2nd International Workshop on Software Solutions for Integrated Computational Materials Engineering

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Sandbox Scenario 1

Manufacturing of a cylindrical shaver cap using three different steels

Introduction

Producer of shaver caps has to make decisions on the material choice and manufacturing routes for three different stainless steels and manufacturing routes, Figure 1. Preferably, all steps are to be evaluated through effective modelling. For the numerical simulation of each individual process step, relevant input material properties are needed, resulting from an earlier simulation. This earlier simulation either delivers representative field values or spatially distributed output quantities.

It needs to be realized that for each step in the chain from material production to final function of the product during its life time different material properties are needed.

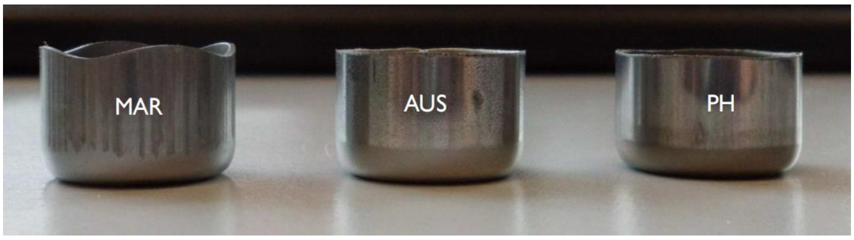


Figure 1: Shaver cups pre-form from three different steels (Source Phillips).

Process route for the material

A steel manufacturer delivers the steel with pre-defined material specifications. In the steel making process, typically a number of process steps are present as shown for a normal steel in Figure 2.

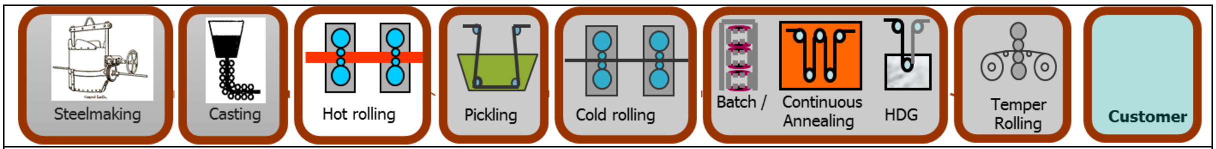
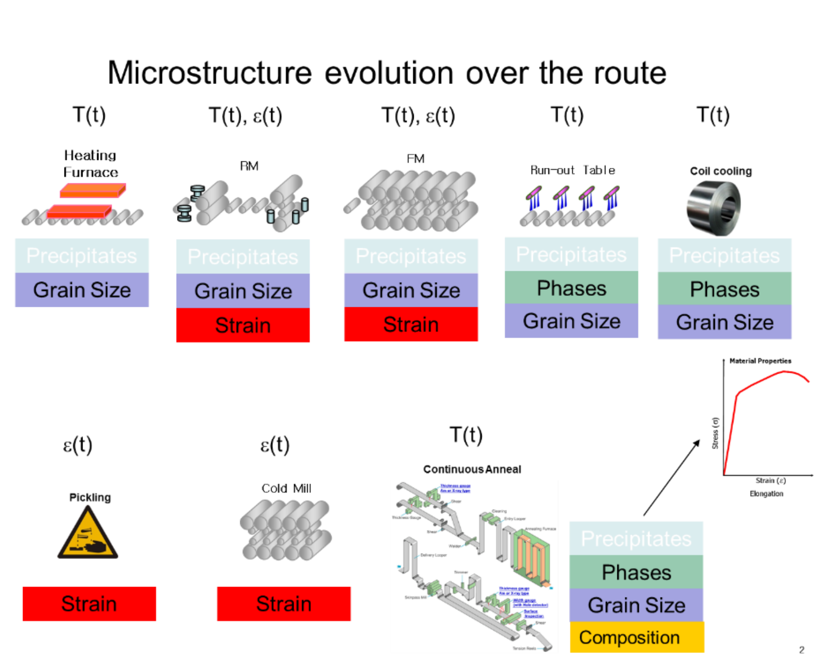


Figure 2: Process chain for steel making (Source Tata Steel).

An important question for a steel maker is how to improve the control over the mechanical properties. This often starts by evaluating how the microstructure and properties change during every process step as indicated in Figure 2.



<u>Figure 2</u>: Change in microstructure during steel processing. Below every processing step, the main material state parameters are listed. Red items are changing during that step. Above every step, the main process parameters are listed. For grain sizes and precipitates, information of the distribution is preferred over average values. For precipitate state, both size and fraction are required.

Can we predict completely through modeling the

- Chemical composition,
- Gradients in properties,
- Micro structure changed during hot and cold rolling,
- Effect on material properties needed for and applied in the subsequent process steps?

Process route for the product

Can we predict the shape accuracy including the residual stress/strain distribution because of the forming process (often involving many forming process steps, including cutting operations)? At the end of the cycle, the material has typical properties such as local hardness.

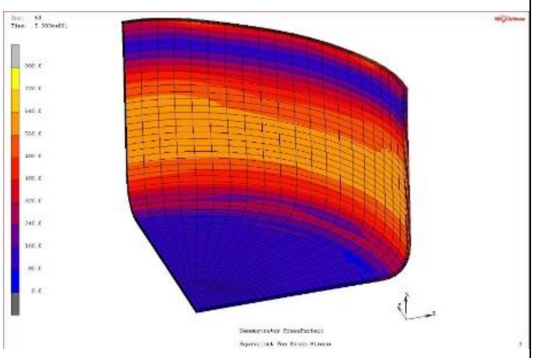
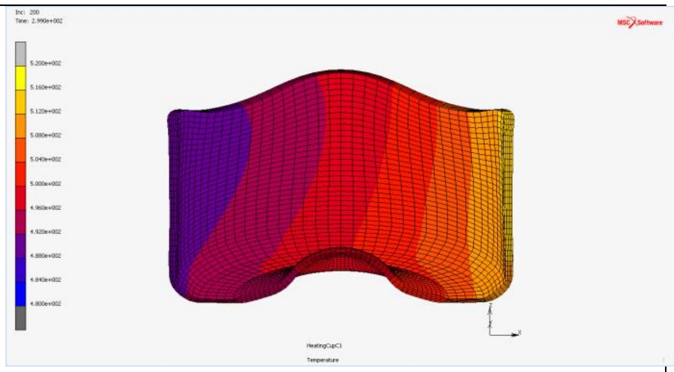
	

Figure 3: Residual Stress distribution after a forming step	Figure 4: Applied thermal gradient in formed cup

- Metal forming process
- Nitriding treatment – hard surface layer with compressive stresses
- Heat treatment – residual stress change and change in material properties
- Finishing step

Functional behavior of product

Can we predict performance of product based on calculated properties required for lifetime evaluation?

- Local property variations due to gradients in metal forming process
- Young's modulus, Poisson ration, fatigue stress
- Conductivity, heat capacity, density, coefficient of thermal expansion
- Hardness (global and local variations)
- Surface roughness
- Wear of the product