



UNIVERSITI PUTRA MALAYSIA

NUMERICAL PERFORMANCE EVALUATION OF PLAIN FIN TUBE HEAT EXCHANGER UNDER FROSTY CONDITIONS

AMAR ALI HUSSEIN

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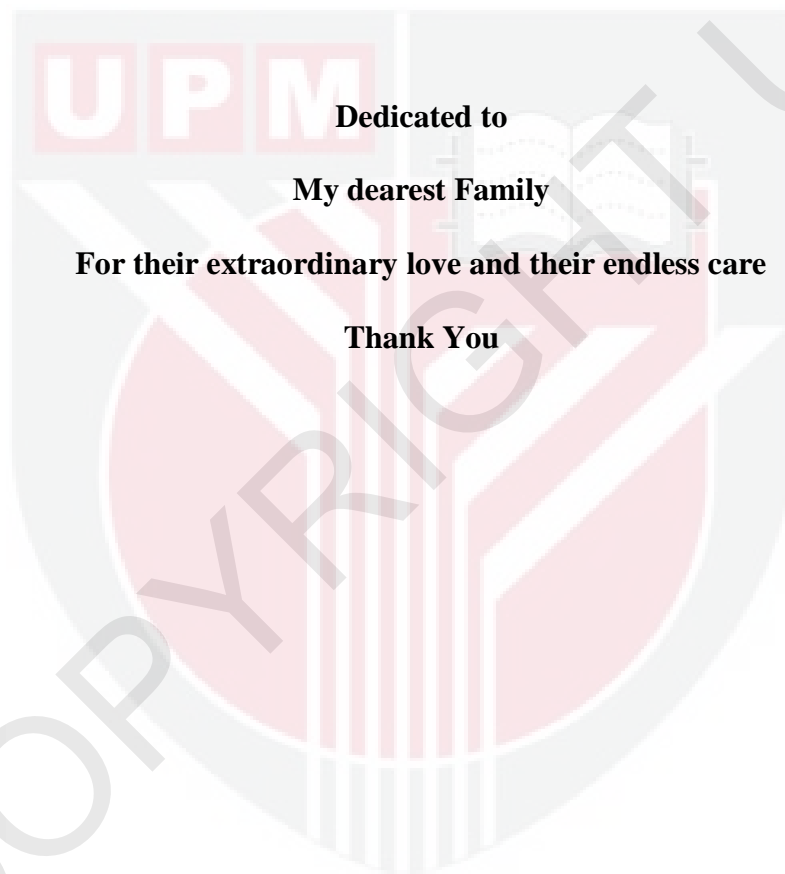
**NUMERICAL PERFORMANCE EVALUATION OF PLAIN FIN TUBE
HEAT EXCHANGER UNDER FROSTY CONDITIONS**

By

AMAR ALI HUSSEIN

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

March 2010



Dedicated to

My dearest Family

For their extraordinary love and their endless care

Thank You



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

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March 2010

Chairman: Abd Rahim Abu Talib, PhD

Faculty : Engineering

Heat exchangers are devices used to transfer thermal energy between two fluids or more, existing in different temperatures. Heat exchangers exist in many types and shapes, so they can be found in many applications. Plain fin and circular tube heat exchangers are commonly used in refrigerators and air-conditioning devices. In this type of heat exchanger, surface's temperature falls below the freezing temperature of water vapor existed in the air flows across these exchangers. The low temperature makes this vapor accumulates on exchanger's surfaces and forms frost. This degrades the performance of these exchangers by decreasing the heat transfer rate as frost works as thermal resistance. As a result to this problem the refrigerator or the air-condition needs more time to reach the desired point of cooling and this makes penalty in saving energy of electricity. In the present research, numerical study has been adopted to analyze and find way to enhance the performance of the plain fin and circular tubes heat exchangers. Three-dimensional simulations have been conducted to analyze the effects of three different collar diameters (7.53, 8.51 and

10.23 mm) on the heat transfer rate and pressure drop as first objective. The effects of three different half-transverse tube pitches to longitudinal tube pitch ratio T_p on the heat transfer rate and pressure drop have been also analyzed. Model geometries have been drawn and meshed in GAMBIT 2.3 and simulations have been performed in commercial CFD code FLUENT 6.3. Results showed that heat transfer rate has increased as the collar diameter increased with penalty in the increasing of pressure drop. It was also found that the heat transfer rate has increased as T_p ratio increased, but the pressure drop increased for $T_p = 0.5$ and decreased for $T_p = 1$. Therefore, to enhance performance without changing the size of the exchanger can be achieved by increasing the collar diameter with consideration of the pressure drop limitations. Instead, if the free space considered in the device has flexibility, the enhancement can be achieved by increasing the transverse tube pitch length.

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

**NUMERIK PRESTASI EVALUASI DARI PINGGAN BERSIRIP TIUB HABA
PENUKAR BAWAH SANGAT DINGIN KEADAAN**

Oleh

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Penukar haba adalah alat yang digunakan untuk memindahkan tenaga haba antara dua atau lebih bendalir, yang hadir dalam suhu yang berbeza. Penukar haba boleh didapati dalam pelbagai jenis dan bentuk, oleh yang demikian ia boleh ditemui dalam pelbagai aplikasi. Penukar haba sirip mendatar dan tiub membulat biasanya digunakan dalam peti sejuk dan peranti penyaman udara. Dalam penukar haba jenis ini, suhu permukaan jatuh di bawah takat beku wap air di dalam udara yang mengalir melalui penukar ini. Suhu yang rendah menyebabkan wap ini terkumpul pada permukaan penukar itu dan membentuk ais. Ini akan mengurangkan prestasi penukar dengan penyusutan kadar pemindahan haba seperti ais bertindak sebagai perintang haba. Akibat daripada masalah ini, peti sejuk atau penyaman udara memerlukan masa yang lebih lama untuk mencapai suhu penyejukan yang dikehendaki dan tidak dapat menjimatkan tenaga elektrik. Dalam penyelidikan ini, kajian berangka telah diadaptasi untuk menganalisis dan mencari kaedah untuk meningkatkan prestasi penukar haba sirip mendatar dan tiub membulat. Simulasi tiga dimensi dijalankan untuk menganalisis kesan diameter tiga tiub relang yang berbeza 7.53, 8.51 dan

10.23 mm terhadap kadar pemindahan haba dan susutan tekanan. Kesan daripada tiga anggul tiub mendatar yang berbeza terhadap nisbah anggul tiub membujur T_p ke atas kadar pemindahan haba dan susutan tekanan juga dianalisis. Model geometri dilukis dan dijarang menggunakan GAMBIT 2.3 dan simulasi dilakukan menggunakan kod CFD komersil, Fluent 6.3. Hasilnya menunjukkan bahawa kadar pemindahan haba meningkat apabila diameter tiub bertambah menyebabkan peningkatan susutan tekanan. Hasil kajian menunjukkan bahawa kadar pemindahan haba meningkat apabila nisbah T_p meningkat, namun susutan tekanan meningkat pada $T_p = 0.5$ dan manurun pada $T_p = 1$. Oleh yang demikian, untuk meningkatkan prestasi penkar tanpa mengubah saiz penukar, boleh dicapai dengan menambah diameter tiub relang dengan mengambil kira had susutan tekanan. Sebaliknya, jika ruang bebas diambil kira pada peranti yang mempunyai keanjalan, penambahbaikan boleh dicapai dengan meningkatkan panjang anggul tiub lintang.

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I certify that a Thesis Examination Committee has met on 26 of March 2010 to conduct the final examination of AMAR ALI HUSSEIN on his thesis entitled “NUMERICAL PERFORMANCE EVALUATION OF PLAIN FIN TUBE HEAT EXCHANGER UNDER FROSTY CONDITIONS“ 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 degree of Master of Science.

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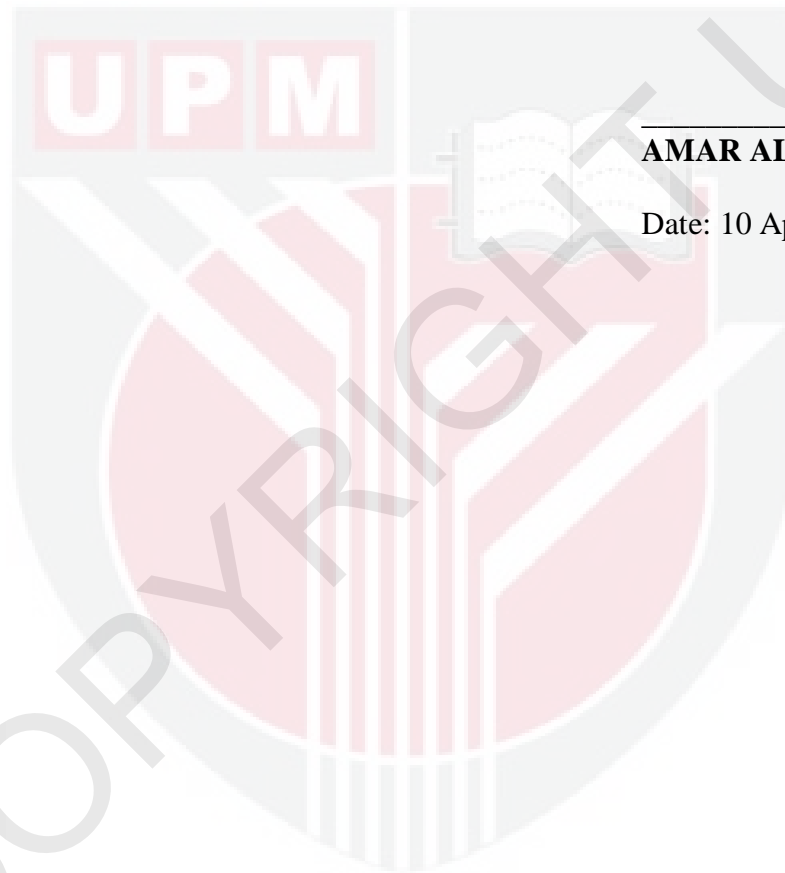
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DECLARATION

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 UPM or other institution.



AMAR ALI HUSSEIN

Date: 10 April 2010

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