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Numerical Investigation of Multiphase Flow Structure for the Flue Gas Desulfurization

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Abstract : This study adopts Computational Fluid Dynamics (CFD) technique to build the multiphase flow numerical model where the interface between the flue gas and desulfurization liquid can be traced by Eulerian-Eulerian model. Inside the tower, the contact of the desulfurization liquid flow from the spray nozzles and flue gas flow can trigger chemical reactions to remove the sulfur dioxide from the exhaust gas. From experimental observations of the industrial scale plant, the desulfurization mechanism depends on the mixing level between the flue gas and the desulfurization liquid. In order to significantly improve the desulfurization efficiency, the mixing efficiency and the residence time can be increased by perforated sieve trays. Hence, the purpose of this research is to investigate the flow structure of sieve trays for the flue gas desulfurization by numerical simulation. In this study, there is an outlet at the top of FGD tower to discharge the clean gas and the FGD tower has a deep tank at the bottom, which is used to collect the slurry liquid. In the major desulfurization zone, the desulfurization liquid and flue gas have a complex mixing flow. Because there are four perforated plates in the major desulfurization zone, which spaced 0.4m from each other, and the spray array is placed above the top sieve tray, which includes 33 nozzles. Each nozzle injects desulfurization liquid that consists of the $Mg(OH)2$ solution. On each sieve tray, the outside diameter, the hole diameter, and the porosity are 0.6m, 20 mm and 34.3%. The flue gas flows into the FGD tower from the space between the major desulfurization zone and the deep tank can finally become clean. The desulfurization liquid and the liquid slurry goes to the bottom tank and is discharged as waste. When the desulfurization solution flow impacts the sieve tray, the downward momentum will be converted to the upper surface of the sieve tray. As a result, a thin liquid layer can be developed above the sieve tray, which is the so-called the slurry layer. And the volume fraction value within the slurry layer is around 0.3~0.7. Therefore, the liquid phase can't be considered as a discrete phase under the Eulerian-Lagrangian framework. Besides, there is a liquid column through the sieve trays. The downward liquid column becomes narrow as it interacts with the upward gas flow. After the flue gas flows into the major desulfurization zone, the flow direction of the flue gas is upward (+y) in the tube between the liquid column and the solid boundary of the FGD tower. As a result, the flue gas near the liquid column may be rolled down to slurry layer, which developed a vortex or a circulation zone between any two sieve trays. The vortex structure between two sieve trays results in a sufficient large two-phase contact area. It also increases the number of times that the flue gas interacts with the desulfurization liquid. On the other hand, the sieve trays improve the two-phase mixing, which may improve the SO2 removal efficiency.

Keywords : Computational Fluid Dynamics (CFD), Eulerian-Eulerian Model, Flue Gas Desulfurization (FGD), perforated sieve tray
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