THERMAL SCIENCE

International Scientific Journal

Authors of this Paper
Related papers
Cited By
External Links

Predrag Stefanović, Dejan Cvetinović, Goran S. Živković, Simeon Oka, Pavle Pavlović

NUMERICAL MODELING OF DISPERSE MATERIAL EVAPORATION IN AXISYMMETRIC THERMAL PLASMA REACTOR

ABSTRACT

A numerical 3D Euler-Lagrangian stochastic-deterministic (LS (D) model of two-phase flow laden with solid particles was developed. The model includes the relevant physical effects, namely phase interaction, particle dispersion by turbulence, lift forces, particle-particle collisions, particle-wall collisions, heat and mass transfer between phases, melting and evaporation of particles, vapour diffusion in the gas flow. It was applied to simulate the processes in thermal plasma reactors, designed for the production of the ceramic powders. Paper presents results of extensive numerical simulation provided (a) to determine critical mechanism of interphase heat and mass transfer in plasma flows, (b) to show relative influence of some plasma reactor parameters on solid precursor evaporation efficiency: 1 inlet plasma temperature, 2 inlet plasma velocity, 3 particle initial diameter, 4 particle injection angle a and 5 reactor wall temperature, (c) to analyze the possibilities for high evaporation efficiency of different starting solid precursors (Si, Al, Ti and B2O3 powder) and (d) to compare different plasma reactor configurations in conjunction with disperse material evaporation efficiency.

KEYWORDS

two-phase flow, thermal plasma, heat and mass transfer, turbulence, solid particles evaporation, ceramic powders synthesis, numerical modeling

PAPER SUBMITTED: 2003-04-25

PAPER REVISED: 2003-06-20

PAPER ACCEPTED: 2003-07-08

CITATION EXPORT: view in browser or download as text file

THERMAL SCIENCE YEAR **2003**, VOLUME **7**, ISSUE **1**, PAGES [63 - 100]

REFERENCES [view full list]

1. Kostic Ž, Stefanovic P., Pavlovic P., 1995. Thermodynamic Consideration of B-O-C-H-N System for Boron Nitride Powder Production in Thermal Plasma, Proceedings of Fourth Euro Ceramics Edited by C.Galassi Gruppo Editoriale Faenza Editrice S.p.A Italy, 1, 307-314.
2. Chang Y., Young R., Pfender E., 1989. Plasma Chem. and Plasma Process., 9, 277-289.

3. Pavlovic P., Kostic Ž., Stefanovic P., 1996. Thermal Plasma Synthesis of Ultrafine Si3N4 and SiC Ceramic Powders Materials Science Forum, 214, Transtec Publications Ltd, Switzerland, pp. 205-214.
4. Stefanovc P., Pavlovic P., Kostic Ž., Šikmanovic S., Cvetinovic D., 1997. Synthesis of ultrafine Si3N4 powder in a DC thermal plasma, Proceedings of ISPC-13, 18-22 August, Beijing, China, 2084-2089.
5. Mostafa, A.A., Elghobashi, S.E., 1985. A two-equation turbulence model for JET flows laden with vaporising droplets, Int. J. Multiphase Flow 11, 515-533.
6. Migdal, D., Agosta, V.D., 1967. A Source Flow Model for Continuum Gas-Particle Flow, Trans. ASME, 34, 860-865.
7. Crowe, C.T., Sharma, M.P., Stock, D.E., 1977. The Particle-Source-in-Cell (PSI-CELL) model for gas-droplet flows. J. Fluids Eng. 99, 325-332.
8. Rubinow, S. I, Keller, B., 1961. The transverse force on a spinning sphere moving in a viscous fluid. J. Fluid Mech. 11, 447-459.
9. Saffman, P.G., 1965. The lift on a small sphere in a shear flow. J Fluid Mech 22, 385-400.
10. Matsumoto, S., Saito, S., 1970. Monte Carlo simulation of horizontal pneumatic conveying based on the rough wall model, J. Chem. Engng. Japan 3, 223-230.
11. Tsuji, Y., Oshima, T., Morikawa, Y., 1985. Numerical simulation of pneumatical conveying in a horizontal pipe, KONA 3, 38-51.
12. Milojevic, D., 1990. Lagrangian stochastic-deterministic (LS(D) prediction of particle dispersion in turbulence, Part. Part. Syst. Charact. 7, 181-190.
13. Sommerfeld, M., Živkovic, G., 1992. Recent advances in the numerical simulation of pneumatic conveying through pipe systems, Computational Methods in Applied Science, Invited Lectures and Special Technological Sessions of the First European Computational Fluid Dynamics Conference, Brussels, 201-212.
14. Oesterle, B., Petitjean, A., 1993. Simulation of particle-to-particle interaction in gas-solid flows, Int. J. Multiphase Flow 19, 199-211.
15. Durst, F., Milojevic, D., Schönung, B., 1984. Eulerian and Lagrangian predictions of particulate two-phase flows: a numerical study. Appl. Math. Modelling 8, 101-115.
16. Hinze, J.O., 1975. Turbulence, 2nd Edition, Mc-Graw-Hill, New York.
17. Patankar, S.V., 1980. Numerical Heat Transfer and Fluid Flow. Hemisphere Pub. Co, New York.
18. Lee, S.L., Durst, F., 1982. On the motion of particles in turbulent duct flows. Int. J. Multiphase Flow 8, 125-146.
19. Ahmad, K., Goulas, A., 1980. A Numerical study of the motion of a single particle in a duct flow. Proc. 5th Int. Conf Pneumatic Transport of Solids in Pipes, London, pp. 75-97.'98, Lyon, France, June 8 - 12, 1998.
20. Durst, F., Raszillier, H., 1989. Analysis of particle-wall interaction. Chem. Eng. Sci. 44, 2872-2879.
21. Matsumoto, S., Saito, S., 1970. On the Mechanism of Suspension of Particles in Horizontal Pneumatic Conveying: Monte Carlo Simulation based on the Irregular Bouncing Model. J. Chem. Engng. Japan 3, 83-92.
22. Živkovic, G., 1996. Mathematical Modelling of Two-Phase Gas-Particle Flow in Horizontal Tubes and Channels, PhD Dissertation, University of Belgrade.
23. Crowe, C.T., 1981. On the relative importance of particle-particle collisions in gas-particle flows. Proc. Conf. Gas-Borne Part., paper C78/81, pp. 135-137.
24. Kostic Ž., Stefanovic P., Pavlovic P., 1996. Thermodynamic Consideration of Si-N and Si-H-N Systems for Silicon Nitride Powder Production in Thermal Plasma, Ceramic International 22 No 3, 179-186.
25. Stefanovic P., Pavlovic P., Kostic Z., Oka S., 1995. Numerical Analysis of Momentum, Heat and Mass Transfer Between Nitrogen Plasma and Injected Si Particles in Axisymmetric

Reactor in HEAT AND MASS TRANSFER UNDER PLASMA CONDITIONS edited by P.Fauchais, Begell House, New York, 169-176.

26. Stefanovic P., Pavlovic P., Kostic Ž., 1993. Numerical analysis of termal plazma inlet parameters influence on Si particle evaporation in axisymmetric reactor, Proceedings of XVI Int. Symp. on the Phisics of ionized gases, Beograd 25-28 Sept., 281-85.
27. Stefanovic P., Pavlovic P., Kostic Ž., 1993. Computer simulation of particle evaporation in thermal plasma flow reactor, Proceedings of the XXIst Inter. Conf. on Phenomena in Ionized Gases 19-25 September, Bochum, Germany, 1, 403-404.
28. Stefanovic P., Pavlovic P., Kostic Ž., Oka S., 1992. Mathematical analysis of critical parameters of Si particles evaporation in axisymmetric DC plasma reactor Supp. au Journal of High Temp. Chem. Processes, 1, No3, 359-366.
29. Stefanovic P., Pavlovic P., Kostic Ž., Oka S., 1994. Numerical analysis of heat transfer between nitrogen plasma and injected Si particles in axisymmetric reactor, Proceedings of the 10th International Conference on Heat Transfer, 18-24 August, Brighton, England, 5, 381-386.
30. Glushko V.P., Gurevich L.V., 1978. Termodinamicheskie svoistva individuanyikh vesheshestv, Nauka, Moskva, T.I, 1978, T.II, 1979, T.III, 1981
31. Stefanovic P., Cvetinovic D., Pavlovic P., Kostic Ž., 1998. Numerical analysis of momentum, heat and mass transfer between nitrogen plasma and injected B2O3 particles in axisymmetric reactor, Paper presented at TPP-5, 13-16 July, St. Petersburg, Russia, published by Beggel House, New York, 1998.
32. Stefanovic P., Cvetinovic D., Pavlovic P., Kostic Ž., 1998. Numerical analysis of Si powder evaporation in axisymmetric reactor with coaxial convergent nitrogen plasma flow, Paper presented at TPP-5, 13-16 July, St. Petersburg, Russia, published by Beggel House, New York, 1998.

PDF VERSION [DOWNLOAD]

NUMERICAL MODELING OF DISPERSE MATERIAL EVAPORATION IN AXISYMMETRIC THERMAL PLASMA REACTOR