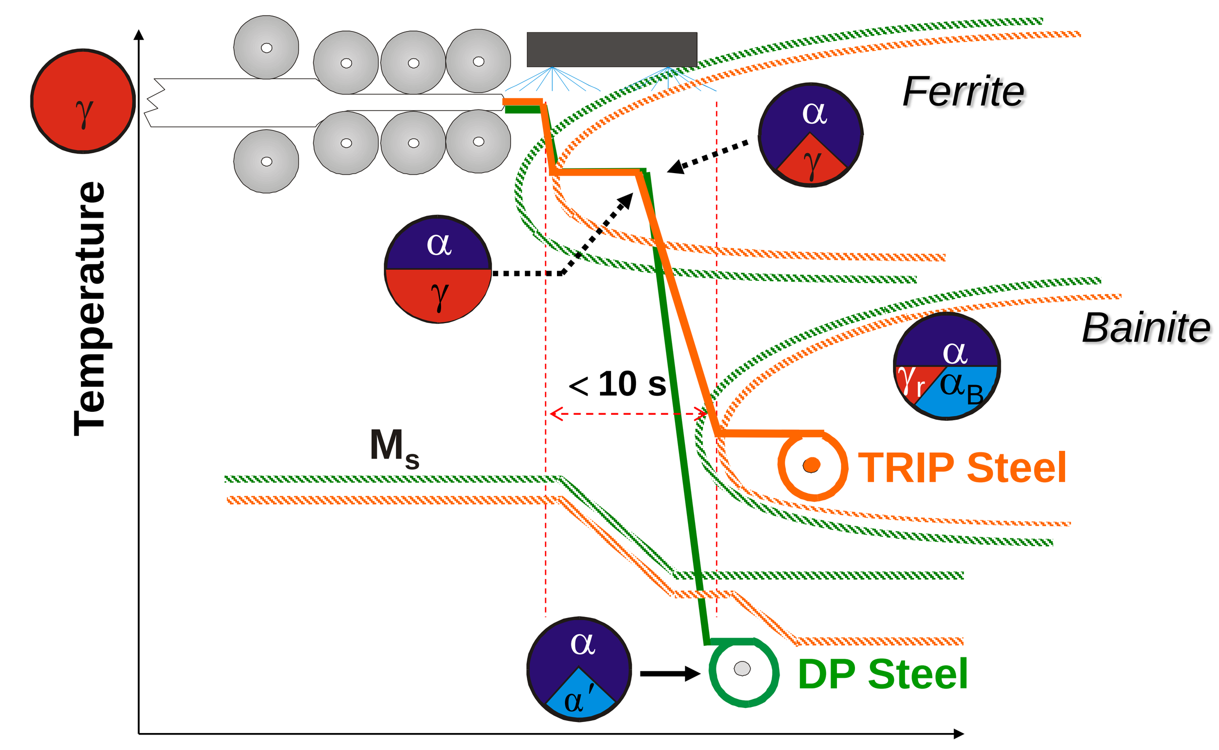
Simulation, Optimierung und Regelung von Gefügebildung und mechanischen Eigenschaften beim Warmwalzen von Mehrphasenstählen

Targets of the Project

Fast Algorithms for the Cooling Control in Hot Rolled Multiphase Steels

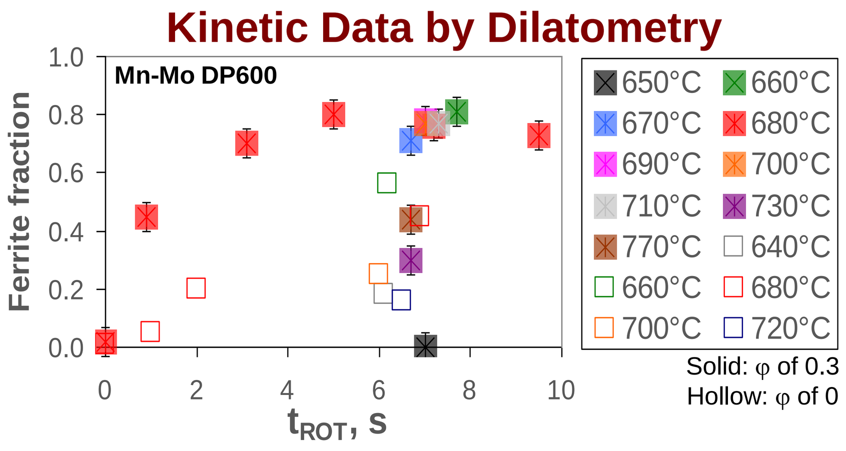
As the precise microstructure adjustment is desired for the homogeneous microstructure in multiphase steels under the complicated stepwise process control, the coupled process model in terms of austenite conditioning, temperature history, carbon redistribution and phase transformation is provided. The optimal process parameters are delivered for the required microstructure by optimal control theory and validated by pilot rolling line. According to the limited industrial process window, the model will be further developed to be applicable on TRIP steels and reduced in calculation time so that it can be applied in the industry.



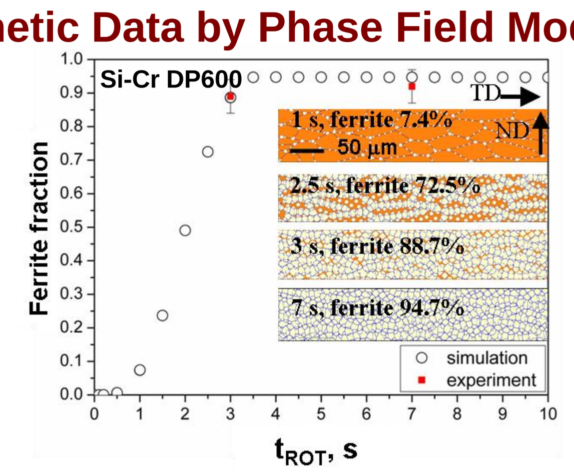
Model Developement + Process-Design

Model Development and Parameter Identification

Kinetic Data by Dilatometry



Kinetic Data by Phase Field Modelling

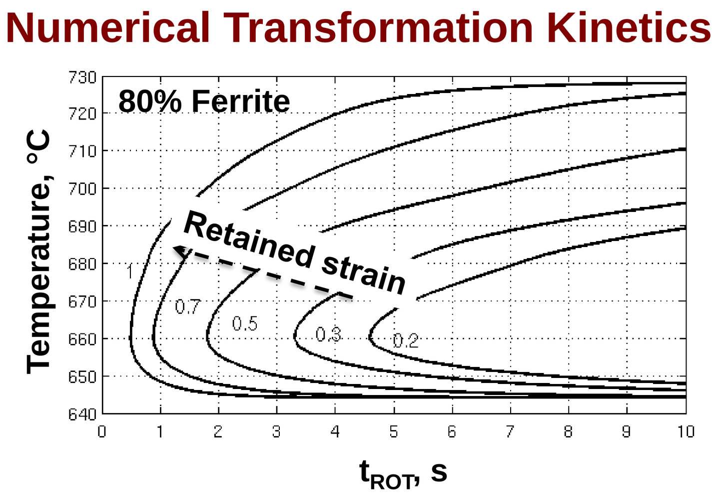


Model Parameter Identification

$$\dot{f}(t) = \left[\bar{f}_{eq} - f\right]_+ \cdot g_{f1}(T) \cdot h_f(\dot{T}) \cdot g_{f2}(D_\gamma, \varepsilon)$$

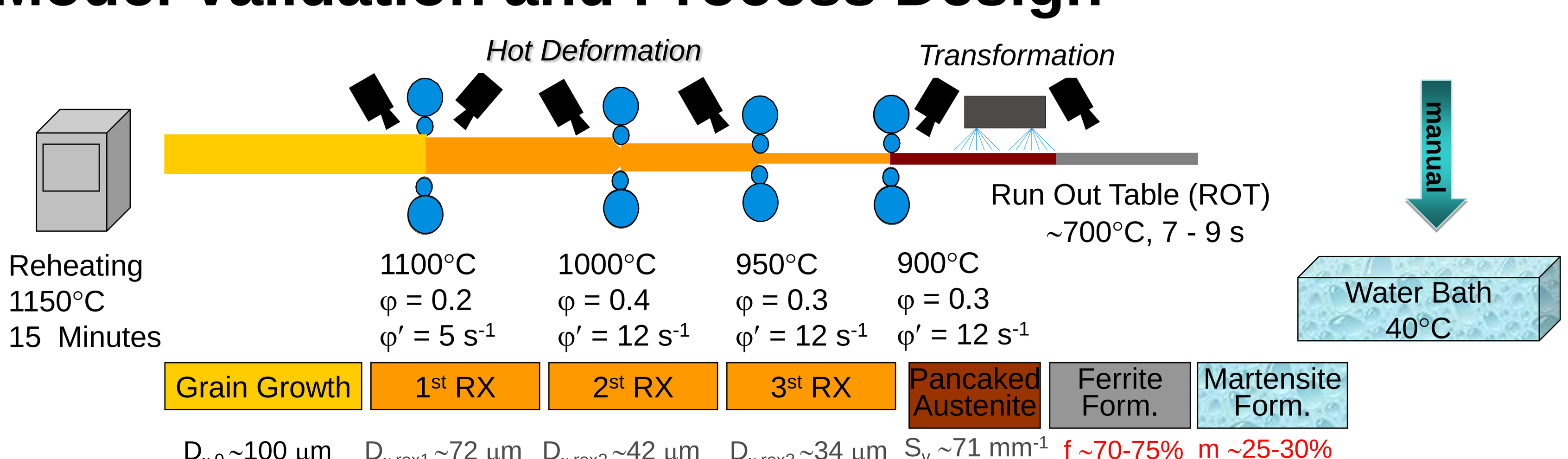
eq. ferrite fraction (TCC/Dilatometer); isotherm. transf.; non-isotherm. transf.; Austenite conditioning

Numerical Transformation Kinetics



P. Suwanpinij, N. Togobytska et al., Steel Res. Int. (2010) (accepted)

Model Validation and Process Design

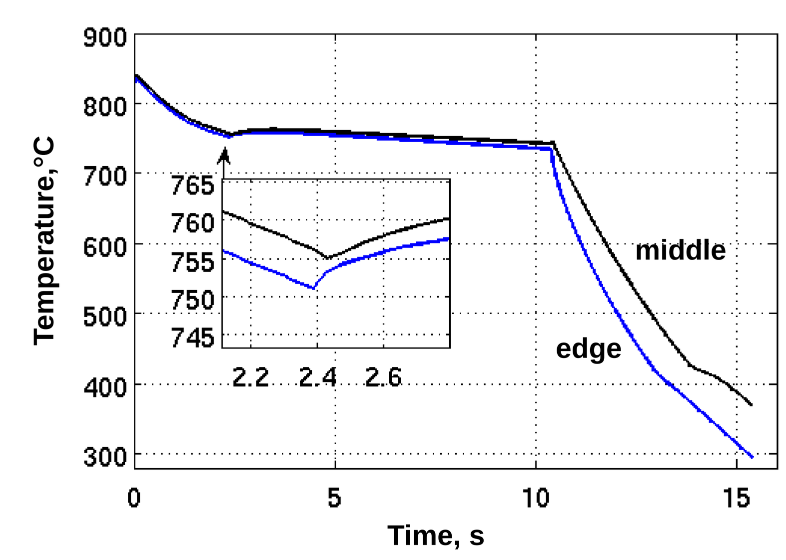


Calculation $D_{\gamma,rex}$: D. Liu, F. Fazeli and M. Militzer: ISIJ Int., 47 (2007), 1789-1798.

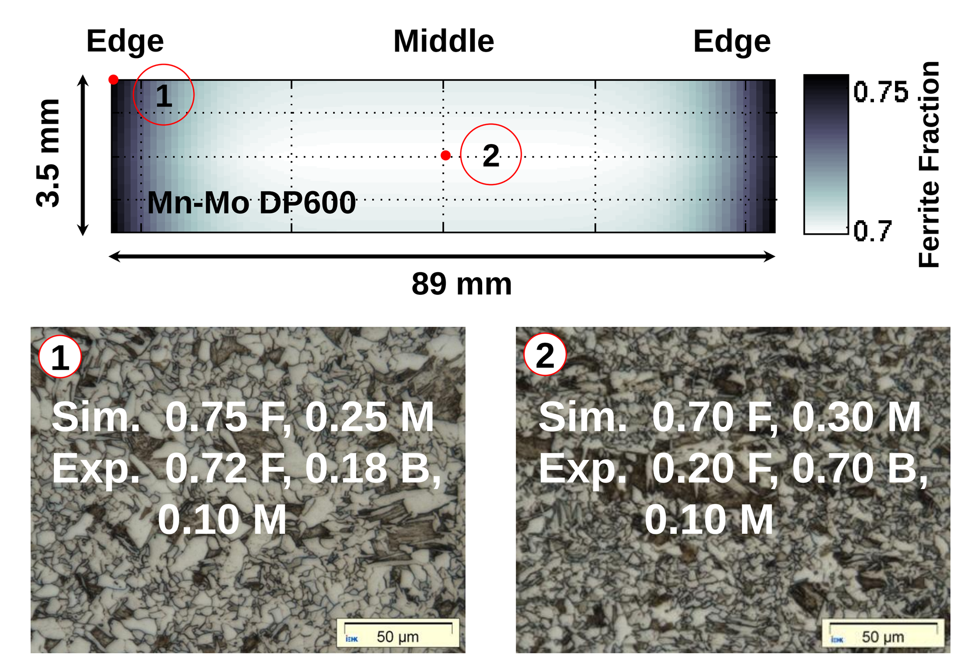
Mn-Mo-DP600 C 0.07% Mn 1.43% Si 0.02% Al 0.05% Mo 0.13%

Simulation and Optimal Control

Simulation of Temperature History and Phase Fraction



Simulated temperature evolution on the cross section



Simulated ferrite fraction and metallography

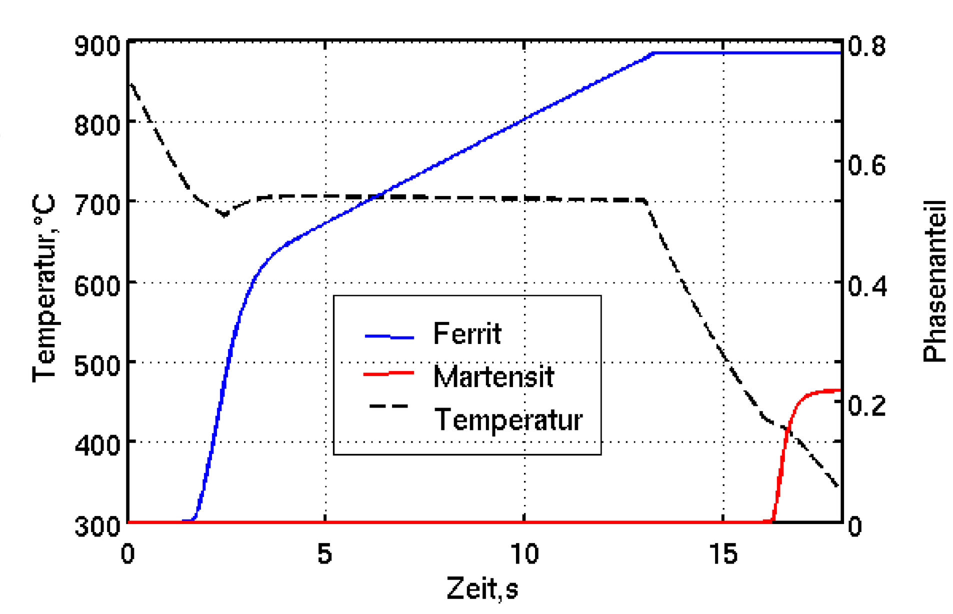
Optimal Control Problem

$$\alpha_1 \int_\Omega (f(t_E,\cdot) - f_d)^2\,dx + \alpha_2 \int_\Omega (T(t_E,\cdot) - T_d)^2\,dx + \alpha_3 \int_0^{t_E} u(t)^2\,dt \rightarrow \underset{u, t_E}{Min}$$

- t_E - holding time
- $u(t)$ - control parameter, water amount
- f_d - aimed ferrite amount: 70-90%
- T_d - aimed temperature: 680-700°C

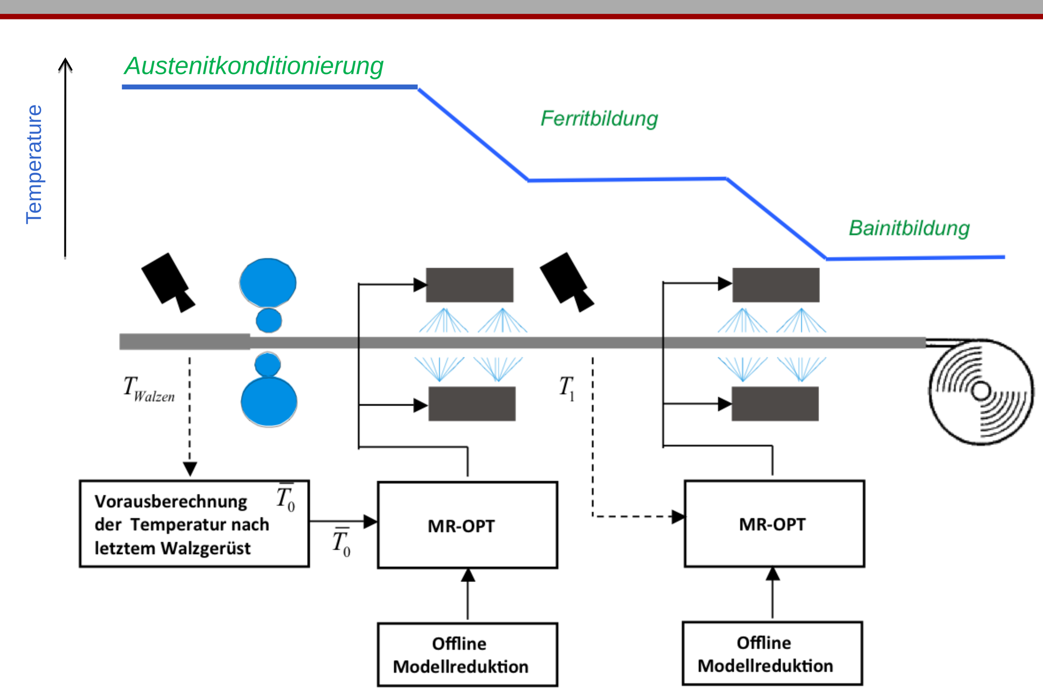
Optimal Parameters

- Water amount 282 l/min
- Holding time 10.57 s



Simulated phase fractions and temperatur evolution in the center of sheet cross section

Targets in the 3rd Application Period



- Introduction of Bainite Phase Transformation in the Rate Law Model

$$\dot{b}(t) = \left[\bar{b}_{eq}(C_\gamma, T) - b\right]_+ \cdot g_b(C_\gamma, T, \dot{T})$$

b - Bainite Fraction, $\bar{b}_{eq}$ - Equilibrium Bainite Fraction, T - Temperature,
C_γ - Carbon Content in Remaining Austenite

- Numerical Process Design for the Hot Rolling of TRIP Steel
- Development of Real-Time Algorithms for the Control of Run Out Table (ROT)
- Reduction of Calculation Time by Application of Model Reduction Techniques

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