ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2006 SESSION

Open book examination

Non-programmable calculators: only authorized models

Duration: 3 hours

98-IND-B2 MANUFACTURING PROCESSES

Problem 1 (2 points)

Using a rule of thumb that the maximum roughness height R_t should be about one-third the tolerance, calculate minimum surface roughness on the turned piece in terms of R_a (arithmetic average) and R_q (root mean square value) that will satisfy the specified tolerance of 0.05 mm.

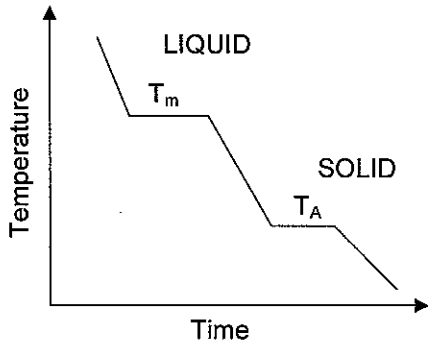
Problem 2 (3 points)

Explain the difference between "tempering" and "recovery annealing" of steel in terms of the processing and applications.

Problem 3 (3 points)

Is the solidification curve presented belongs to pure metal or solid solution? Justify your answer.

Explain physical reasons of appearance of two plateaus: at temperature T_m (a) and T_A (b).



Problem 4 (3 points)

Explain, with the aid of an appropriate sketch, what measure is generally taken to make up for metal shrinkage before and during solidification and thus to prevent the formation of shrinkage cavities in the casting.

Problem 5 (3 points)

Make simple sketches showing the principal distinguished features of the hot-chamber and cold-chamber die casting machines and compare their application fields.

Problem 6 (2 points)

If an alloy demonstrates ideally plastic behaviour, would it be possible to process this material by (a) extrusion and (b) by drawing? Justify your answer.

Problem 7 (5 points)

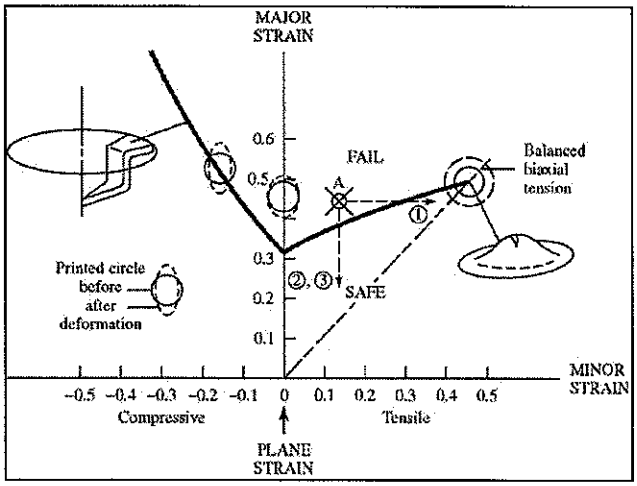
Estimate the springback in making 90° bend to 5mm radius of the Al6061-0 sheet of 2 mm of thickness.

(a) Calculate: (a) radius of the final bend and (b) the angle after springback. Propose two techniques to combat springback. If necessary, make a sketch.

(b) State the two mechanical properties of materials that influence the springback value. State whether the springback increases or decreases with these properties.

Problem 8 (3 points)

Optical grid analysis is used to determine critical points on the stretched piece. Square grid of 4 mm diameter circles is etched on the sheet surface. After stretching, two measurements of deformed circles are made in two distinctive zones of the stretched piece: (4.2mm by 5.6mm) et (5.6mm by 6.0mm). Considering the Forming Limit Diagram of low-carbon steel, determine which case is more critical in terms of localized necking.



Problem 9 (6 points)

A ring of aluminium 6061-0 is deformed in compression to 60% of its initial height. This operation is realized at a speed of 0.5 mm/s:

(a) in hot conditions (400°C);

(b) in cold conditions;

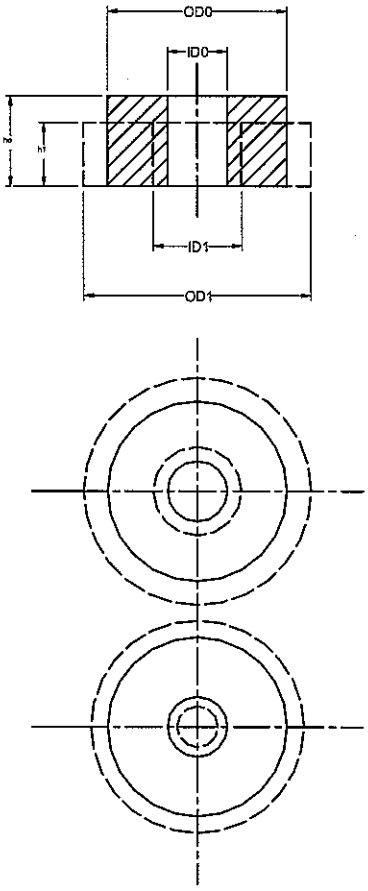
During deformation, MoS_2 and dry soap are respectively used for hot-upset and cold-upset.

Calculate the force of upset for the two deformation conditions considering following initial dimensions of the ring:

ID_0 = 6.35 mm ;

OD_0 = 19 mm; h_0 = 9.5 mm.

Take pressure multiplying factor Q_a=1.2 for both cases.



Problem 10 (6 points)

The length of the steel tubular bar (hardness 40HRC) is 200 mm, its external diameter is 100 mm and internal, 50 mm. The bar is machined to obtain internal diameter of 51.3 mm using WC tooling.

a) Suggest cutting speed and feed.

b) Evaluate the time necessary for machining.

c) Using Taylor's equation, calculate WC tool life using cutting speed and feed found in point (a) and the number of pieces that can be machined with one tool.

d) Determine whether the lath available in the shop and having power of 6kW will suffice for this operation.

e) Calculate the force of cut and evaluate the thrust force.

f) From Taylor's equation, find the effect of decreasing in half the cutting speed on the WC tool life.

Problem 11 (6 points)

A self-lubricating bronze bushing is produced by powder metallurgy. Lubricating properties are obtained by impregnating the bushing with oil after sintering. To produce green product, 100 grams of the fine bronze powder (theoretical density is 8.8 g/cm^3) is poured into the container having internal and external diameters of 13 and 26 mm and then cold compacted under 230 MPa pressure. Sintering is performed than at 750 C.

1. Calculate the height of the powder in the container before compaction?
2. Calculate the density of green product after compaction and its dimensions (compaction curve is given in Figure 1a)? What press you suggest for this operation: 75 or 125 kN? Justify.
3. Calculate the density of the sintered product and its dimensions if the shrinkage is uniform in all directions and there is no change in mass (sintering curve after compaction at 230 MPa is given in Figure 1b)?

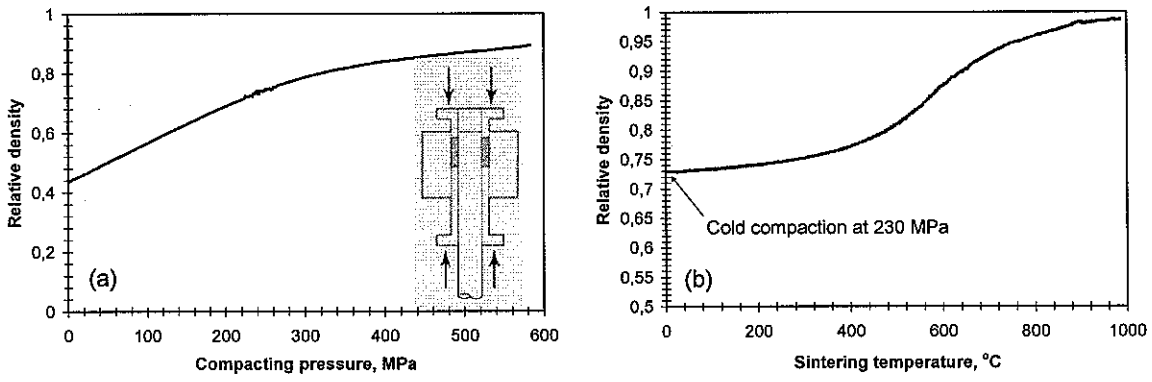


Figure 1: Bronze powder: (a) compaction curve and (b) sintering curve after compaction at 230 MPa

Problem 12 (4 points)

During shielded metal-arc welding (SMAW), the arc efficiency is 0.8.

a) Calculate the nominal heat input during welding (H [kJ/cm]) for two operating conditions:

Parameters	A	B
Voltage, V	25	25
Current, A	125	150
Speed of travel, mm/s	10	5

b) Which operating conditions, A or B, are more risky in respect to cold cracking when they are applied for medium-carbon steels? Justify.

Problem 13 (4 points)

Respond to three following questions on polymers:

a) The same piece can be produced by injection of a thermoplastic or thermosetting polymer. For these two cases, should one cool or heat the mould to fix the shape of the piece? Justify.

b) Many oils are paraffins and are formed of the same monomers as polyethylene. Explain why, at room temperature, polyethylene are solid, while oils liquid?

c) It is known, from a practical point of view, that the glass transition, for an amorphous polymer, is a point of softening. Explain why this temperature indicates the upper limit of application for plastics and lower limit, for elastomers?