THEORY AND SIMULATION OF INCIPIENT INSTABILITY IN GAS-SOLID FLUIDIZATION

LOOK KAR YANG

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

THEORY AND SIMULATION OF INCIPIENT INSTABILITY IN GAS-SOLID FLUIDIZATION

By

LOOK KAR YANG

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Chairman: **Associate Professor Thomas Choong Shean Yaw, PhD**

Faculty: **Engineering**

The mechanism of incipient instability in gas-solid fluidized bed was investigated by using Computational Fluid Dynamics (CFD) simulation – FLUENT version 6.1.18. The Finite Volume Method (FVM) is employed to simulate the complex flow behaviours and heterogeneous structure of the gas-solid fluidized bed. Fluidization of Geldart group A, B and C particles were simulated.

The formation and development of the plumes during incipient fluidization were studied. Different fluidization behaviours of Geldart group A, B and C particles were observed from the contours of gas volume fraction and velocity vector. The observations agreed well with characteristics and behaviours of particles in gas-solid fluidized bed as reported by Geldart (1973).

A theory of transient instability adopted with the principles advanced by Tan and Thorpe (1992 and 1996) was proposed to calculate the theoretical transient Rayleigh number (Ra_c) for the onset of incipient instability. The mobilization of the particles occurred once a critical value of transient Rayleigh number was exceeded. Different type of particles exhibited different Ra_c values. However, the Ra_c is almost independent of the superficial velocity.

The incipient instability of gas-solid fluidized bed was first identified when the initial stable air diffusion became distorted and particles began to move chaotically. The fluidization parameters such as gas volume fraction, bubble rise velocity and bed pressure drop were used to determine the critical time for onset of incipient instability.

The simulated critical onset time (t_c) and transient Rayleigh Number (Ra_c) for the incipient instability of gas-solid fluidized bed were then investigated. A correlation between Ra_c and permeability was derived, which provides a convenient and simple way to estimate the Ra_c. The predicted values of Ra_c were found to agree fairly well with the literature data.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

TEORI DAN SIMULASI KETIDAKSTABILAN INSIPIEN DALAM PEMBENDALIRAN GAS-PEPEJAL

Oleh

LOOK KAR YANG

Disember 2006

Pengerusi: **Profesor Madya Thomas Choong Shean Yaw, PhD**

Fakulti: **Kejuruteraan**

Mekanisme ketidakstabilan insipien dalam turus terbendalir gas-pepejal telah dikaji dengan menggunakan simulasi komputasi bendalir dinamik (CFD) – FLUENT version 6.1.18. Kaedah Isipadu Terhingga (FVM) telah diguna untuk mensimulasikan kelakuan aliran yang kompleks dan struktur heterogen dalam turus terbendalir gas-pepejal. Pembendaliran butiran kumpulan Geldart A, B dan C telah disimulasikan.

Pembentukan dan perkembangan ruang udara semasa pembendaliran insipien telah dikaji. Sifat pembendaliran yang berbeza untuk butiran dari kumpulan Geldart A, B dan C telah diperhatikan daripada kontur pecahan isipadu gas dan vektor halaju. Cerapan ini bersetuju dengan ciri dan sifat butiran dalam turus terbendalir gas-pepejal seperti yang dilaporkan oleh Geldart (1973).

Teori transien ketidakstabilan yang berdasarkan prinsip yang dimajukan oleh Tan dan Thorpe (1992 and 1996), Tan *et al.* (2003) dan Tan (2004) telah dicadangkan untuk menghitung nombor Rayleigh transien (Ra_c) secara teori untuk permulaan ketidakstabilan insipien. Pergerakan butiran terjadi apabila nilai kritikal nombor Rayleigh transien telah dilebihi. Butiran yang berlainan akan mempamerkan nilai Ra_c yang berbeza. Walau bagaimanapun, nilai Ra_c adalah tidak tersandar kepada kelajuan gas.

Ketidakstabilan insipien turus terbendaliran gas-pepejal pertama dikenalpastikan apabila resapan awal gas stabil mula terherot dan butiran bergerak secara tidak tertertib. Parameter seperti pecahan isipadu gas, halaju buih dan susutan tekanan telah diguna untuk menentu masa kritikal untuk permulaan ketidakstabilan insipien.

Simulasi masa kritikal permulaan (t_c) dan nombor Rayleigh transien (Ra_c) untuk ketidakstabilan insipien dalam turus terbendalir gas-pepejal telah dikaji. Satu hubungan di antara Ra_c dan ruangan butiran telah diterbitkan. Ini menyediakan kaedah yang mudah dan ringkas untuk meramalkan Ra_c. Nilai ramalan Ra_c didapati bersetuju dengan data dalam literatura.

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My love and appreciation to my family, especially dad and mom for providing me countless support throughout the years.

Thank you!!

I certify that an Examination Committee met on **7th November 2006** to conduct the final examination of Look Kar Yang on his Master of Science thesis entitled "Theory and simulation of incipient instability in gas-solid fluidization" 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:

Sa'ari Mustapha, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Luqman Chuah Abdullah, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Siti Aslina Hussain, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Yinghe He, PhD
Associate Professor
Faculty of Engineering
James Cook University, Australia
(External Examiner)

_____

HASANAH MOHD. GHAZALI, PhD
Professor/Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

Thomas Choong Shean Yaw, PhD
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Mohamad Amran, PhD
Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Member)

AINI IDERIS, PhD
Professor/Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

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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LOOK KAR YANG

Date:

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