THEORY AND SIMULATION OF THE INCIPIENT GAS-SOLID FLUIDIZED BED

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MASTER OF SCIENCE
UNIVERSITI PUTRA MALAYSIA
MARCH 2004
TO DAD AND MOM
THEORY AND SIMULATION OF THE INCIPIENT GAS-SOLID
FLUIDIZED BED

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March 2004

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The incipient instability in gas fluidized bed has not been fully understood despite extensive studies were conducted. A new transient theory was proposed by adopting the principles advanced by Tan and Thorpe (1992 and 1996) and Tan et al. (2003), and this was verified by computational fluid dynamic (CFD) simulations. The theory of instability in porous media has two functions. One involved the molecular diffusion of a microscopic mass flux in the gas phase with potential adverse density gradient, buoyancy convection in gas will occur, but the solid particles will stationary. If the solid particles were subjected to very high mass fluxes which is characterized by its high gas velocity such as those exceeding the minimum velocity of fluidization, then the buoyancy force of the particles will be overcome and the solids will be moved and fluidized almost instantaneously.

2D time dependent simulations were conducted using a CFD package - FLUENT for gas diffusion in porous media to observe buoyancy convection and also the incipient
instability in fluidized bed, using various gas pairs, mass fluxes and particles sizes. As a prelude to these studies, transient convection induced by gas diffusion in another gas was conducted, so as to understand fully the instability induced by mass diffusion. The simulated critical Rayleigh number were found to be 531 and 707 for top-down and bottom-up gas-gas diffusion respectively, which were very close to the theoretical value of 669 and 817. For transient buoyancy instability induced by gas diffusion in porous media, the average simulated critical Rayleigh number was found to be 26.7, which agreed very well with the theoretical value of 27.1. The simulated onset time of buoyancy convection were also found to be in good agreement with the predicted value. Very often gas velocity is used in designing a fluidized bed, despite that the instability of the bed is actually induced by the mass fluxes of the gas which provide the required velocity. Incipient instability in fluidized bed is caused by fluid velocity higher than the minimum fluidization velocity, \( U_{mf} \). The simulations of incipient instability showed that the bed behavior was dependent on the fluid velocity and the particle size and porosity. The incipient instability was preceded by the gas or pressure saturation of the interstices, induced a high momentum force due to the high mass flux which mobilized and lifted the particles once the critical Rayleigh number was exceeded. The simulated critical Rayleigh number was found to be 30.4, which agreed with the theoretical value of 27.1 for buoyancy instability in porous media. The simulated critical times of the incipient instability in fluidized bed were in good agreement with the predicted values and reported experiments in literature. The bed pressure drop, expansion ratio and void fraction after the fluidization were successfully simulated and were found to be in good agreement with experiments and theoretical values.
THEORI DAN SIMULASI UNTUK KETAKSTABILAN INCIPIEN TURUS TERBENDALIR GAS-PEPEJAL

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Simulasi 2D ketakmantapan telah dilakukan dengan menggunakan CFD- FLUENT untuk resapan gas dalam poros media untuk memperhatikan perolakan pengapungan
I would like to express my deepest gratefulness to my supervisor, Associate Professor Dr. Tan Ka Kheng, for his enormous support, invaluable guidance, generous advises, and most important of all, all the amazing solutions not only in completing the research but also in searching a way to deal with the havocs in life. 
Also my thanks to Dr Thomas, Dr Cuah, Dr Amran and Dr Tay for their generous and valuable advises, in helping me to materialize this thesis.
My love and appreciation to my family, especially dad and mom for allowing me hanging around here without a single word of complain. Last but not least to Han, for given me so much of happiness moments, which I will never forget.

Thank you!!
I certify that an Examination Committee met on date of viva to conduct the final examination of TAN YEE WAN on his Master of Science thesis entitled "Theory and Simulation of Incipient Gas-solid Fluidized Bed " in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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