Modeling and Simulation of Macrosegregation Induced by Thermomechanical Deformation in Steels

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Introduction

Metallurgical processes have known a great evolution during the last 60 years. The advancement is attributed to research disciplines, like physical metallurgy, which investigated a great deal of solidification-related phenomena. Nowadays, metallurgists and physicists seek to understand deeper the connection between the different scales involved. From the nucleation theory to the mechanical behavior of metals, an chain of intricate phenomena occur in a such a way to create defects in the final product. This has been seen in casting processes like continuous casting and ingot casting. Suface and volume porosity, hot tearing and composition heterogeneities are known defects to the casting community. As far as the current project is concerned, the last defect, widely known as macrosegregation, is the subject of our interest.

Defects

Worth checking notes from the Ecole Thématique CNRS oléron (Check Mail Draft)

- Hot tearing
- Porosity
- Freckles
- Macrosegregation

Industrial Worries

Production

- Talk about total steel production, variations over the last few decades
- Quality constraints for many applications thats require steel like construction, nuclear engines ?
- Difficulties to meet these constraints and what are the present solutions

Research and Simulation

- Need for software handling multicomponent alloys

- Need for software handling finite diffusion in the solid
- Need for realistic alloy properties (not only constants)
- Need for handling moulds along with volume change (creating thermal resistances)

Worth discussing Isabelle Poitraut and David Cardianaux - and Claudine Allentin (respo comm Arcelor Dunkerque, search for mail)

CCEMLCC contribution

- some words about this ESA project
- in what ways does this project tries to alleviate the aforementionned problems ?
- academic and industrial partners and how does each of them contribute actually
- mention *Thercast* as the final developped code destination ?

Chapter 1

Modelling Review

Contents

In this chapter the following points are discussed

- what does a typical solidifications problem consist of ? heat - fluid - solid - chemical species
- what are the modeling scales of these physics ? direct (micro: phase field / macro: CA) and indirect (micro Nancy models / macro: current FE model)

  Maybe worth showing the 2x2 table that CAG showed at the ICASP conference ?

- Overview of these models ??
- Presence of AIR requires a new problem definition : Lagrangian or Eulerian framework

1.1 Standard FE model

A section presenting the main FE equations that will be solved in the metal being a single domain. I call it "standard" because it doesnt contain anything about levelsets, compressibility, ...

- Energy (chapter 1)
- Species mass (voller prakash)

  should I mention the tabulation approach that I couldnt finalize because of the equality between w and wl in liquid phase ?

- Fluid mechanics (vms: darcy model with boussinesq)

talking about Eulerian approach Air Metal will be presented in the next chapters

1.2 Biblio test

[1] are going to appear in the paper

Bibliography

[1] Tommy Carozzani, Charles-André Gandin, Hugues Digonnet, Michel Bellet, Kader Zaidat, and Yves Fautrelle. Direct simulation of a solidification benchmark experiment. *Metallurgical and Materials Transactions A*, 44(2):873–887, February 2013. ISSN 1073-5623, 1543-1940. doi: 10.1007/s11661-012-1465-1. URL http://link.springer.com/article/10.1007/s11661-012-1465-1.