

## Exam in Material och tillverkningsteknik, January 15<sup>th</sup>, 2007

**Examiner:** Uta Klement (772 1264)

and Antal Boldizar (772 1314) responsible with respect to polymer materials

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The answers will be posted on Tuesday, January 16<sup>th</sup> 2007.

The results of the exam will be posted on Tuesday, January 30<sup>th</sup>.

Checking (*granskning*) of the corrected exams: Wednesday, January 31<sup>st</sup>, between 12:30 and 13:15h at the department.

### Questions:

**First, please read all questions!** Don't write long answers but always motivate them.

**Please, give back all the pages, even this front page!**

1. Electron configuration and chemical bonding	4 P
2. Phase diagrams	4 P
3. Joining techniques	4 P
4. Mechanical properties	6 P
5. Metal Cutting: BUE and surfaces (lösegg och ytor)	6 P
6. Metal Cutting: Calculation of machine settings in turning	3 P
7. Metal Forming: Wire drawing (Tråddragning)	5 P
8. Metal Forming: Forging (Smidning)	4 P
9. Structure and stiffness of polymers	5 P
10. Processing of polymers	4 P
11. Engineering plastics	5 P

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**S : 50 P**

<b>Ranking :</b>	3 ≥ 40 % (20,5 P)
	4 ≥ 60 % (30,5 P)
	5 ≥ 75 % (37,5 P)

**Notice:** During the exam a **type-approved calculator** (*typgodkänd räknare är tillåten*) and an English-Swedish dictionary (or the wordlist) is allowed. The periodic system and 3 pages with formulas are included in the exam handout - **nothing else is needed!**

Göteborg, January 12<sup>th</sup>, 2007

**Good luck !!**

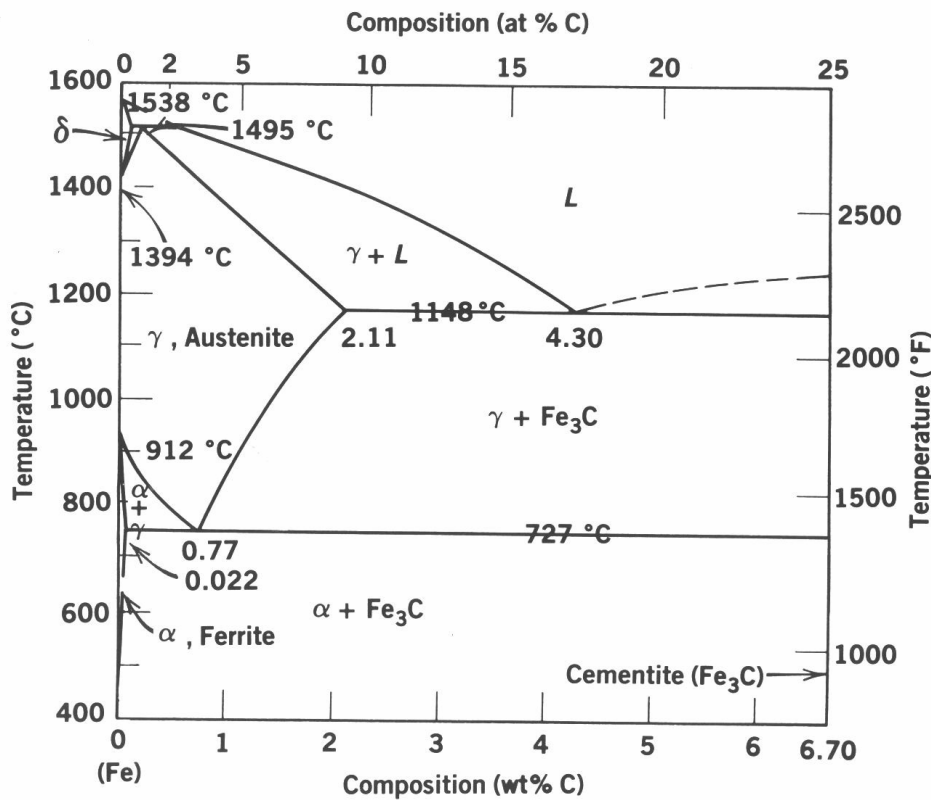
**Uta & Antal & Gustav**

## 1. Electron configuration and chemical bonding (4 P)

- The atom is fully described by 4 quantum numbers. What do they describe and how are they related? (2 P)
- The concept of energy states is only valid for single atoms. For solids there is instead a so-called band structure. Explain why! (1 P)
- Looking at the periodic system, where to find materials showing ionic bonding and covalent bonding? Motivate your answer! (1 P)

## 2. Phase diagram (4 P)

- Draw cooling curves of a single component system and a binary system! (1 P)
- Where to find martensite in the Fe-C phase diagram and how is martensite formed? (1 P)
- For a Fe – 0.5 wt% C alloy at a temperature around the eutectoid temperature determine the fractions of total ferrite and cementite phase. (1 P)
- Make sketches of the microstructure of the Fe – 0.5 wt% C alloy at 750 and 650°C! (1 P)



### **3. Joining techniques (4 P)**

- a) From the manufacturing perspective it may be advantageous to make a product in one piece. Name 3 production processes which can be used! (1.5 P)
- b) When discussing joining techniques we are distinguishing between welding, brazing and soldering. Explain briefly (!) the processes and name their characteristics/differences! (1.5 P)
- c) Eutectic or near-eutectic systems are usually used for soldering of electronic components. Why? (1 P)

### **4. Mechanical properties (6 P)**

- a) What are (i) toughness, (ii) stiffness (iii) strength, and (iv) ductility? Describe briefly by use of the stress-strain curve! (2 P)
- b) What is described by the Hall-Petch relationship and how can it be used to strengthen a metal? (2 P)
- c) What is described by the Charpy or impact test? Describe briefly? (2 P)

### **5. Metal Cutting: BUE and surfaces (lösegg och ytor) (6 P)**

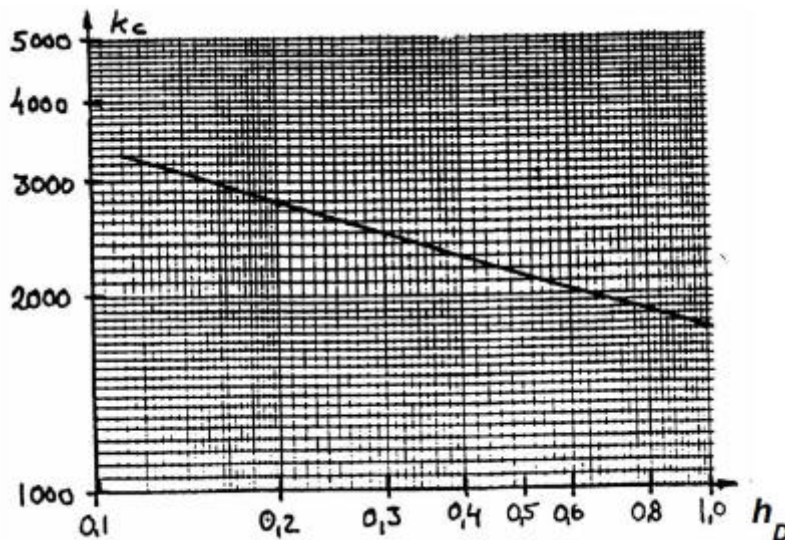
- a) Built-up-edge (lösegg) can affect the surface of the machined part. What is built-up-edge? Why does it occur, and how can it be avoided? (3 P)
- b) What cutting parameters (skärparametrar) influence directly the surface of the machined part (ytan hos den bearbetade detaljen)? Explain how and why they influence the surface! (2 P)
- c) Are there any other factors which influence the surface of the machined part? Mention at least two. (1 P)

### **6. Metal Cutting: Calculation of machine settings in turning (svarvning) (3 P)**

A straight-turning operation (längdsvärningsoperation) has a feed-rate (matning) of 0,7 mm/rev and a cutting depth (skärdjup) of 3 mm. The attack angle (ställvinkel) of the tool is  $\kappa=60^\circ$ . The power of the lathe (svärvens effekt) is 20 kW, and the lathe has an efficiency (verkningsgrad) of  $\eta_{\text{tot}}=75\%$ .

The material has a specific cutting force (specific skärkraft) which follows the graph in below.

Calculate the maximum cutting speed (skärhastighet)! (3 P)



### **7. Metal Forming: Wire drawing (Tråddragning) (5 P)**

- Explain in detail why there is an optimum entrance angle of a wire drawing die (varför finns en optimal konvinkel hos en dragskiva) with respect to energy consumption. (4 P)
- Explain shortly how the arrangements of dies and pulleys (dragskivor och dragblock) can be made when drawing in consecutive steps (dragning i flera steg). (1 P)

### **8. Metal Forming: Forging (Smidning) (4 P)**

For a cold forging operation the thickness reduction of the part is 30%. The deformation can be considered to be plain-strain (plan deformation). The thickness reduction is in the direction normally noted as "direction 1".

The material follows Ludwik's equation with a strain-hardening exponent (deformationshårdnande exponent)  $n$  of 0,32. The materials strength coefficient  $K$  is twice the materials original yield strength (styrkefaktorn  $K$  är dubbelt så stor som materialets ursprungliga sträckgräns).

Question: How much will the material's yield strength (sträckgräns) increase in percent due to the operation? (4 P)

### **9. Structure and stiffness of polymers (5 P)**

- Describe the basic molecular structure of termoplastics, rubbers and termo-setting polymers! (2 P)
- For each of the termoplastics, rubbers and termo-setting polymers, make schematic figures of the changes of the stiffness with changing temperature! (2 p)

- c) In what temperature region are each of the thermoplastics, rubbers and thermo-setting polymers used? Preferably, indicate in your figures drawn in c) above! (1 P)

**10. Processing of polymers (4 P)**

- a) Give the names of four commonly used melt processing manufacturing techniques used for thermoplastics! (2 P)
- b) Describe the three basic steps, common for all melt-processing techniques! Guidance: relate to what happens with the material! (1 P)
- c) What are the main two difficulties, when melt processing of polymers. Guidance: Relate to two important physical properties, typical for polymers. (1 P)

**11. Engineering plastics (5 P)**

- a) Give names of 6 engineering plastics! (4 P)
- b) What are the most important better properties of engineering plastics, compared to the commodity plastics? Give three examples! (1 P)