The Role of Turbulence Modelling in Picturing Gas Stirred Steel Ladle Flow

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In secondary metallurgy gas stirring is applied for homogenisation, efficient dissolution of alloys as well as for acceleration of liquid-liquid and liquid gas reactions. Besides these positive aspects excess of gas stirring might cause slag entrainment and increased erosive wear of refractories. All these metallurgical phenomena are triggered by the convective flow pattern induced by the bubble plumes. Since the harsh environment of steel making plants prohibits direct measurements, numerical simulations are commonly applied as investigation tool. In this study state-of-the-art multiphase simulations were applied in order to picture the unsteady spin-up process of gas stirring from start to steady state operation. In this numerical model the stratified liquids (metal and slag) are considered in a Volume of Fluid (VoF) model, while representative gas bubbles are traced in a Lagrangian frame of reference. In terms of turbulence modelling a classical Reynolds Averaged Navier-Stokes (RANS) model is compared to a Scale Adaptive Simulation (SAS) and finally to Large Eddy Simulations (LES). Numerical results are carefully evaluated with respect to resolved velocity fluctuations and unresolved turbulent (or sub-grid) viscosity. Fast Fourier Transformation (FFT) analysis of velocity signals shows that the numerical results of the SAS model are in between classical RANS and LES; at the same time computational efforts are significantly less than with LES. This set of numerical simulations leads to the conclusion that the SAS model might be a good candidate in simulating turbulence in gas stirred steel ladle flows.

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