KTH Industriell teknik
och management

EXAM IN
MH2252 CASTING PROCESSING

PART I

Date: 2019-10-25
Time: 08.00 - 13.00
Location: W43

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 assistant: Yu-Chiao Lu, 072 296 27 49

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 2019-11-21.

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 (12,5p) Component casting and cast house processes (LM3)

Foundry production of components are often done in non-recurrent moulds. There exist two major production methods by this principle; Sand mould casting and Investment casting

- Describe the two casting methods, from model to finished component, as well by some drawings.
- Explain when each of the methods should be used, by describing at least two major advantages/disadvantages for each production method.

Name:..... Personal number:.....

Problem 2 (15p) Casting hydrodynamics (LM1)

Make a sketch of a standard gating system for component casting – uphill casting.

- Add relevant casting terminology to your drawing (at least four concepts).
- Derive by help of basic hydrodynamic laws an equation for the filling time, t_f of your mould cavity (a fifth concept).

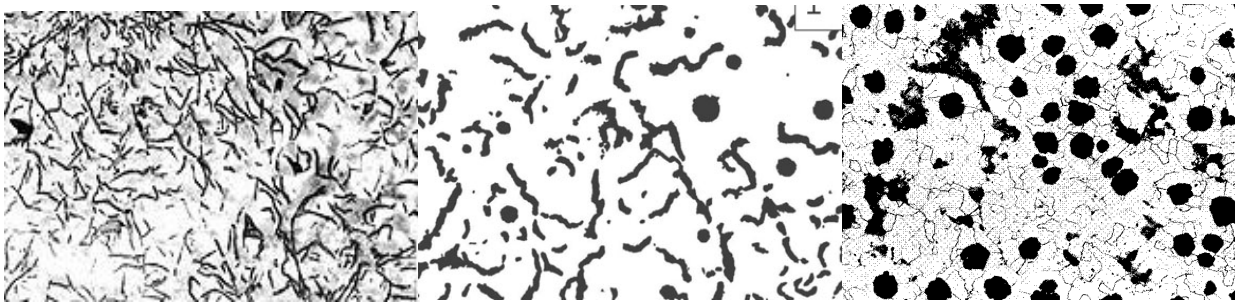
Hint: The basic hydrodynamic laws are: Principle of continuity ($A_1v_1 = A_2v_2$) and Bernoulli's eqn. ($p_1 + \rho g h_1 + \frac{\rho v_1^2}{2} = const.$) Note, you need to make an important assumption to get an answer.

Name:..... Personal number:.....

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

Cast iron is a Fe-C alloy, which is widely used because of its good casting ability and favourable properties. In the figures below the micro-structures of three different cast irons are found.

- Give and motivate for which type of grey cast iron the figures describes, as well describe the different microstructures in each figure.
- Arrange the mechanical properties, tensile strength (low, medium, high) and the thermal conductivity (low, medium, high) for each of the different cast irons.
- Suggest and motivate which of the cast irons that has the "most suitable" properties for a cylinder head respectively an engine block of a Scania truck.

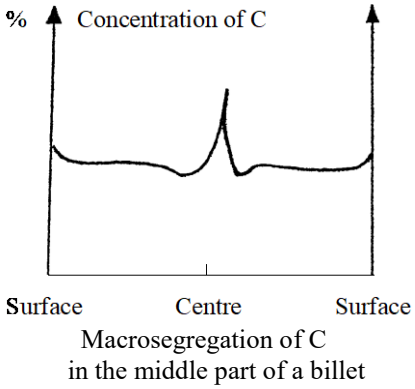


Name:..... Personal number:.....

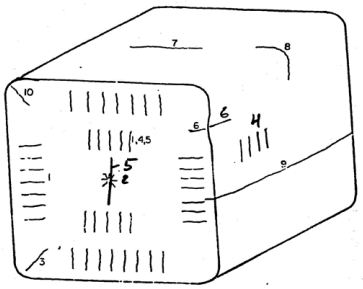
Problem 4 (15p) Macrosegregation during continuous casting (LM2)

In continuous casting some special and some well-known defects might arise.

- Give and describe/explain the appearance of the surface defects in the figures to the left and to the right and the macrosegregation pattern, in the middle figure. Explain as well what can be done to minimize these kind of defects.



Macrosegregation of C
in the middle part of a billet



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EXAM IN
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PART II

Date: 2019-10-25
Time: 08.00 - 13.00
Location: W43

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) Heat transport during casting (LM1+LM2)

The Åkers group cast large support rolls (diameter 800 mm) for hot rolling. The rolls are cast in cast iron and at solidification they normally get a white cast iron structure at the surface and a grey cast iron structure in the core. The rolls are cast in grey cast iron moulds of around 2 m height.

- Estimate the thickness of the white structure of the rolls. The transformation to a grey cast iron structure occurs when the solidification rate is less than, $v = 1.8 \cdot 10^{-4}\ m/sek$. Explain your estimations and clearly show your calculations.

- Shortly discuss the reason to have a white cast iron structure at the surface and a grey cast iron structure at the bore of the rolls.

Material constants

ρ_{Fe}	= 7.7·10 ^{3} kg/m^3
$(-\Delta H)$	= 170 kJ/kg
k	= 30 W/m K
T_L	= 1200 ^{o}C.
$h_{metal/mould}$	= 400 W/m^2 K

Name:..... Personal number:….....

Problem 6 (15p) Precipitation of pores and slag inclusions during casting (LM2)

A steel melt initially contains 0.04 wt-% O and 0.03 wt-% C. Manganese is added to the melt as a deoxidation compound in order to prevent CO precipitation. The temperature of the melt is constantly at 1500 ℃ throughout the process concerned.

- Calculate the minimum initial Mn concentration required to prevent formation of gaseous CO. The equilibirum between the concentrations of O and C in the steel and the partial pressure of CO is given by;

$$c_{\underline{C}}^{L} \cdot c_{\underline{O}}^{L} = 0.0019\, p_{CO} \qquad (wt-\% \text{ and } atm)$$

The solubility product of MnO in the melt can be written as:

$$K_{MnO} = c_{\underline{Mn}}^{L} \cdot c_{\underline{O}}^{L} = \exp[-(\frac{12760}{T}) - 5.68] \qquad (wt-\%)^2$$

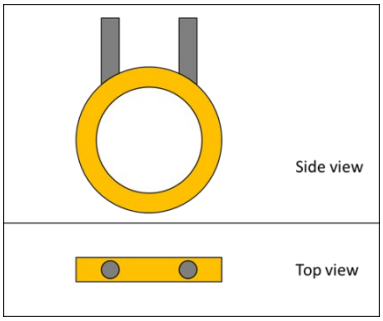
Note: Carbon and oxygen are interstitial elements, whereas manganese is not. Thus, the Lever rule should be used for O and C and the Scheil equation for Mn. The partition coefficients of O and C are 0.054 respectively 0.20 and the partition coefficient of Mn is 0.67.

Name:..... Personal number:….....

Problem 7 (12,5p) Solidification and cooling shrinkage of metals (LM1/LM2)

The gating system for a precious gold ring (r_1 = 10 mm, r_2 = 13 mm, width 5 mm) uses two risers, i.e. open feeders, each with radius 5 mm and height 5 cm (see figure below). The melt is poured into one of the risers until the other riser fills to the rim.

- You are to purchase gold for the casting of (The) one ring, how much gold should you order?
  Explain your estimations and clearly show your calculations.



Material constants

T_m (Au) = 1064 °C
$(-\Delta H)_{Au}$ = 66 kJ/kg
ρ_{liq}(Au) = $17.310 \cdot 10^3$ kg/m^3
$\rho_{solid,\ Tm}$(Au) = $17.617 \cdot 10^3$ kg/m^3
$\rho_{solid,\ RT}$(Au) = $19.300 \cdot 10^3$ kg/m^3
