Faculty of Mechanical Engineering

CFD SIMULATIONS OF ENHANCEMENT OF JET MIXING BY LATERAL SYNTHETIC JET PAIR

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DECLARATION

I declare that this thesis entitled "CFD Simulations of Enhancement of Jet Mixing by Lateral Synthetic Jet Pair" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : ……..……

Name : Hong Mun Hoh

Date : ……..…….

APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Master of Science in Mechanical Engineering.

Signature : ……..…

Supervisor Name : Dr. Cheng See Yuan

Date : …….

DEDICATION

To my beloved mother and father.

ABSTRACT

The use of synthetic jet in enhancing mixing ensures the success of many applications, including biomedical devices and chemical processing. Previous studies have found that modifications of the orifice edges and orifice width can alter the jet flow characteristics particularly in regard to flow mixing behaviours. It is expected that a change in these parameters could improve the mixing effectiveness of jet mixing technique. Therefore, the main goal of this research was to investigate the mixing characteristics of synthetic jet under the influence of various orifice edge configurations at different orifice width. First, a CFD model was developed for the evaluation of synthetic-jet-enhanced mixing performance in a mixing channel. The numerical modelling utilized a viscous laminar model to simulate the unsteady incompressible flow 3D model under a net flow Reynolds number of 83. Validation and verifications were conducted to examine the quality of the results. The mixing mechanisms and influence of three different orifice edges configurations (sharp, rounded, and chamfered) at different orifice widths (1.6, 2.4 and 4 *mm*) on the mixing degree between two fluid streams were then identified and discussed. The findings indicated that there is an optimal ratio of orifice width to the width of the mixing channel (d/h = 0.3), which will give the best mixing degree with a value of 0.6584 for a given width of the mixing channel with sharp-edged orifice. The findings also revealed that the rounded orifice showed the best mixing degree with a value of 0.6201 at lower d/h whereas the sharp-edged orifice showed the best mixing degree with a value of 0.6584 at higher d/h. This research work will serve as a guideline for selecting a suitable orifice width and orifice edge configuration to enhance the mixing performance of a synthetic-jet-assisted fluid mixer.

ABSTRAK

Penggunaan jet sintetik dalam meningkatkan tahap prestasi pencampuran telah memainkan peranan yang penting untuk menjaminkan penggunaannya dalam banyak aplikasi, termasuk bidang biomedikal dan kajian kimia. Kajian terdahulu telah menunjukkan bahawa pengubahsuaian tepian dan kelebaran saluran keluar orifis dapat mengubah ciri-ciri aliran jet yang dapat menjejaskan tahap prestasi pencampuran. Perubahan dalam parameter ini dijangka dapat meningkatkan tahap prestasi pencampuran teknik tersebut. Oleh sebab itu, matlamat utama penyelidikan ini adalah untuk menyiasat kesan pengubahsuaian tepian dan kelebaran saluran keluar orifis atas ciri-ciri aliran jet dalam prestasi pencampuran. Untuk mencapai matlamat ini, satu model CFD telah dihasilkan untuk menilai prestasi pencampuran dalam alat pencampur yang menyatah. Pemodelan berangka ini menggunakan model lamina untuk menyelesaikan perhitungan model 3D ini dengan nilai nombor Reynolds, 83. Pengesahan telah dijalankan untuk mengkaji kualiti hasil kajian. Mekanisme pencampuran dan kesan pengubahsuaian tepian saluran keluar orifis yang berbeza, iaitu tajam, bundar, dan pemotongan secara serong pada lebar orifis yang berbeza (1.6, 2.4 dan 4 mm) atas tahap prestasi pencampuran antara dua jenis aliran bendalir telah dikenalpasti dan dibincangkan. Hasil kajian ini telah menunjukkan bahawa terdapat nisbah optimum kelebaran orifis pada kelebaran saluran pencampuran (d/h = 0.3), yang akan memberikan tahap prestasi pencampuran yang terbaik dengan nilai 0.6584 bagi kes yang mempunyai kelebaran saluran pencampuran yang malar dengan tepian saluran keluar orifis yang tajam. Penemuan ini juga mengindikasikan bahawa tepian saluran keluar orifis bundar menunjukkan nilai pencampuran yang terbaik, 0.6201 pada nilai nisbah d/h yang rendah manakala tepian saluran keluar orifis tajam menunjukkan nilai pencampuran yang terbaik, 0.6584 pada nilai nisbah d/h yang tinggi. Kajian penyelidikan ini akan menjadi garis panduan untuk memilih kelebaran dan tepian saluran keluar orifis yang sesuai supaya dapat meningkatkan prestasi pencampuran dalam peranti pencampuran bendalir dengan jet sintetik.

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