

ORDRE DES INGÉNIEURS DU QUÉBEC

MAY 2014 SESSION

Open-book examination
Calculators: authorized models only
Duration: 3 hours

Metal Fabrication
14-MT-B3

- *The exam contains a maximum of 100 marks.*
- *Please, answer all questions.*

Question 1. Metal Shaping (5+5+5+5+5 points)

- a) Describe the angle of attack during cold rolling? What is the relation between this angle and the reduction ratio?
- b) Describe the formability limit diagram.
- c) If the design criteria for the selection of a component is toughness, would you prefer a forged or an extruded component? Explain why.
- d) What are the main metallurgical differences between warm and hot forging?
- e) Indicate the mathematical equation for the flow curve.

Question 2. Metal Welding (5+5+5+5+5 points)

- a) Why Scheil cooling is often used during welding to predict the solidification path? What are the limits of such analysis.
- b) What information can be obtained from the code designation of the following stick electrode: E6013?
- c) What is the relationship between welded structure and fatigue properties?
- d) Describe the tandem-GMAW process.
- e) Distortion (warping) is a serious problem in fusion welding, particularly arc welding. What are some of the techniques that can be taken to reduce the incidence and extent of distortion?

Question 3. Powder Metallurgy (5+5+5+5 points)

- a) What is the major problem occurring during sintering of stainless steel PM part?
- b) Why toughness of PM components is typically low?
- c) What are the required characteristics of a metal powder to serve as feedstock in additive manufacturing?
- d) What mechanisms would you consider in the prediction of the densification behavior of a metal powder during hot pressing?

Question 4. Metal Casting (5+5+5+5 points)

- a) Describe how the grain structure develops during casting of a small ingot?
- b) Would segregation be more, less or of equal importance during casting of a large vs a small ingot?
- c) What are the two parameters that control the grain size and solidification structure?
- d) Explain the differences between hot tearing and lamellar tearing.

Question 5. Calculations on shaping process (10 points)

A 42.0-mm-thick plate made of low carbon steel is to be reduced to 34.0 mm in one pass in a rolling operation. As the thickness is reduced, the plate widens by 4%. The yield strength of the steel plate is 174 MPa and the tensile strength is 290 MPa. The entrance speed of the plate is 15.0 m/min. The roll radius is 325 mm and the rotational speed is 49.0 rev/min. Determine (a) the minimum required coefficient of friction that would make this rolling operation possible, (b) exit velocity of the plate, and (c) forward slip.