hardening exponent = 0.30 and strength coefficient = 500 MPa, determine the tensile strength for the metal. Note that tensile strength is an engineering stress.

Solution: Tensile strength occurs at maximum value of load, and necking begins immediately thereafter. At necking, $\epsilon = n$, and true stress $\sigma = 500(0.30)^{0.30} = 348.4 \text{ MPa}$.

Given that $n = 0.30$ and $\epsilon = n$, then $\epsilon = 0.30$ at this value of true stress.

From Equation (3.7), $\epsilon = 0.30 = \ln(L_f/L_o)$, then $L_f/L_o = \exp(0.30) = 1.3499$

Tensile strength TS is an engineering stress defined by Equation (3.2): $e = (L_f - L_o)/L_o = L_f/L_o - 1$

Thus, $e = 1.3499 - 1 = 0.3499$

From Equation (3.9), $\sigma = s(1 + e)$. Rearranging, $s = \sigma/(1 + e) = 348.4/(1 + 0.3499) = 258.1 \text{ MPa}$

Therefore, $TS = \mathbf{258.1 \text{ MPa}}$

3.16 (USCS Units) A torque of 6000 ft-lb is applied in a torsion test on a thin-walled tubular specimen whose radius = 1.5 in, wall thickness = 0.125 in, and gage length = 2.0 in. This causes an angular deflection = 1° . Determine (a) shear stress, (b) shear strain, and (c) shear modulus, assuming the specimen had not yet yielded. (d) If the specimen fails at a torque = 8000 ft-lb and an angular deflection = 20° , calculate the shear strength of the metal.

Solution: (a) Shear stress $\tau = T/(2\pi R^2 t) = (6000 \times 12)/(2\pi(1.5)^2(0.125)) = \mathbf{40,744 \text{ lb/in}^2}$

(b) Converting 1° to radians, $\alpha = 1(2\pi/360) = 0.01745 \text{ rad}$.

Shear strain $\gamma = R\alpha/L = 1.5(0.01745)/2.0 = \mathbf{0.01309}$

(c) Shear modulus $G = \tau/\gamma = 40,744/0.01309 = \mathbf{3.11 \times 10^6 \text{ lb/in}^2}$

(d) Cross-sectional area of tube $A = 2\pi R t = 2\pi(1.5)(0.125) = 1.1781 \text{ in}^2$

Shear strength $S = T/A = (8000 \times 12)/1.1781 = \mathbf{81,487 \text{ lb/in}^2}$

3.22 (SI Units) Two flat plates are separated by a gap of 4 mm and move relative to each other at a velocity of 5 m/s. The space between them is occupied by a fluid of unknown viscosity. The

motion of the plates is resisted by a shear stress of 10 Pa due to the viscosity of the fluid. Assuming that the velocity gradient of the fluid is constant, determine the coefficient of viscosity of the fluid.

Solution: Bushing internal bearing area $A = \pi(125.6)^2 \times 50/4 = 19729.6 \text{ mm}^2 = 19729.2(10^{-6}) \text{ m}^2$

$$d = (125.6 - 125)/2 = 0.3 \text{ mm}$$

$$v = (125\pi \text{ mm/rev})(400 \text{ rev/min})(1 \text{ min}/60 \text{ sec}) = 2618.0 \text{ mm/s}$$

$$\text{Shear rate} = 2618/0.3 = 8726.6 \text{ s}^{-1}$$

$$\tau = (0.14)(8726.6) = 1221.7 \text{ Pa} = 1221.7 \text{ N/mm}^2$$

$$\text{Force on surface between shaft and bushing} = (1221.7 \text{ N/mm}^2)(19729.2(10^{-6})) = 24.1 \text{ N}$$

$$\text{Torque } T = 24.1 \text{ N} \times 125/2 \text{ mm} = \mathbf{1506.4 \text{ N-mm} = 1.506 \text{ N-m}}$$

ABOVE AVERAGE

Madison J. Stoneham

DR. JIANG

September 9, 2021

Homework 1

$$1.7) T_c = 24 + 6 + 3 = 33 \text{ sec} \quad T_p = 0 + \frac{33}{60} = 0.55 \text{ min/pc}$$

$$R_p = \frac{60}{0.55} \times 1 \times (1-0) = 109.09 \text{ pc/hr}$$

$$= 109.09 \text{ pc/hr} \times 8 \text{ hr/day} = 872 \text{ pc/day}$$

A) without the parts loading device

$$C_{pc} = 0.15 + (27 + 18) \left(\frac{0.55}{60} \right) + 0 = 0.15 + 0.4125 = \boxed{\$0.5625/\text{pc}}$$

B) with the parts loading device installed

$$T_c = 24 + 3 + 3 = 30 \text{ sec} \quad T_p = 0 + \frac{30}{60} = .5 \text{ min/pc}$$

$$R_p = \frac{60}{.5} \times 1 \times (1-0) = 120 \text{ pc/hr} \times 8 \text{ hr/day} = 960 \text{ pc/day}$$

$$C_L = .25(27) = 6.75/\text{hr} \quad C_{eq} = \frac{36000}{60(4)(250 \times 8)} (1+0)$$

$$= 0.075/\text{min} \rightarrow = (0.075 \times 60)/\text{hr} = 4.5/\text{hr}$$

$$C_{pc} = 0.15 + (6.75 + 18 + 4.5) \left(\frac{.5}{60} \right) + 0 = 0.15 + 0.24375$$

$$= \boxed{\$0.39375/\text{pc}}$$

c) how many days of production are required to pay for the automatic loading device?

$$\frac{872 \text{ pc}}{\text{day}} \times \frac{0.5625}{\text{pc}} D = 36000 + \left(\frac{960 \text{ pc}}{\text{day}} \times \frac{0.39375}{\text{pc}} D \right)$$

$$\begin{array}{rcl} 490.5 D & = & 36000 + 378 D \\ -378 D & & -378 D \end{array} \rightarrow \begin{array}{rcl} 112.5 D & = & 36000 \\ 112.5 D & 112.5 & \end{array}$$

$$D = 320 \text{ days}$$

1.12) $t_a = 80 - 3.8 = 76.2 \text{ hr}$ $T_t = \frac{1.5}{25} = 0.06 \text{ Min}$

$$T_c = 2.14 + 0.65 + 0.06 = 2.85 \text{ Min} \quad T_p = \frac{0}{Q} + 2.85 = 2.85 \text{ Min}$$

$$76.2 \times 60 = 2.85 \times (n_a + 38) \quad \frac{76.2 \times 60}{2.85} = n_a + 38$$

$$n_a = 1605 - 38 = 1567$$

find scrap rate first

B) scrap rate during the period

$$S = \left(\frac{38}{1567 + 38} \right) \times 100 = 0.0237 \times 100 = 2.37\%$$

A) hourly production rate of acceptable parts

$$A = \left(\frac{80 - 3.8}{80} \right) \times 100 = \left(\frac{76.2}{80} \right) \times 100 = 0.9525 \times 100 = 95.25\%$$

$$R_p = \frac{60}{2.85} \times 0.9525 \times (1 - 0.0237) = 19.58 \text{ parts/hr}$$

3.3) A) Plot the ENGINEERING stress-strain curve

$$(1) \quad s = \frac{\text{FORCE}}{\text{AREA}} = \frac{17790 \text{ N}}{150 \text{ mm}^2} = 118.6 \text{ N/mm}^2$$

$$e = \frac{L - L_0}{L_0} = \frac{100.2 \text{ mm} - 100 \text{ mm}}{100 \text{ mm}} = 0.002$$

$$(2) \quad s = \frac{23040 \text{ N}}{150 \text{ mm}^2} = 153.6 \text{ N/mm}^2 \quad e = \frac{103.5 - 100}{100} = 0.035$$

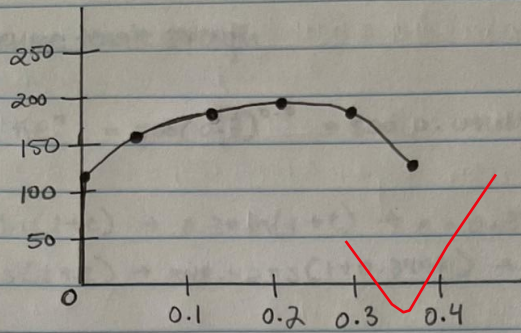
$$(3) \quad s = \frac{27370 \text{ N}}{150 \text{ mm}^2} = 182.4667 \text{ N/mm}^2 \quad e = \frac{110.5 \text{ mm} - 100 \text{ mm}}{100 \text{ mm}} = 0.105$$

$$(4) \quad s = \frac{28910 \text{ N}}{150 \text{ mm}^2} = 192.7333 \text{ N/mm}^2 \quad e = \frac{122.0 \text{ mm} - 100 \text{ mm}}{100 \text{ mm}} = 0.22$$

$$(5) \quad s = \frac{27400 \text{ N}}{150 \text{ mm}^2} = 182.6667 \text{ N/mm}^2 \quad e = \frac{130.0 \text{ mm} - 100 \text{ mm}}{100 \text{ mm}} = 0.3$$

$$(6) \quad s = \frac{20460 \text{ N}}{150 \text{ mm}^2} = 136.4 \text{ N/mm}^2 \quad e = \frac{135.1 \text{ mm} - 100 \text{ mm}}{100 \text{ mm}} = 0.351$$

CASE	load(N)	length(mm)	STRESS	STRAIN
w/ no load	0	0	0	0
1	17790	100.2	118.6	0.002
2	23040	103.5	153.6	0.035
3	27370	110.5	182.4667	0.105
4	28910	122.0	192.7333	0.22
5	27400	130.0	182.6667	0.3
6	20460	135.1	136.4	0.351



B) yield strength

$$Y = \frac{F_{\text{yield}}}{A_0}$$

yielding occurred at 19390 N

$$Y = \frac{19390 \text{ N}}{150 \text{ mm}^2} = 129.26667 \text{ N/mm}^2$$

C) modulus of elasticity

$$E = \frac{s}{e} = \frac{118.6 \text{ N/mm}^2}{0.002} = 59300 = 59.3 \times 10^3 \text{ N/mm}^2$$

D) tensile strength

$$TS = \frac{F_{\text{max}}}{A_0} = \frac{28960 \text{ N}}{150 \text{ mm}^2} = 193.06667 \text{ N/mm}^2$$

E) percent elongation

$$\% = \frac{\text{final length} - \text{initial length}}{\text{initial length}} \times 100 = \frac{135.1 - 100}{100} \times 100$$

$$= 35.1\%$$

+10

3.10) determine tensile strength

$$\sigma = K\epsilon^n = 500(0.3)^{0.3} = 500(0.69684) = 348.42 \text{ MPa}$$

$$\epsilon = \ln(1+e) \rightarrow 0.3 = \ln(1+e) \rightarrow e = 0.3498$$

$$\sigma = s(1+e) \rightarrow 348.42 = s(1+0.3498) \rightarrow \frac{348.42}{1.3498} = \frac{s(1.3498)}{1.3498}$$

$$s = 258.127 \text{ MPa}$$

3.16) A) SHEAR STRESS

$$\tau = \frac{T}{2\pi R^2 t} = \frac{6000 \text{ ft-lb}}{2\pi (1.5 \text{ in})^2 (0.125 \text{ in})} \quad \text{convert to inches}$$

$$\rightarrow \frac{6000 \times 12 \text{ in-lb}}{2\pi (1.5)^2 (0.125)} = \frac{72000}{1.767145} = 40743.66 \text{ lb/in}^2$$

B) SHEAR STRAIN

$$\gamma = \frac{R\alpha}{L} = \frac{(1.5)(1^\circ)}{(2.0)} = \frac{(1.5)(1^\circ \times \frac{\pi}{180} \text{ RAD})}{(2.0)}$$

$$= \frac{(1.5)(0.01745)}{(2.0)} = \frac{0.02618}{2.0} = 0.01309$$

C) SHEAR MODULUS, ASSUMING the specimen had not yet yielded

$$G = \frac{\tau}{\gamma} = \frac{40743.66}{0.01309} = 3112579.068 = 3.112 \times 10^6 \text{ lb/in}^2$$

D) torque = 8000 ft-lb ANGULAR deflection = 20°

$$\tau = \frac{T}{2\pi R^2 t} = \frac{8000 \text{ ft-lb}}{2\pi (1.5 \text{ in})^2 (0.125 \text{ in})} = \frac{8000 \times 12 \text{ in-lb}}{2\pi (1.5)^2 (0.125)} = \frac{96000}{1.767145}$$

$$= 54324.88 \text{ lb/in}^2$$

3.22) Determine the magnitude of the torque due to viscosity that acts to resist the rotation of the shaft

$$A = \pi (125.6 \text{ mm}) (50.0 \text{ mm}) = 19729.2 \text{ mm}^2 \times \frac{10^{-6} \text{ m}^2}{1 \text{ mm}^2}$$

$$\rightarrow 19729.2 \times 10^{-6} \text{ m}^2$$

$$\Delta y = \frac{125.6 \text{ mm} - 125 \text{ mm}}{2} = 0.3 \text{ mm}$$

$$V = \pi D N = \pi (125) (400) \rightarrow \frac{\pi (125) (400)}{60} = \frac{157079.6}{60} = 2618 \text{ mm/s}$$

$$\dot{\gamma} = \frac{2618 - 0}{0.3} = 8726.6 \text{ s}^{-1}$$

$$\tau = (0.14) (8726.6) = 1221.7 \text{ N/mm}^2$$

$$F = (1221.7) (19729.2 \times 10^{-6}) = 24.1 \text{ N}$$

$$T = \frac{FD}{2} = \frac{(24.1)(125)}{2} = \frac{3012.5}{2} = \boxed{1506.25 \text{ N}}$$

+10

AVERAGE

H/W 1

Idris Agboola

Manufacturing processes

Solution

1.7a) starting piece required in an hour

$$= \frac{3600}{(24+6+3)} = 109.09$$

⇒ Cost of man per hour = \$27

Cost of machine per hour = \$18.00

Cost of starting pieces for 1 hr

$$= 109.09 \times 0.15 = \$16.364$$

Total cost for hour = 27 + 18 + 16.36

$$= 61.364$$

Total cost for 4 years, 250 days per year

$$8 \text{ hrs day} = 4 \times 250 \times 8 \times 61.36 \\ = \$490880$$

(b) Labour cost per hr = 0.25×27
= \$6.75

Cost of machine per hr = \$18.00

$$\text{Total cost per hour} = 6.75 + 18.00 + 6.364 \\ = \$41.11$$

Total cost for 4 years, 250 days per year

$$8 \text{ hour per day} = 4 \times 250 \times 8 \times 41.11 \\ = \$328880$$

(c) Cost difference per hr = $61.364 - 41.11$
= \$20.25

total hrs required to pay back for the machine = $\frac{36,000}{20.25} = 1777.77$

How many days

$$= \frac{1777.77}{24} = 74.1 \text{ day}$$

Given:

time of production = 3.8 hr, Period of production = 80 hr

1.12

(a)

Defective product = 38, processing time = 2.14, total part = 2.5

Calc the cycle time of unit operation handling time = 0.65 min

Tc = process time + handling time + change time for each part

$$Tc = 2.14 + 0.65 + \frac{1.30}{25} = \underline{\underline{2.85 \text{ min}}}$$

Production hours →

$$\text{Studying Substard by lost time production} = 80 - 3.8 = \underline{\underline{76.2 \text{ hrs}}}$$

$$\text{total number part} = \frac{76.2 \times 60}{2.85} = \underline{\underline{1604.21}}$$

$$\text{Parts that are acceptable} = 1604 - 38 = 1566.21$$

hourly production rate of acceptable

$$Pr = \frac{\text{acceptable part}}{\text{Studying production}} = \frac{1566.21}{80} = \underline{\underline{19.57 \text{ Pc/hr}}}$$

(b)

Scrap rate

$$Sr = \frac{\text{Defective product}}{\text{acceptable part}} = \frac{38}{1566.21} = 0.02426 \approx \underline{\underline{0.0243}}$$

+10

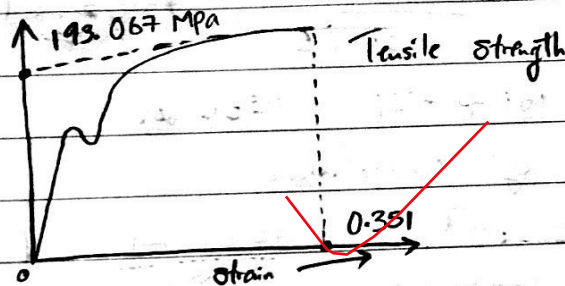
Given

3.3

$$l = 100.0 \text{ mm}, A = 150 \text{ mm}^2$$

Force	l'	$\Delta l = l' - l$	Strain = $\Delta l / l$	Stress (MPa)
17790	100.2	0.2	0.002	118.6
23040	103.5	3.5	0.035	153.6
27370	110.5	10.5	0.105	182.47
28910	122.0	22	0.12	193.03
27400	130	30	0.30	182.16
20460	135.1	35.1	0.351	136.4

(a)



(b)

$$\text{Yield strength (}\sigma_y\text{)} = \frac{\text{Yielding load}}{A_{\text{mpa}}} = \frac{19390}{150} = \sigma_y = 129.2667 \text{ MPa}$$

(c)

$$\text{Modulus of elasticity (E)} = \frac{\text{Stress}}{\text{Strain}}$$

table 1 $\rightarrow E = \frac{118.6 \text{ MPa}}{0.002} \rightarrow E = 59.3 \times 10^3 \text{ MPa}$

(d)

$$\text{Tensile strength} = \frac{28910 \text{ N}}{150} = 193.067 \text{ MPa}$$

(e)

$$\text{Percent Elongation} = \left(\frac{\text{Final Length} - \text{init. Length}}{100} \right)$$

$$\Rightarrow \left(\frac{135.1 - 100}{100} \right) \times 100\% = 35.1\%$$

Determine the tensile strength for the metal.

3.10 Calculate the true stress of the material:

$$\sigma = K \epsilon^n$$

Write the maximum tensile strength condition

$$\epsilon = n$$

$$\sigma = K \epsilon^n$$

$$= 500(0.3)^{0.3}$$

$$\text{True stress} = 348.423 \text{ MPa}$$

$$\rightarrow \epsilon = \ln\left(\frac{L_f}{L_0}\right) = \frac{L_f}{L_0} = e^n = \frac{L_f}{L_0} = e^{0.3}$$

$$\frac{L_f}{L_0} = 1.3499$$

Eqs of engineering strain:

$$e = \frac{L_f - L_0}{L_0} = \frac{L_f}{L_0} - 1$$

$$e = 1.3499 - 1 = 0.3499$$

Calc the tensile strength of material

$$\sigma = S(1+e)$$

$$S = \frac{\sigma}{(1+e)} = \frac{348.4}{1+0.3499}$$

$$S = 258.1 \text{ MPa}$$

+10

3.16

(a) Shear stress = $T(2\pi R^2 t)$
 $= (6000 \times 12) / ((2\pi (1.5)^2 (0.125)))$
 $= \underline{\underline{40743.67}}$

(b) Shear strain
 Convert 1° to radians =
 $1 \cdot (2\pi / 360)$
 $= 0.01745 \text{ rad}$

(c) Shear modulus assuming the specimen had not yielded
 $= 40744 / 0.01309$
 $= 3.11 \times 10^6 \text{ lb/in}^2$

(d) $2\pi(1.5)(0.125) = 1.1781 \text{ in}^2$
 Calc Shear strength of metal
 Shear strength = $T/A = (8000 \times 12) / 1.1781$
 $= \underline{\underline{81487 \text{ lb/in}^2}}$

+ 8

Given

3.22 125.0-mm shaft diameter

Inside diameter = 125.6mm

Length = 50.00mm

Viscosity $\mu = 0.14 \text{ Pa}\cdot\text{s} = 0.14 \frac{\text{N}}{\text{m}^2}\cdot\text{s}$

$$D = 125\text{mm} = 125 \times 10^{-3} \text{m} \\ = 0.125\text{m}$$

Thickness of oil film = bush inside diameter

$$125.6 - 125$$

$$= 0.6\text{mm} = 0.6 \times 10^{-3} \text{m}$$

Speed Length of shaft, $L = 50\text{mm}$

$$50 \times 10^{-3} \text{m}$$

Speed, $N = 400 \text{ rpm}$

Calc. the Torque, Tangential velocity of shaft, u

$$u = \frac{\pi \times 0.125 \times 400}{60} = 2.617 \text{ m/s}$$

Law of viscosity $\rightarrow \tau = \mu \frac{du}{dy}$

$$2.617 \text{ m/s}$$

Thickness of oil = $0.6 \times 10^{-3} \text{m}$

$$\tau = 0.14 \times \frac{2.617}{0.6 \times 10^{-3}} = 610.865 \text{ N/m}^2$$

Shear stress $\times$ Area

$$= 610.865 \times \pi D L$$

$$610.865 \times \pi \times 0.125 \times 50 \times 10^{-3} \\ = 11.989 \text{ N}$$

Torque On the shaft = Torque $\times \frac{D}{2}$

$$= 11.989 \times \frac{0.125}{2}$$

$$= 0.749 \text{ N}\cdot\text{m}$$

BELOW AVERAGE

Dr. Wang

Facion, Anya

MCEG 3303

Manufacturing Process Lab Hand #1

1/2

1.7) Worker's cost rate = \$24/hr = R_H $t_0 = 24 \text{ sec}$ worker's cost = 24×0.25
 Machine's cost rate = \$18/hr = R_L $t_L = 6 \text{ sec}$ $C_i = \$6.45/\text{hr}$
 Start-up parts cost = \$0.15/pa $t_{AU} = 3 \text{ sec}$ $N = 250 \text{ days/yr}$
 Install (IC) = \$36,000 $L_{AL} = 3 \text{ sec}$ $N = 4 \text{ yrs}$ $H = 8 \text{ hr/day}$

normal loading

$$T_1 = 24 + 6 + 3 = 33 \text{ sec}$$

$$u_1 = \frac{250 \times 8 \times 36000}{33} = 218,181.818$$

automatic loading

$$T_2 = 24 + 3 + 3 = 30 \text{ sec}$$

$$u_2 = \frac{250 \times 8 \times 36000}{30} = 240,000$$

$$\text{cost of machine} = \frac{36000}{4} = \$9,000$$

total cost/yr

$$= 24 \times 250 \times 8 + 18 \times 250 \times 8 + 0.15 \times 218,181.818$$

$$= 54,000 + 36,000 + 32,727.2727$$

with normal loading

$$= \$122,727.27/\text{yr}$$

total cost/yr

$$= \frac{24}{4} \times 250 \times 8 + 18 \times 250 \times 8 + 0.15 \times 240,000 + \frac{36000}{4}$$

$$= 13,500 + 36,000 + 36,000 + 9,000$$

with automatic loading

$$= \$94,500/\text{yr}$$

without loading device

$$= \frac{122,727.27}{218,181.82} = \$0.56/\text{pc}$$

with loading device

$$= \frac{94,500}{240,000} = \$0.39/\text{pc}$$

Break-even point

$$24 \times u \times 8 + 18 \times u \times 8 + \frac{0.15 \times 8 \times 36000 \times u}{33} = 6.45 \times 8 \times u + 18 \times u \times 8 + \frac{0.15 \times 8 \times 36000 \times u}{30} + 36000$$

$$216u + 144u + \frac{43200u}{33} = 54u + 144u + \frac{43200u}{30} + 36000$$

$$360u + 130.91u = 198u + 144u + 36000$$

$$490.91u = 342u + 36000$$

$$-342u \quad -342u$$

$$\frac{148.91u}{148.91} = \frac{36000}{148.91} = 241.75$$

or
242 days

Dr. Slawig

Fachbereich Informatik

MCCE 3305

Manufacturing Process Lab Hand #1

2/2

1.12) $T_0 = 2.14 \text{ min/pc}$ $T_c = 2.14 + 0.65 + \frac{1.50}{25}$ $80 - 3.8 = 46.2 \text{ hr}$
 $T_u = 0.65 \text{ min/pc}$ $= 2.49 + 0.04$
 $T_L = \frac{1.50 \text{ min}}{25 \text{ pc}}$ $T_c = 2.85 \text{ min}$

$$\frac{46.2(60)}{2.85} = \frac{4,572}{2.85}$$

parts produced = 1,604 pc

acceptable parts

$$1,604 - 38 = 1,566$$

$$R_p = \frac{1,566}{80} = 19.58 \approx 20 \text{ pc/hr}$$

①
 $Q = \frac{38}{1,566} = 0.0242\% = 2.42\%$

+ 9

**MANUFACTURING PROCESSES
FALL 2021**

HOMEWORK 2

TOPICS COVERED

Chapters 20, 21

Homework 2 Solutions

20.5 (A) (USCS units) A turning operation is performed using a rake angle of 15° . Cutting speed = 200 ft/min, feed = 0.012 in/rev, and depth of cut = 0.100 in. The chip thickness ratio measured after the cut = 0.48. Determine (a) chip thickness after the cut, (b) shear angle, (c) friction angle, (d) coefficient of friction, and (e) shear strain.

Solution: (a) Using the orthogonal model, $f = t_o : t_c = t_o / r = 0.012 / 0.48 = \mathbf{0.025 \text{ in}}$

Solutions for *Fundamentals of Modern Manufacturing*, 6e (published by Wiley) MPGroover 2015

$$(b) \phi = \tan^{-1} (0.48 \cos 15 / (1 - 0.48 \sin 15)) = \tan^{-1} (0.5294) = \mathbf{27.9}$$

$$(c) \beta = 2(45) + \alpha - 2(\phi) = 90 + 15 - 2(27.9) = \mathbf{49.2^\circ}$$

$$(d) \mu = \tan 49.2 = \mathbf{1.16}$$

$$(e) \gamma = \tan(27.9 - 15) + \cot 27.9 = 0.229 + 1.889 = \mathbf{2.118}$$

20.11 (USCS units) A turning operation is performed with a rake angle of 10° , a feed of 0.010 in/rev, and a depth of cut = 0.100 in. Shear strength of the work metal = 50,000 lb/in², and the chip thickness ratio after the cut = 0.40. Determine the cutting force and the feed force. Use the orthogonal cutting model as an approximation of the turning process.

$$\textbf{Solution: } \phi = \tan^{-1} (0.4 \cos 10 / (1 - 0.4 \sin 10)) = \tan^{-1} (0.4233) = \mathbf{22.9^\circ}$$

$$A_s = (0.010)(0.10) / \sin 22.9 = 0.00257 \text{ in}^2$$

$$F_s = A_s S = 0.00256(50,000) = \mathbf{128 \text{ lb}}$$

$$\beta = 2(45) + \alpha - 2\phi = 90 + 10 - 2(22.9) = 54.1^\circ$$

$$F_c = 128 \cos (54.1 - 10) / \cos (22.9 + 54.1 - 10) = \mathbf{236 \text{ lb}}$$

$$F_t = 128 \sin (54.1 - 10) / \cos (22.9 + 54.1 - 10) = \mathbf{229 \text{ lb}}$$

20.21 (A) (USCS units) A cast iron workpiece is turned on a lathe whose mechanical efficiency = 0.87. Cutting speed = 400 ft/min, feed = 0.011 in/rev, and depth of cut = 0.120 in. Cutting force = 250 lb. Determine (a) the horsepower consumed by the turning operation; (b) horsepower that must be generated by the lathe; (c) unit horsepower and specific energy for the work material in this operation.

$$\textbf{Solution: } (a) \text{ Given } F_c = 250 \text{ lb, } HP_c = F_c v / 33,000 = 250(400) / 33,000 = \mathbf{3.03 \text{ hp}}$$

$$(b) HP_g = HP_c / E = 3.03 / 0.87 = \mathbf{3.48 \text{ hp}}$$

$$(c) R_{MR} = 12 v f d = (400 \times 12)(0.011)(0.120) = 6.336 \text{ in}^3 / \text{min}$$

$$HP_u = HP_c / R_{MR} = 3.03 / 6.336 = \mathbf{0.478 \text{ hp/(in}^3 / \text{min)}}$$

$$U = F_c v / R_{MR} = 250(400 \times 12) / 6.336 = \mathbf{189,394 \text{ in-lb/in}^3}$$

21.3 (USCS units) A facing operation is performed on a cylindrical part with diameter = 6 in and length = 15 in. The engine lathe spindle rotates at 200 rev/min. Depth of cut = 0.110 in, and feed = 0.008 in/rev. Assuming the cutting tool moves from the outer diameter of the workpiece to exactly the center at a constant velocity, determine (a) the velocity of the tool as it moves from the outer diameter toward the center and (b) the cutting time.

Solution: (a) $f_r = fN = (0.008 \text{ in/rev})(200 \text{ rev/min}) = \mathbf{1.60 \text{ in/min}}$

(b) $L = \text{distance from outside to center of part} = 0.5D = 0.5(15 - 6) = 3.0 \text{ in}$

$T_m = L/f_r = 0.5D/f_r = 3/(1.6) = \mathbf{1.875 \text{ min}}$

21.10 (USCS units) A gun-drilling operation is used to drill a 9/64-in diameter hole. It takes 2.5 min to perform the operation using high pressure fluid delivery of coolant to the drill point. The current spindle speed = 4000 rev/min, and feed = 0.0017 in/rev. In order to improve surface finish in the hole, it has been decided to increase the speed by 20% and decrease the feed by 25%. How long will it take to perform the operation at the new cutting conditions?

Solution: $f_r = Nf = 4000 \text{ rev/min} (0.0017 \text{ in/rev}) = 6.8 \text{ in/min}$

Hole depth $d = 2.5 \text{ min}(6.8 \text{ in/min}) = 17.0 \text{ in}$

New speed $v = 4000(1 + 0.20) = 4800 \text{ rev/min}$

New feed $f = 0.0017(1 - 0.25) = 0.001275 \text{ in/min}$

New feed rate $f_r = 4800(0.001275) = 6.12 \text{ in/min}$

New drilling time $T_m = 17.0/6.12 \text{ in/min} = \mathbf{2.78 \text{ min}}$

21.12 (SI units) A face milling operation removes 6.0 mm from the top surface of a rectangular piece of aluminum that is 250 mm long by 75 mm wide by 50 mm thick. Thickness after the cut = 44.0 mm. The cutter follows a path that is centered over the workpiece. It has four teeth and an 85-mm diameter. Cutting speed = 2.0 m/s, and chip load = 0.18 mm/tooth. Determine (a) machining time and (b) maximum metal removal rate during cutting.

Solution: (a) $N = v/\pi D = 2.0(10^3) \text{ mm/s}/85\pi = 7.49 \text{ rev/s}$

$f_r = Nn_f = 7.49(4)(0.18) = 5.39 \text{ mm/s}$

$A = 0.5 \left(D - \sqrt{D^2 - w^2} \right) = 0.5 \left(85 - \sqrt{85^2 - 75^2} \right) = 0.5(85 - 40) = 22.5 \text{ mm}$

$T_m = (L + A)/f_r = (250 + 22.5)/5.39 = \mathbf{50.6 \text{ s} = 0.84 \text{ min}}$

(b) $R_{MR} = wdf_r = 75(6)(5.39) = \mathbf{2426 \text{ mm}^3/\text{s}}$

ABOVE AVERAGE

MADISON J. STONEHAM

DR. JIANG

OCTOBER 1, 2021

HOMEWORK 2

20.5) Given: RAKE Angle = 15°

Cutting speed = 200 ft/min

feed = 0.012 in/rev

depth of cut = 0.100 in

chip thickness ratio = 0.48

A) chip thickness after the cut

$$\text{chip thickness ratio} = \frac{\text{uncut chip thickness}}{\text{cut chip thickness}} \quad 0.48 = \frac{\text{feed}}{\text{cut chip thickness}}$$

$$\frac{1}{\text{cut chip thickness}} = \frac{0.48}{0.012} \quad \text{cut chip thickness} = 0.025 \text{ in}$$

B) shear angle

$$\tan \phi = \frac{r \cos \alpha}{1 - r \sin \alpha} = \frac{0.48 \cos 15^\circ}{1 - 0.48 \sin 15^\circ} = 0.529 \quad \phi = \tan^{-1}(0.529) = 27.88^\circ$$

C) friction angle

$$2\phi + \beta - \alpha = 90^\circ \quad \beta = 90^\circ - 2\phi + \alpha = 90^\circ - 2(27.88^\circ) + 15^\circ$$

$$\beta = 49.24^\circ$$

D) coefficient of friction

$$\mu = \tan \beta = \tan(49.24^\circ) = 1.160$$
$$\mu > 1 \quad \mu = \frac{\ln\left(\frac{1}{r}\right)}{\frac{\pi}{2} - \alpha} = \frac{\ln\left(\frac{1}{0.48}\right)}{\frac{\pi}{2} - 27.88^\circ} = 1.160$$

$$\mu = .560 \quad \mu = \tan \beta \quad \beta = \tan^{-1}(.560) \quad \boxed{\beta = 29.25^\circ}$$

E) SHEAR STRAIN

$$\begin{aligned} & \cot \phi + \tan(\phi - \alpha) \\ &= \cot(27.88) + \tan(27.88 - 15) \\ &= \cot(27.88) + \tan(12.88) \\ &= \boxed{2.118} \end{aligned}$$

+10

20.11) GIVEN: $\alpha = 10^\circ$

$$f = \text{feed} = 0.010 \text{ IN/REV}$$

$$d = \text{depth of cut} = 0.100 \text{ IN}$$

$$\tau = 50000 \text{ lb/IN}^2$$

$$r = 0.40$$

$$\tan \theta = \frac{r \cos \alpha}{1 - r \sin \alpha} = \frac{0.4 \times \cos 10}{1 - 0.4 \sin 10} \quad \theta = 22.94^\circ \quad A_s = \frac{b(t_1)}{\sin \theta}$$

$$b = d = 0.1 \text{ IN} \quad t_1 = 0.010 \text{ IN/REV} \quad A_s = \frac{0.1(0.010)}{\sin 22.94} = 2.565 \times 10^{-3} \text{ IN}^2$$

$$F_s = \tau(A_s) = 50000 \frac{\text{lb}}{\text{IN}^2} (2.565 \times 10^{-3}) = \boxed{128.28 \text{ lb}}$$

$$2\theta + \beta - \alpha = 90^\circ \quad \theta = 22.94^\circ \quad \alpha = 10^\circ$$

$$(2(22.94)) + \beta - 10 = 90^\circ \quad \beta = 54.12 \rightarrow \text{friction angle}$$

$$F_c = F_s \cdot \frac{\cos(\beta - \alpha)}{\cos(\theta + \beta - \alpha)} = 128.28 \cdot \frac{\cos(54.12 - 10)}{\cos(22.94 + 54.12 - 10)}$$

$$= 128.28 \left(\frac{0.7178}{0.3897} \right) = \boxed{236.31 \text{ lb}}$$

$$F_T = F_s \frac{\sin(\beta - \alpha)}{\cos(\theta + \beta - \alpha)} = 128.28 \left(\frac{\sin(54.12 - 10)}{\cos(22.94 + 54.12 - 10)} \right)$$

$$= \boxed{229.16 \text{ lb}}$$

+ 1 D

20.21) Given: $E = 0.87$

$$V = 400 \text{ ft/min}$$

$$f = 0.011 \text{ in/rev}$$

$$d = 0.120 \text{ in}$$

$$\text{cutting force} = 250 \text{ lb}$$

$$A) HP_c = \frac{F_c V}{33000} = \frac{250 \times 400}{33000} = \frac{100000}{33000} = \boxed{3.03 \text{ hp}}$$

$$B) HP_g = \frac{HP_c}{E} = \frac{3.03}{0.87} = \boxed{3.48 \text{ hp}}$$

$$C) R_{MR} = Vfd$$

$$= 400 \times 12 \times 0.011 \times 0.12 = 6.336 \text{ in}^3/\text{min}$$

$$HP_o = \frac{HP_c}{R_{MR}} = \frac{3.03}{6.336} = 0.478 \text{ hp/(in}^3/\text{min)}$$

$$U = \frac{P_c}{R_{MR}} \quad \text{--- ①}$$

$$P_c = F_c \times V$$

$$= 250 \times 400 = 100000 \text{ lb} \cdot \text{ft/min}$$

$$= 100000 \times 12 \text{ lb} \cdot \text{in/min}$$

$$= 1200000 \text{ lb} \cdot \text{in/min}$$

$$U = \frac{P_c}{Q_{MR}} = \frac{1200000}{6.336} = 189393.93 \text{ lb} \cdot \text{IN} / \text{IN}^3$$

+ 10

21.3) GIVEN: $D = 6 \text{ IN}$.

$$L = 15 \text{ IN}$$

$$N = 200 \text{ RPM}$$

$$\text{feed} = f = 0.008 \text{ IN/REV}$$

$$\text{depth of cut} = 0.110 \text{ IN}$$

A) velocity of the tool

$$V_t = FN$$

$$= 0.008(200) = 1.6 \text{ IN/MIN}$$

B) cutting time

$$T_M = \frac{1/2 D}{V_t} = \frac{1/2 (6)}{1.6} = 1.875 \text{ MIN}$$

+ 10

21.10) GIVEN: spindle speed = 4000 REV/MIN

$$\text{feed} = f = 0.0017 \text{ IN/REV}$$

$$\text{INCREASE of speed} = 20\%$$

$$\text{DECREASE of feed} = 25\%$$

$$t = 2.5 \text{ MIN}$$

$$T_M = \frac{d}{f_r} \quad \text{--- (1)}$$

$$N = 4000(1 + 0.20)$$

$$= 4000(1.20) = 4800 \text{ REV/MIN}$$

$$f = 0.0017(1 - 0.25) = 0.001275 \text{ IN/REV}$$

$$f_r = Nf = (4000)(0.0017) = 6.8 \text{ IN/MIN}$$

$$d = (2.5 \text{ MIN}) f_r = 2.5 \times 6.8 = 17 \text{ IN}$$

$$f_r = N f = (4800)(0.001275) = 6.12 \text{ IN/MIN}$$

$$T_M = \frac{d}{f_r} = \frac{17}{6.12} = 2.7777 \approx \boxed{2.8 \text{ MIN}}$$

+10

21.12) GIVEN: $V = 2 \text{ M/S}$

$$D = 85 \text{ MM}$$

$$W = 75 \text{ MM}$$

$$n = 4$$

$$f = 0.18 \text{ MM/tooth}$$

$$L = 250 \text{ MM}$$

A) MACHINING TIME

$$N = \frac{V}{\pi D} = \frac{2 \times 10^3}{\pi (85)} = 7.489 \text{ REV/S} \rightarrow 7.49 \text{ REV/S}$$

$$V = N n f = (7.49)(4)(0.18) = 5.393 \text{ MM/S}$$

$$L_c = \frac{1}{2} (D - \sqrt{D^2 - W^2}) = \frac{1}{2} (85 - \sqrt{85^2 - 75^2})$$

$$= 22.5 \text{ MM}$$

$$t = \frac{L + L_c}{V} = \frac{250 + 22.5}{5.393} = 50.53 \text{ S} = \boxed{0.842 \text{ MIN}}$$

+10

B) MAX. METAL REMOVAL RATE

$$= W d V = (75)(6)(5.393) = \boxed{2426.85 \text{ MM}^3/\text{S}}$$

AVERAGE

MANUFACTURING PROCESSES

Idris Agboola
Due Oct 1

Given

Homework #2

20.5

(a)

Rake angle of 15°

Cutting Speed = 200 ft/min,

Feed = 0.012 in/rev

Depth of cut = 0.48.

Chip thickness $\rightarrow$ $\frac{\text{uncut chip thickness}}{\text{cut chip thickness}}$

So, $0.48 = \frac{\text{feed}}{\text{cut chip thickness}}$

$$\frac{1}{\text{cut chip thickness}} = \frac{0.48}{\text{feed}} = \frac{0.48}{0.012}$$

Cut chip thickness = 0.015 in

(b)

$$\text{Shear angle } \tan \phi = \frac{\alpha \cos \alpha}{1 - \alpha \sin \alpha} = \frac{0.48 \cos 15}{1 - 0.48 \sin 15} = 0.529$$

$$\phi = \tan^{-1}(0.529)$$

$$\phi = 27.89^\circ$$

(c)

From Merchant

$$\phi + \beta - \alpha = 90^\circ$$

$$\beta = 90^\circ - 2\phi + \alpha$$

$$\beta = 90^\circ - 2(27.89) + 15$$

$$\beta = 49.22^\circ$$

(d)

Coeff of friction $\mu = \tan \beta$

$$= \tan 49.22$$

$$= 1.159$$

$$\mu > 1$$

$$\text{Frictional theorem } \mu = \ln\left(\frac{1}{\pi}\right)$$

$$\frac{\pi}{2} = \alpha \rightarrow \text{in Radians}$$

$$= \ln\left(\frac{1}{0.48}\right)$$

$$3.14 - 0.261$$

$$\mu = 0.254$$

$$\mu = \tan \beta$$

$$\beta = \tan^{-1}(0.254)$$

$$\beta = 14.251^\circ$$

$$\begin{aligned}
 \text{Shear strain} &= \cot \phi + \tan (\phi - \alpha) \\
 &= \cot 27.89 + \tan (27.89 - 15) \\
 &= 1.889 + 0.228 \\
 &= 2.117
 \end{aligned}$$

20.11 Given

Rake angle (α) = 10°

feed = 0.010 in/rev $\rightarrow$

τ_s = Shear strength = 50,000 lb/in²

chip thickness ratio = 0.40

$$\begin{aligned}
 \tan \phi &= \frac{r \cos \alpha}{1 - r \sin \alpha} \rightarrow \tan \phi = \frac{0.4 \cos 10^\circ}{1 - 0.4 \sin 10^\circ} \\
 \phi &= 22.94^\circ
 \end{aligned}$$

For orthogonal Cond.

width of the cut = depth of the cut = $d = w$

Feed = uncut chip thickness

$$\tau_s = \frac{F_s}{A_s} \left(\frac{w}{\sin \phi} \right) \rightarrow F_s = \frac{\tau_s \times w}{\sin \phi}$$

$$F_s = \frac{50,000 \times 0.1 \times 0.01}{\sin 22.94^\circ}$$

$$F_s = 128.26 \text{ lb}$$

$$\begin{aligned}
 (2 \times 22.94) + \beta - 10 &= 90^\circ \\
 \beta &= 54.12^\circ
 \end{aligned}$$

By Merchant Circle

$$F_s = R \cos (\phi + \beta - \alpha)$$

$$\begin{aligned}
 128.26 &= R \cos (22.94 + 54.12 - 10) \\
 R &= 329.06 \text{ lb}
 \end{aligned}$$

$$F_c = R \cos (\beta - \alpha)$$

$$= 329.6 \cos (54.12 - 10) = 236.232 \text{ lb}$$

$$F_T = R \sin (\beta - \alpha)$$

$$= 329.06 \sin (54.12 - 10) = 229.08 \text{ lb}$$

Givens

20.21 Max. Efficy = 0.87, Cutting speed = 400 ft/min, Feed = 0.011 deep cut = 0.120 in

(a) Calculate a horse power consumed by the turning operation using the relation,

$$HP_c = \frac{F_c V}{33000} = \frac{250 \times 400}{33000}$$

$$HP_c = \frac{100000}{33000} = 3.03 \text{ hp}$$

(b) Calculate the horse power generated in the turning operation using the relation.

$$HP_g = \frac{HP_c}{E} = \frac{3.03}{0.87}$$

$$HP_g = 3.48 \text{ hp}$$

(c) Calc the metal removal rate using the Relation

$$\begin{aligned} RMR &= V_f d \\ &= 400 \times 12 \times 0.011 \times 0.12 \\ &= 6.336 \text{ in}^3/\text{min} \end{aligned}$$

Calc the unit horse power of the turning operation using the relation,

$$HP_u = \frac{HP_c}{RMR} = \frac{3.03}{6.336}$$

$$HP_u = 0.478 \text{ hp}/(\text{in}^3/\text{min})$$

Now we calc the specific energy of the turning operation

$$P_c = F_c \times V$$

$$= 250 \times 400$$

$$100000 \text{ lb.ft/min}$$

$$100000 \times 12 \text{ lb.in/min}$$

$$P_c = 1200000 \text{ lb.in/min}$$

$$\text{Specific Energy } U = \frac{P_c}{RMR} = \frac{1200000}{6.336} = 189393.93 \text{ lb.in/in}^3$$

+ 10

21.3

Givens

$$D_{ia} = 6 \text{ in}$$

$$\text{Length} = 15 \text{ in}$$

$$\text{rotation of spindle} = 200 \text{ rev/min}$$

$$\text{Depth} = 0.110 \text{ in}$$

$$\text{Feed} = 0.008 \text{ in/rev}$$

a) Constant velocity

$$V_s = FN$$

$$= 0.008 \times 200$$

$$V_s = 1.6 \text{ in/min}$$

b) Cutting time

$$T_m = \frac{0.5 \times D}{V_s} = \frac{0.5 \times 6}{1.6} = 1.875 \text{ min}$$

+ 10

21.10 Givens

$$\text{Spindle speed} = 4000 \text{ rev/min}$$

$$\text{Feed} = 0.0017 \text{ in/rev}$$

$$\text{Increase speed} = 20\%$$

$$\text{decrease of feed} = 25\%$$

* To express the cutting time required to perform gun drilling operation.

$$T_m = \frac{L}{V_s} \rightarrow (1)$$

$$N = 4000 (1 + 0.20) \rightarrow \text{rotation speed increase by } 20\%$$

$$N = 4000 (1.20)$$

$$= 4800 \text{ rev/min}$$

Consider the surface finish in the drill hole is decreased by the feed cut up to 25% $\rightarrow f = 0.0017 (1 - 0.25)$

$$f = 0.001275 \text{ in/rev}$$

Feed rate from current speed & feed cut

$$f_r = Nf$$

$$f_r = (4000)(0.0017)$$

$$f_r = 6.8 \text{ in/min}$$

Calc the drill hole depth

$$d = (2.5 \text{ min}) f_r$$

$$d = 2.5 \times 6.8$$

$$d = 17 \text{ inch}$$

Calc machine time required drilling operation,

$$f_r = Nf$$

$$f_r = (4800)(0.01295)$$

$$f_r = 6.12 \text{ in/min}$$

From eqn. $\rightarrow$ ①

$$T_m = \frac{d}{f_r}$$

$$T_m = \frac{17 \text{ in}}{6.12 \text{ in/min}}$$

$$T_m = 2.7777 \text{ min}$$

$$T_m = 2.8 \text{ min}$$

$$T_m = 2.8 \text{ min}$$

+10

21.12

Given

$$V = 2 \text{ m/s} \quad D = 85 \text{ mm} \quad W = 75 \text{ mm}$$

$$n = \phi \quad f = 0.18 \text{ mm/tooth} \quad L = 250 \text{ mm}$$

$$\textcircled{a} \quad N = \frac{V}{\pi D} = \frac{2 \times 10^3}{\pi(85)} = 7.49 \text{ rev/s}$$

$$V = N_n f = 7.49 \times 4 \times 0.18 = 5.393 \text{ mm/s}$$

$$L_c = 0.5(D - \sqrt{D^2 - W^2}) = 0.5\sqrt{85^2 - 75^2}$$

$$L_c = 22.5 \text{ mm}$$

$$t = \frac{L + L_c}{V} = \frac{250 + 22.5}{5.393} = 50.53$$

(b) Calc the maximum metal Remove rate during Cutting.

$$MRR = WdU = 76 \times 6 \times 5.393$$

$$= \underline{\underline{2426.85 \text{ mm}^3/\text{s}}}$$

+ 10

BELOW AVERAGE

- 20.5 (A) (USCS units) A turning operation is performed using $\alpha = 15^\circ$. The chip thickness ratio is $r = 0.53$. Determine (a) chip thickness after the cut, (b) shear angle, (c) friction angle, (d) coefficient of friction, and (e) shear strain.

(a)

$$t_o = \frac{f_{\text{cut}}}{\text{rev}}$$

$$= \frac{0.012 \text{ in/rev}}{0.48}$$

$$= 0.025 \text{ in}$$

b)

$$\phi = \tan^{-1} \left(\frac{r \cos \alpha}{1 - \sin \alpha} \right)$$

$$= \frac{0.48 \cos 15}{1 - 48 \sin 15}$$

$$= \tan^{-1}(0.53)$$

$$= 27.9^\circ$$

(c)

$$\phi = 45 + \frac{\alpha}{2} - \frac{\beta}{2}$$

$$\beta = 2 \left(45 + \frac{\alpha}{2} - \phi \right)$$

$$= 2 \left(45 + \frac{15}{2} - 27.9 \right)$$

$$= 49.2^\circ$$

(d)

$$\mu = \tan \beta$$

$$\mu = \tan 49.2$$

$$= 1.158$$

(e)

$$\gamma = \tan(27.9 - 15) +$$

$$\cot 27.9$$

$$= 2.12$$

$$+ 10$$

Shear strength of the work material, σ_s , and the chip thickness ratio after the cut, r . Determine

the cutting force and the feed force. Use the orthogonal cutting model as an approximation of the turning process.

$$\phi = \tan^{-1} \left(\frac{r \cos \alpha}{1 - r \sin \alpha} \right)$$

$$= \left(\frac{0.4 \cos 10^\circ}{1 - 0.4 \sin 10^\circ} \right)$$

$$= \tan^{-1}(0.4233)$$

$$= 22.94^\circ$$

$$A_s = \frac{t_o w}{\sin \phi}$$

$$= \frac{(0.010 \text{ in})(0.100 \text{ in})}{\sin 22.94^\circ}$$

$$= 0.00257 \text{ in}$$

$$F_s = A_s \sigma_s$$

$$= (0.00257)(50,000)$$

$$= 128.5 \text{ lb}$$

$$\phi = 45^\circ - \frac{\alpha}{2} - \frac{\beta}{2}$$

$$\beta = 2 \left(45 + \frac{10}{2} - 22.94 \right)$$

$$= 54.12$$

$$F_c = \frac{(128.5) \cos(54.12 - 10)}{\cos(22.94 + 54.12 - 10)}$$

$$= 236.6 \text{ lb}$$

$$F_r = \frac{F_s \sin(\beta - \alpha)}{\cos(\phi + \beta - \alpha)}$$

$$F_r = \frac{(128.5) \sin(54.12 - 10)}{\cos(22.94 + 54.12 - 10)}$$

$$= 89.45$$

$$0.3847$$

$$= 229.5 \text{ lb}$$

110

20.21 (A) (USCS units) A cast iron workpiece is turned on a lathe whose motor is 7.5 hp. Determine (a) the horsepower consumed by the turning operation; (b) horsepower that must be generated by the lathe; (c) unit horsepower and specific energy for the work material in this operation.

$$HP_c = \frac{F_c V}{33000}$$

$$= \frac{250 \times 400}{33000}$$

$$= \frac{100000}{33000}$$

$$= 3.03 \text{ HP}$$

$$\frac{HP_c}{R_{mr}}$$

$$= \frac{3.03}{6.336}$$

$$HP_u = 0.478 \text{ HP}$$

$$U = \frac{P_c}{R_{mr}}$$

$$HP_g = \frac{HP_c}{E}$$

$$= \frac{3.03}{0.80}$$

$$= 3.78 \text{ HP}$$

$$P_c = F_c \times V$$

$$= 250 \times 400$$

$$R_{mr} = V F_d$$

$$= 6.336 \times 12 \times 0.011 \times 0.12$$

$$= 189393.93 \text{ lb} \cdot \text{in} / \text{min}$$

$$\frac{1200000}{6.336}$$

+8

21.3 (USCS units) A facing operation is performed on a cylindrical part with d [redacted] and l [redacted]. The engine lathe spindle rotates at [redacted] rpm. Depth of cut = [redacted]. Assuming the cutting tool moves from the outer diameter of the workpiece to exactly the center at a constant velocity, determine the (a) velocity of the tool as it moves from the outer diameter toward the center and (b) cutting time.

$$f_r = f_r N$$

$$= (0.008)(200)$$

$$= 1.6 \text{ in/min}$$

$$T_m = \frac{L}{f_r}$$

$$= \frac{D_0}{2f_r}$$

$$= \frac{6}{2(1.6)}$$

$$\frac{6}{3.2}$$

$$= 1.875 \text{ min}$$

21.10 (USCS units) A gun-drilling operation is used to drill a hole in a 17-in. diameter workpiece. The current spindle speed is 4800 rev/min, and the feed is 0.0017 in/rev. In order to improve surface finish in the hole, it has been decided to change the spindle speed and feed to 6.8 in/min and 0.001275 in/rev. How long will it take to perform the operation at the new cutting conditions?

Milling

$$T_m = \frac{d}{f_r} = \frac{17 \text{ in}}{6.12 \text{ in/min}}$$

$$N = 4800 \frac{\text{rev}}{\text{min}} (1 + 0.2) = 5760 \text{ rev/min}$$

$$f = 0.0017 \text{ in/rev} (1 - 0.25) = 0.001275 \text{ in/rev}$$

$$d_r = (2.5 \text{ min})(f) = (2.5 \text{ min})(6.8 \text{ in/min}) = 17 \text{ in}$$

$$f_r = Nf$$

$$= (4800 \text{ rev/min})(0.001275 \text{ in/rev}) = 6.12 \text{ in/min}$$

$$T_m = \frac{d}{f_r}$$

21.12 (SI units) A face milling operation removes material from the top surface of a rectangular piece of aluminum that is 250 mm long and 85 mm wide. Thickness of the workpiece is 20 mm. The cutter follows a path that is centered over the workpiece. The cutter has a diameter of 100 mm and 4 teeth. Determine the (a) machining time and (b) maximum metal removal rate during cutting.

$$A = 0.5(D - \sqrt{D^2 - w^2})$$

$$= 0.8422 \text{ m}$$

$$A = 0.5(85 - \sqrt{85^2 - 75^2})$$

$$= 22.5 \text{ mm}$$

$$(b) R_{mr} = ?$$

$$N = \frac{V}{\pi D}$$

$$= \frac{2 \text{ m/s} \times \frac{1000 \text{ mm}}{1 \text{ m}} \times \frac{60 \text{ s}}{1 \text{ min}}}{\pi \times 85}$$

$$+ 7$$

$$= 449.37 \frac{\text{rev}}{\text{min}}$$

$$f_r = N_n f$$

$$= 449.37 \times 4 \times 0.18$$

$$= 323.54 \text{ mm/min}$$

$$T_m = \frac{L + A}{f_r}$$

$$= \frac{(250 + 22.5)}{323.54}$$

**MANUFACTURING PROCESSES
FALL 2021**

HOMEWORK 3

TOPICS COVERED

Chapters 22, 10, 11

Homework 3 Solutions

22.8 (USCS units) Tool life tests in turning yielded the following data: (1) at $v = 350$ ft/min, $T = 5.2$ min; (2) at $v = 250$ ft/min, $T = 55$ min. (a) Determine the parameters n and C in the Taylor tool life equation. (b) Based on these values, what is the likely tool material used in this operation? (c) Using your equation, compute the tool life for a cutting speed of 300 ft/min. (d) Compute the cutting speed for a tool life = 10 min.

Solution: (a) Two equations for $vT^n = C$: (1) $350(5.2)^n = C$ and (2) $250(55)^n = C$

$$350(5.2)^n = 250(55)^n$$

$$350/250 = (55/5.2)^n$$

$$1.40 = (10.577)^n$$

$$\ln 1.40 = n \ln 10.577$$

$$0.3365 = 2.359 n \quad \quad \quad n = 0.143$$

$$C = 350(5.2)^{0.143} = 350(1.2652) \quad C = 442.8$$

$$\text{Check: } C = 250(55)^{0.143} = 250(1.771) = 442.8$$

$$\text{Use } C = 443. \text{ The tool life equation is } vT^{0.143} = 443 \text{ ft/min}$$

(b) Comparing these values of n and C with those in Table 22.2, the likely tool material is high speed steel.

$$(c) \text{ At } v = 300 \text{ ft/min, } T = (C/v)^{1/n} = (443/300)^{1/0.143} = (1.477)^{7.009} = 15.4 \text{ min}$$

$$(d) \text{ For } T = 10 \text{ min, } v = C/T^n = 443/10^{0.143} = 443/1.389 = 319 \text{ ft/min}$$

10.8 (A) (USCS units) The volume flow rate of molten metal into the downsprue from the pouring cup is 50 in³/sec. At the top where the pouring cup leads into the downsprue, the cross-sectional area = 1.0 in². Determine what the area should be at the bottom of the sprue if its length = 6.0 in. It is desired to maintain a constant flow rate, top and bottom, in order to avoid aspiration of the liquid metal.

Solution: Velocity at base $v = (2gh)^{0.5} = (2 \times 32.2 \times 12 \times 6)^{0.5} = 68.1$ in/sec

$$\text{Assuming volumetric continuity, area at base } A = (50 \text{ in}^3/\text{sec})/(68.1 \text{ in/sec}) = 0.734 \text{ in}^2$$

10.19 (A) (SI units) A riser in the shape of a sphere is to be designed for a sand-casting mold. The casting is a rectangular plate, with length = 200 mm, width = 100 mm, and thickness = 18 mm. If the total solidification time of the casting itself is known to be 3.5 min, determine the diameter of the riser so that it will take 25% longer for the riser to solidify.

Solution: Casting volume $V = LWt = 200(100)(18) = 360,000 \text{ mm}^3$

$$\text{Casting area } A = 2(200 \times 100 + 200 \times 18 + 100 \times 18) = 50,800 \text{ mm}^2$$

$$V/A = 360,000/50,800 = 7.0866$$

$$\text{Casting } T_{TS} = C_m(7.0866)^2 = 3.50 \text{ min}$$

$$C_m = 3.5/(7.0866)^2 = 0.0697 \text{ min/mm}^2$$

$$\text{Riser volume } V = \pi D^3/6 = 0.5236D^3$$

$$\text{Riser area } A = \pi D^2 = 3.1416D^2$$

$$V/A = 0.5236D^3/3.1416D^2 = 0.1667D$$

$$T_{TS} = 1.25(3.5) = 4.375 \text{ min} = 0.0697(0.1667D)^2 = 0.001936D^2$$

$$D^2 = 4.375/0.001936 = 2259.7 \text{ mm}^2$$

$$D = 47.5 \text{ mm}$$

11.4 (SI units) Brass bushings are made by horizontal true centrifugal casting. The bushings have length = 10 cm, outside diameter = 15 cm, and inside diameter = 12 cm. (a) Determine the rotational speed that obtains a G-factor of 70. (b) When operating at this speed, what is the centrifugal force per square meter (Pa) imposed by the molten metal on the inside wall of the mold? Density of brass = 8.62 g/cm³.

Solution: (a) Using the outside wall diameter of the casting, which is equal to the inside wall diameter of the mold, $D = 15 \text{ cm}$

$$N = (30/\pi)(2g \times 70/0.15)^{.5} = \mathbf{913.3 \text{ rev/min}}$$

(b) Use 1.0 cm of mold wall length as basis of area calculations.

$$\text{Area of this length of mold wall } A = \pi D_o L = \pi(15 \text{ cm})(10 \text{ cm}) = 150\pi \text{ cm}^2 = 0.0471 \text{ m}^2$$

$$\text{Volume of cast metal } V = \pi(R_o^2 - R_i^2)(10) = \pi((7.5)^2 - (6)^2)(10) = 636.2 \text{ cm}^3$$

$$\text{Mass } m = (8.62 \text{ g/cm}^3)(636.2 \text{ cm}^3) = 5484 \text{ g} = 5.484 \text{ kg}$$

$$v = \pi R N / 30 \text{ Use mean radius } R = (7.5 + 6.0)/2 = 6.75 \text{ cm}$$

$$v = \pi(6.75)(913.3)/30 = 645.6 \text{ cm/s} = 6.456 \text{ m/s}$$

$$\text{Centrifugal force per square meter on mold wall} = F_c/A \text{ where } F_c = mv^2/R$$

$$F_c = (5.484 \text{ kg})(6.456 \text{ m/s})^2/(6.75 \times 10^{-2} \text{ m}) = 3386 \text{ kg-m/s}^2 = 3386 \text{ N}$$

$$F_c/A = (3386 \text{ N})/(0.0471 \text{ m}^2) = \mathbf{7.1853(10^4) \text{ N/m}^2} = \mathbf{71,853 \text{ Pa}}$$

11. 11 (USCS units) Vertical true centrifugal casting is used to cast brass tubing that is 15.0 in long with outside diameter = 8.0 in. Density of brass = 0.313 lb/in³. If the speed of rotation during solidification is 1000 rev/min, determine the inside diameters at the top and bottom of the tubing if the total weight of the final casting = 75.0 lbs.

$$\text{Solution: Volume of casting } V = 75.0/0.313 = 239.6 \text{ in}^3$$

Assume the inside wall of the casting is straight from top to bottom (an approximation of the parabolic shape). The average inside radius $R_i = (R_t + R_b)/2$

$$\text{Volume } V = \pi(R_o^2 - R_i^2)L = \pi(4.0^2 - R_i^2)(15.0) = 239.6 \text{ in}^3$$

$$(4.0^2 - R_i^2) = 239.6/15\pi = 5.085$$

$$R_i^2 = 16.0 - 5.085 = 10.915 \text{ in}^2 \quad R_i = 3.304 \text{ in}$$

Let $R_t = R_i + y = 3.304 + y$ and $R_b = R_i - y = 3.304 - y$, where $y =$ one-half the difference between R_t and R_b .

$$N = (30/\pi)(2gL/(R_t^2 - R_b^2))^{.5} = (30/\pi)(2 \times 32.2 \times 12 \times 15/((3.304 + y)^2 - (3.304 - y)^2))^{.5}$$

Given $N = 1000 \text{ rev/min}$, thus

$$1000\pi/30 = (11592/((3.304 + y)^2 - (3.304 - y)^2))^{.5}$$

$$((3.304 + y)^2 - (3.304 - y)^2)^{.5} = 30(11592)^{.5}/1000\pi = 1.02814$$

$$(3.304^2 + 6.608y + y^2 - (3.304^2 - 6.608y + y^2))^{.5} = 1.02814$$

$$(3.304^2 + 6.608y + y^2 - 3.304^2 + 6.608y - y^2)^{.5} = 1.02814$$

$$(2 \times 6.608y)^{.5} = (13.216y)^{.5} = 1.02814$$

$$3.635 (y)^{.5} = 1.02814 \quad y = .080 \text{ in}$$

$$R_t = 3.304 + 0.080 = 3.384 \text{ in} \quad \mathbf{D_t = 6.768 \text{ in}}$$

$$R_b = 3.304 - 0.080 = 3.224 \text{ in} \quad \mathbf{D_b = 6.448 \text{ in}}$$

ABOVE AVERAGE

Madison J. Stoneham
DR. Jiang

October 15, 2021
Homework 3

22.8) Given: $v = 350 \text{ ft/min}$ } ①
 $T = 5.2 \text{ min}$

$v = 250 \text{ ft/min}$ } ②
 $T = 55 \text{ min}$

A) $vT^n = C$

$350 \times 5.2^n = C$

$C = 250 \times 50^n$

$350 \times 5.2^n = 250 \times 50^n$

$\ln(350 \times 5.2^n) = \ln(250 \times 50^n)$

$\ln 350 + n \ln 5.2 = \ln 250 + n \ln 50$

$n \ln 5.2 - n \ln 50 = \ln 250 - \ln 350$

$n = \frac{\ln 250 - \ln 350}{\ln 5.2 - \ln 50} = 0.1487$

$C = 350 \times 5.2^n$

$= 350 \times 5.2^{0.1487} = 447.24 \text{ ft/min}$

B) high speed steel

C) $vT^n = C$

$300 \times T^{0.1487} = 447.24$ $T^{0.1487} = \frac{447.24}{300}$ $T = 14.66 \text{ min}$

D) $vT^n = C$ $v \times 10^{0.1487} = 447.24$ $v = \frac{447.24}{10^{0.1487}} = 317.57 \text{ ft/min}$

+10

10.8) Given: $Q = 50 \text{ in}^3/\text{sec}$

Area = 1.0 in^2

length = 6.0 in

$$v = \sqrt{2gh} = \sqrt{2(32.2 \text{ ft/s}^2) \times \frac{12 \text{ in} \times 6}{1 \text{ ft}}}$$

$$= \sqrt{2(32.2 \text{ ft/s}^2)(6 \text{ in})}$$

$$= \sqrt{4636.8} = 68.09 \text{ in/s}$$

$$A = \frac{Q}{v} \quad A = \frac{50}{68.09} = 0.734 \text{ in}^2$$

+ (10)

10.19) Given: $l = 200 \text{ mm}$

$w = 100 \text{ mm}$

thickness = 18 mm

time = 3.5 min

$$T_s = C_M \left(\frac{V}{A} \right)^2 \rightarrow C_M = \frac{T_s}{\left(\frac{V}{A} \right)^2} \quad V = lwt$$

$$= (200)(100)(18)$$

$$= 360,000 \text{ mm}^3$$

$$A = 2(lw + lT + wT)$$

$$= 2((200)(100) + (200)(18) + (100)(18))$$

$$= 2(20000 + 3600 + 1800)$$

$$= 50800 \text{ mm}^2$$

$$C_M = \frac{3.5 \text{ min}}{\left(\frac{360000}{50800} \right)^2} = \frac{3.5}{(7.0866)^2} = 0.0697 \text{ min/mm}^2$$

$$V = \frac{\pi D^3}{6} \rightarrow V = 0.5236 D^3 \quad T_{TS} = 1.25(3.5 \text{ min}) = 4.375 \text{ min}$$

$$A = \pi D^2 \rightarrow A = 3.1416 D^2 \quad 4.375 = (0.0697) \left(\frac{0.5236 D^3}{3.1416 D^2} \right)^2$$

$$\frac{(0.1667 D)^2}{0.0697} = \frac{4.375}{0.0697} \quad 0.02778 D^2 = 62.769$$

$$D^2 = \frac{62.769}{0.02778} = 2259.7 \quad D = \sqrt{2259.7} = 47.5 \text{ mm} \quad +10$$

11.4) Given: $l = 10 \text{ cm} \rightarrow 0.1 \text{ m}$

$$d_{\text{out}} = 15 \text{ cm} \rightarrow 0.15 \text{ m}$$

$$d_{\text{in}} = 12 \text{ cm} \rightarrow 0.12 \text{ m}$$

$$GF = 70$$

$$\begin{aligned} \text{A) } N &= \frac{30}{\pi} \sqrt{\frac{2g(GF)}{D}} = \frac{30}{\pi} \sqrt{\frac{2 \times 9.81 \times 70}{0.15}} = \frac{30}{\pi} (95.687) \\ &= 913.7 \text{ rev/min} \end{aligned}$$

$$\text{B) } A = \pi D_o L = \pi (0.15)(0.1) = 0.0471 \text{ m}^2$$

$$R_o = \frac{D_o}{2} = \frac{0.15}{2} = 0.075 \text{ m} \quad R_i = \frac{D_i}{2} = \frac{0.12}{2} = 0.06 \text{ m}$$

$$\begin{aligned} V &= \pi (R_o^2 - R_i^2) L = \pi [(0.075)^2 - (0.06)^2] (0.1) \\ &= 0.362 \times 10^{-4} \text{ m}^3 \end{aligned}$$

$$M = V\rho$$

$$= (6.862 \times 10^{-4}) \times 8.62 \left(\frac{g}{cm^3} \right) \left(\frac{(100)^3 cm^3}{1 m^3} \right)$$

$$= 5484.044 g \left(\frac{1 kg}{1000 g} \right) = 5.484 kg$$

$$R = \frac{R_o + R_i}{2} = \frac{0.075 + 0.06}{2} = 0.0675 m$$

$$V = \frac{\pi R N}{30} = \frac{\pi \times 0.0675 \times 913.74}{30} = 6.4585 m/s$$

$$F_c = \frac{M V^2}{R} = \frac{5.484 \times (6.458)^2}{0.0675} = 3388.36 (kg \cdot m/s^2) \left(\frac{1 N}{9.81} \right)$$

$$= 345.39 N \quad \text{centrifugal force} = \frac{F_c}{A} = \frac{345.39}{0.0171} = 7383.1 Pa$$

11.11) Given: $l = 15 in.$

$$d_{out} = 8.0 in$$

$$\text{density} = 0.313 lb/in^3$$

$$N = 1000 \text{ REV/MIN}$$

$$M = 75.0 lb$$

$$\frac{V}{\rho} = \frac{M}{\rho} = \frac{75}{0.313} = 239.61 in^3 \quad V = \pi (R_o^2 - R_i^2) L$$

$$239.61 = \pi [(4)^2 - (R_i)^2] (15) \rightarrow \frac{239.61}{\pi (15)} = (4)^2 - (R_i)^2$$

$$(R_i)^2 = 16 - 5.085 \rightarrow R_i = \sqrt{10.915} = 3.304 \text{ IN}$$

$$R_i = \frac{R_t + R_b}{2} \quad R_t = R_i + R \quad R_b = R_i - R$$

$$R_t = 3.304 + R \quad R_b = 3.304 - R$$

$$N = \frac{30}{\pi} \sqrt{\frac{2gL}{R_t^2 - R_b^2}} \quad 1000 = \frac{30}{\pi} \sqrt{\frac{2(32) \left(\frac{12 \text{ IN}}{16} \right) (15)}{(3.304 + R)^2 - (3.304 - R)^2}}$$

$$\frac{\pi(1000)}{30} = \sqrt{\frac{11520}{4(3.303)(R)}} \quad \frac{871.671}{R} = (104.72)^2$$

$$R = \frac{871.671}{(104.72)^2} = 0.08 \text{ IN}$$

$$R_t = 3.304 + 0.08 = 3.384 \text{ IN} \quad R_b = 3.304 - 0.08 = 3.224 \text{ IN}$$

$$D_t = 2R_t = 2(3.384 \text{ IN}) = 6.768 \text{ IN}$$

$$D_b = 2R_b = 2(3.224 \text{ IN}) = 6.448 \text{ IN}$$

+ 10

AVERAGE

Homework #3

Manufacturing Process

10.8 Length = 6.0 in
calc velocity at the

$$\begin{aligned}v &= \sqrt{gh} \\&= \sqrt{2 \times 32.2 \times 12 \times 6} \\&= \sqrt{4636.8} \\&= 68.094 \text{ in/s}\end{aligned}$$

Problem
22.8?

Consider the volumetric

$$\begin{aligned}A &= \frac{Q}{v} \\&= \frac{50}{68.094} \\&= \underline{\underline{0.7342 \text{ in}^2}}\end{aligned}$$

+10

10.19

$$\begin{aligned}L \times W \times t &= 200 \times 100 \times 18 = 360000 \text{ mm}^3 \\&= 2(Lw + Lt + wt) \\&= 2((200 \times 100) + (200 \times 18) + (100 \times 18)) \\&= 50,800 \text{ mm}^2\end{aligned}$$

$$\text{Eqn 1} \quad 3.5 = \left(\frac{360000}{50,800} \right)^2 \quad K_1 = 0.06969 \text{ mm/mm}^2$$

$$(V) = \frac{\pi D^3}{6} = 0.5235 D^3$$

$$\pi D^2 = 3.1415 D^2$$

$$T = 1.25(3.5) = 4.375 \text{ min} \quad T = \left(\frac{V}{A_s} \right)^2 K_1$$

$$4.375 = \left(\frac{0.5235 D^3}{3.1415 D^2} \right)^2 \times 0.06969$$

$$\begin{aligned}4.375 &= (0.027768 D) \times 0.06969 \\D^2 &= 2260.728 \Rightarrow D = \underline{\underline{47.547 \text{ mm}}}\end{aligned}$$

+10

11.4 Given

$$D_1 = 15 \text{ cm} = 0.15 \text{ m}$$

$$D_2 = 12 \text{ cm} = 0.12 \text{ m}$$

$$G_f = 70$$

$$N = \frac{30}{\pi} \sqrt{\frac{2 \times g \times (G_f)}{D_0}}$$

$$N = \frac{30}{\pi} \sqrt{\frac{2 \times 9.81 \times 70}{0.15}}$$

$$N = 913.7434 \text{ rev}$$

$$A = \pi (15)(1)$$

$$= 47.123 \text{ m}^2 = 47.123 \times 10^{-4} \text{ m}^2$$

$$V = \pi (R_1^2 - R_2^2) (L)$$

$$V = \pi \left[\left(\frac{15}{2} \right)^2 - \left(\frac{12}{2} \right)^2 \right] (1) = 63.617 \text{ m}^3$$

$$m = \rho V$$

$$= 8.62 \frac{\text{g}}{\text{cm}^3} \times 63.617 \text{ cm}^3$$

$$= 548.38 \text{ g} \approx 0.5483 \text{ kg}$$

$$V = \pi \frac{R_{\text{cm}} N}{30} = \pi \left[\left(\frac{15}{2} \right)^2 + \left(\frac{12}{2} \right)^2 \right] (913.74)$$

$$30$$

$$= 645.88 \text{ cm}^3 = 6.4588 \text{ m}^3$$

$$F_C = \frac{mv^2}{R_{\text{cm}}} = \frac{0.5483 \text{ kg} \times (6.4588 \text{ m/s})^2}{6.75 \times 10^{-2} \text{ m}}$$

$$47.123 \times 10^{-4} \text{ m}^2$$

$$= 338.858 \text{ kg} \cdot \text{m}^2/\text{s}^2$$

$$47.123 \times 10^{-4} \text{ m}^2$$

$$= 71909.32 \text{ N/m}^2$$

+ 8

11.11 Given

$$L = 15.0 \text{ m} \quad \rho = 0.313 \text{ lb/m}^3$$

$$N = 1000 \text{ rev/min} \quad W = 75.0 \text{ lb}$$

$$V = \frac{\text{weight}}{\text{density}} = \frac{75.0}{0.313} = 239.6 \text{ m}^3$$

$$V = \pi (R_o^2 - R_i^2) \cdot L = \pi (4.0^2 - R_i^2) (15.0)$$

$$\pi (4^2 - R_i^2) 15 = 239.6$$

$$(4^2 - R_i^2) = \frac{239.6}{15\pi} = 5.085$$

$$R_i = 3.304 \text{ in}$$

$$N = \left(\frac{30}{\pi} \right) \left[\frac{2\pi L}{(R_o^2 - R_i^2)} \right] = \left(\frac{30}{\pi} \right) \left[\frac{2 \times 32.2 \times 12 \times 15}{(3.304 + y)^2 - (3.304 - y)^2} \right]^5$$

$$1000 = \frac{30}{\pi} \left[\frac{11.592}{(3.304 + y)^2 - (3.304 - y)^2} \right]^5$$

$$\frac{1000\pi}{30(11.592)^5} = \left[\frac{1}{(3.304 + y)^2 - (3.304 - y)^2} \right]^5$$

$$\left[(3.304 + y)^2 - (3.304 - y)^2 \right]^5 = \frac{30 \times (11.592)^5}{1000 \times \pi} = 1.02814$$

$$(2 \times 6.608y)^5 = 1.02814$$

$$y = 0.080 \text{ in}$$

$$R_t = 3.304 + 0.080 = 3.384 \text{ inch}$$

$$\Delta t = 2 \times R_t = 2 \times 3.304$$

$$\Delta t = 6.608 \text{ inch}$$

$$R_t = 3.304 - 0.080 = 3.224 \text{ in}$$

$$\Delta t = 2 \times R_t = 2 \times 3.224 = 6.448 \text{ inch}$$

+10

BELOW AVERAGE

22.8

A) $vT^n = C$

$350 \cdot 5 \cdot 2^n$

$350 \cdot 5 \cdot 2^n = 250 + 50^n$

$\ln 2^n \ln 1750 = \ln 250 + n \ln 50$

$n \ln 52 + \ln 350 = \ln 250 + n \ln 50$

$n \ln 52 + n \ln 50 = \ln 250 + \ln 350$

$$n \frac{(\ln 52 + \ln 50)}{(\ln 52 + \ln 50)} = \frac{\ln 250 + \ln 350}{\ln 52 + \ln 50}$$

$$n = \frac{\ln 250 + \ln 350}{\ln 52 + \ln 50}$$

$$n = .1486602$$

$$350 \cdot 5 \cdot 2^{.1486602}$$

$$447.207683$$

$$\frac{300 \cdot T^{.1486}}{300} = \frac{447.207683}{300}$$

$$T^{.1486} = 1.4906923$$

$$\frac{1.4906}{1.4906} \ln T = \frac{\ln 1.4906923}{1.4906}$$

$$= .267$$

$$= 1.307141$$

B) High speed steel

D) $vT^n = C$ $v \cdot 10^{.14866} = 447.207$

$$v = 317.264$$

(C)?

+8

10.9

$$\sqrt{2(52.2) \cdot 12.6} = \sqrt{68.0941}$$

68

$$A = \frac{Q}{V}$$

$$= \frac{50}{68.09}$$

$$A = .7343 \text{ in}^2$$

+10

10.14

$$V = lWT$$

$$200 \cdot 100 \cdot 18$$

$$3.6 \cdot 10^5$$

$$2(200 \cdot 100) + 200 \cdot 18 + 100 \cdot 18$$

$$50800 \text{ mm}^2$$

$$C_m = \frac{2.5 \text{ min}}{\left(\frac{360000}{50800}\right)}, \quad - \frac{3.5}{(7.0966)^2} = .069643$$

$$T_{fs} = 1.25(3.5) = 4.375$$

$$4.375 = .069643 \left(\frac{.5236D^2}{3.1416D^2} \right)^2$$

$$(.1667D)^2 = \frac{4.375}{.0697}$$

$$.02778D^2 = " "$$

$$= \sqrt{\frac{1}{.77} \left(\frac{4.375}{.0697} \right)}$$

$$D = 47.534 \text{ mm}$$

+10

11.4

a

$$N = \frac{30}{\pi} \sqrt{\frac{2 \cdot 9.81 \cdot 70}{.15}}$$

$$N = 913.7434$$

b

$$A = \pi D_o L = \pi (.15)(.1) = .0471 \text{ m}^2$$

$$R_o = \frac{D_o}{2} = \frac{.15}{2} = .075 \text{ m}$$

$$R_i = \frac{D_i}{2} = \frac{.12}{2} = .06 \text{ m}$$

$$= \pi [(.075)^2 - (.06)^2] (.1)$$

$$= 6.362 \cdot 10^{-4} \text{ m}^3$$

$$6.362 \cdot 10^{-4} \cdot (8.62) \cdot \frac{1000000}{1} = 5484.044 \cdot \frac{1}{1000} = 5.484 \text{ kg}$$

$$R = \frac{R_o + R_i}{2} = \frac{.075 + .06}{2} = .0675$$

$$v = \frac{\pi R N}{30} = \frac{\pi \cdot .0675 \cdot 913.74}{30} = 6.4588475$$

$$\frac{5.484 \cdot 6.458^2}{.0675} = 3388.36163 \cdot \frac{1}{.0675} = 345.399$$

$$\frac{345.39}{.0471} = 7335 \text{ Pa}$$

+ 9

11.11

$$\frac{75}{.313} = 239.617$$

$$\sqrt{16 - \frac{239.61}{\pi (.15)}} = R_i$$

$$3.764 = R_i$$

**MANUFACTURING PROCESSES
FALL 2021**

HOMEWORK 4

TOPICS COVERED

Chapters 13, 32

Homework 4 Solutions

13.11 (USCS units) Consider an extruder in which the barrel diameter = 4.5 in and length = 11 ft. The extruder screw rotates at 60 rev/min; its channel depth = 0.35 in and flight angle = 20°. The plastic melt has a shear viscosity = $125(10^{-4})$ lb-sec/in². Determine (a) Q_{max} and p_{max} , (b) the shape factor for a circular die opening with diameter = 0.312 in and length = 0.75 in, and (c) the values of Q and p at the operating point.

Solution: (a) $Q_{max} = 0.5\pi^2 (4.5)^2 (1)(0.35)\sin 20 \cos 20 = 34.975(0.342)(0.9397)$
 $= 11.24 \text{ in}^3/\text{sec}$

$$p_{max} = 6\pi(4.5)(1)(132)(0.0125)(\cot 20)/(0.35)^2 = 3139 \text{ lb/in}^2$$

(b) Given: $D_d = 0.312$ in, $L_d = 0.75$ in

$$K = \pi D \eta L = \pi(0.312)^4 / 128 / 128(0.0125)(0.75) = 0.024808 \text{ in}^5/\text{lb-sec}$$

(c) From (a), $Q_x = Q_{max} - (Q_{max}/p_{max})p = 11.24 - 0.003581p$

From (b), $Q_x = 0.024808p$

Combining, $0.024808p = 11.24 - 0.003581p$

$$0.02839p = 11.24 \quad p = 395.9 \text{ lb/in}^2$$

$$Q_x = 11.24 - 0.003581(395.9) = 9.82 \text{ in}^3/\text{sec}$$

13.16 (SI units) The foreman in the injection-molding department says that a high-density polyethylene part produced in one of the operations has greater shrinkage than the calculations indicate it should have. The important dimension of the part is specified as 120.5 ± 0.25 mm. However, the actual molded part measures 120.02 mm. (a) As a first step, the corresponding mold cavity dimension should be checked. Compute the correct value of the mold dimension, given that the shrinkage value for HDPE in Table 13.1. (b) What adjustments in process parameters could be made to reduce the amount of shrinkage?

Solution: (a) Given: $S = 4.0\% = 0.04$ for HDPE from Table 13.1.

$$D_c = 120.5 + 120.5(0.04) + 120.5(0.04)^2 = 125.513 \text{ mm}$$

(b) Adjustments to reduce shrinkage include: (1) increase injection pressure, (2) increase compaction time, and (3) increase molding temperature.

32.10 (A) (SI units) A part prototype is to be fabricated using stereolithography. The base of the part is shaped like a right triangle with dimensions 36 mm by 48 mm. In application, the part will stand on this base. The height of the part is 30 mm. In the stereolithography process, the layer thickness = 0.15 mm. Diameter of the laser-beam spot = 0.40 mm, and the beam is moved across the surface of the photopolymer at a velocity of 2200 mm/s. Compute the minimum possible time required to build the part, if 25 s are lost each layer to lower the height of the platform that holds the part. Neglect the time for setup and post-processing.

Solution: The part should be oriented on its side in the stereolithography process; thus, layer area A_i and time to complete are the same for all layers.

$$T_i = \frac{A}{vD} + T_r = \frac{36 \times 48 / 2}{2200 \times 0.40} + 25 = 25.98 \text{ s}$$

$$T_c = T_{su} + \sum T_i = T_i \times \frac{h}{t} = 25.98 \times \frac{30}{0.15} = 5196.4 \text{ s} = 86.61 \text{ min} = 1.44 \text{ hr}$$

ABOVE AVERAGE

1311)

Given data

Barrel diameter = 4.5 inch

$N = 60 \text{ rev/min}$

Channel depth $\rightarrow 0.35 \text{ inch}$

flight angle $\rightarrow 20^\circ$

$$Q_{\max} \rightarrow 0.5 \pi D^2 N d \sin A \cos A$$

$$0.5 \pi^2 (4.5)^2 (1) (0.35) \sin 20^\circ \cos 20^\circ$$

$$Q_{\max} \rightarrow 11.24 \text{ in}^3/\text{sec}$$

$$P_{\max} = 6 \pi (4.5) (1) (132) (0.0125)$$

$$\frac{(132 \cos 20^\circ)}{0.35}$$

$$P_{\max} = 3139.16 \text{ lb/in}^2$$

6) Given $D_y = 0.312 \text{ inch}$ $L_d = 0.75$

$$K_s = \frac{\pi D_d^4}{128 L_d} = \frac{\pi (0.312)^4}{128 (0.0125) (0.75)}$$

$$K_s = 0.024808 \text{ in}^5/\text{lb-in}^2$$

C) from (a) $Q_y =$

$$a_{max} - (c_{max}/\rho_{max})\rho$$

$$= 11.24 - 0.003581\rho$$

from b $Q_y = 0.024808\rho$

Comparing $0.024808\rho =$

$$11.24 - 0.003581\rho$$

$$0.02839\rho = 11.24$$

$$\rho = 395.9 \text{ lb/m}^2$$

$$Q_y = 11.24 - 0.003581(395.9)$$

$$Q_x = 9.82 \text{ m}^3/\text{sec}$$

13.16

13-16

a) Given $S = 0.028$

$$D_c = 120.5 + 120.5 \times (0.04) + 120.5 \times (0.04)^2 = 128.8728 \text{ mm}$$

$$D_c = 128.5 \text{ mm}$$

$$D_c = \cancel{113.55 \text{ mm}}$$

b) Adjustments reduce shrinkage

i) Increase in section Pressure

ii) Increase Compaction time

iii) Increase molding temperature

32.10)

$$\begin{aligned} A_1 &= 0.5 \times bh \\ &= 0.5 \times (36 \times 48) \\ &= \underline{864} \text{ mm}^2 \end{aligned}$$

$$T_c = \frac{A_1}{\text{spot size} \times \text{velocity}} + \text{load time}$$

$$\frac{864}{0.4 \times 2200} + 25$$

$$= 25.985$$

$$\# \text{ of layers} = n_b = \frac{t}{\text{layer thickness}} = \frac{30}{0.15}$$

$$b_c = T_c = n_b T_b = 200$$

$$= 200 \times 25.98 = 5196 \text{ sec}$$

$$\boxed{T_c = 1.443 \text{ hr}}$$
 Minimum possible time required to build

AVERAGE

Given
13.11

Manufacturing Processes

$$d = 4.5 \text{ in}$$

$$L = 11 \text{ ft}$$

$$N = 60 \text{ rev/min}$$

$$\text{depth of channel} = 0.35 \text{ in}$$

$$\text{Angle} = 20^\circ$$

$$\text{Shear viscosity} = 125 \times 10^{-4} / 6 - \text{sec/in}^2 =$$

$$\begin{aligned} 1) Q_{\max} &= 0.5 \pi^2 D^3 N d_c \sin(x) \cos d \\ &= 0.5 \times \pi^2 \times 4.5^2 \times \frac{60}{60} \times 0.35 \sin(20) \cos(20) \\ &= 11.24 \text{ in}^3/\text{sec} \quad \checkmark \end{aligned}$$

$$\begin{aligned} 2) P_{\max} &= \frac{6 \pi D \times 8 \times N \times L (10 \times \alpha)}{d_c^2} \\ &= \frac{6 \pi \times 4.5 \times 125 \times 10^{-4} \times \frac{60}{60} \times (11 \times 12) \text{ in} \cot(20)}{0.35^2} \end{aligned}$$

$$D_{\max} = 3139.03 \text{ lb/in}^2$$

$$\begin{aligned} \text{Shape factor } (K_s) &= \pi (D_{\max})^4 / 1288 \times L d \\ &= \frac{\pi \times (0.312)^4}{128 \times 125 \times 10^{-4} \times 0.75} \end{aligned}$$

$$K = 0.02480$$

$$\begin{aligned} Q_x &= Q_{\max} - \left(\frac{Q_{\max}}{D_{\max}} \right)^4 P \\ Q_x &= 11.24 - \left[\frac{11.24}{3139.03} \right]^4 P = 11.24 - [e^{-3.58072 \times 10^{-3}}] P \\ 11.24 - 3.580 \times 10^{-3} P &\rightarrow 1) \\ Q_x &= K_s P \quad 11.24 - 3.5807 \times 10^{-3} P = 0.02480 P \\ P &= 396.04 \text{ lb/in}^2 \Rightarrow Q_x = 0.02480 \times 396.04 \\ &= 9.8192 \text{ in}^3/\text{sec} \quad \checkmark \end{aligned}$$

3.16

$$S = \frac{5\%}{100}$$

$$S\% = 4$$

therefore $\rightarrow S = \frac{4}{100}$

$$S = 0.04$$

$$D_c = D_p + D_p S + D_p S^2$$

D_p is the moulded part dimension

Substitute 120.5mm for D_p and 0.04 for S .

$$D_c = 120.5 + 120.5(0.04) + 120.5(0.04)^2$$

$$D_c = 125.512 \text{ mm}$$

32.10

$$A_1 = 0.5 \times (bh)$$

$$= 0.5 \times (36 \times 48)$$

$$= 864 \text{ mm}^2$$

Time to complete one layer. T is same for all layers

$$T = \frac{A_1}{\text{Spot size} \times \text{velocity}} + \text{lost time}$$

$$= \frac{864}{0.4 \times 2200} + 25$$

$$= 25.985$$

$$\text{Number of layers} = N_t = \frac{+}{\text{layer thickness}} = \frac{30}{0.15} = 200$$

Minimum possible time required

→

$$= T_c = n + T_t$$

$$= 200 \times 25.98$$

$$= 5196 \text{ Sec}$$

$$T_c = \underline{\underline{1.443 \text{ hr}}}$$

BELOW AVERAGE

Homework 4 Dakin Mitchell

$$\begin{aligned}
 13.11) \ a) \ Q_{max} &= Q_d = 0.5 \pi^2 D^2 N d_c \sin A \cos A \\
 &= 0.5 \pi^2 (4.5)^2 (60) (0.35) \sin 20 \cos 20 \\
 &= 674.42 \text{ in}^3/\text{min} / 60 \text{ sec} \\
 [Q_d &= 11.24 \text{ in}^3/\text{sec}] \quad \checkmark
 \end{aligned}$$

$$P_{max} = 6 \pi D N L n (\cot A) / d_c^2 \quad L = 11 + (12 \text{ in})$$

$$L = 132 \text{ in}$$

$$= \frac{6 \pi (4.5) (60/60) (132) (125 \times 10^{-4}) (\cot 20)}{(0.35)^2}$$

$$= (1140)(2.747) / 0.1225$$

$$P_{max} = 3,139.16 \text{ lb/in}^2 \quad \checkmark$$

$$b) \ k_s = \pi D^4 / 128 \eta L$$

$$= \pi (0.312)^4 / 128 (125 \times 10^{-4}) (0.75)$$

$$k_s = 0.0248008 \quad \checkmark$$

$$c) \ Q_x = Q_{max} - (Q_{max} / P_{max}) P$$

$$Q_x = k_s P$$

$$11.24 - 0.003581 P = 0.0248008 P$$

$$= 11.24 - (11.24 / 3,139.16) P$$

$$11.24 = 0.0248008 P + 0.003581 P$$

$$Q_x = 11.24 - 0.003581 P$$

$$[P = 395.9 \text{ lb/in}^2]$$

$$Q_x = k_s P$$

$$= 0.0248008 (395.9)$$

$$Q_x = 9.82 \text{ in}^3/\text{s} \quad \checkmark$$

Devan mitchell

13.16

a) $S = 5\% / 100$ $S\% = 4$
 $= 4/100$
 $S = 0.04$

$$D_c = D_p + D_p S + D_p S^2$$
$$= 120.5 + 120.5(0.04) + 120.5(0.04)^2$$
$$D_c = 125.5128 \text{ mm} \quad \checkmark$$

32.10) $T_i = A_i / v_i + T_r$
 $= 864 / 400 (11.15) + 8$
 ~~$[T_i = 22.45]$~~

$$A_i = \frac{1}{2} \pi b h$$
$$= \frac{1}{2} (36) (48)$$
$$[A_i = 864 \text{ mm}^2] \quad \checkmark$$

$$n_i = n_i / l_i$$
$$= 25 / 0.20$$
 ~~$[n_i = 125 \text{ mm}]$~~

$$T_c = \sum_{i=1}^{n_i} T_i$$

$$= (n_i) (T_i)$$

$$= (125) (22.4) (1 \text{ hr} / 3,600 \text{ s})$$

~~$[T_c = 0.777 \text{ hr}]$~~

**MANUFACTURING PROCESSES
FALL 2021**

HOMEWORK 5

TOPICS COVERED

Chapters 18, 19

Homework 5 Solutions

18.6 (A) (SI units) A low-carbon steel plate is 270 mm wide and 25 mm thick. It is reduced in one pass in a two-high rolling mill to a thickness of 20 mm. Roll radius = 600 mm, and roll speed = 30 m/min. Strength coefficient = 500 MPa, and strain hardening exponent = 0.25. Determine the (a) roll force, (b) roll torque, and (c) power required to perform the operation.

Solution:

(a) Draft $d = 25 - 20 = 5$ mm

Contact length $L = (600 \times 5)^{.5} = 54.77$ mm

True strain $\varepsilon = \ln(25/20) = \ln 1.25 = 0.223$

$Y_f = 500(0.223)^{0.25} / 1.25 = 274.9$ MPa

Rolling force $F = 274.9(270)(54.77) = \mathbf{4,065,194}$ N

(b) Torque $T = 0.5(4,065,194)(54.77 \times 10^{-3}) = \mathbf{111,325}$ N-m

(c) $N = (30 \text{ m/min}) / (2\pi \times 0.600) = 7.96 \text{ rev/min} = 0.133 \text{ rev/s}$

Power $P = 2\pi(0.133)(4,065,194)(54.77 \times 10^{-3}) = 186,061 \text{ N-m/s} = 186,061 \text{ W} = \mathbf{186.1}$ kW

18.20 (A) (USCS units) A part is hot-forged in an impression die. The projected area of the part, including flash, = 14.1 in^2 . After trimming, the part has a projected area of 10.3 in^2 . Part geometry is complex. At room temperature, the work metal has a strength coefficient = $35,000 \text{ lb/in}^2$ and a strain-hardening exponent = 0.15. As heated, the work metal yields at $12,000 \text{ lb/in}^2$ and no strain hardening occurs. Determine the maximum force required to perform the forging operation.

Solution: Since the work material has no tendency to work harden, $n = 0$

From Table 18.1, choose $K_f = 8.0$

$F = 8.0(12,000)(14.1) = \mathbf{1,353,600}$ lb

18.27 (A) (SI units) An L-shaped structural section is direct extruded from an aluminum alloy billet whose length = 500 mm and diameter = 100 mm. Dimensions of the extruded cross section are given in Figure P18.27. The strength coefficient and strain-hardening exponent of the aluminum alloy are 240 MPa and 0.15, respectively (Table 3.4). The die angle = 90° , and the Johnson strain equation has constants $a = 0.8$ and $b = 1.5$. Determine the (a) extrusion ratio, (b) shape factor, and (c) length of the extruded section if the butt remaining in the container at the end of the ram stroke is 25 mm long. (d) Compute the maximum force required to drive the ram forward at the start of extrusion.

Solution: (a) $r_x = A_o / A_f$

$A_o = \pi(100)^2 / 4 = 7854 \text{ mm}^2$

$A_f = 2(12 \times 50) = 1200 \text{ mm}^2$

$r_x = 7854 / 1200 = \mathbf{6.545}$

(b) To determine the die shape factor, to determine the perimeter of a circle whose area is equal to that of the extruded cross section, $A = 1200 \text{ mm}^2$. The radius of the circle is $R = (1200/\pi)^{0.5} = 19.54 \text{ mm}$, $C_c = 2\pi(19.54) = 122.8 \text{ mm}$.

The perimeter of the extruded cross section $C_x = 62 + 50 + 12 + 38 + 50 + 12 = 224 \text{ mm}$

$K_x = 0.98 + 0.02(224/122.8)^{2.25} = \mathbf{1.057}$

(c) Total original volume $V = 0.25\pi(100)^2(500) = 3,926,991 \text{ mm}^3$

The final volume consists of two sections: (1) butt, and (2) extrudate. The butt volume $V_1 = 0.25\pi(100)^2(25) = 196,350 \text{ mm}^3$. The extrudate has a cross-sectional area $A_f = 1200 \text{ mm}^2$.

Its volume $V_2 = LA_f = 3,926,991 - 196,350 = 3,730,641 \text{ mm}^3$.

Thus, length $L = 3,730,641/1200 = \mathbf{3108.9 \text{ mm} = 3.109 \text{ m}}$

(d) $\varepsilon = \ln 6.545 = 1.879$

$\varepsilon_x = 0.8 + 1.5\ln(6.545) = 3.618$

$Y_f = 240(1.879)^{0.15} / 1.15 = 229.4 \text{ MPa}$

Maximum ram force occurs at beginning of stroke when length is maximum at $L = 250 \text{ mm}$

$p = K_x Y_f (\varepsilon_x + 2L/D_o) = 1.057(229.4)(3.618 + 2(500)/100) = 3302.03 \text{ MPa}$

$F = pA_o = 3302.03(7854) = \mathbf{25,934,186 \text{ N} = 25.9 \text{ MN}}$

18.33 (SI units) Bar stock of initial diameter = 90 mm is drawn with a draft = 15 mm. The draw die has an entrance angle = 18° , and the coefficient of friction at the work-die interface = 0.08. The metal behaves as a perfectly plastic material with yield stress = 105 MPa. Determine the (a) area reduction, (b) draw stress, (c) draw force required for the operation, and (d) power to perform the operation at an exit velocity = 1.0 m/min.

Solution: (a) $r = (A_o - A_f)/A_o$

$A_o = 0.25\pi(90)^2 = 6361.7 \text{ mm}^2$

$D_f = D_o - d = 90 - 15 = 75 \text{ mm},$

$A_f = 0.25\pi(75)^2 = 4417.9 \text{ mm}^2$

$r = (6361.7 - 4417.9)/6361.7 = \mathbf{0.3056}$

(b) Draw stress σ_d :

$\varepsilon = \ln(6361.7/4417.9) = \ln 1.440 = 0.3646$

$Y_f = 105 \text{ MPa}$

$D = (90 + 75)/2 = 82.5 \text{ mm}$

$L_c = (90 - 75)/(2\sin 18^\circ) = 24.3 \text{ mm}$

$\phi = 0.88 + 0.12(D/L_c) = 0.88 + 0.12(82.5/24.3) = 1.288$

$\sigma_d = Y_f(1 + \mu/\tan\alpha)\phi(\ln A_o/A) = 105(1 + 0.08/\tan 18^\circ)(1.288)(0.3646) = \mathbf{61.45 \text{ MPa}}$

(c) $F = A_f \sigma_d = 4417.9 (61.45) = \mathbf{271,475 \text{ N}}$

(d) $P = 271,475(1 \text{ m/min}) = 271,475 \text{ N-m/min} = 4524.6 \text{ N-m/s} = \mathbf{4524.6 \text{ W}}$

19.3 (SI units) A compound die is used to blank and punch a large washer out of 6061ST aluminum alloy sheet stock 3.2 mm thick. The outside diameter of the washer is 25.0 mm, and the inside diameter is 12.0 mm. Determine the punch and die sizes for the (a) blanking operation and (b) punching operation.

Solution:

From Table 19.1, $A_c = 0.060$. Thus, $c = 0.060(3.2) = 0.192 \text{ mm}$

(a) Blanking punch diameter = $D_b - 2c = 25.0 - 2(0.192) = \mathbf{24.62 \text{ mm}}$

Blanking die diameter = $D_b = \mathbf{25.00 \text{ mm}}$

(b) Punching punch diameter = $D_h = 12.00 \text{ mm}$

Punching die diameter = $D_h + 2c = 12.0 + 2(0.192) = 12.38 \text{ mm}$

19.8 (SI units) Solve part (a) of the previous problem except that the bend radius $R = 10.5 \text{ mm}$.

Solution:

From drawing, $\alpha' = 40^\circ$, $R = 11.35 \text{ mm}$

$\alpha = 180 - \alpha' = 140^\circ$

$A_b = 2\pi(\alpha/360)(R + K_{ba}t)$

$R/t = (10.5)/(5.00) = 2.1$; therefore, $K_{ba} = 0.5$

$A_b = 2\pi(140/360)(10.5 + 0.5 \times 5.00) = 31.76 \text{ mm}$

Dimensions of starting blank: $w = 35 \text{ mm}$, $L = 58 + 31.76 + 46.5 = 136.26 \text{ mm}$

19.16 (USCS units) A deep drawing operation is performed to produce a cylindrical cup in which the inside diameter = 4.25 in and height = 2.65 in. Stock thickness = 3/16 in, and blank diameter = 7.7 in. Punch and die radii = 5/32 in. The metal has a tensile strength = 65,000 lb/in², yield strength = 32,000 lb/in², and shear strength of 40,000 lb/in². Determine the (a) drawing ratio, (b) reduction, (c) drawing force, and (d) blank-holder force.

Solution:

(a) $DR = 7.7/4.25 = 1.81$

(b) $r = (D_b - D_p)/D_b = (7.7 - 4.25)/7.7 = 3.45/7.70 = 0.448 = 44.8\%$

(c) $F = \pi D_p t(TS)(D_b/D_p - 0.7) = \pi(4.25)(0.1875)(65,000)(7.7/4.25 - 0.7) = 180,900 \text{ lb}$

(d) $F_h = 0.015Y\pi(D_b^2 - (D_p + 2.2t + 2R_d)^2)$
 $F_h = 0.015(32,000)\pi(7.7^2 - (4.25 + 2.2 \times 0.1875 + 2 \times 0.15625)^2)$
 $= 0.015(32,000)\pi(7.7 - 4.975^2) = 52,100 \text{ lb}$

ABOVE AVERAGE

Madison J. Stoneham

11/24/2021

DR. JIANG

Homework 5

18.6) Given: $w = 270 \text{ mm}$ $n = 0.25$
 $t_0 = 25 \text{ mm}$ $K = 500 \text{ MPa}$
 $t_f = 20 \text{ mm}$ $V_r = 30 \text{ m/min}$
 $R = 600 \text{ mm}$

A) Rolling force: $\epsilon = \ln\left(\frac{t_0}{t_f}\right) = \ln\left(\frac{25}{20}\right) = .2231$

$$\bar{Y}_f = \frac{K(\epsilon)^n}{1+n} = \frac{500(.2231)^{.25}}{1+.25} = 274.906 \text{ MPa}$$

$$L = \sqrt{R(t_0 - t_f)} = \sqrt{600(5)} = \sqrt{3000} = 54.77 \text{ mm}$$

$$\begin{aligned} F &= \bar{Y}_f w L \\ &= (274.906 \times 10^6)(270 \times 10^3)(54.77 \times 10^3) \\ &= 4065289 \text{ N} \end{aligned}$$

B) Rolling torque: $T = \frac{1}{2} FL$

$$= \frac{1}{2} (4065289)(54.77 \times 10^3)$$

$$= 111328 \text{ N}\cdot\text{m}$$

C) Required power

$$P = 2\pi N F L \quad V_r = 2\pi R N$$

$$30 = 2\pi (600 \times 10^3) \times N$$

$$N = 7.95775 \text{ rev/min}$$

$$\begin{aligned}
 P &= 2\pi NFL \\
 &= 2\pi (7.95775)(4005289)(54.77 \times 10^3) \\
 &= 11132798 \frac{\text{N}\cdot\text{m}}{\text{min}} \left(\frac{1 \text{ min}}{60 \text{ sec}} \right) = 185546.7 \frac{\text{N}\cdot\text{m}}{\text{s}}
 \end{aligned}$$

$$= 185546.7 \text{ W}$$

18.20) Given: $Y_f = 12000 \text{ lb/in}^2$
 $A = 14.1 \text{ in}^2$
 $K_f = 8.0$

$$\begin{aligned}
 F &= K_f Y_f A \\
 &= (8.0)(12000)(14.1) \\
 &= 1353600 = 1353.6 \text{ kips}
 \end{aligned}$$

18.21) Given: $L = 500 \text{ mm}$ $L_1 = 25 \text{ mm}$

$$D_o = 100 \text{ mm}$$

$$K = 240 \text{ MPa}$$

$$n = 0.15$$

$$\theta = 90^\circ$$

$$a = 0.8$$

$$b = 1.5$$

A) extrusion ratio: $A_o = \frac{\pi D_o^2}{4} = \frac{\pi (100)^2}{4} = 7853.98 \text{ mm}^2$

$$\begin{aligned}
 A_f &= (50)(12) + (50)(12) \\
 &= 1200 \text{ mm}^2
 \end{aligned}$$

$$\begin{aligned}
 r_x &= \frac{A_o}{A_f} = \frac{7853.9816}{1200} = 6.545
 \end{aligned}$$

b) shape factor: $C_x = 62 + 50 + 12 + 38 + 50 + 12$
 $= 224 \text{ mm}$

$$\pi R^2 = A_f \quad \pi R^2 = 1200 \text{ mm}^2 \quad R^2 = \frac{1200}{\pi} \quad R = \sqrt{\frac{1200}{\pi}}$$

$$= 19.54 \text{ mm}$$

$$C_c = 2\pi R = 2\pi(19.54) = 122.77 \text{ mm}$$

$$K_x = 0.98 + 0.02 \left(\frac{224}{122.77} \right)^{2.25} \quad \boxed{K_x = 1.057}$$

c) length of the extruded section:

$$V = \frac{\pi D_o^2}{4} L = \frac{\pi (100)^2}{4} \times 500 = 3926990.81 \times \left(\frac{1000 \text{ mm}^3}{1 \text{ mm}^3} \right)$$

$$= 3926.9 \text{ m}^3$$

$$V_1 = \frac{\pi D_o^2}{4} L_1 = \frac{\pi (100)^2}{4} \times 25 = 196349.54 \times \left(\frac{1000 \text{ mm}^3}{1 \text{ mm}^3} \right)$$

$$= 196.3 \text{ m}^3$$

$$V_2 = A_f L_2 = (120) L_2 \quad V = V_1 + V_2$$

$$3926.9 = 196.3 + (120) L_2 \quad L_2 = \frac{3730.6}{120} = \boxed{3.109 \text{ m}}$$

$$3730.6 = 1200 L_2$$

D) MAXIMUM FORCE: $F = p A_0$

$$A_0 = \frac{\pi D_0^2}{4} = \frac{\pi (100)^2}{4} = 7853.9 \text{ mm}^2$$

$$p = K \bar{\epsilon}_f \left(\epsilon_x + \frac{2L}{D_0} \right) \quad \epsilon = \ln r_x = \ln(6.545) = 1.8787$$

$$\epsilon_x = a + b \ln r_x = 0.8 + 1.5 \ln 6.545 = 3.6180$$

$$\bar{\epsilon}_f = \frac{K \epsilon^n}{n+1} = \frac{(240)(1.8787)^{.15}}{.15+1} = 229.39 \text{ MPa}$$

$$p = (1.057)(229.39) \left(3.6180 + \frac{2(500)}{100} \right) = 3192.78 \text{ MPa}$$

$$F = p A_0 = (3192.78)(7853.98) = 25076030.26 \text{ N OR } 25.07 \text{ MN}$$

18.33) Given: $D_0 = 90 \text{ mm}$

$$d = 15 \text{ mm}$$

$$\alpha = 18^\circ$$

$$\mu = 0.08$$

$$K = 105 \text{ MPa}$$

A) AREA REDUCTION

$$A_0 = \frac{\pi D_0^2}{4} = \frac{\pi (90)^2}{4} = 6361.7 \text{ mm}^2$$

$$D_f = D_0 - d = 90 - 15 = 75 \text{ mm}$$

$$A_f = \frac{\pi (75)^2}{4} = 4417.9 \text{ mm}^2$$

$$r = \frac{(6361.7) - (4417.9)}{6361.7} = \boxed{0.3056}$$

B) draw stress

$$\epsilon = \ln \left(\frac{A_0}{A_f} \right) = \ln \left(\frac{6361.7}{4417.9} \right) = 0.3646$$

$$\bar{\sigma}_f = \frac{(105)(0.3646)^{0.0}}{1+0.0} = 105 \text{ MPa}$$

$$D = \frac{(90) + (75)}{2} = 82.5 \text{ mm}$$

$$L_c = \frac{D_0 - D_f}{2 \sin 18} = \frac{90 - 75}{2 \sin 18} = 24.3 \text{ mm}$$

$$\phi = .88 + .12 \left(\frac{82.5}{24.3} \right) = 1.288$$

$$\sigma_d = (105) \left(1 + \frac{0.08}{\tan 18} \right) (1.288) \ln \left(\frac{4.91}{3.46} \right) = \boxed{61.45 \text{ MPa}}$$

C) draw force

$$F = (4417.9)(61.45) = \boxed{271475 \text{ N}}$$

D) power to perform

$$P = (271475)(1) \left(\frac{1 \text{ Min}}{60 \text{ sec}} \right) = 4524.5 \text{ W}$$

19.3) Given: $a = 0.04$
 $t = 3.2 \text{ mm}$

$$D_b = 25 \text{ mm}$$

$$D_h = 12 \text{ mm}$$

$$c = at = (0.04)(3.2) = 0.128 \text{ mm}$$

A) punch and die sizes

$$\begin{aligned} \text{Blanking Punch diameter} &= D_b - 2c \\ &= 25 - 2(0.128) \\ &= 24.744 \text{ mm} \end{aligned}$$

$$\text{blanking die diameter} = 25 \text{ mm}$$

B) punching operation

$$\begin{aligned} \text{punching die diameter} &= D_h + 2c \\ &= 12 + 2(0.128) \\ &= 12.256 \text{ mm} \end{aligned}$$

$$\text{punching punch diameter} = 12 \text{ mm}$$

19.8) Given: $\alpha = 40^\circ$

$$R = 10.5 \text{ mm}$$

A) blank size required:

$$\alpha = 180^\circ - \alpha = 180 - 40 = 140^\circ$$

$$\frac{R}{t} = \frac{10.5}{5} = 2.1 \quad R = 2.1t$$

$$A_b = \frac{2\pi \times \alpha}{360} \times (R + K_{\text{lat}}) = \frac{2\pi \times 140}{360} (10.5 + (0.5)5)$$

$$= 81.765 \text{ mm} \quad L = 58 + 46.5 + 81.765 = 186.265 \text{ mm}$$

$$\begin{array}{l} L = 186.265 \text{ mm} \\ W = 35 \text{ mm} \end{array}$$

19.10) Given:

$$D_p = 4.25 \text{ in}$$

$$TS = 65000 \text{ lb/in}^2$$

$$= 2.65 \text{ in}$$

$$Y = 32000 \text{ lb/in}^2$$

$$t = 3/16 \text{ in}$$

$$= 40000 \text{ lb/in}^2$$

$$D_b = 7.7 \text{ in}$$

$$R_d = 5/32 \text{ in}$$

A) drawing ratio: $DR = \frac{D_b}{D_p} = \frac{7.7}{4.25} = 1.81$

B) Reduction: $r = \frac{D_b - D_p}{D_b} = \frac{7.7 - 4.25}{7.7} = 0.448$

C) drawing force:

$$F = \pi D_p t (TS) \left(\frac{D_b}{D_p} - 0.7 \right) = \pi (4.25) \left(\frac{3}{16} \right) (65000) \left(\frac{7.7 - 0.7}{4.25} \right)$$

$$= 180911.55 \text{ lb}$$

D) blankholder force:

$$\begin{aligned} F_n &= 0.015 Y \pi (D_b^2 - (D_p + 2 \cdot 2t + 2R_d)^2) \\ &= 0.015 (32000) \pi (7.7^2 - (4.25 + 2 \cdot 2 \left(\frac{3}{16} \right) + 2 \left(\frac{5}{32} \right))^2 \\ &= 0.015 (32000) \pi (34.54) \\ &= 52685.09 \text{ lb} \end{aligned}$$

AVERAGE

18.6 (A) (SI units) A low-carbon steel plate and 25 mm thick. It is reduced in one pass in a two-high rolling mill to a thickness of 20 mm. Roll diameter is 600 mm, and roll speed is 120 rpm. Strain-hardening exponent is 0.25. Determine the (a) roll force, (b) roll torque, and (c) power required to perform the operation.

a)

$$F = \bar{Y} w L$$

$$\bar{Y} = \frac{K(\epsilon)^n}{1+n}$$

$$\epsilon = \ln\left(\frac{A_0}{A_f}\right)$$

$$= \frac{506(0.2231)^{0.25}}{1+0.25} = \ln\left(\frac{25}{20}\right)$$

$$= 0.2231$$

$$= \frac{343.633}{1.2}$$

$$= 274.906 \text{ MPa}$$

$$L = \sqrt{R(t_0 - t_f)}$$

$$= \sqrt{(600)(5)}$$

$$= \sqrt{3000}$$

$$= 54.77 \text{ mm}$$

$$F = \bar{Y} w L$$

$$= (274.906 \times 10^6) (270 \times 10^{-3}) (54.77 \times 10^{-3})$$

$$F = 4065287 \text{ N}$$

b)

$$T = 0.5 FL$$

$$= (0.5)(4065289)(54.77 \times 10^{-3})$$

$$= 111328 \text{ N}\cdot\text{m}$$

c)

$$P = 2\pi N F L$$

$$V_n = 2\pi R N$$

$$30 \text{ min} = 2\pi \cdot (600 \times 10^{-3}) N$$

$$N = 7.95 \text{ KeV/min}$$

$$P = 2\pi (7.95)(4065289)(54.77 \times 10^{-3})$$

$$= 185546 \text{ W}$$

18.20 (A) (USCS units) A part is hot-forged in an impression die. The projected area of the part, including flash, = 14.1 in². After trimming, the part has a projected area of 12000 in². Part geometry is complex. At room temperature, the work metal has a strength coefficient of 8.0 and a strain-hardening exponent of 0.25. When the work metal is heated, the work metal strength decreases and no strain hardening occurs. Determine the forging force.

$$\begin{aligned}
 F &= K_f Y_p A \\
 &= (8.0)(12000 \text{ in}^2)(14.1 \text{ in}^2) \\
 &= 1353.6 \times 10^3 \text{ lb} \cdot \frac{1}{1000} \\
 &= 1353.6 \text{ kip}
 \end{aligned}$$

18.27 (A) (SI units) An L-shaped structural section is direct extruded from an aluminum alloy billet with a diameter of 100 mm. Dimensions of the extruded cross section are given in Figure P18.27. The strength coefficient and strain-hardening exponent of the aluminum alloy are 7853.98 and 0.25, respectively (Table 3.4). The die is 25 mm long. (a) Determine the forging force.

$$\begin{aligned}
 R_x &= \frac{A_0}{A_f} & A_0 &= \frac{\pi D_0^2}{4} & A_f &= (50)(12) + (50)(12) \\
 &= \frac{7853.98 \text{ mm}^2}{1200 \text{ mm}^2} & &= \frac{\pi (100)^2}{4} & &= 1200 \text{ mm}^2 \\
 &= 6.545 & &= 7853.98 \text{ mm}^2 & C_x &= 62 + 50 + 12 + 38 + 50 + 12 \\
 & & & & &= 224 \\
 K_x &= 0.984 + 0.02 \left(\frac{C_x}{C_0} \right)^{0.25} & \pi R^2 &= A_f & \pi R^2 &= 1200
 \end{aligned}$$

$$= 0.98 + 0.02 \left(\frac{224}{122.77} \right)^{2.25}$$

$$= 1.057$$

$$R = \sqrt{\frac{1260}{\pi}}$$

$$= 19.54 \text{ mm}$$

$$C_1 = 2\pi R$$

$$= 2\pi (19.54 \text{ mm})$$

$$= 122.77$$

$$V = \frac{\pi D_o^2 L}{4}$$

$$= \frac{\pi (100 \text{ mm})^2 (500)}{4}$$

$$= 3.926,990 \times \frac{1000}{1}$$

$$= 3926.9 \text{ m}^3$$

$$V_1 = \frac{\pi D_o^2}{4} L_1$$

$$= \frac{\pi (100)^2 (25)}{4}$$

$$= 196349.54 \text{ mm} \cdot \frac{1000}{1}$$

$$= 196.3 \text{ m}^3$$

$$V_2 = A_f L_2$$

$$= (120 \text{ m}^2) (L_2)$$

$$V = V_1 + V_2$$

$$3926.9 = 196.3 + (120) L_2$$

$$L_2 = \frac{3730.6}{1200}$$

$$= 3.109$$

$$F = P A_o$$

$$A = \frac{\pi D_o^2}{4}$$

$$= \frac{\pi (100)^2}{4}$$

$$= 7853.98 \text{ mm}^2$$

$$P = K_x \bar{Y}_f \left(\epsilon_x + \frac{2L}{D_0} \right)$$

$$\epsilon_x = a + b \ln r_x$$

$$= 0.8 + 1.5 \ln 6.545$$

$$= 0.8 + 2.8785$$

$$= 3.6180$$

$$= (1.057)(229.39) \left[3.6180 + \frac{2(500)}{100} \right]$$

$$= 3192.78$$

$$F = P_A$$

$$F = P_A$$

$$= (3192.78 \text{ MPa})(7853.98 \text{ mm})$$

$$= 25076030.26 \text{ N}$$

$$\boxed{= 25.07 \text{ MN}}$$

$$\epsilon = \ln R$$

$$= \ln(6.545)$$

$$= 1.8787$$

$$\bar{Y}_f = \frac{K \epsilon^n}{n+1}$$

$$= \frac{(240)(1.8787)^{0.15}}{0.15 + 1}$$

$$= \frac{(240)(1.8787)^{0.15}}{1.15}$$

$$= 229.39 \text{ MPa}$$

18.33 (SI units) Bar stock of initial diameter D_0 is drawn with a die of diameter D_d . The draw die has an initial diameter D_d and the final diameter of the bar is D_f . The metal behaves as a hardening material with a yield strength σ_y . a. Determine the (a) true strain, (b) true stress, (c) true strain rate, and (d) true stress rate.

18.34 (USCS units) Wire stock of initial diameter $= 0.125$

$$n = \frac{A_0 - A_f}{A_0} \quad r = \frac{(6361.7 \text{ mm}^2) - (4417.9 \text{ mm}^2)}{6361.7 \text{ mm}^2}$$

$$= \frac{\pi D_0^2}{4} \quad = \frac{1943.9}{6361.7}$$

$$= \frac{\pi (40)^2}{4} \quad = 0.3056$$

$$= \frac{25947}{4} \quad \bar{\sigma} = \bar{\sigma}_f \left(1 + \frac{n}{\tan \alpha}\right) \phi \ln \left(\frac{A_0}{A_f}\right)$$

$$= 6361.7 \text{ mm}^2 \quad \bar{\sigma}_f = \frac{K(\epsilon)^n}{1+n}$$

$$A_f = \frac{\pi D_f^2}{4} \quad A_f = 4417.9 \text{ mm}^2 \quad \epsilon = \ln \left(\frac{A_0}{A_f}\right)$$

$$D_f = D_0 - d \quad \epsilon = \ln \left(\frac{6361.7}{4417.9}\right)$$

$$= 40 - 15 \text{ mm} \quad = 0.3646$$

$$= 25 \text{ mm}$$

$$A_f = \frac{\pi (25)^2}{4} \quad \bar{\sigma}_f = \frac{(105 \text{ MPa})(0.3646)^{0.05}}{1+0.05} = 105 \text{ MPa}$$

$$\phi = 0.88 + 0.12 \left(\frac{D}{L_c} \right)$$

$$D = \frac{D_o + D_f}{2}$$

$$= \frac{90 + 75}{2}$$

$$= 82.5 \text{ mm}$$

$$L_c = \frac{D_o - D_f}{2 \sin \alpha}$$

$$= \frac{90 \text{ mm} - 75 \text{ mm}}{2 \sin 18^\circ}$$

$$= \frac{15}{0.618}$$

$$= 24.3 \text{ mm}$$

$$\phi = 0.88 + 0.12 \left(\frac{82.5}{24.3} \right)$$

$$= 0.88 + 0.4074$$

$$= 1.288$$

$$\phi_a = (105 \text{ MPa}) \left(1 + \frac{0.58}{\tan 18^\circ} \right) (1.288) \ln \left(\frac{4.91}{3.46} \right)$$

$$= (105)(1.246)(1.288)(0.3646)$$

$$= 61.45 \text{ MPa}$$

$$F = A_f \sigma_a$$

$$= (4417.9)(61.45)$$

$$= 271475 \text{ N}$$

$$P = F V_f$$

$$= (271475)(1 \text{ m/min}) \left(\frac{1}{60} \right)$$

$$= 4524.6 \text{ N} \cdot \text{m/sec}$$

$$= 4524.6 \text{ W}$$

19

Punch Die Diamanten

$$= 12 + 2(0.192)$$

$$= 12.384 \text{ mm}$$

Die diameter = $D_b - zC$

$$= 25 - 0.384$$

$$= 24.616$$

$$\alpha = 180 - \alpha'$$
$$= 180 - 40$$
$$= 140^\circ$$
$$\frac{140}{2} = \underline{\underline{70}}$$

$$\frac{8.5}{5}$$

$$R = 1.74$$

$$L = 58 + 46.5 + 24.80$$
$$= 129.30 \text{ mm}$$

$$F = \frac{K_{\text{tot}}(TS) \omega^2}{D}$$

$$= \frac{(1.33)(350)(35)(5)^3}{40}$$

$$= 10,182.8125 \text{ N}$$

19.16 (USCS units) A deep drawing operation is performed to produce a cylindrical cup in which the inside diameter = $\frac{3}{16}$ in. and height = 2.2 in. The punch diameter is $\frac{5}{32}$ in. The metal has a tensile strength $S_u = 65,000 \text{ psi}$, yield strength $S_y = 32,000 \text{ psi}$, and strain hardening exponent $n = 0.015$. Determine the (a) drawing ratio and (b) drawing force.

$$DR = \frac{D_o}{D_p}$$

$$= \frac{7.7}{4.25}$$

$$= 1.81$$

$$n = \frac{D_o - D_p}{D_o}$$

$$= \frac{7.7 - 4.25}{7.7}$$

$$= 0.448$$

$$F = \pi U_p + (TS) \left(\frac{D_o}{D_p} - 0.7 \right)$$

$$= \pi (4.25) \left(\frac{3}{16} \right) (65000) \left(\frac{7.7}{4.25} - 0.7 \right)$$

$$= 180,911.55 \text{ lb}$$

$$F_n = 0.015 \gamma \pi \left[D_o^2 - \left(D_p + 2.2 + 2R_d \right)^2 \right]$$

$$= 0.015 (32000) \pi \left[(7.7)^2 - \left(4.25 + 2.2 \left(\frac{3}{16} \right) + 2 \left(\frac{5}{32} \right) \right)^2 \right]$$

$$= 0.015 (32000) \pi (59.29 - 24.75)$$

$$= 0.015 (32000) \pi (34.54)$$

$$= 52,085.09 \text{ lb}$$

BELOW AVERAGE

18-6

$$\begin{aligned}\text{Contact length } L &= \sqrt{Kd} \\ &= \sqrt{600 \times 5} \\ &= 54.77 \text{ mm}\end{aligned}$$

$$\text{true strain } \epsilon = \ln\left(\frac{25}{20}\right) = 0.2231$$

$$\text{Flow stress } \sigma_f = \frac{K \epsilon^n}{1+n}$$

$$\text{Strength Coefficient } K = 500 \text{ MPa}$$

$$\text{strain hardening exponent } n = 0.25$$

$$\sigma_f = \frac{500(0.2231)^{0.25}}{1+0.25} = 274.906$$

$$F = \sigma_f \times B \times L$$

$$= 274.906 \times 600 \times 54.77$$

$$= 9.034 \times 10^6 \text{ N}$$

$$b) \text{ true } \tau = 0.5 \times \sigma_f$$

$$= 0.5 \times 9.034 \times 10^6 \times 54.77$$

$$= 8.4 \times 10^6 \text{ N-m}$$

$$\text{rolling power } P = \tau \times V$$

$$= 8.4 \times 10^6 \times \frac{50}{60}$$

$$= 415 \times 10^3 \text{ W}$$

4.517 MW

18.20)

Projected area of flange
(A) = 14.19 in²

After trimming the projected area is 14.19 in²

Strength coefficient = 35,000 lb/in²

Strain hardening exponent = 0.15

Yield strength of material $K_F = 12,000$ lb/in²

Since no Strain hardening ($n=0$)

$K_F = 8.0$

Sum of force required to perform the operation is

$$F_{max} = K_F Y_F A$$

$$8 \times 12,000 \times 14.1$$

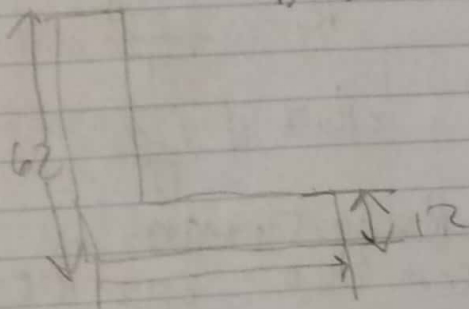
$$1,353,600 \text{ lb}$$

$$F_{max} = 1,353,600 \text{ KIPS}$$

18.27)

$L_D = 500 \text{ mm}$ $D_o = 100 \text{ mm}$

$L_S = 2.8 \text{ mm}$



$$M_x = \frac{A_0}{A_F}$$

A_0 Gross Section
exterior section

A_F Gross Section
exterior section

$$A_0 = \frac{\pi}{4} D_0^2 L$$

$$A_0 = \frac{\pi}{4} (100)^2 L$$

$$A_0 = 7853.98 \text{ mm}^2$$

$$A_t = 2(X \times 6)$$

$$A_t = 2(R \times 50)$$

$$A_t = 1200 \text{ mm}^2$$

$$\frac{7853.98}{1200}$$

$$K_X = 6.5469$$

6) Shape factor

$$K_X = 0.98 + 0.02 \left(\frac{C_X}{C_C} \right)^{2.25}$$

$$1200 = \pi R^2$$

$$R^2 = \frac{1200}{\pi}$$

$$R = \sqrt{\frac{1200}{\pi}}$$

$$R = 19.54 \text{ mm}$$

$$C_C = 2R = 2 \times 19.54$$

$$C_C = 39.08 \text{ mm}$$

$$C_X = 62 + 50 + R + 58 + 50 + 12$$

$$C_X = 224 \text{ mm}$$

$$K_v = 0.98 + 0.02 \left(\frac{224}{122798} \right)^{2.25}$$

$$K_v = 0.98 + 0.00773$$

$$K_y = 0.98 + 0.00773$$

$$K_x = 0.98 + 0.00773$$

$$K_x = 1.0573$$

c) length of extruded section

$$V_0 = \frac{\pi}{4} D_0^2 L$$

$$V_0 = \pi/4 (100)^2 (500)$$

$$V_0 = 3926990.817 \text{ mm}^3$$

$$V_1 = \frac{\pi}{4} D_1^2 (L_s)$$

$$V_1 = \frac{\pi}{4} \times (100)^2 (25)$$

$$V_1 = 196349.5408 \text{ mm}^3$$

$$V = A \cdot L$$

$$V_0 - V_1 = A \cdot L \quad 3926990.817 - 196349.5408 = 1200 \times L$$

$$L = \frac{3730641.276}{1200}$$

$$L = 3108.8677 \text{ mm} \approx 3.108 \text{ m}$$

$$a) \text{ Area reduction} = r_a \\ = A_i^2 - A_f^2$$

$$r_a = \frac{D_i^2 - D_f^2}{D_i^2} = \frac{90^2 - 75^2}{90^2}$$

$$r_a = 0.3056 \checkmark \text{ or } 30.56\%$$

$$(b) \text{ true strain } (\epsilon) = \ln(A_i/A_f) = \ln(D_i^2/D_f^2)$$

$$\epsilon = \ln(90^2/75^2) = 0.3646$$

$$\text{length}(L_c) = \frac{D_i - D_f}{2 \sin \alpha} = \frac{90 - 75}{2 \sin 18}$$

$$24.27$$

$$D_m = \frac{D_i + D_f}{2} = \frac{90 + 75}{2} = 82.5 \text{ mm}$$

$$0.88 + 0.12 D_m/L_c$$

$$0.88 + 0.12 (82.5/24.27) \\ = 1.2879$$

Draw stress $\sigma_y \left(1 + \frac{M}{t \pi r^2}\right) \sigma_e$

$$\sigma_2 = 105 \left(1 + \frac{0.08}{t \pi r^2}\right) 1.2879$$

$$\sigma_2 = 61.48 \text{ MPa}$$

$$F = A \sigma d$$

$$F = \frac{\pi}{4} (75)^2 \times 61.48 = 271426.5 \text{ N}$$

$$F = 271.43 \text{ kN}$$

$$C_d = P = F V = 271426.5 \times \frac{1}{60} \text{ J/s}$$

$$P = 4523.78 \text{ watt Ans}$$

19.3

Size of punch & blanking
are equal to diameter

$$D_b = 28 \text{ mm} \quad \text{diameter of blanking punch}$$

$$15 \quad D_b = 28 \quad A_c = 0.06$$

$$C = 0.06 \times 3.2 = 0.192 \text{ mm}$$

$$d_{\text{punch}} = 24.616 \text{ mm}$$

b) diameter of punching punch is equal to inside diameter of washer, then diameter of punching

$$D_{die} = D_h + 2c$$

$$= 12\text{mm} + 2(0.142)$$

$$D_{die} = 12.284\text{mm}$$

19.8

$$\alpha = 40^\circ$$

$$R = 10.5$$

$$\alpha = 180 - 40 \rightarrow 140$$

$$A_b = 2\pi (\alpha/360) (R + k b^4)$$

$$\frac{1}{6} \frac{10.5}{5} \rightarrow 2.1$$

$$A_b = 2\pi \left[\frac{140}{360} \right] (10.5 + 0.55 \times 5)$$

$$12.15$$

$$A_b = 29.688\text{mm}$$

$$L = 58 + 29.68 + 46.65 \rightarrow 134.33$$

$$K_b = 1.33$$

$$= 1.33 \times 350 \times 35 \times 5^2 / 40$$

$$11082.5\text{N}$$

b) Drawing ratio

$$DR = \frac{7.7 - 4.25}{7.7} = 0.448$$

$$r = 44.8\%$$

A) $DR = \frac{7.7}{4.25} = 1.81$

C) drawing Force

$$F = \pi D p t (TS) (DR - 0.7)$$

$$F = \pi \times 4.25 \times 0.1875 \times 65000$$
$$\left(\frac{7.7}{4.25} - 0.7 \right)$$

$$F = 180911.5816$$

d) $F_w = 0.015 \times \pi (D_o^2 - [D_o + 2r + 2r_d])^2$

$$F_w = 0.015 \times 32000 \times \pi \times [7.7^2 (4.25) + 2.2 + 0.1875 + 2 \times 0.1875]^2$$

$$F_w = 520025$$

**MANUFACTURING PROCESSES COURSE PROJECT
FALL 2021**

Comprehensive Report on a Family of Manufacturing Processes

In fulfillment of Outcome - 4

MCEG 3303 Manufacturing Processes Course Project
Fall 2021
Comprehensive Report on a Family of Manufacturing Processes

Due: Nov. 23, 2021, at midnight

I. Project Description

Pick any of the big families of manufacturing processes introduced in this course, e.g., machining, casting, plastic manufacturing, metal processing, etc., and write a comprehensive report. In this report, you should address the manufacturing processes family you chose; introduction to this family, state-of-the-art of this family, and its future developments. You should also recognize ethical and professional responsibilities of your subject involving global, and societal contexts, as well as make informed judgments on ethical and professional responsibilities in the family you have chosen for your report while considering the impact of engineering solutions in global, economic, environmental, and societal contexts.

II. Report

A comprehensive literature review report is required from each student. The review report should follow these guidelines:

- (1) The report should be typed in a **Word file, with 1.5 lines spacing, and Times Roman 12-point font.**
- (2) Your report should **review no less than 10 pieces of literature.**
- (3) Literature should be cited properly in the report. A “List of References” should be provided at the end of the report. The **citation and references should follow the ASME format**, which can be found at: <https://www.asme.org/shop/proceedings/conference-publications/references>.
- (4) The report should be **5 pages minimum, 10 pages maximum excluding the cover page and list of references.**
- (5) The report should be organized using headings and subheadings, and should include (but not limited to) the following contents:

Title

Abstract (no more than one page) - A concise summary of your review including the scope of your review, what you found as a result of your topic. It should give the reader a complete picture of your review from the start to finish.

Introduction

Main contents

Conclusion

III. Evaluation

The report will be evaluated by the following criteria:

1. Writing quality (grammar, punctuation, writing skills): 20%
2. Presentation quality (formatting, figures, tables, references, headings): 20%
3. Technical content (completeness, relevance, how up-to-date it is, etc.): 50%
4. Taskstream submission to Outcome 4: 10%
5. Taskstream submission: 10%

**ABOVE AVERAGE
PROJECT REPORT**

Matthew Handerson

90

1. Writing quality = 20
2. Presentation quality = 10
3. Technical content = 50
4. Task stream submission = 10

Abstract

The purpose of this report addresses the additive manufacturing process and its impact on global advancements, societal effects, economic stability, and engineering ethics. Additive manufacturing is an expedited way to prototype 3D computer-aided design models much faster than other traditional manufacturing processes which utilize modern materials such as polymers, metals, ceramics, and plastics. Additive manufacturing started in the 1980s by Chuck Hull, he invented the stereolithography process which used lasers to create layers, which would make a 3-dimensional object over time as layers kept being added, this process was the foundation of modern 3D printing. Additive manufacturing is used to address climate change by creating lighter parts, using less material which makes the supply chain less difficult. Climate change is one of the biggest problems we face globally additive manufacturing is a way we can reduce the carbon footprint of many industries that use manufacturing to produce goods. The economy has benefited from this technology because it requires fewer material resources and there is more opportunity to create complex devices. The additive manufacturing process has changed the global market for manufacturing making parts easier to produce. The integration of complex parts when manufacturing aerospace components has become possible with the additive manufacturing process. The integration of parts describes the process of utilizing complex parts and systems to serve one than one purpose on the aircraft which saves resources and time than creating singular parts that only serve one function. Additive manufacturing has become popular in many industries due to versatility and many benefits over the traditional manufacturing process such as its cost-effectiveness, simplicity, and technical application which has developed the modern manufacturing process.

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Introduction to Additive Manufacturing

Additive manufacturing is a type of manufacturing process that uses a variety of materials such as polymers, metals, ceramics, and plastics as an expedited way to prototype 3D computer-aided design models much faster than other traditional manufacturing processes. Additive manufacturing allows engineers to go from a 2D engineering drawing to a 3D computer-aided design (CAD) model to a physical prototype in a short period, this is very beneficial to engineers working in industries such as aerospace, automotive, biomedical, industrial... etc. The additive manufacturing process was started in the 1980s when an engineer by the name of Chuck Hull

invented the stereolithography process which used lasers to create layers that would make a 3-dimensional object over time as layers kept being added. This process was the foundation of modern 3D printing which makes up a great majority of the modern additive manufacturing process that we know today, and it is constantly changing as new technologies are discovered. Rapid prototyping and 3D printing are families of fabrication that take minimal time to create physical models from CAD models, and they differ in process, material, and time to make a physical prototype. Processes such as fused deposition modeling (FDM) and droplet deposition manufacturing use molten filament heated to temperatures slightly higher than the materials melting point to create layers. While stereolithography (SLA), masked projection stereolithography (MPSL), and selective laser sintering require liquid and powder-based materials to create prototypes that use lasers or UV lights to shape when solidified. Finally, laminated object manufacturing (LOM) techniques use stacking layers of materials to the cross-section of the CAD model then cutting the excess material. Additive manufacturing as a process much broader creating 3D models using additive processes, this technology allows for the production of three-dimension parts from a virtual design without having to use machine tools to create molds additive manufacturing provides engineering solutions to environmental, societal, and economic problems while simultaneously fueling global competition and progression.

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Environmental Solutions of Additive Manufacturing

Today we recognize climate change as one of the biggest problems we face globally and the race to reverse centuries of carbon damage has become one of the biggest challenges to scientists and engineers worldwide. Climate change describes the average change in temperature and rainfall in a region over a given period over the past century that trend has been rising which has caused global warming which directly correlates to the intensity of disasters and how the atmosphere interacts with precipitation. The biggest contributing factor to global warming is the emission of carbon into the atmosphere and this can be traced to every industry and individual by their carbon footprint. As stated in "What is Additive Manufacturing? definition and processes," many different types of materials can be used to create 3D prototypes in a quicker more efficient way as opposed to traditional manufacturing processes that may require machine tools or heavy machinery with high carbon emissions. Since its discovery the additive manufacturing has revolutionized the manufacturing industry, creating a way to make lighter parts from polymers,

ceramics, and metal alloys in addition to rapid prototypes. The rapid advancement and development of the additive manufacturing process in recent years have made a smoother transition from raw goods to manufactured materials reducing the amount of material needed to produce goods. As a direct effect, the supply chain for primary, secondary, and tertiary industries has lowered negative environmental impact saving time and resources. In "Sustainability of Additive Manufacturing: An overview on its energy demand and environmental impact," Peng highlights the importance of eco-conscious conceptional design, and additive manufacturing has been identified as "the most promising and effective technology". Innovative design and implementation of large-scale additive manufacturing with industrial 3D printers allow strong, complex weight-reducing parts to be made cost-effectively. Parts manufactured using this method are lighter than those produced by conventional means. Weight savings means a leaner cost structure, material savings which reduce the carbon footprint when less is used to produce goods.

Societal and Global Impact of Additive Manufacturing

Currently, there are many different types of additive manufacturing available with varying levels of complexity and cost. Therefore, industries have been able to benefit economically from this technology since it requires fewer material resources and more versatility. Given the developmental and revolutionary nature of the additive manufacturing process, the global market for manufacturing has changed as a result making parts easier to produce by the 3D printing process, and with the advancements in materials sciences, the materials to create these parts are becoming stronger and lighter which is beneficial to the global market. Specifically, additive manufacturing in the field of aerospace has led to more technological advancements, development in the aerospace industry is often the first to experiment and implement the newest and best technology which is then utilized in other industries such as LiDAR technology which is the main system used in autopilot for commercial and military aircraft. Blakey-Milner states in "Metal additive manufacturing in aerospace: A review" the ability to use metal alloys as well as different composite materials in the 3D printing process opens the aerospace industry to grow technology with lighter parts, fewer parts required to assemble which is more cost-effective, and increased designs unachievable in the past due to inability to prototype. Weight reduction using composite materials and plastics in the aerospace industry has several benefits compared to using

metal in aerospace applications and components. Plastic parts and composite parts made from additive manufacturing are more beneficial than metals alloys for fuel consumption because they are typically lighter and more durable in some applications. In addition to the simplified manufacturing process to fabricate these parts, lighter parts mean more money is saved using them over metal components. The integration of complex parts is also one of the additional benefits of manufacturing aerospace components with the additive manufacturing process. The integration of parts describes the process of utilizing complex parts and systems to serve one than one purpose on the aircraft which saves resources and time than creating singular parts that only serve one function, this allows engineers to refocus resources, time, and efforts to multiple projects. With the benefit of time and resources engineers can turn their efforts to more innovative solutions in manufacturing such as the integration of parts which couldn't happen in the past, there was no practical way to manufacture complex parts that could function in multiple systems so most parts could only serve a single purpose. Additive manufacturing is also beneficial to society because of its application in the biomedical sector, the ability to mass-produce applications for medical purposes allows more people access to health care devices such as heart valves. This increases the average lifespan of countries with access to this technology, it being affordable means more people can get the care they need. In "Additive Manufacturing and its societal impact: A literature review" Huang speaks on the trend of additive manufacturing becoming more mainstream in different fields such as healthcare which has improved the different populations' health and quality of life on a global scale in addition to improving environmental effects making manufacturing more sustainable than years before additive manufacturing discovery.

The Future of Additive Manufacturing

The future of additive manufacturing is a bright one because of its versatility among multiple industries in addition to its many benefits over the traditional manufacturing process such as its cost-effectiveness, simplicity, and technical application which has developed the modern manufacturing process. The logistics of parts production is a focus when implementing additive manufacturing to the different industries, parts can be customized and produced in record time so complex logistics and supply chains are reduced. Gonzalez discusses in "On-demand additive manufacturing is the future" how additive manufacturing saved the supply chains of many

different industries due to the global pandemic in 2020. The COVID-19 pandemic shifts the world in 2020 every person, industry, and economy was affected by the pandemic during this some companies used additive manufacturing to combat the drastic shift in the supply chain and logistics required to manufacture goods. As we recover from the pandemic additive manufacturing is still advancing in certain industries such as healthcare. In "3D printing: The Future of the Healthcare Industry," the application and benefit of 3D printing in the healthcare sector are discussed in detail. Devices such as prosthetics, organs, and dental equipment such as dentures are all available in mass because of additive manufacturing, having these devices readily available is not only cost-effective but also feasible for the average person to obtain. An example would be the lack of respirators during the climax of the pandemic 3D printers were used to make parts to create more respirators. As additive manufacturing grows in the health care industry so does the opportunity for medical professionals to treat patients in new ways previously impossible due to lack of equipment. This is just one example of how additive manufacturing has changed the health care industry for the better, but the same improvements can be seen in the aerospace, automotive, and packaging industries. Additive manufacturing is the future of manufacturing

Conclusion

Additive manufacturing is the most effective manufacturing process because of its versatility and the way it has changed modern manufacturing in just a few decades. This process has become much broader than creating 3D models using additive processes, this technology is the basis for rapid prototyping and advanced development in materials science and engineering which has changed the global market, improved society by development in healthcare applications, and addressed climate change. Additive manufacturing provides engineering solutions to environmental issues, addressing climate change by providing the manufacturing industry a way to prototype and make components in a more environmentally friendly way than traditional manufacturing reducing multiple industries' carbon footprint on a global scale. Additive manufacturing impacts the global economy as well as technical advancement across the globe by increasing competition among nations an example being the aerospace industry which has benefited from utilizing the additive manufacturing process creating lighter components, integrating parts and systems which save material and time. The global economy improves due

to many different nations using additive manufacturing in a variety of industries which save money on raw materials and increase output times for manufactured parts.

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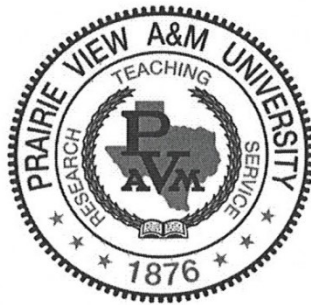
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AVERAGE
PROJECT REPORT

MECHANICAL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY



Manufacturing Processes
Fall 2021 - MCEG 3303 Y01

Comprehensive Report Manufacturing Process:

The Family of Casting

Submitted by:

Aniya Facion

Submitted to:

Dr. Jiang

By:

November 23, 2021; 11:59 pm

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1. Writing quality: 13
2. Presentation quality: 15
3. Technical content: 40
4. Taskstream Submission: 10

Abstract

The world has many different devices and technologies that help make the world move. Many of those devices are manufactured with parts and pieces that are formed by casting. In this report will be discussed what casting is, where it originated, and how it got us here today. Also discussed is where it is going in the future along with how it has impacted the world around us now. The goal of this report is to inform about just one of the amazing aspects of the manufacturing world.

Introduction

What is casting? Casting is a manufacturing process in which materials such as metal or plastic are heated up to their respective melting points and higher, then the viscous liquid material is poured into a mold or cast. There the material rests into the shape of the mold or cast cooling back below the melting point returns to a solidified state now fixed in the desired shape set by the mold. Once the cooling step is finished all that is left is for the manufacturer to remove the new structure from the mold either by ejecting it or breaking it. This technique is used to create a large variety of different tools, equipment, parts, structure, and jewelry.

As stated previously this technique is being used to make so many different components in everyday life, this is accredited to the thousands of years of tested and proven experience. With the earliest accounts recorded ~~dating date~~ back to three-thousand B.C.E. or over five-thousand years ago back in the era of Mesopotamia, now known as the Middle East and India. It is theorized that the actual founding of this technique was founded either in Mesopotamia or in ancient China around the same time.

As the knowledge of casting began to grow from artisans to smiths, the skills and materials changed to match. Copper became less used, while tin and lead became frequently used in the now developing industry. The process became easier to reproduce during this time as flame ovens were used to help the melting step in the process. Also during this time, around fifteen-hundred C.E, the ~~still~~ ~~still~~-developing permanent and sand casting ~~were~~ ~~was~~ introduced. With permanent casting being used to create a constant and uniform item and sand casting ~~is~~ used to make smaller pieces most frequently for replication.

The next evolution is also considered the last by many, with credit being given to the Chinese since by five-hundred mastered the casting of the most iconic metal known to mankind, iron. This was over two-thousands years before Europe mastered it. Though once the Europeans mastered it guns and bullets were the first things ~~mass-mass~~-produced. Following all the rules of technology once the military used it was soon passed on to the public creating things like iron stoves, ovens, structures, and art. This soon leads to industrialization and to the world we see today. The only thing that awaits the casting art is the future.

State of the Art

The continuous development stages of a product must be incorporated with the most recent technological ideas and features. It is a crucial part of the casting family to focus on methods that continue to pursue effective ingenuity. Therefore, it is critical to focus on the creation of a casting that generates the only state of the art results

The best and most successful castings are the ones that focus on ~~energy~~-energy-saving methods. Casting is a very ~~time~~-time-consuming job, and that can vary between the materials used and the types of methods and molds used for the casting. For instance, metal molds have been falling out of favor lately in favor of die casting. As you are only able to use the mold once and must then waste materials and time by creating another mold. Unlike with die casting, which allows continuous use of the molds, metal molds just end up increasing the number of scraps we have in the end with our casting, more scraps mean more melting to be done.

Melting is a process that can take up to 55% of the energy costs depending on the metal and procedure used. ~~It is also something that has to.~~ It is also a matter to take into consideration when choosing the alloy, as an increased yield strength can also save on energy costs; the most common types of ~~alloy~~alloys used are zinc, magnesium, aluminum, and brass. When the yield strength is taken into consideration with the melting point This is a full circle of positives if you take in the possibilities; because another way to ensure the ~~successfulness~~ of a-casting is focusing on environmental benefits.

When focusing on ~~cost~~-cost-saving mechanisms, if you take into account that you want to spend less time on machining and processes, ~~less~~-fewer emissions will be emitted. This will

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leave a positive impact on the environment thus allowing a positive impact on the community in the surrounding area of the plants operating them. Remembering at the end of the day, that this process is to ensure the quality of life for everyone, it is of most importance to take into account the future of the environment and with that the future of casting.

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Future Generations

When considering the future generations of casting, one should contemplate on what the consumers following the us would want. More complicated and complex molds, producing resilient and lightweight results that meet customer specifications and are used continuously for mass production, this alone will help reduce waste in discarding castings or mold that cannot be reused. However, one has to also contemplate the environmental aspect, you cannot produce too many uneconomically friendly castings. You must be able to contemplate the idea of how the mold will be able to be broken down, or even possibly reused for a different purpose.

Even when considering the wide array of nonferrous and ferrous metals, in the future they will continue to be developed to help reduce melting time and processing time. Castings is a family that welcomes adaptability and change through various branches. That doesn't mean that it does not come without its adverse effects and it's up to everyone involved to look out for the environment and everyone that relies on it.

Global Warming Affects

Though casting has created so many wonderful things and opportunities in the world we live in, all good lights cast shadows. In the case of casting, it is the byproduct from of creating. As the technique has grown over the thousands of years of life. It has had to adapt to the ever-growing needs of the world. During the end of the industrial era, a major phenomenon appeared that affected the entirety of the world, global warming and all the many things that feed into it.

How does global warming affect casting? In recent years the casting and manufacturing industry has been accredited to being a major contributor to the progression of the phenomenon as a major source of pollution into the environment. The table below shows different waste byproducts from different components of the metal casting process.

Table 1-7. Waste Products of the Metalcasting Industry		
Operation	Materials Used	Potential Waste/Emissions
Pattern Making	Wood, plastic, metal, wax, polystyrene	Nonmetal scrap materials, solvents, cleaners, particulates, VOCs
Mold and Core Preparation	Sand, chemical binders, plaster, refractory slurry, wax, plastic, steel, salt	Spent sand; damaged cores; mold plaster; particulates; organic compounds; HAPs; VOCs; carbon monoxide; hydrogen sulfide; sulfur dioxide; nitrous oxide; metallic oxide fumes; ammonia; hydrogen cyanide; nitrogen oxides; polystyrene vapors; wastewater with suspended solids, phenols, dissolved salts, and elevated temperature
Furnace Charge & Metal Melting	Metal scrap, ingot and returned castings, fluxing agents, refractory materials, fuel	Particulates, combustion products, chloride and fluoride compounds, metallic oxide fumes, hydrochloric acid, emissions from additives, wastewater with metals, solvents, refractory materials
Quenching, Finishing, Cleaning, Coating	Paint, rust inhibitor, unfinished castings, water, steel shot, solvents	VOCs; dust and metallic particulates; spent solvents; steel shot; cutting wheels; metallic filings; wastewater with solvents, oil and grease, suspended solids, elevated temperature, low or high pH
Shakeout, Cooling, Sandhandling	Water, caustic for wet scrubbers	Waste sand; fines (nonmetals); particulates; carbon monoxide, other gases; organic compounds; wastewater with mold coating, elevated temperature
Die Casting	Metal, fuel, lubricants, fluxing agents, hydraulic fluid	Waste hydraulic fluid, lubricants, floor absorbent, plunger tips; wastewater with oil, phenols, elevated temperature

Source: Adapted from U.S. Environmental Protection Agency 1997.

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As represented in the table, the different steps of casting can produce at most almost four times as many harmful byproducts as the material used in the original operation. As a result, the responsibilities of the parties involved in the process may follow the code of ethics set by all professional industries. Which-This means they must make sure that all waste is taken care of to the best of their ability and in the best possible manner in accordance with the codes set in place by groups such as the Society of Manufacturing Engineers (SME).

Conclusion

In the end, casting is a family that has been in development for over a millennium and it is important to recognize its impact, mostly from the automobile and aviation industry. I hope that even though castings can be fun, ingenuitive, and even ~~life-life~~-changing, that the biggest outlook is out it can better our community for a better chance. Looking at the past for clues to better understand the steps needed to take and evaluate the future is what is ~~truly-true~~ to ~~the~~ conclusion.

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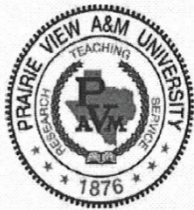
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BELOW AVERAGE
PROJECT REPORT

**MECHANICAL ENGINEERING DEPARTMENT
PRAIRIE VIEW A&M UNIVERSITY**



MCEG 3303 Manufacturing Process

Fall 2021 Section Y01

REPORT ON

"The Process of Machining"

**Conducted on
November 20, 2021**

**Submitted by
Devan Mitchell
On
November 23, 2021**

To

Dr. Lai Jiang

- 60
1. Writing quality: 13
 2. Presentation quality: 17
 3. Technical content: 20
 4. Task sheet submission: 10

Abstract:

In this paper, the process of machining, the different cutting patterns, and the tools needed for machining. In the introduction, it is mentioned that the processes of machining. It also lists the examples of each type of machining process. The main contents go into more detail of about the machining process and why it is important to the manufacturing process. The tools need to effectively use the machining process. The cutting conditions such as turning, milling, and drilling. The process of how the final work piece comes together with using two final cuts. It is also mentioned that the machining process requires a power tool to complete the workpiece. The four simple types of chips in the machining process and how power and energy are interconnected to the machining process.

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Introduction:

Machining is the process where a material, most often it is metal, is cut to the desired final shape and size requested. Most of the time is it used on metals but can also be used on various variety of other materials such as wood, plastic, ceramic, and composite materials. The basic elements of machining are workpiece, tool, and chip. A cutting motion is required to have relative motion between the tool and the workpiece. As for unwanted material, it is removed from the workpiece via the cutting motion of the tool being used. Examples include turning, milling, and drilling. Other examples are shaping and planing, broaching, and sawing. The abrasive process is where the material is removed by hard, abrasive particles. An example is grinding. The nontraditional process is using other energy forms to remove material rather than use a sharp tool. An example of the nontraditional is electrical discharge machining (EDM) and water-jet machining.

Main contents:

There are a variety of reasons why machining is important. There is a plethora of work materials that can be machined although it is mostly used on metals, a variety of shapes and special figures are plausible: screw threads, precise round holes, and straight edges and surfaces. There is good dimensional precision and surface finishes. The tolerance that can be achieved is $\pm 0.025\text{mm}$ ($\pm 0.001\text{in}$). The disadvantages are that it can be wasteful of the material. The chips that are generated in machining are wasted pieces of the material that is being machined. Machining can be time-consuming. Machining takes long to shape one part than in other shaping processes.

Within the manufacturing sequence, machining is usually happening after other simple manufacturing processes such as casting, forging, or bar drawing. These other processes formulate the shape of the beginning workpiece. With machining, it is the final part where it finalizes the shape, dimensions, finish, and special details of the workpiece that the other processes cannot do. Machining is unique in the sense that there isn't not another part of the manufacturing sequence that can do what machining does.

Cutting tools include single-point tools and multiple cutting-edge tools. Single-point tools have one cutting edge that is the cutting force. The tip is typically rounded to form a nose-like radius. The machining method of turning utilizes single-point tools. Turning uses a single-point cutting tool to remove the material from the rotating workpiece to form a cylindrical shape. The workpiece is rotating whereas the single point cutting tool is not moving. Multiple cutting-edge tools have more than one cutting edge. The motion that is relative to the work achieved is done by the rotation of the tool. The machining methods of drilling and milling are used by the rotation of the multiple cutting-edge tools. Drilling is used to make a round hole with a drill bit or some form of a rotating tool; it has two cutting edges. Milling uses multiple-cutting-edges to move across the workpiece to cut a straight plane or surface. There are two types of milling are peripheral and face. Peripheral is cutting horizontally or parallel and face is cutting directly on top of the surface of the workpiece.

There are cutting conditions when it comes to turning. The three main components are speed, feed, and depth of the cut in a turning process. The cutting speed is the primary motion. Feed is the secondary motion. Lastly, there is the depth of the cut, which is the puncturing of the tool right below the original work's surface. For turning the rate of material removal can be calculated as $\text{Material removal rate} = \text{cutting speed (mm/s or in./min.)} \times \text{feed (mm or in.)} \times \text{depth of cut (mm or in.)}$. For turning the rate of material removal can be calculated as $\text{Material removal rate} = \text{cutting speed (mm/s or in./min.)} \times \text{feed (mm or in.)} \times \text{depth of cut (mm or in.)}$.

When it comes to real production, there are several different rough cuts made on one part which are then followed by one or two finishing cuts. Roughing is the method of removing large amounts of the certain materials from the starting workpiece. There are some parts of the material that hangs on until the final cutting part. There are high feeds and depths but low cutting speeds to make for those rough cuts. Finishing is the method of completing the part of the

geometry. It achieves the final dimensions, tolerances, and finishes of the workpiece. There are low feeds and depths in high cutting speeds throughout the workpiece.

The machine tool used in machining is a power tool machine that is driven to perform any of the machining operations. The function of machining is to hold the workpiece, it positions the tool in the right place in order for it to be cut, and it provides power at speeds that cannot be met by a human-machine tool and the specific depth that has been set by the operator. Examples of machine tools are a lathe, milling machine, and a drill press.

The cutting action requires a shear deformation of work material to make a chip and as the chip is removed, the new surface is has exposed this method is called the orthogonal cutting model. ~~Cross~~The cross-sectional view of machining is a simplified 2-D model of machining that describes the machining precisely.

Four simple types of chips in machining are discontinuous, continuous, continuous with a built-up edge (BUE), and serrated chip. Discontinuous chip is brittle work materials (ex. Cast irons), low cutting speeds, and large feed with the depth of cut, and high tool-chip friction. There is an irregular surface due to chip discontinuities and the high tool-chip friction. Continuous chip is ductile work materials (ex. Carbon steel), high cutting speeds, small feeds and depths of the cuts, there is a sharp cutting edge, and low tool-chip frictions. There is a good typical finish. Continuous chip with BUE is ductile materials with low-to-medium cutting speeds and tool-chip frictions causing portions of the chip to adhere to the rake face. BUE then forms and generally breaks off in a cyclically motion. Serrated chip is difficult-to-machine metals with high cutting speeds (ex. Titanium alloys and austenitic stainless steels). Serrated chips use semi-continuous like a saw-tooth look. There is also a cyclical chip forms with alternating high-low shear strain.

The power and energy relation are that a machining operation requires power. This can be calculated by cutting power = cutting force*cutting speed. The power in hp is calculated by cutting horsepower = cutting force*cutting speed / 33,000. This is how power is traditionally expressed as horsepower in the United States. Gross power is used to operate the machine tool. Unit power in machining is the power per unit volume rate of metal cut. Unit power is also expressed as specific energy.

Machining is a very technical process that is more than just cutting materials. It is specific in the sense of the type of tools used in the actual cutting the materials down to the amount of energy used to cut the workpiece. The different types of materials utilized in the process of

2 pages short.

machining is are interesting and wide. It is mainly used on metals but can be used on a variety of materials and workpieces.

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