Infiltration Velocity and Thickness of Flowing Slag Film on Porous Refractory of Slagging Gasifiers

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Abstract:

Two analytical formulations that describe the fluid interactions of slag with the porous refractory linings of gasification reactors have been derived. The first formulation considers the infiltration velocity of molten slag into the porous microstructure of the refractory material that possesses an inherent temperature gradient in the direction of infiltration. Capillary pressures are assumed to be the primary driving force for the infiltration. Considering that the geometry of the pores provides a substantially shorter length scale in the radial direction as compared with the penetration direction, a lubrication approximation was employed to simplify the equation of motion. The assumption of a fully developed flow in the pores is justified based on the extremely small Reynolds numbers of the infiltration slag flow. The second formulation describes the thickness of the slag film that flows down the perimeter of the refractory lining. The thickness of the film was approximated by equating the volumetric slag production rate of the gasification reactor to the integration of the velocity profile with respect to the lateral flow cross-sectional area of the film. These two models demonstrate that both the infiltration velocity into the refractory and the thickness of the film that forms at the refractory surface were sensitive to the viscosity of the fluid slag. The slag thickness model has been applied to predict film thicknesses in a generic slagging gasifier with assumed axial temperature distributions, using slag viscosity from the literature, both for the case of a constant slag volumetric flow rate down the gasifier wall, and for the case of a constant flyash flux distributed uniformly over the entire gasifier wall.

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