Department of Mining and Materials Engineering

Faculty of Engineering, Prince of Songkla University

Final Examination 2nd Semester	Academic Year 2007
Date: 20th February 2008	Time: 09.00am-12.00pm
Subject: 237 – 302 Metals and Materials forming	Room: A400

Instructions:

1. There are 5 problem sets in total. Please **do 3 out of 5 questions**.
2. Write your answer in the answering sheets provided.
3. Dictionary, calculator and stationary are allowed.
4. Textbook, lecture notes and other studying materials are **not** allowed.
5. This final exam is accounted for 40% of the total grade point.

"ทุจริตในการสอบ โทษขั้นต่ำ คือ พักการเรียน 1 ภาคการศึกษาและ ปรับตก ในรายวิชาที่ทุจริต"

Question 1 (20 marks)

Explain the following terms:

1) Tube sinking
2) Fine blanking
3) Springback in bending operation
4) Redrawing
5) Stretcher strains (or Lueder's bands)
6) Stretch forming
7) Powder metallurgy
8) Clearance in Sheet Metal Cutting
9) Erichsen cupping test
10) Tandem rolling mill

Question 2 (20 marks)

i) Consider extruding an aluminum alloy billet through a flat-faced die. Using the data given below, suggest whether it is possible to perform an extrusion at an initial billet temperature of 500°C, with a ram speed of 30mm/s without any major surface defects on the final extruded product. Carefully explain your reasoning.

Extrusion Load (MN) = $\frac{1500}{T} + (0.4).\ln(V)$

Exit Temperature (°C) = T + 3.V

where:-

T = Initial Billet Temperature (°C)

V = Ram Speed (mm/s)

Maximum Load Available from extrusion press = 5 MN

Melting point of lowest melting point phase in alloy = 550°C

ii) There are several types of defects that could occur in extrusion. Explain these terms and suggest any alterations that could be made to the extrusion conditions in order to eliminate these problems.

- Surface cracking
- Pipe
- Chevron cracking

<u>Question 3</u> (20 marks)

i) Aluminum sheet (1m wide) is cold rolled in a 2 high mill from an original thickness of 2.5mm down to 2mm in a single pass with a roll speed of 20 revolutions per minutes. The roll diameter is 0.55m. Using the following information, <u>calculate the roll gap</u> required, in order to achieve a final sheet thickness of 2mm.

Mill stiffness = 5MN/mm

Mill stiffness (E_{mill}) = $\frac{F}{h_f - h_{mill}}$

where h_f = final thickness

h_{mill} = roll gap

The rolling force (F) under plain strain conditions can be given by:-

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

χ = factor allowing for friction (~1.2 for cold rolling)

w = width of sheet

R	=	roll radius
h_o	=	initial sheet thickness
h_f	=	final sheet thickness
$\bar{\sigma}_o$	=	<u>mean</u> flow stress of material

The **strain rate** during rolling is given by:-

$$\dot{\varepsilon} = \frac{V_r.\ln(h_o / h_f)}{\sqrt{R.(h_o - h_f)}}$$

Where Vr = the surface speed of the rolls

Normally the speed of the rolls is referred to in terms of the number of revolutions per minute (N). The surface speed of the rolls (Vr) can be calculated as:-

$$V_r = \frac{2.\pi.R.N}{60}$$

Stress Strain Data	
True plastic strain ($\dot{\varepsilon}$) s^{-1}	True stress (σ_o) MPa
0	40
1	51
2	62
3	73
4	84
5	95
6	106
7	117
8	128
9	139
10	150
11	160
12	171

ii) Explain the term "alligatoring" and what causes it.

<u>**Question 4**</u> (20 marks)

(i) A cup is being drawn from a sheet metal that has a normal anisotropy of 3. Estimate <u>the maximum ratio of cup height to cup diameter</u> that can be drawn successfully in a single draw. Assume that thickness of the sheet throughout the cup remains the same as the original blank thickness. (**Hint:** *use the relation between the average normal anisotropy and the LDR)*

(ii) If a sheet metal has R values of 1.0, 1.5 and 2.0 for the 0°, 45° and 90° directions to rolling, respectively. If a round blank is 200 mm in diameter, estimate the smallest cup diameter to which it can be drawn.

(iii) Explain the term "earing". Using data in question (ii), explain whether ears will form in this case and explain your reason.

Data:

The *drawability* of a metal is measured by the ratio of initial blank diameter (D_o) to the diameter of the cup drawn from the blank or punch diameter (D_p) and represents as *a limiting draw ratio* (LDR);

$$\text{LDR} = \frac{D_o}{D_p}$$

$$\text{Normal anisotropy (R)} = \frac{\varepsilon_w}{\varepsilon_h} = \frac{\ln(w_o - w)}{\ln(h_o - h)}$$

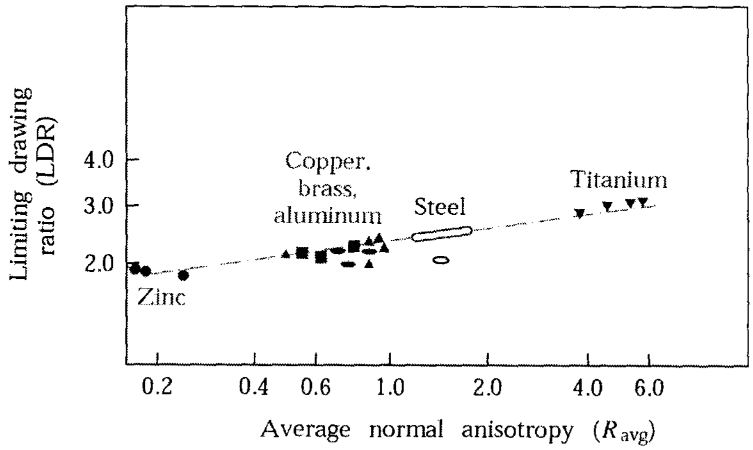
where w_o and w are the initial and final width

h_o and h are the initial and final thickness

$$\text{Average normal anisotropy } (\bar{R}) = \frac{(R_0 + 2R_{45} + R_{90})}{4}$$

where R_0, R_{45}, R_{90} are normal anisotropy for the 0°, 45° and 90° directions to rolling.

$$\text{Planar anisotropy } (\Delta R) = \frac{(R_0 - 2R_{45} + R_{90})}{2}$$



Relationship between average normal anisotropy and the limiting drawing ratio for various sheet metals

Data:

The stress required for wire drawing, σ_D, is given by the following equation

$$\sigma_D = \bar{\sigma}.\ln\frac{A_0}{A_1} + \frac{\mu}{\tan\alpha}.\bar{\sigma}.\ln\frac{A_0}{A_1} + \frac{2}{3}.\bar{\sigma}.\alpha$$

where

A_o	=	initial wire cross section
A_1	=	final wire cross section
μ	=	coefficient of friction
α	=	approach angle in radian
$\bar{\sigma}$	=	average yield strength of the material being drawn

The optimum approach angle (α_{opt}) in a wire drawing operation is given as

$$\sin\alpha_{opt} = \sqrt{\frac{3.\mu}{2}.\ln\frac{A_o}{A_1}}$$

Good Luck !!!

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