ORDRE DES INGÉNIEURS DU QUÉBEC

NOVEMBER 2017 SESSION

All document permitted Calculators: all model permitted Duration of exam: 3 hours

14-IN-B1 MANUFACTURING PROCESSES

Question #1 (10 points)

Fig. 1 shows a rectangular aluminum part (K = 35; n = 0.13) during a cool rolling operation. Rolls diameter is 15 cm, the lubricant used is mineral oil ($\mu = 0.3$), and the rolling speed (V_0) is 0.2 m/s. The material is initially in annealed state.

a) Calculate the rolling force to perform this manufacturing operation in one pass. (7 pts)

b) Could we perform this manufacturing operation in only one pass? Justify your answer. (3 pts)

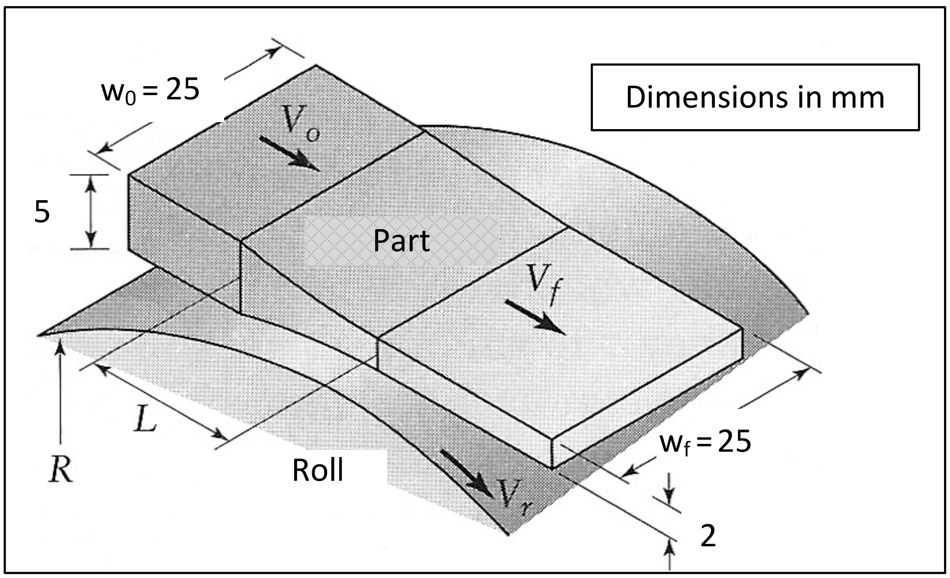

Fig. 1: View of rectangular part during flat rolling.

Question #2 (2 points)

Briefly describe the main steps required to joint two metal parts by brazing using the following two processes:
(a) torch brazing
(b) furnace brazing

Question #3 (6 points)

Fig. 2 presents a cross section view of a mold cavity used for the fabrication of metal parts by sand mold casting.

a) What is the role of the riser? (3 pts)
b) Identify three defects that may be visible in this part after casting and explain the possible cause for each defect. (3 pts)

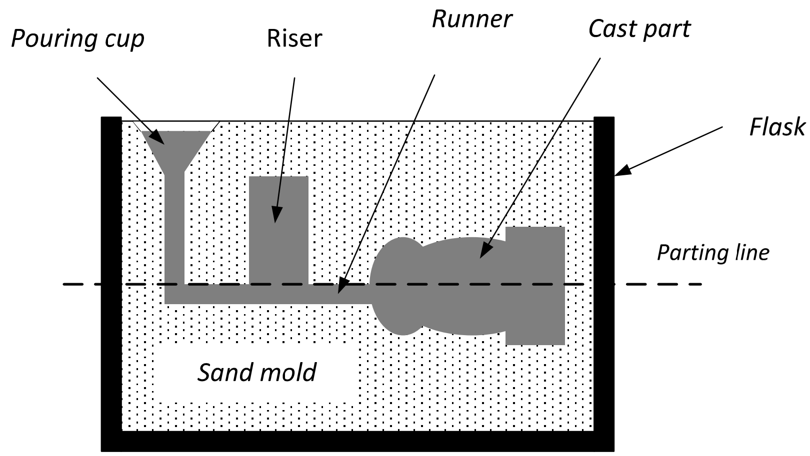

Fig. 2: Mold cavity used for sand mold casting

Question #4 (5 points)

Fig. 3 shows the evolution of specific volume as a function of temperature for amorphous, semi-crystalline and crystalline polymers.
a) Among the curves A, B or C, which one represents the result obtained with a 100% amorphous polymer? Justify your answer? (3 pts)
b) Describe the phenomenon observed at the temperature "T_m" and comment this phenomenon from a polymer shaping point of view. (2 pts)

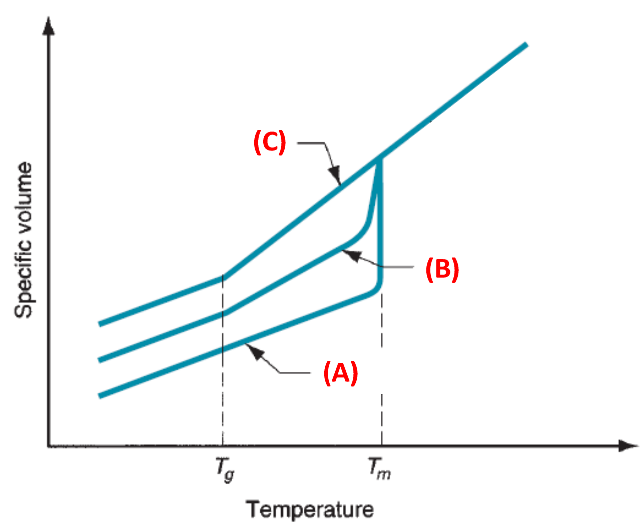

Fig. 3: Behavior of three polymers as a function of temperature.

Question #5 (4 points)

The welding processes (1) SMAW : shielded metal arc welding, and (2) GMAW : gas metal arc welding produce a molten pool in order to joint metal parts after the solidification of the molten zone. For each of these two welding processes, briefly describe method used to protect the molten pool from the oxidation.

Question #6 (8 points)

Fig. 4 shows a solidification curve for a metal. Using the Fig. 4, determine:

a) The pouring temperature. (1 pt)
b) The solidification temperature (i.e. freezing completed). (1 pt)
c) Overheating. (1 pt)
d) The total solidification time. (1 pt)
e) Is this cooling curve corresponds to the profile of a pure metal or an alloy? Justify your answer. (4 pts)

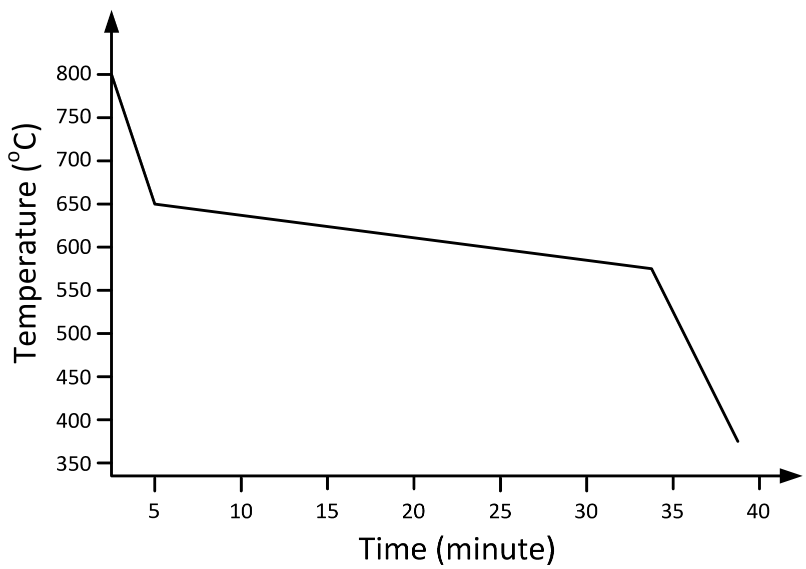

Fig. 4: Cooling curve for a metal.

Question #7 (6 points)

Fig. 5 shows the TTT (time-temperature-transformation) curve for an eutectoid steel (Fe-0.80% C). For a part initially at 800°C, determine the phases and the proportion of the phases at 20°C according to the three cooling paths shown in Fig. 5 (i.e. path #1, 2 & 3). Consider that the part is in the austenitic phase before each cooling path.

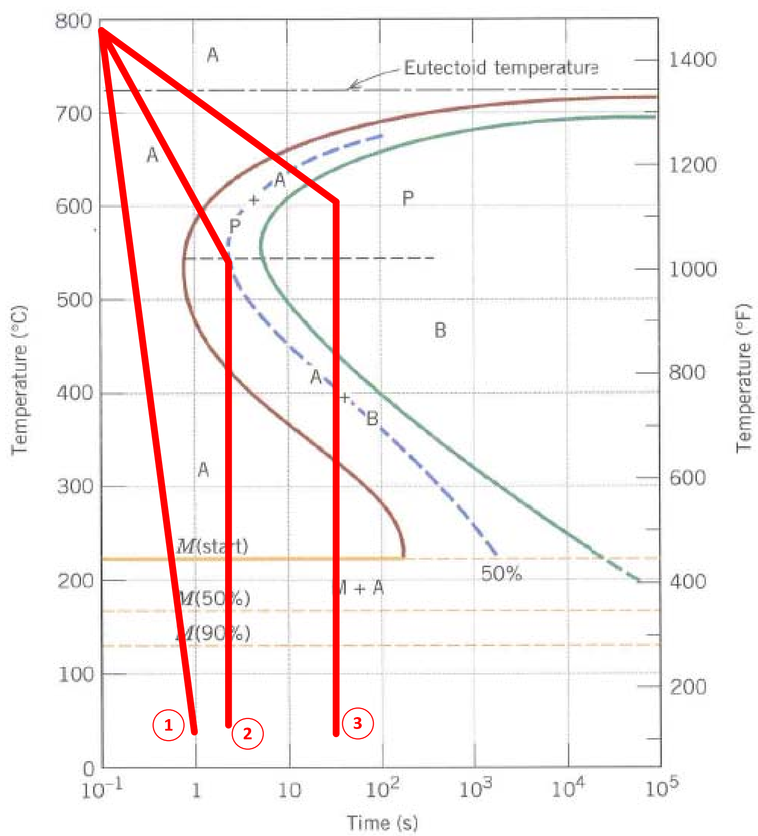

Fig. 5: TTT curve for eutectoid steel

Question #8 (9 points)

A turning operation (conventional turning using tungsten carbide (WC) cutting tool) is performed on a cylindrical steel bar whose initial diameter = 150 mm and final diameter = 147 mm. Cutting speed = 2.5 m/s, feed = 0.30 mm/revolution, and machined length = 500 mm.

a) Calculate the machining time required for this machining operation. (4 pts)
b) Calculate the cutting force (consider specific energy = 4.4 N·m/mm^3). (2 pts)
c) Using the Taylor equation, estimate the number of parts that can be produced without changing the tool. Use the Taylor parameter C = 220 and the Taylor exponent n = 0.27. (3 pts)