Department of Mining and Materials Engineering

Faculty of Engineering, Prince of Songkla University

การสอบปลายภาค ประจำภาคการศึกษาที่ 2 **ปีการศึกษา** 2551

วันอาทิตย์ ที่ 22 **กุมภาพันธ์** 2552 **เวลา** : 09.00-12.00 **น.**

วิชา : 237-302 Metal Forming **ห้อง** : R200

คำสั่ง

1. ทำข้อสอบทุกข้อในกระดาษคำตอบที่แจกให้

2. ตรวจสอบข้อสอบให้เรียบร้อยก่อนสอบ

3. เขียนคำตอบเป็น**ภาษาไทย**และอธิบายให้สมบูรณ์เพื่อให้ได้คะแนนเต็ม

4. อนุญาตให้นำเครื่องคิดเลข, Dictionary และ lecture note ขนาด A4 จำนวน 2 แผ่น เข้าห้องสอบได้

"ทุจริตในการสอบ โทษขั้นต่ำ คือ พักการเรียน 1 ภาคการศึกษาและ ปรับตกในรายวิชาที่ทุจริต"

Name _____ Student ID No. _____

Question 1 (Include as much detail as possible for example drawing relevant pictures) (25 marks)

a) Explain the difference in extrusion pressure between direct and indirect extrusion.

b) Compare advantages and disadvantages between flat faced die and conical die in extrusion.

c) Compare and contrast including advantages and disadvantages of the stretch forming over stamping processes.

d) Explain the following terms:

1) Reverse redrawing
2) Ironing
3) Stretcher strains (or Lueder's bands)
4) Clearance in Sheet Metal Cutting
5) Cluster mill or Sendzimir mill
6) Springback in bending operation
7) Tube sinking
8) Defect that would occur if the approach angle is too small in wire drawing process.

Question 2 (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 given information, calculate the roll gap required, in order to achieve a final sheet thickness of 2mm.

Mill stiffness = 5MN/mm

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

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
$\bar{\sigma}_o$	=	mean 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) Give an example of defect that could happen in metal rolling operation and explain it.

Question 3 (15 marks)

i) Consider extruding an aluminum alloy billet through a flat-faced die from a diameter of 100 mm to a new diameter of 18.9 mm. The extrusion is to be performed on a 2MN press, operating in the indirect mode, with a ram speed of 5mm/s and flow stress of 32 MPa. The billet/die chamber lubrication is very good.

Using the data given below, suggest whether it is possible to perform an extrusion at an initial billet temperature of 475°C without any major surface defects on the final extruded product. Carefully explain your reasoning with relevant calculations.

Extrusion pressure (P) is given by: $P = \sigma_o (0.8 + 1.8 \ln R)$

where σ_o is the flow stress

R is extrusion ratio

The temperature rise during indirect extrusion is given by the following equation

$$0.9\,P = \rho.C_P.(T_E - T_I)$$

where P = Extrusion Pressure

ρ = Density of the material

C_P = Heat capacity of the material

T_E = Exit temperature after extrusion

T_I = Initial billet temperature

Density of Al = 2700 kg/m^3

Heat capacity of Al = 1180 J/kg.K

Melting point of lowest melting point phase in alloy = 525°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

Question 4 (10 marks)

(a) In order to make a cup-shaped product, a cold-rolled steel sheet is deformed by a deep drawing operation and earing sometimes occurs. Explain the term "earing" and what causes it.

(b) Two pieces of low carbon steel sheet which are produced by rolling under different operating conditions are to be deep drawn into cup-shaped products. Using given information, which material will exhibit the worst "earing" and suggest which of the two alloys would you select for the deep drawing operation? Explain your reasoning with relevant calculations.

Tensile samples are cut from each alloy at 0°, 45° and 90° to the rolling direction. After subjecting all samples to the same tensile load, the samples plastically deformed and the width and thickness for each alloy is measured and the normal anisotropy (R) for both alloys are calculated with the following results:

Cut	Normal anisotropy (R) for alloy A	Normal anisotropy (R) for alloy B
At 0°	0.35	1.0
At 45°	0.45	1.5
At 90°	0.22	2.0

Data:

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

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

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

Good Luck !!!

Aj.Weerawan Sutthisripok