SUCCESS STORY

IC-MPPE
Integrated Computational Materials Process and Product Engineering.

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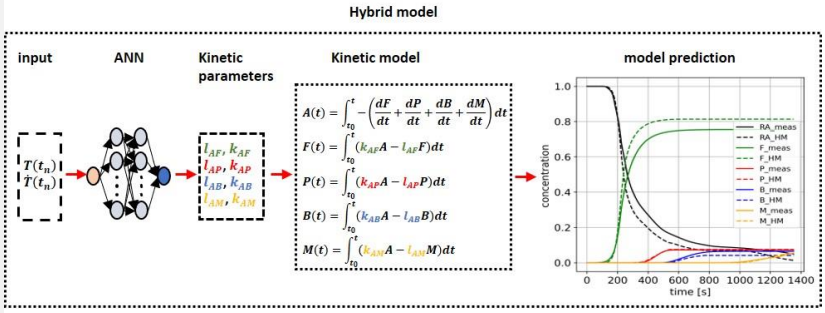

The architecture of a hybrid model (machine learning + physical model) for predicting the microstructure of steels after processing. A neural network (ANN) determines the model parameters of a physically based kinetic model, taking process parameters such as target temperature and cooling rate into account. Picture: MCL

PHYSICS MEETS AI FOR THE CO_2-REDUCED MANUFACTURING OF STEEL PRODUCTS

THE MANUFACTURING OF HIGH-QUALITY STEEL PRODUCTS WITH CUSTOMIZED PROPERTIES AND A REDUCED CO_2 FOOTPRINT IS POSSIBLE THROUGH THE USE OF PHYSICALLY INFORMED ARTIFICIAL INTELLIGENCE

The manufacture of high-end steel products is essential for industries such as energy technology and automotive engineering. In terms of the circular economy, the development of new manufacturing routes with a reduced CO_2 footprint plays a major role, whereby classic “trial and error” approaches, in which alloying elements and heat treatment cycles are varied empirically, should be avoided. The final heat treatment of a steel product plays a decisive role in its microstructure and mechanical properties. By intelligently optimizing the heat treatment processes, it is possible to develop manufacturing routes with more recycled content and the same or even better material properties, while at the same time reducing the associated development costs.

Physical understanding and modeling of phase transformations

Chemistry-dependent modeling of phase transformations in steels during heat treatments is an important and active area of research, as it is essential for the adjustment of the resulting microstructure and mechanical properties. A wide range of models have been developed to describe the kinetics of phase transformations, including empirical and physically based approaches. However, due to the complexity of the phenomena involved, these models are often limited to specific conditions and are not generally applicable to industrial applications.

Federal Ministry Innovation, Mobility and Infrastructure Republic of Austria
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Advances in machine learning, big data analytics and GPU computing power have opened new ways to develop sophisticated modeling approaches. At MCL, expertise in materials science is integrated with machine learning models to create highly efficient solutions tailored to industrial applications. A hybrid model was developed and trained on the basis of a broad field of heat treatment data from the industrial partner voestalpine. An artificial neural network (ANN) is used to determine the material parameters of the physical model part, which are difficult to measure experimentally. These parameters generally depend on the chemical composition of the steel grade, the heat treatment temperature and the cooling rate.

CO_2-reduced production of crude steel with optimized recycling content. The processes can be flexibly controlled in future in order to set the desired product properties. Image: voestalpine

Impact and effects

The hybrid model that was developed enables a simultaneous quantitative description of components of the microstructure. The long-term goal is to use such models in industrial production lines to enable intelligent control and optimization of production processes.

This makes it possible to manufacture steel products from the high-quality segment with 60% or even 90% recycled content instead of the current 20%. This approach thus paves the way for more environmentally friendly and cost-efficient steel production that can react flexibly to available primary and secondary raw materials.

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