NUMERICAL SIMULATION OF HEAT EXCHANGER USING TWO STAGE FSI

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ABSTRACT

Heat exchangers are widely used in industries for energy exchange. Cement and mineral processing industries use rotary cylindrical heat exchangers (rotary kiln) to transfer heat from a counter current hot gas stream to granulate feed. Numerical modeling and thermal calculations of such heat exchangers are complicated and computationally expensive because of the radiation calculations which are highly non linear. Moreover, the heat transfer coefficients - one of the main parameters in thermal calculations is often not well known. In most of the previous work on rotary cylindrical heat exchangers, the thermal resistances due to gas radiation and surface to surface radiation were either not considered or were calculated using equivalent heat transfer coefficients using empirical formulas, which need verifications. This paper presents a simplified numerical modelling methodology called two-stage FSI to estimate the temperature distributions and heat transfer coefficients in cylindrical heat exchangers subjected to surface-to-surface radiation boundaries. The numerical approach used is fluid structure interaction (FSI) which uses both finite element analysis (FEA) and computational fluid dynamics (CFD). The suggested FSI approach used to calculate temperatures, takes into account the gas flow and gas radiation using CFD and uses FEA to account for surface radiations and convections, modeled more accurately than any of the previous work. The hot gas flow in the cylindrical heat exchanger is considered including gravity effects without the granulate feed, which is a worst case scenario for the design. ANSYS commercial tool is used for the calculations. The limitations of computationally more expensive two-way FSI calculations have been overcome by suggesting two-stage FSI approach—a combination of two-way FSI and one-way FSI. The results of two-way FSI (without radiation, FE Model with coarse mesh) are used as input for one-way FSI (with radiation, FE Model with fine mesh) to estimate the temperature distribution in heat exchanger due to hot gas flow. The temperature distribution results using suggested two-stage FSI methodology are compared with the conventional two-way FSI and also compared with the results from laboratory test for the similar boundary conditions. The suggested two-stage FSI is found to reduce the computation time by approximately thirty percent and the thermal results do not deviate much from the conventional two-way FSI approach.

Keywords: Fluid structure interaction; Finite element analysis; Computational fluid dynamics Heat exchanger; Rotary kiln; Radioactive heat transfer