

# Coupling thermal and metallurgical phenomena in description of mechanisms occurring during bainitic transformation in steels

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## ABSTRACT

Due to a wide range of mechanical properties, bainitic steels are good candidate for many applications, for example in automobiles, power generating industries or premium rails. To reach these specific properties special thermal cycles have to be applied. Design of these cycles can be supported by numerical modelling, assuming that reliable and accurate models are available. Therefore, the objective of this paper was investigation of possibilities of modelling of various complex phenomena occurring during bainitic transformation in steels.

A variety of phase transformation models is available in the scientific literature. Classification based on models predictive capabilities and computing costs can be found in [1]. Two models were analysed in the present work. The first is JMAK (Johnson-Mehl-Avrami-Kolmogorov) equation, which was upgraded to predict occurrence of the retained austenite (RA), see [2] for details. The idea was based on a displacive theory [3], according to which the formation of bainite causes changes of carbon concentration in the austenite. As soon as the carbon rejection begins, its concentration at the interface reaches the value  $c_{70}$  calculated from the  $T_0$  temperature concept. This concentration is a boundary condition for calculation of the carbon distribution in the austenite. The average carbon content in the austenite, which is determined from the mass balance equation, influences the martensite start temperature ( $M_s$ ). When the temperature drops to the room temperature, the austenite can either remain as retained austenite (RA) (if  $M_s < T_r$ ) or can be partly transformed into the martensite (if  $M_s > T_r$ ). In consequence, the upgraded JMAK model is capable to predict RA volume fraction depending on the thermal cycle used in the processing.

The physical background of the second model is the same as in the first model but the carbon diffusion is simulated explicitly in the grains of austenite. Nucleation of new platelets of the bainitic ferrite is controlled by the probability  $p$ . Growth of the platelets is determined by the carbon diffusion in the austenite microstructure. The general idea, which was used for the ferrite transformation in [4], was applied here. Application of this model for the temperature range of bainitic transformation allowed to predict growth of the platelets of the bainitic ferrite and carbon distribution in the austenite around these platelets. In consequence, prediction of the occurrence of the RA islands in the areas of high carbon concentration was possible.

The results from the two models were compared and relatively good agreement was obtained for the average phase composition. However, the second model predicted additionally distribution of chemical composition and morphology of phases. This information is crucial for determination of mechanical properties of steel.

## REFERENCES

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