ME 355 Manufacturing Processes

Winter 2006, Kumar

MIDTERM EXAM #2 SOLUTION

February 10, 2006
Time: **50 minutes**
Maximum points: **100**

Name: ______________________________

Student No: __________________________

Notes

1. This exam is **CLOSED BOOK** and **CLOSED NOTES**. *There are a total of six pages, including the cover page. There are 17 questions, each worth 5 points unless specified otherwise. Please make sure you have the complete exam before you begin.*

2. Please be brief and to the point.

3. Do not turn this page until the bell rings.

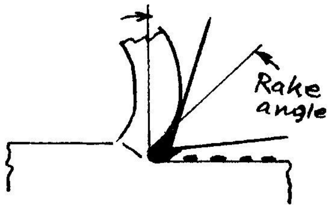
Good Luck!

Give a short answer to the following questions within the space provided.

Draw a sketch to support your answer wherever possible.

1. Explain the mechanism of the BUE formation.

*A BUE forms when **sticking friction** prevails on the rake face and cutting **energy is minimized** by the formation of a **dead-metal zone** attached to the tool edge.*



2. A steel is cut on a lathe with HSS tooling. There are three options to increase production rate: (a) speed v, (b) feed f, (c) depth of cut w. Make a recommendation on which variable should be increased first and which last.

(Extended Taylor formula: $t = \dfrac{K}{v^{1/n_1} f^{1/n_2} w^{1/n_3}}$

Typical values for HSS are n_1 = 0.1, n_2 = 0.18, n_3 = 0.45)

(16C-18 tool life)

Leaving the other two variables at their base value; the base value can be taken as unity.

For HSS tools, from Eq. (16-21) (p643), with K = 100

	Relative tool life
Basic tool life for v = f = w = 1	*100/1 = 100*
For v = 1.3	$100/1.3^{1/0.1} = 7.25$
For f = 1.3	$100/1.3^{1/0.18} = 23.3$
For w = 1.3	$100/1.3^{1/0.45} = 55.82$

Thus, tool life drops, from its original value, by a factor of 100/7.25 = 14 for speed, 100/23.3 = 4.3 for feed, 100/55.82 = 1.8 for depth of cut.

*Obviously, if production rates must be increased, one should first increase **depth of cut, then feed, and only lastly speed.***

3. Define superplasticity (a) in descriptive terms and (b) by reference to the relevant power law. (c) in terms of grain size.

(8A-12)

(a) The condition in which metals deform at a very low stress and are capable of very large tensile deformation.
(b) m becomes very high (at some low strain rates).
(c) Very fine grain size (or microduplex structure).

4. State at least two differences between impression-die forging and closed-die forging.

(p328)

- *Flash;*
- *Defects: Fracture; Barreling for impression-die forging*
  Cracking; incomplete fill for closed-die forging
- *Closed-die forging requires very tight process control.*

5. Rank the following attributes of cold, warm, and hot working in the following table. (use "*low, medium or high*")

	COLD	WARM	HOT
Flow stress	High	Medium	Low
Die pressure	High	Medium	Low
Surface finish	High	Medium	Low
Ease of lubrication	High	Medium	Low
Healing of defects	Low	Medium	High

(9A-1)

6. Which of the following favor machinability of a material? Answer "Yes" or "No" for each item listed.

   1) High ductility *No*
   2) Low strain-hardening exponent (n) *Yes*
   3) Low fracture toughness *Yes*
   4) A strong metallurgical bond (adhesion) between tool and workpiece *No*
   5) Elements such as silicon, embedded in the workpiece material *No*

The following favor machinability of a material:

- *Low ductility, low strain-hardening exponent (n), low fracture toughness.*
- *Low shear strength (low TS), low hardness.*

- *A strong metallurgical bond (adhesion) between tool and workpiece is undesirable when it weakens the tool material.*
- *Very hard compounds, such as some oxides, all carbides, many intermetallic compounds, and elements such as silicon, embedded in the workpiece material accelerate tool wear, thus should be avoided.*
- *Inclusions that soften at high temperatures are beneficial.*
- *High thermal conductivity is helpful.*

7. What is fluidity? State at least three factors that influence this property.

Fluidity is used to characterize the mold filling ability ,and sometimes is called castability.

Superheat;
Mold temperature;
Mold material;
Viscosity of melt;
The type of solidification (dendrites will block flow path. Fluidity can be improved if dendrites are broken)

8. What is the importance of grain size in a casting? How would you control the grain size?

It affects material strength.

Mold temperature;
Cooling rate;
Etc.

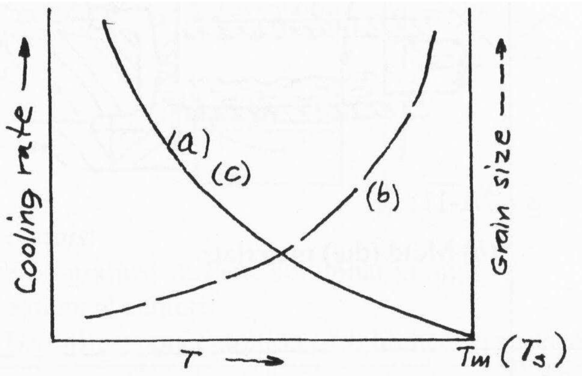
9. Respectively state what kind of alloys solidify in dendritic solification pattern and planar solidification pattern.

(7A-1)

- *Eutectic compositions and pure metals have planar solidification pattern;*
- *Solid solutions for solidify as dendrites.*

10. Draw a diagram showing the effects of mold temperature on (a) cooling rate, (b) grain size, (c) productivity.

(7A-6)



Essentials:

(a) and (c) may be the same curve. If Tm is shown, (a) goes to zero at Tm, (b) does not touch the line.

11. State at least three defects in casting, and choose one to elaborate how to avoid it.

• *Porosity: add chill plates*
• *Impurities - oxides*
• *Cold Shut*
• *Hot Tearing*
• *Dimensional tolerance and part geometry*
• *Warping*
• *Shrinkage*

12. State at least three bulk deformation processes.

1) *Forging*
2) *Extrusion*
3) *Drawing*
4) *Rolling*

13. State one possible defect in open-die forging, and give a solution to avoid the defect.

Defects:
1) *Fracture*
2) *Barreling - Friction*

Solution:
3) *limited deformation per step*
4) *Process anneal between steps*

14. Explain microsegregation in a casting.

> *When the alloy is cooled very slowly, each dendrite or grain develops a uniform composition. Under* ***fast cooling (non-equilibrium cooling)****, the alloy element will not be able to diffuse into the core. Therefore, the compositions at the surface and the core are different. This phenomenon is known as microsegregation or coring.*

15. A lathe is driven by a 6-hp motor. Estimate the possible metal removal rates (in units of in^3/min) if the workpiece material is cast iron (HB 200). What if the material is steel (HB 150)?

(Find the required data in the attached sheets)

From Table 16-1 (p632),

Material	*E_1 (hp· min/in^3)*	*K_1(in^3/ hp· min)*	*MMR (in^3/min for 6 hp)*
Cast iron (HB 200)	0.9	1.1	**6.7**
Steel (HB 150)	0.8	1.25	**7.5**

Where: Material removal factor $K_1 = 1/E_1$,

Material removal rate MMR = Power · K_1

If set efficiency coefficiency as 0.7, MMR will be 4.7 in^3/min and 5.25 in^3/min respectively. Both answers are acceptable.

From the results, MMR for these materials are about the same.

16. A 4340 steel bar of HB 270 hardness is cut at a speed of 0.6 m/s. The underformed chip thickness is 0.3 mm and the width of the chip is 1.5 mm. Calculate the power requirement and cutting force. (***10 points***)

(Find the required data in the attached sheets)

From Table 16-1 (p632), $E_1 = 2.4$ w·s/mm^3 *(in the table, there is no corresponding data for steel (HB 270), so any E_1 value for steel ranged from 2.1 to 6 is acceptable)*

The adjusted specific cutting energy is, from Eq. (16-15), $E = 2.4(0.3)^{-0.3} = 3.44$ w·s/mm^3. The rate of material removal is simply chip cross section multiplied by cutting speed: $V_t = (0.3)(1.5)(600) = 270$ mm^3/s. Power, from Eq. (16-16a): 3.44(270)/0.7 = 1328 W , Cutting force, from Eq. (16-17a), 1328/0.6 = 2213 N.

Or for dull tools, Power: 1328(1.3) = 1727 W. Cutting force, from Eq. (16-17a), 1727/0.6 = 2878 N.

Both sets of answers are acceptable.

17. An AISI 1045 steel billet of d_0 = 6 inch and height h_0 = 2 inch is cold upset to a height of 1 inch (K = 140,000 psi; n = 0.12).Assume no lubrication is used. For the end of the stroke, find: (***15 points***)
   1) True strain
   2) Flow stress
   3) Average pressure required
   4) Force required
   5) What is the force required when there is no friction

(Find the required data in the attached sheets)

$$1)\ \varepsilon = \ln(h_0 / h_1) = \ln 2 = 0.693$$

$$2)\ \sigma_f = k \cdot \varepsilon^n = (140{,}000)(0.693)^{0.12} = 133973\ (or\ 134{,}000)\ lb/in^2$$

$$3)\ \text{No lubricant} \rightarrow \text{assume sticking condition}$$

$$\pi d_0^2 h_0 / 4 = \pi d_1^2 h_1 / 4 \Rightarrow \pi \cdot 6^2 \cdot 2/4 = \pi d_1^2 \cdot 1/4 \Rightarrow d_1 = 8.49\ in.$$

$$\therefore d/h = 8.49/1 = 8.49$$

$$\text{From Fig. 9 - 6},\ Q_a \approx 2$$

$$\therefore p_a = Q_a \cdot \sigma_f = 2 \times 134{,}000 = 268{,}000\ lb/in^2$$

$$4)\ A_1 = \pi d_1^2 / 4 = 3.14 \times 8.19^2 / 4 = 56.58\ in^2$$

$$P = p_a \cdot A_1 = 268{,}000 \times 56.58 = 15164{,}000\ lb = 15.1 \times 10^6\ lb$$

$$5)\ \text{From Fig. 9 - 6},\ Q_a' = 1$$

$$P' = p_a' \cdot A_1 = Q_a' \cdot \sigma_f . A_1 = \frac{Q_a'}{Q_a} \cdot P = 0.5 \times 15.1 \times 10^6 = 7.5 \times 10^6\ lb$$