Numerical and experimental studies of heat transfer in particle-laden gas flows

through a vertical riser

Samy M. El-Behery

a

,

⇑

, W.A. El-Askary

a

, Mofreh H. Hamed

b

, K.A. Ibrahim

a

a

Faculty of Engineering, Menoufiya University, Shebin El-kom, Egypt

b

Faculty of Engineering, Kafrelsheikh University, Kafrelsheikh, Egypt

article info

Article history:

Received 29 December 2010

Received in revised form 12 September 2011

Accepted 26 September 2011

Available online 22 October 2011

Keywords:

Gas–solid

Heat transfer

CFD

Pneumatic transport

Compressible flow

Equilibrium temperature

abstract

This paper presents numerical and experimental studies of gas–solid flow with heat transfer during

pneumatic transport. The experimental work investigates the flow with two different cases of inlet

thermal conditions namely; hot gas with cold solid particles, while the second case is cold gas with

hot particles. Crushed limestone particles with different sizes are used in the experimental study. The

Eulerian–Lagrangian approach is utilized to simulate the process under consideration. In the present

study, the SIMPLE algorithm is extended to compressible flow. The model takes into account the effects

of particle–particle and particle wall collisions, gas phase turbulence modulation and turbulence disper-

sion (i.e., four-way coupling). The effect of wall roughness is simulated using the virtual-wall model. The

model is validated with available published experimental data for high speed gas–solid flow and a good

agreement is obtained. Also, the model predictions are found to be in a good agreement with the present

experimental measurements. The present results show that pressure drop increases in dilute phase and

decreases in dense phase pneumatic conveying when hot particles are introduced in cold gas flow, and an

opposite effect is obtained when cold particles is introduced in a hot gas stream. In addition, it is noticed

that the equilibrium temperature and the distance required to reach equilibrium are greatly affected by

the flow conditions. Furthermore, the present results show that gas–solid flows with heat transfer can be

accurately modeled using incompressible ideal gas law for low conveying speed, while for high conveying

speed; the full compressible model should be use