MICtoMEC: from MICrostructures to MEChanical properties

M. Vittorietti[@,*] G. Jongbloed[*] J. Sietsma[†] W. Li[†]

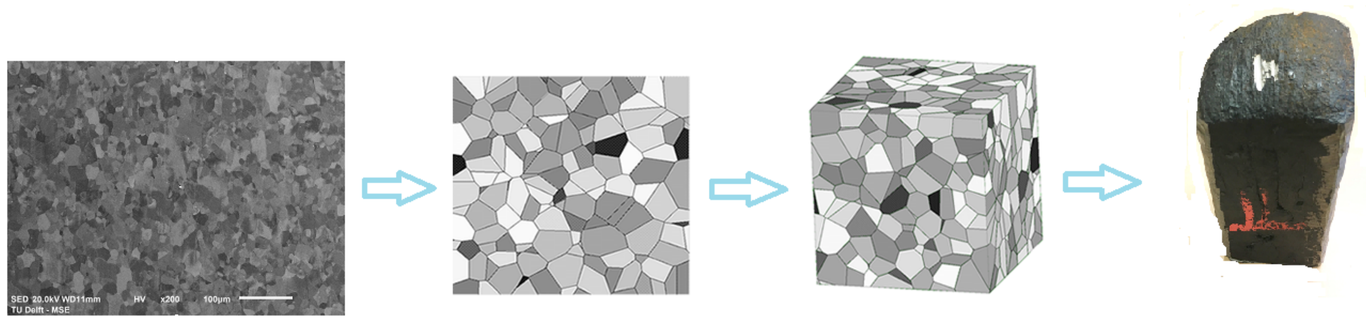
[@]m.vittorietti@tudelft.nl, [*]Department of Applied Mathematics, TU Delft, [†]Department of Materials Science and Engineering, TU Delft

1. Introduction

This research aims at the development of physical relations between the intricate 3D features of multi-phase metallic microstructures of Advanced High-Strength Steels (AHSS) and the mechanical properties of the material. The quantitative characterisation of the microstructure will be far more involved than is now in use for estimations of the mechanical properties, which is a necessity because of the complexity of AHSS microstructures. A statistical approach will be used to find relations between microstructural and mechanical quantities, which will be the basis for the development of physical relations.

2. Research Contents

- Characterization of multi-phase microstructures and mechanical behavior;
- Statistical analysis of microstructure features;
- Microstructural modelling of mechanical behavior;
- Stochastic modelling of the relation between microstructural features and mechanical properties.



3. Grain Size - Materials Science

Aim :

be able to investigate the strengthin relation to grain size distribution without or with limited other effects' influence, such as solid solution hardening, precipitation hardening, phase volume fraction, etc.

Approach :

1. Material: Interstitial free (IF) steel
2. Using optical microscope cooperated with ImageJ software
3. Using EBSD to determine the accurate grain size distribution

Micro scale	Macro scale
Dilatometer sample	IF plate heat treated in furnace
Hardness test	Tensile test
Micro-torsion test	Deep drawing test

4. Voronoi Diagrams

Among the many areas of applications of Voronoi diagrams, the field of materials science stands out. In fact, they are now among the most used mathematical models for microstructure characterization and depending on the specific kind of materials, it is possible to use a proper category of Voronoi diagrams.

- Poisson-Voronoi Diagrams
- Johnson-Mehl Tessellations
- Laguerre-Voronoi Tessellations
- Multi-Level Voronoi Diagrams

5. Grain Size - Statistics

3D : analytical expression - simulation approach for the distributions of the geometrical characteristics of a typical cell of the underlying diagram

2D : exploiting just the 2D plane section information for 3D characterization

Model Test : assessing the reasonability of using a specific kind of Voronoi diagram

Future plans

Performing simulations on the mechanical behaviour of well-defined virtual microstructures. This will yield a strengthened insight into the relation between microstructural features, physical behaviour and mechanical properties.

References

Kok P.J.J., Spanjer W., Vegter H. A microstructure based model for the mechanical behaviour of multiphase steels. Key Engineering Materials; 2015.

Vittorietti M., Jongbloed G., Kok P.J.J., Sietsma J. Accurate approximation of the distributions of the 3D Poisson-Voronoi typical cell geometrical features. 2017.