TEKNISKA HÖGSKOLAN
HÖGSKOLAN I JÖNKÖPING

Course PM 2015 (MaModCast)

Mathematical Modeling of Casting PhD course 7,5 credits

LECTURERS

Attila Diószegi, (DiAt) , course leader attila.dioszegi@jth.hj.se
Jakob Olofsson (OlJa) jakob.olofsson@jth.hj.se
Taishi Matsushita, (MaTa) taishi.matsushita@jth.hj.se

OBJECTIVES

The course aims to give students the background to how calculation models are formulated for the simulation of phenomena associated with the casting of technical alloys. E.g. Fe- Al- and Mg alloys. The basic heat conduction problem and coupled models are solved using FDM CV method.
Simulation of solidification and solid phase transition are formulated by enthalpy and kinetic methods. The results of the solidification simulation are linked to both microstructure and defect formation. The course provides training in the calculation of phase diagrams and thermo-physical properties for input data in casting simulation.
From solidification to room temperature, the cast material undergoes thermally induced deformation. Deformation and variation of the stress state is calculated by thermo-mechanical models. The course provides training in the transmission of the calculated material properties, stress state and the solid model resulting from calculated deformation during the casting and cooling process. The course also aims to reflect the research and development trends in casting simulation.

CONTENTS

The course includes the following topics:

• Introduction of the course and outlook to research and development trends in casting simulation. **(Lecture 1, DiAt)**

• Calculation of phase diagrams and thermo-physical properties. **(Lecture 2, MaTa)**

• Formulation of kinetic models for solidification, solid phase transformation and resulting microstructure. **(Lecture 3, DiAt)**

• Phenomena associated with solidification leading to defects (shrinkage and gas) **(Lecture 4, DiAt)**

• Thermo-mechanical calculations (stress and deformation). **(Lecture 5 - 6, OlJa)**

• Calculation of material properties. Transfer of material properties and residual stresses to simulation software for function-related strength calculations. **(Lecture 7, OlJa)**

LEARNING OUTCOMES

On completion of the course, the student should:

• Have a good overview on simulation methods of phenomena related to the production of shape casting.

• Have the ability to create numerical models describing the phenomena that take place in connection with casting, such as solidification, segregation, microstructure, properties, defects, thermally induced stresses and deformation.

• Have a good knowledge on how thermo-physical properties, thermo-mechanical properties and boundary conditions used in the simulation affects the simulation result.

• Have knowledge of how the simulated thermo-physical and thermo-mechanical properties can be transferred for use in other simulation programs.

PREREQUISITES

According to the eligibility rules of the PhD program. Passed course of Modelling and Simulation of Casting (ModSimCast), TMSS20 at MSc-level or equivalent. For those students who are not familiar with the FDM and FDM-CV formulation of heat transfer and the solidification model according to the Entalpy formulation are recommended to follow Lecture 3, 4 and 5 of ModSimCast course. Furthermore students not familiar with the basic of programing in MATLAB are recommended to follow the basic MATLAB block within the ModSimCast course. Students missing experience in using the simulation program MAGMAsoft are recommended to follow the exercises within the ModSimCast course. Time schedule for the course ModSimCast is available on the webb.

TEACHING METHODS

Lectures, exercises and software training. Home assignments.

LITERATURE

Fundamentals of Numerical Modelling of Casting Processes by Jesper Hattel are available for purchasing from: www.polyteknisk.dk

Appended literature and literature list.

Simulation programs: Matlab, MAGMAsoft, JMatPro, ThermoCalc, Abaqus

GRADES

The course uses the report grades “passed” or “not passed” and is based on the submitted home works.

The submitted home works are:

Submission 1:

Solidification simulation of plate casting according to the Enthalpy method using FDM-CV 1D in Matlab and FDM-CV 3D in MAGMAsoft. (DiAt)

Submission 2:

Calculation of phase equilibrium and material properties (MaTa).

Submission 3:

Solidification and Microstructure formation (DiAt).

Submission 4:

Solidification and Gas porosity formation (DiAt)

Submission 5:
Thermal induced stress and deformation (OlJa, DiAt)

Submission 6:
Material properties and transfer procedures (OlJa, DiAt)

SCHEDULE

Lecture 1 (DiAt) 2015-01-21, 10:00 – 17:00, E1215
Introduction to the course and outlook to research and development trends in casting simulation.
Home task 1 and literature will be handed out.
Terminal work Magma and Matlab

Lecture 2 (MaTa) 2015-02-04, 10:00 – 17:00, E1215
Calculation of phase diagrams and thermo-physical properties. Partition coefficients, Latent heat, Cp, etc.

Home task 2 and literature will be handed out.
Terminal work Thermo Calc and JMatPro

Lecture 3 (Diat) 2015-02-18, 10:00 – 17:00, E1215

Formulation of kinetic models for solidification, solid phase transformation and resulting microstructure.

Home task 3 and literature will be handed out.
Terminal work Matlab

Lecture 4 (DiAt) 2015-03-04, 10:00 – 17:00, E1215

Phenomena associated with solidification leading to defects (shrinkage and gas)

Home task 4 and literature will be handed out. Terminal work Matlab

Lecture 5 – 6 (OlJa) 2015-04-01, 10:00 – 17:00 & 2015-04-15, 10:00 – 17:00, E1215.

Thermo-mechanical calculations (stress and deformation).

Home task 5 – 6 and literature will be handed out. Terminal work Matlab.

Lecture 7 (OlJa) 2015-04-29, 10:00 – 17:00, E1215.

Calculation of material properties based on microstructure and defects. Transfer of material properties and residual stresses to simulation software for function-related calculations.

Home task 7 and literature will be handed out.
Terminal work Magma, Abaqus

COURSE FEE:

PhD students participate in the course free of charge. Participants from companies are charged a participation fee of 9000 SEK + VAT.

COURSE REGISTRATION:

Participation in this course must be registered before 15th of December 2014. Those students who wish to participate in the noncompulsory Lectures 4,5,6, and Magma or Matlab blocks in the course ModSimCast have to contact the course leader marking which moments of the course they will attend.

Participation intent should be sent to:

Attila Diószegi
Jönköping University
School of Engineering
Materials and Manufacturing - Castings
P.O. Box 1026
SE-551 11 Jönköping, Sweden

Phone +46 (0) 36 10 16 56
Mobile: +46 (0) 73 686 21 14
e-mail: attila.dioszegi@jth.hj.se