KTH Industriell teknik
och management

EXAM IN
MH2252 CASTING PROCESSING

PART I

Date: **2022-10-28**
Time: **08.00 - 13.00**
Location: **Blå**

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. 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 2022-11-18.

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 (20p) Casting processes for component casting and cast house processes (LM1)

Foundry production of components are normally done either by non-recurrent moulds/sand mould casting or in permanent moulds/high-pressure die casting.

- Describe by sketches and in text each of these casting methods
- Give at least five of each's specific characteristics, (tolerances, surface quality, type of alloys, costs, typical cast component) and at least two major ad-, and disadvantages.

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Problem 2 (10p) Casting hydrodynamics for metal flow (LM2)

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

- Describe/sketch and explain the function of the three methods below, normally used for component castings.
    - Swirl-trap
    - Mechanical impurity trap
    - Runner extension
- As well, make a sketch of a standard gating system for component casting and place these different inclusion control methods in suitable positions.

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Problem 3 (10p) Heat transport and solidification of metals (LM3)

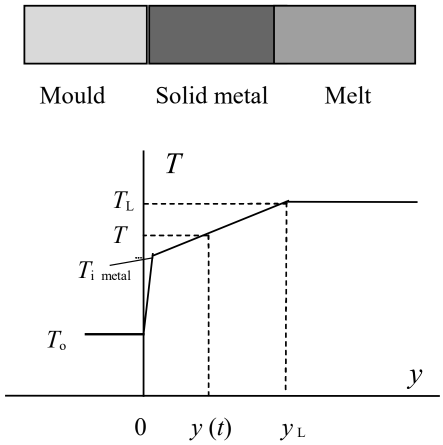
Heat transport and solidification processes at casting processes are often very complicated. At poor contact between metal and mould the below temperature distribution and solidification eqn. is valid.

- Give and explain the modifications done by temperature distribution at poor contact between metal and mould.

However, at thin component castings even more modifications can be done!

- Give and explain the modifications done by temperature distribution at thin component casting and explain how this as well will affect the time for solidification.

$$t = \frac{\rho\left(-\Delta H\right)}{T_L - T_o} \cdot \frac{y_L}{h} \cdot \left(1 + \frac{h}{2k} \cdot y_L\right)$$



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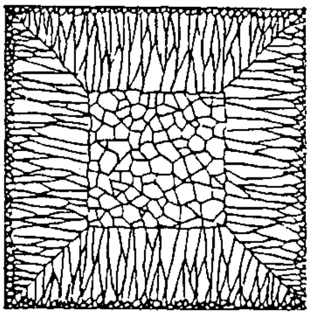
Problem 4 (15p) Structure formation and micro and macro segregations at solidification (LM4)

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



- Describe and explain the appearance of these macrostructural zones.

The Swedish metallurgist Hultgren found that the relation of the macro-structural zones was affected by some different factors.

- Describe and explain for the variations in macrostructure achieved by:
  - Sand mould casting
  - Ingot casting
  - Continuous casting
  - Inoculation

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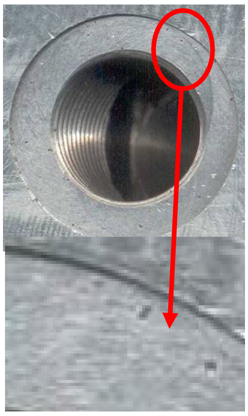
Problem 5 (15p) Casting defects, porosity, slags, secondary phases and cracks (LM5)



Castings might contain some kind of porosity by some different origin, see the figures.

- Explain how to distinguish between shrinkage and gas porosity?

Shrinkage porosity can further be divided into two subgroups: micro-, and macro porosity.

- Describe and explain the influence of 1) alloy composition and 2) cooling rate on the appearances of this kind of porosity.

Please make use of sketches to back up your explanations.

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PART II

Date: 2022-10-28
Time: 08.00 - 13.00
Location: Blå

Means of assistance

- Handed out "Summary sheet" from the text book "Materials Processing during Casting" by Hasse Fredriksson and Ulla Åkerlind.
- The text book "Materials Processing during Casting" by Hasse Fredriksson and Ulla Åkerlind.
- Formula/table collection book like "Beta"
- Calculator
- Dictionaries (as well electronic ones)

Note: Exercise documents, solved or unsolved are *not allowed*

Note, this cover sheet should be separated and not scanned

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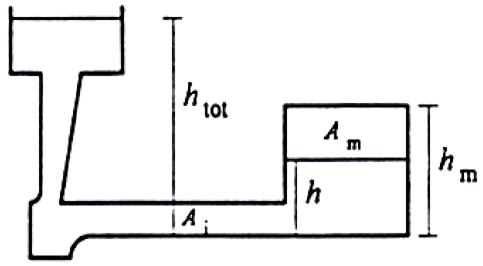
Problem 6 (10p) Casting hydrodynamics for metal flow (LM2)

A foundry cast grey cast iron cylinder heads in resin sand. The dimension of a head is 350x200x200 mm (width×thickness×height).
The casting cup is placed 200 mm above the lying head as in the schematic figure. A filling time of 20 sec is wanted by a short rectangular inlet A_i.



- Calculate the dimension of the inlet, by 40 mm width. Clearly present your assumptions and calculations.

Material constants

ρ_{Fe}	$= 7.2 \cdot 10^3$ kg/m^3
$-\Delta H_{Fe}$	= 162 kJ/kg
T_L(Fe)	= 1160 ^oC
c_p^{Fe}	= 420 J/kg K
ρ_{sand}	$= 1.5 \cdot 10^3$ kg/m^3
c_p^{sand}	= 1.05 kJ/kg K
k_{sand}	= 0.63 J/m s K

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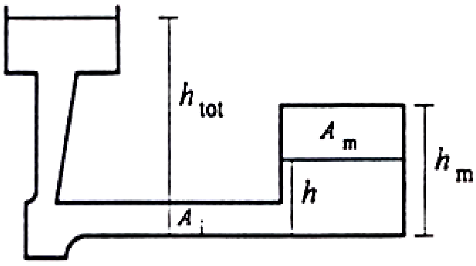
Problem 7 (10p) Heat transport and solidification of metals (LM3)



Now the gating system is correct, however what might the solidification time be for the cylinder head, perhaps the "thumb rule eq." could be used, or perhaps some calculations?
The dimension of a head is 350x200x200 mm (width×thickness ×height). It is cast in grey cast iron in a resin sand mould, material constants is found in the table.

- Calculate the solidification time of the cylinder head. Note, assume a massive head and clearly present your assumptions and calculations.
- Compare your results by the one given by the "thumb rule equation" ☺

Material constants

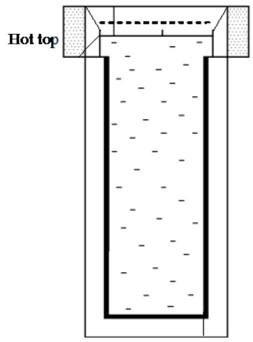
ρ_{Fe} = $7.2 \cdot 10^3$ kg/m^3
$-\Delta H_{Fe}$ = 162 kJ/kg
T_L(Fe) = 1160 ^{o}C
c_p^{Fe} = 420 J/kg K
ρ_{sand} = $1.5 \cdot 10^3$ kg/m^3
c_p^{sand} = 1.05 kJ/kg K
k_{sand} = 0.63 J/m s K

Name:.. Personal number:…..

Problem 8 (10p) Structure formation and micro and macro segregations during solidification (LM4). Casting defects, shrinkage, gas porosity, slags (LM5)

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