6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11 – 15 June 2018, Glasgow, UK

Softening and melting modeling of iron ore particles using a discrete - continuous coupling method

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Key Words: *Multiphysics Problems, Softening, Melting, XDEM.*

The blast furnace iron making is the main method to produce liquid iron. A blast furnace is charged with ore and coke from the top along with a preheated gas introduced to the furnace through the tuyeres in the lower part. The combustion of coke generates reducing gas ascending through the blast furnace to reduce iron-bearing materials. The reduced iron-bearing particles start softening and melting because of the weight of burden above and the high temperature in the middle of the blast furnace so-called cohesive zone. In this region, as particles are softened, the void space between particles decreases. As the temperature increases further, the softened particles start melting and generate two different liquids: molten iron and slag. Then the generated liquids trickle down to the lower part of the blast furnace. The softening and melting process forms the impermeable ferrous layers forcing gas to flow horizontally through the permeable coke windows. This causes a high-pressure drop. Softening and melting has a big effect on the operation of the blast furnace and since it is not possible to interrupt the blast furnace to investigate details of the phenomena occurring inside, the numerical simulation becomes more practical.

In this contribution, the eXtended Discrete Element Method (XDEM) [1,2] as an advanced numerical tool based on the Eulerian-Lagrangian framework, is used. Within this platform, the gas and liquid phases are described by computational fluid dynamics (CFD) and the soft-sphere discrete element approach (DEM) is used for the coke and iron ore particles. Continuous phases are coupled to the discrete entities through mass, momentum, and energy exchange. Moreover, the internal temperature distribution of the particles is described. Therefore, the XDEM is able to model multiphase and multiscale phenomena as can occur in the cohesive zone. The particle's deformation, temperature, melting, and shrinking along with gas and liquids pressure, temperature and velocity patterns are examined using the XDEM method.

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