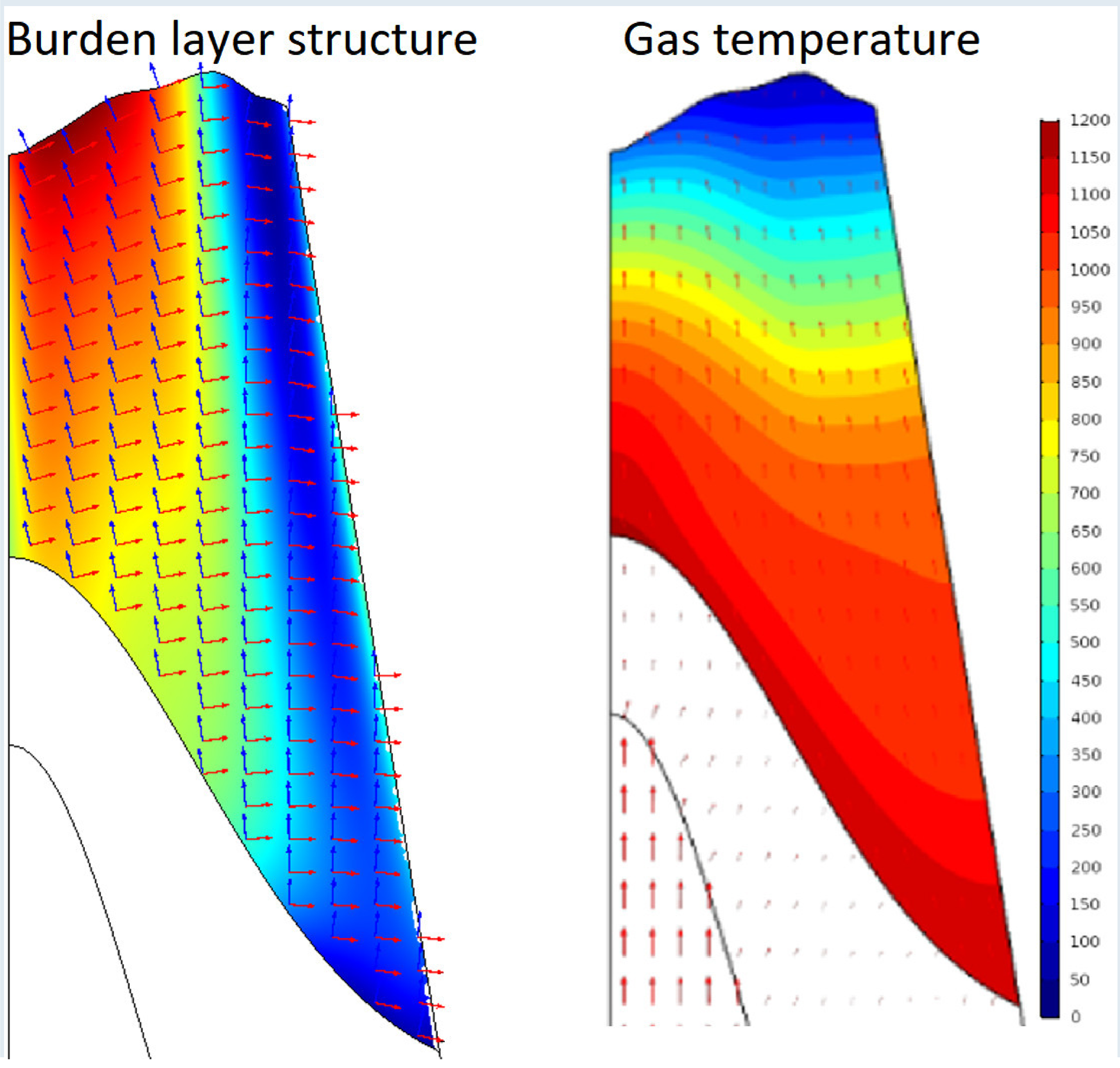

A Complex Online Model for the Iron Ore Reduction in the Blast Furnace

A complex online multiphysics model of the blast furnace shaft for various operational conditions and charging programs

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Abstract

A complex multiphysics model has been developed to simulate the reduction of iron ore in the BF shaft for various operational conditions and charging programs. The model includes heat exchange between gas and burden, reaction heat sources, mass transfer from solid to gas, compressible non-isothermal porous flow, transport of solid and gas species, coke/ore distribution and burden layer structures in the computation. The shrinking core reaction kinetics has been adopted and calibrated by laboratory trials. Matlab LiveLink Module is used to prepare input and access the operational database (DB) (i.e., burden structure, blast gas rates, solid and gas composition are taken from the process DB).

TABLE 1. Main chemical reactions in the BF shaft.

RHM:	$3\ Fe_2O_{3(s)} + CO_{(g)}$	$\rightarrow 2\ Fe_3O_{4(s)} + CO_{2(g)}$
RMW:	$Fe_3O_{4(s)} + CO_{(g)}$	$\rightarrow 3\ FeO_{(s)} + CO_{2(g)}$
RWF:	$FeO_{(s)} + CO_{(g)}$	$\rightarrow Fe_{(s)} + CO_{2(g)}$
RHMh:	$3\ Fe_2O_{3(s)} + H_{2(g)}$	$\rightarrow 2\ Fe_3O_{4(s)} + H_2O_{(g)}$
RMWh:	$Fe_3O_{4(s)} + H_{2(g)}$	$\rightarrow 3\ FeO_{(s)} + H_2O_{(g)}$
RWFh:	$FeO_{(s)} + H_{2(g)}$	$\rightarrow Fe_{(s)} + H_2O_{(g)}$
BR:	$C_{(s)} + CO_{2(g)}$	$\rightarrow 2\ CO_{(g)}$
WG:	$C_{(s)} + H_2O_{(g)}$	$\rightarrow CO_{(g)} + H_{2(g)}$
WGS:	$CO_{(s)} + H_2O_{(g)}$	$\rightarrow CO_{2(g)} + H_{2(g)}$
DRY:	$H_2Os_{(l)}$	$\rightarrow H_2O_{(g)}$

Methodology

Shrinking core reaction kinetics have been used to model the iron ore reduction in the BF. Transport of species, gas flow, heat exchange between solid and gas, density field of solid particles are solved using COMSOL Multiphysics®.

- Transport of Concentrated Species SOLIDs *(tcsS)*
- Transport of Concentrated Species GASes *(tcsG)*
- Brinkman Equations *(br)*
- Heat Transfer in Solids S *(hts)*
- Heat Transfer in Fluids G *(htg)*
- Stabilized Convection-Diffusion Equation - rhoS *(scdeq)*
- Multiphysics

Results

Some results can be seen in Figure 1, which shows the gas pressure on the wall (left) and top gas temperature over the burden surface (right).

The approximate position of the cohesive zone (CZ) can be noticed from the pressure curve.

The coke volume ratio distribution of a charging program (fVc curve in the right diagram) significantly influences the process.

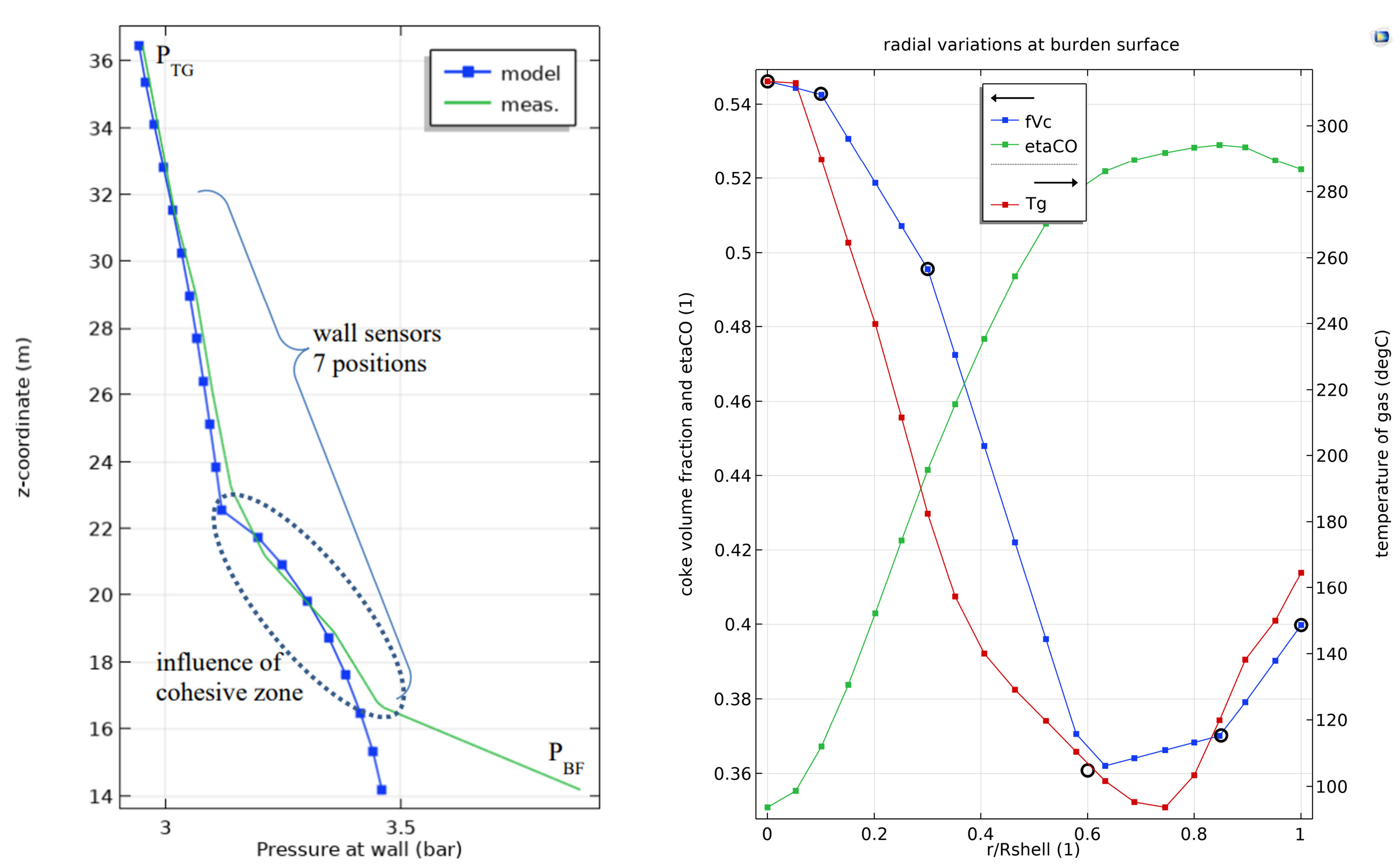

FIGURE 1. Left: wall pressure. Right: top gas temperature.

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