KTH Industriell teknik
och management

EXAM IN
MH2252 CASTING PROCESSING

PART I

Date: **2019-12-17**
Time: **08.00 - 13.00**
Location: **B23**

Means of assistance, part 1

- **Calculator (without text information regarding the course content)**
- **Dictionaries (as well electronic ones)**

Information

- The written examination is divided into two parts. The first part (Part I) is handed out when the examination starts. The second part (Part II) is handed out when Part I is handed in. No time limit exists between the two parts of the examination.

- The exam consists of assignments on the course's learning objectives. To pass the exam, grade E, a basic / sufficient level of knowledge corresponding to approximately 50% correct answers of each ILO. Higher grades are given at good (C) / very good knowledge (A) of the learning objectives. Completion grade Fx can be offered when a basic / sufficient level of knowledge has not been shown in all learning objectives.

Examiner: Anders Eliasson, tel. 08-790 7255, anderse@kth.se
Responsible teacher: Anders Eliasson, tel. 073 614 95 73

Submission

Write your name on all answer sheets. Preferably write the answers on the distributed papers, you may use the back of paper as well. Do not fold any external answer sheets, place them unfolded within the exam!

Obs, det går även bra att svara på Svenska.

Your exam is available on KTH's "Personal Menu" / courses the first weekday after the examination date. Both results and the assessed examinations are published approximately 15 correcting days and 4 working days after the examination, latest by 2020-01-20.

Appeal of reassessment and completion of the exam (Fx) should take place within 3 weeks from the date of notification. In case of reassessment, contact the ITM's student office, and by completion of the exam (Fx), the course responsible.

Note, this cover sheet should be separated and not scanned

Name:.. Personal number:...

Problem 1 (15p) Component casting and cast house processes (LM3)

When casting in permanent moulds, made of cast iron or steel, some different methods are used. Describe by a sketch and in text the methods below with its specific characteristics and ad-, and disadvantages.

- Gravity die casting
- High-pressure die-casting
- Low-pressure die-casting

Name:.. Personal number:...

Problem 2 (12,5p) Casting hydrodynamics (LM1)

At casting, it is necessary to separate slag inclusions, mould particles and other non-desirable cinders from the melt before it enters the mould cavity.

Describe and explain the function of the methods below, normally used for component casting. As well, make a sketch of a standard gating system for component casting and place the methods in the correct positions.

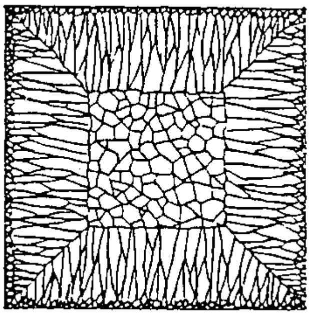
- Swirl-trap
- Mechanical impurity trap
- Runner extension

There exist one more method, give and describe briefly that one as well.

Name:.. Personal number:..

Problem 3 (15p) Structure and structure formation in cast materials (LM1)

At the end of the 19th century, the Russian metallurgist Tschernoff found that the macrostructure of a steel ingot could be divided into some distinct zones, as in the figure.



- Give and explain the appearance of these different macrostructure zones.

The Swedish metallurgist Hultgren found that a parameter that influenced the structure zones was the cooling rate.

- Give and explain the variations in macrostructure achieved by:
    - Sand mould casting (weak cooling rate)
    - Ingot casting (medium cooling rate)
    - Continuous casting (strong cooling rate).

Name:.. Personal number:..

Problem 4 (12,5p) Macrosegregation in steel ingots (LM2)

Macrosegregation, due to sedimentation of free crystals, sedimentation segregation appears in large ingots and give rise to positive and negative segregation.

- Describe/explain the principle for sedimentation segregation in large ingots. Please make use of both sketches and a simple schematic phase diagram in your explanation.
- Show in a figure and explain the appearance of the positive/negative macrosegregation pattern for an alloy Sn-2,5 wt% Pb (ρ_{Sn} = 7,3 g/cm^3, ρ_{Pb} = 11,3 g/cm^3).

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MH2252 CASTING PROCESSING

PART II

Date: 2019-12-17
Time: 08.00 - 13.00
Location: B23

Means of assistance

- **Handed out "Summary sheet" from the text book "Materials Processing during Casting" by Hasse Fredriksson and Ulla Åkerlind.**
- **Formula/table collection book like "Beta"**
- **Calculator (without text information regarding the course content)**
- **Dictionaries (as well electronic ones)**

Note: Exercise documents, solved or unsolved are *not allowed, nor* any Casting and solidification text book.

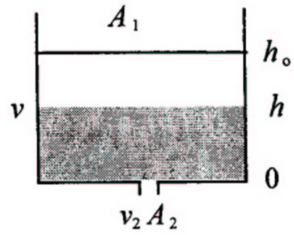
Note, this cover sheet should be separated and not scanned

Name:.. Personal number:…...

Problem 5 (15p) Casting hydrodynamics (LM1)

A bathtub (see cross-section in figure) is filled to a height of h_0 = 30 cm, and then it contains 300 l (dm^3) of nice hot water (density 998 kg/m^3). You enter it, but suddenly your cell phone rings and you rush up and accidentally unplug the tube.

- What is the maximum time for your telephone conversation before the bathtub is emptied? The bottom-hole diameter is 40 mm.
- Will there be any difference in the time for emptying if the tube instead is a ladle by the same dimensions and the water is molten steel (density 7036 kg/m^3)? Motivate your answer!



Name:.. Personal number:…..

Problem 6 (15p) Microsegregation in Alloys (LM2)

The high-pressure die-casting foundry Finnveden Gjutal AB in Hultsfred, Sweden cast components for precipitation hardening. No eutectic θ-phase (Al_2Cu) should be found in the as-cast structure but by practice 1,5 % eutectic fraction are accepted.

a) Calculate the maximum content (the composition) of Cu in the cast Al-Cu alloy, by assuming:
   - Complete equilibrium conditions during solidification (the Lever rule valid)
   - Negligible diffusion in the solid metal (the Scheil's model valid).

b) Motivate for which of these models that will give the most reliable answer about the as-cast composition of Cu. Note, the correction term B might give you some clues about the validity of the models.

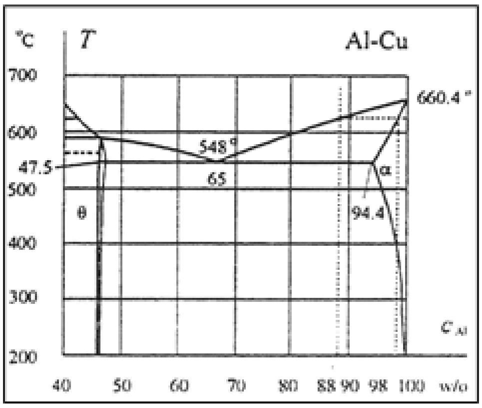


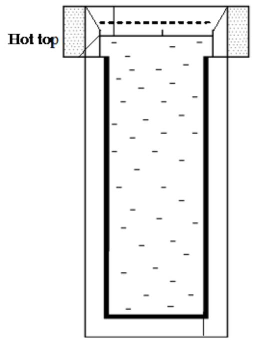
Figure: Part of the phase diagram Cu-Al

Name:.. Personal number:…..

Problem 7 (15p) Solidification and cooling shrinkage of metals (LM1+LM2)

Copper ingots by the dimensions 200×800×1200 mm (width×thickness×height) are cast in water-cooled chill-moulds with an insulating hot top, see the figure. The heat transfer coefficient chill-mould/ingot is 400 W/m^2 K.

a) Calculate the minimum height of a hot top to avoid a shrinkage pipe, when the copper ingots are cast in water-cooled chill-moulds. Note, simplify the problem by using a 1-dim solidification model.
b) If sand mould casting were to be used instead of permanent moulds (chill-moulds). What will then the size/minimum height of the hot top/feeder be? Clearly state your assumptions.



Material constants

k	= 398 W/mK
ρ_{Cu}	= $8.94 \cdot 10^3$ kg/m^3
T_L(Cu)	= 1083 ^oC
$-\Delta H_{Cu}$	= 206 kJ/kg
β (Cu)	= 3.8 %
k_{sand}	= 0.63 W/mK
ρ_{sand}	= $1.6 \cdot 10^3$ kg/m^3
c_p^{sand}	= $1.05 \cdot 10^3$ J/kgK