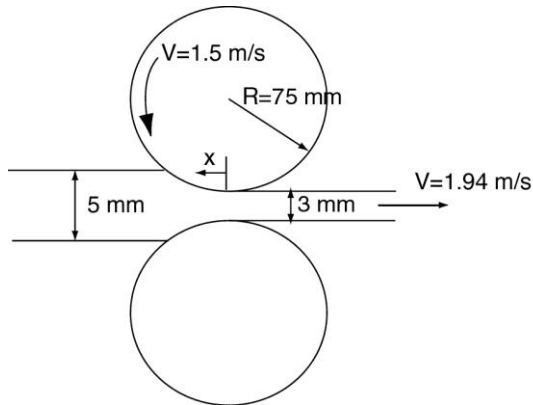


Manufacturing Qualifier Exam Fall 2022

Answer 5 of the following 6 questions

1. A rolling operation takes place under the conditions shown. What is the velocity of the metal in the inlet zone? What is the position, x_n , of the neutral point? Note that there is a front and back tension that has not been specified! Sketch the pressure distribution on the work rolls.



Additional Data:

Material: 5052-O Aluminum
 $\mu=0.1$
 Hardened Steel Rolls
 Roll surface roughness = $0.02 \mu\text{m}$
 Workpiece surface roughness = $0.15 \mu\text{m}$
 Temperature = 210°C
 $V_f=1.94 \text{ m/s}$
 $V_r=1.5 \text{ m/s}$
 $y_i=5 \text{ mm}$
 $y_f=3 \text{ mm}$
 $R=75 \text{ mm}$

2. The following part is to be cast of 10% Sn bronze at the rate of 100 parts per month. To find an appropriate casting process, consider all processes, then reject those that are (a) technically inadmissible, (b) technically feasible but too expensive for the purpose, and (c) identify the most economical one. Write a rationale using common-sense assumptions about cost.

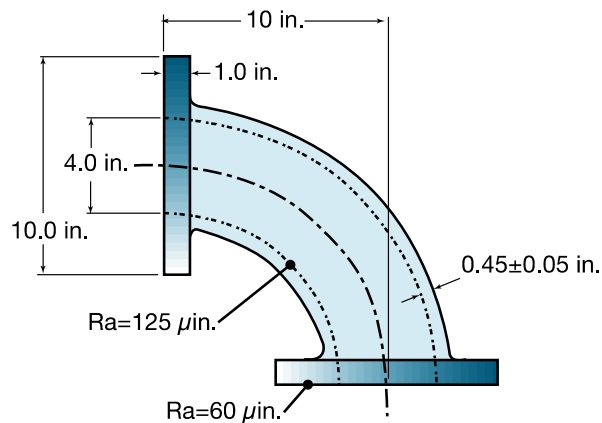


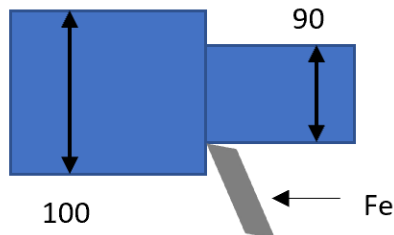
Figure for question 2

3. Polymer based composite materials are finding increased usage due to their high specific strength.
 - a) Name two common reinforcement materials found in polymer based composite materials and how they compare to each other with respect to cost and mechanical properties. (Assume both reinforcement materials have the same % vol in the final composite product).
 - b) Illustrate (draw) a low strength isotropic composite structure, a high strength isotropic composite structure, and composite structure with highly anisotropic strength.
 - c) Explain three **distinctly** different factors that affect the final mechanical properties of a composite structure.

4. Laser powder bed fusion (LPBF) is a metal additive process capable of realizing parts with higher geometric complexity than typically possible with a conventional 3 axis machine tool. In the unlikely scenario that both systems were used to fabricate a metal cube of dimensions 25mm × 25 mm × 25mm, comment on the expected differences between the machined and printed cube with respect to the following attributes:
 - a) Surface finish
 - b) Geometric accuracy
 - c) Microstructure
 - d) Residual stresses

Note: The initial workpiece material for the machined cube is a block of material cut (band saw) from a larger continuously cast slab of dimensions 30 mm × 500mm × 1200mm, and the powder used in the LPBF process has the same alloying composition as the cast material.

5. For the turning operation shown, complete parts a-d.



- a) What is the depth of cut (in mm)?
- b) What is the cutting speed (in m/s) if the spindle rotates at 500 rpm?
- c) Calculate the feed per revolution (in mm/rev) if the tool's feed velocity is 200 mm/min.
- d) Determine the material removal rate in mm³/min **and** in³/s

6. Different material removal processes are used to remove material from brittle and ductile materials.
 - a. How do the material removal mechanisms differ between grinding and milling? In your answer state which process is more appropriate for brittle materials.
 - b. Suggest a non-traditional process that could also be used to remove material from a brittle material. In your answer describe its material removal mechanism and any material constraints for the process.
 - c. Subsurface damage (SSD) can occur when removing material from brittle materials. What is SSD and how can it be subsequently removed?