Department of Mining and Materials Engineering

Faculty of Engineering, Prince of Songkla University

Midterm Examination 2nd Semester	Academic Year 2004
Subject: 237 – 302 Materials forming	Date: 18th December 2004
Time: 13.30-16.30pm	Room: A201

Instructions: 1. Only a sheet of A4 note is allowed and must be handed in.

2. Students are allowed to bring in calculator and dictionary.

3. Answer all questions in the answering sheets provided.

ทุจริตในการสอบโทษขั้นต่ำ คือ ปรับตกในรายวิชาที่ทุจริตและพักการเรียน 1 ภาคการศึกษา

Question 1

(a) **Derive** the following equation for the strain rate ($\dot{\varepsilon}$) during extrusion and **state any assumptions you made**. (2 marks)

$$\dot{\varepsilon} = \frac{6.v_{ram}.\ln R}{D_o}$$

where v_{ram} is the ram speed

R is the extrusion ratio

D_o is the container diameter

(b) If an aluminium alloy billet of diameter 100m is indirectly extruded through a 25mm diameter die with a ram speed of 2.5mm/s, **derive the expression below** for the exit temperature (T_E) of the extrusion as a function of initial billet temperature (T_I). Ignore any heat losses to the tooling:- (8 marks)

$$T_E = T_I + (0.028)\text{Exp}(5500/T_I)$$

(Note that: T_E and T_I are in K)

DATA:

Extrusion pressure (P) is given by the following equation:-

$P = \sigma\ (0.8 + 1.8\ \ln R)$

σ is the flow stress of the alloy in MPa and is given by:-

$$\sigma = (0.02)\dot{\varepsilon}^{0.15} Exp(5500/T)$$

where T is temperature in K and $\dot{\varepsilon}$ is strain rate

The specific heat capacity of the aluminium alloy is 1180 $J.kg^{-1}.K^{-1}$ and the density is 2700 $kg.m^{-3}$.

(c) It is known that if the natural logarithm of the temperature-compensated strain rate (Zener Holloman Parameter, Z) during deformation of this alloy is maintained at a level less than 22 (i.e. $\ln Z < 22$), then recrystallisation of the alloy will not occur during subsequent solution treatment. **Is it possible to extrude the alloy at an initial billet temperature of 400°C** such that **recrystallisation** during solution treatment **does not take place**? (6 marks)

$$Z = \dot{\varepsilon}.Exp(18000/T_E)$$

(d) **Explain** the term "Incipient Melting" as applied to the extrusion of an aluminium alloy and **give suggestions** on how to reduce this defect.

(4 marks)

Question 2

(a) **Show** that the **strain rate** ($\dot{\varepsilon}$) under plain strain condition during rolling is (4 marks)

$$\dot{\varepsilon} = \frac{2.\pi.N}{60}.\sqrt{\frac{R}{(h_o - h_f)}}.\ln\left(\frac{h_o}{h_f}\right)$$

where

h_o is the initial sheet thickness

h_f is the final sheet thickness

R is the roll radius

N is the roll speed in number of revolutions per minute

(b) It is proposed to hot roll aluminium alloy plate (500mm wide) from an initial thickness of 10mm to a final thickness of 6mm, using a roll speed (N) of 12 revolutions per minute.

(i) If the plate is preheated to 425°C, **what is the maximum roll radius** that can be employed to prevent recrystallisation occurring after subsequent heat treatment? (6 marks)

It has been shown that if the temperature-compensated strain rate (Zener Holloman Parameter, Z) is kept below a value of $\ln Z < 26$, the alloy will not recrystallise.

Z in this case is given by

$$Z = \dot{\varepsilon}.\exp\left(\frac{18000}{T}\right)$$ where T is temperature in K

(ii) Using this maximum roll radius, **calculate the rolling torque** assuming that (6 marks)

$$F = \chi.w.\sqrt{R(h_o - h_f)}.\sigma_o$$

where

F is the rolling load

χ is a friction factor (for hot rolling = 1.4)

w is the width of the sheet

σ_o is the flow stress of material being rolled

The flow stress in this case is given by an equation of the form

$\sigma_o = 50\dot{\varepsilon}^{0.15}$

(c) **Explain** briefly the reasons why cold rolling is often used after hot rolling to reduce the thickness of steel sheet down to as little as 0.025mm.
(4 marks)

Good luck!!!