UNIVERSITI PUTRA MALAYSIA

EFFECTS OF NON-ISOTHERMAL SINGLE CIRCULAR IMPINGING JET ON A QUASI-ADIABATIC FLAT PLATE

HELMEY RAMDHANEY MOHD SAIAH

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By

HELMEY RAMDHANEY MOHD SAIAH

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

March – 2011

DEDICATIONS

to both of my parents Mohd Saiah Bahaudin and Zaiton Jaafar

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the Degree of Master of Science

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Chairman : Associate Professor Abd. Rahim Abu Talib, PhD

Faculty : Faculty of Engineering

A test facility for the jet impingement cooling technique was redesigned based on literatures to investigate the effect of varying jet impingement hole diameter and jet impingement Reynolds number to the flow thermal behaviour. The total hydraulic diameter of the facility, inlet nozzle and the orifice plates were designed in accordance to the British Standards for fluid flow in a closed conduit, BS1042. Jet impingement test plates were fabricated by scaled factors to represent the real condition in the turbine blade itself. The experimental tests include single jet impingement hole arrangements with hole diameter of 5, 7, and 10 mm, and jet impingement Reynolds number ranging from 20000 - 30000. Video images of the experiment were captured using a digital video camera, and the video images were then extracted into still images. These still images were analyzed using MatLab software to get the heat transfer coefficient and surface temperature. The most suitable design parameters at a given range of design parameters were pointed out.

The experimental data obtained includes the effects of varying the jet impingement hole diameter and the jet impingement Reynolds number on heat transfer coefficient distribution and the non-dimensional parameter, Nusselt number. The coverage area of the stagnation region and the location of the wall jet region were also considered. It was found that increasing jet impingement hole diameter resulted in an increase towards the stagnation region area and wall jet region location. Development of jet impingement potential core was also discussed and optimal design parameters for the current test facility were pointed out. At jet impingement Reynolds number of 20000, the 5 mm jet impingement hole diameter design achieved the highest heat transfer process, but as the jet impingement Reynolds number increased to 25000 and 30000, the 10 mm jet impingement hole diameter dominated the heat transfer process.

Recommendation on future work would include the integration of turbine stage internal cooling technique and external cooling technique and also the utilization of multiple thermochromic liquid crystals coating for a better heat transfer coefficient distribution.

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

KESAN HENTAMAN JET BULAT TUNGGAL BERSUHU TIDAK TETAP PADA PLAT RATA SEPARA ADIABATIK

Oleh

HELMEY RAMDHANEY MOHD SAIAH

Mac – 2011

Pengerusi : Profesor Madya Abd. Rahim Abu Talib, PhD

Fakulti : Fakulti Kejuruteraan

Sebuah fasiliti ujikaji untuk teknik penyejukan hentaman jet telah direka semula berdasarkan risalah terdahulu bagi mengkaji kesan mempelbagaikan diameter lubang hentaman jet dan nombor Reynolds hentaman jet kepada kelakuan haba aliran. Diameter hidrolik keseluruhan fasiliti, muncung kemasukan, dan plat orifis telah direka mengikut Piawai British untuk aliran cecair dalam saluran tertutup, BS1042. Plat ujikaji hentaman jet telah difabrikasi menggunakan faktor skala untuk mewakili keadaan nyata bilah turbin itu sendiri. Ujian eksperimentasi merangkumi aturan hentaman jet tunggal dengan diameter lubang 5, 7, dan 10 mm, dan nombor Reynolds hentaman jet berjulat antara 20000 hingga 30000. Video eksperimen dirakam menggunakan kamera video digital, dan kemudiannya diekstrak kepada imej kaku. Imej kaku ini dianalisis menggunakan perisian Matlab bagi mendapatkan pekali pemindahan haba dan suhu permukaan. Reka bentuk parameter yang paling sesuai bagi satu julat reka bentuk parameter telah ditunjukkan.

Data eksperimen yang diperolehi merangkumi kesan memvariasikan lubang diameter hentaman jet dan nombor Reynolds hentaman jet pada edaran pekali pemindahan haba dan parameter tidak berdimensi, nombor Nusselt. Liputan kawasan stagnasi dan lokasi kawasan dinding jet juga dipertimbangkan. Didapati bahawa peningkatan lubang diameter hentaman jet menghasilkan peningkatan liputan kawasan stagnasi dan lokasi kawasan dinding jet. Pembentukan teras berpotensi hentaman jet telah dibincangkan dan rekabentuk parameter yang optimal bagi fasiliti ujikaji ini telah ditunjukkan. Pada nombor Reynolds hentaman jet 20000, lubang hentaman jet berdiameter 5 mm menghasilkan proses pemindahan haba yang tertinggi, tetapi peningkatan nombor Reynolds hentaman jet ke 25000 dan 30000, lubang hentaman jet berdiameter 10 mm mendominasi proses pemindahan haba.

Cadangan kerja masa hadapan merangkumi integrasi teknik penyejukan dalaman dan teknik penyejukan luaran peringkat turbin dan juga penggunaan pelbagai lapisan cecair hablur termokromik untuk edaran pekali pemindahan haba yang lebih jitu.

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I am forever in debt to my parents. Thank you for your limitless support.

I certify that a Thesis Examination Committee has met on 21 March 2011 to conduct the final examination of Helmey Ramdhaney Mohd Saiah on his thesis entitled "Effects Of Non-Isothermal Single Circular Impinging Jet on a Quasi-Adiabatic Flat Plate" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Thesis Examination Committee were as follows:

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Date: 23 August 2011

This thesis was 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 were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

HELMEY RAMDHANEY MOHD SAIAH

Date: 21 March 2011

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