SUCCESS STORY

K1-MET
Competence Center for Advanced Metallurgical and Environmental Process Development

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RECURRENCE CFD

ONE STEP CLOSER TO SIMULATION BASED PROCESS MONITORING

Motivation

Due to the highly complex calculation and interpolation algorithms, conventional CFD is only able to simulate relatively short periods of time. In industrial applications, these periods are even shorter due to the large and/or complex geometries and the constantly increasing demands on the mesh fineness.

For this reason, a novel approach was proposed [1], which saves computational time for variables that have recurring patterns on smaller time scales (e.g., velocity, pressure, turbulent quantities). Only variables that change on larger time scales are calculated, whereby the time step can also be increased.

There are many processes in metallurgy with repetitive flow patterns. For such flows it is possible to describe these recurring patterns by a chronological sequence of snapshots of the flow field. The database of the snapshots is created in a conventional CFD-Simulation.

The study

Dephosphorization is one such process, see Figure 1. Removing phosphorus from liquid metal in a BOF converter has been an important task in steelmaking for several decades. The decrease in the phosphorus concentration improves the steel quality.

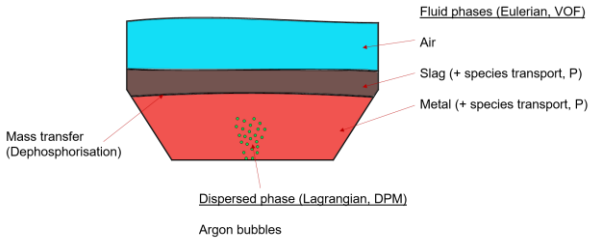

Figure 1: Outline of the dephosphorization process. (Source K1-MET)

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The simulation cases were based on the experiments described in [2]. There, the phosphorus transfer at the interface between metal and slag was measured in a small crucible.

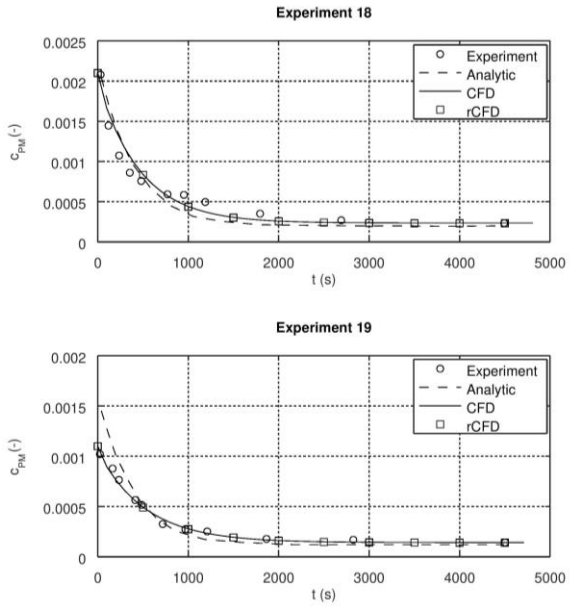

Figure 2: Phosphorus mass concentration in liquid metal. Experimental and analytic results from [2]. (Source K1-MET)

Impact and effects

The "Recurrent" simulation (rCFD) of a dephosphorization process was validated based on measurements, see Figure 2. Compared to conventional CFD simulation, rCFD achieves simulation times that are up to an order of magnitude shorter, which reduces computational costs and enables numerical simulations of long-lasting processes. The computational time reduction should be even higher for larger geometries and computational meshes.

There is also good agreement with quantitative experimental results, making this method a promising candidate for numerical simulations of many similar metallurgical processes.

[1] Lichtenegger, T.; Pirker, S.: *Recurrence CFD – A novel approach to simulate multiphase flows with strongly separated time scales*, Chemical Engineering Science, 153 (2016), pp 394-410.
[2] Manning, C.P.; Fruehan, R.J.: *The rate of the phosphorous reaction between liquid iron and slag*, Metallurgical and Materials Transactions B, 44B (2013), pp 37-44.

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- RHI Magnesita GmbH, Austria
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