
**UNIVERSITI PUTRA MALAYSIA**

***THERMAL EVALUATION AND SIMULATION OF GLASS WOOL/MAEROGEL® BLANKET***

**BAHADOR DASTORIAN JAMNANI**

**FK 2014 33**

# THERMAL EVALUATION AND SIMULATION OF GLASS WOOL/MAEROGEL® BLANKET

**By**

**BAHADOR DASTORIAN JAMNANI**

**Thesis Submitted To the School of Graduate Studies, Universiti Putra Malaysia, in fulfillment of the requirements for the Degree of Master of Science**

**June 2014**

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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**June 2014**

**Chairman: Mohd Roshdi Hassan,PhD**
**Faculty: Engineering**

Aerogel blankets are composites of silica aerogel particles dispersed in a reinforcing fiber matrix that turns the brittle aerogel into a durable and flexible insulating mat. While aerogel blanket manufacture from either organic or inorganic material, they are still some concerns over current environmental issues which are common worldwide are global warming, greenhouse effect, and climate change. Awareness of this environmental concern has led to the rise in an effort to renew agricultural waste like RHA (rice husk ash) which is cheaper precursor or a simple method in ambient pressure. As part of this study, to produce an insulator; glass wool was modified by ambient pressure drying methods to fabricate the flexible aerogel blanket. In order to evaluate thermal resistance of aerogel blanket, a hot plate is used. The microstructure of these aerogel blankets are also investigated for better understanding of the production process. Knowledge of the thermo-mechanical properties is important for the optimization of the design for these heterogeneous materials. In order to assess the aerogel blanket, some technics such as thermal gravimetric analysis (TGA), scanning electron microscopic (SEM) and Fourier Transform Infrared spectrum (FTIR) was done. Moreover a simple numerical micro model have been developed to predict the effective thermal conductivity of flexible aerogel blankets, which consist of fibers, aerogel particles and air-pockets. This simulation has two parts. In the first part of simulation, the effective thermal conductivity of the aerogel composites is computed with different aerogel particles and different volume ratios using the finite element method. The numerical analysis of thermal conductivity is conducted by generating 3D models of the microstructure of the aerogel blanket. In the second part of model, the extracted result from the micro model is inputted to the real sized model to predict top surface temperature. Finally all experiment data are validated by a numerical real sized model.

In this study, a flexible aerogel blanket shows very good thermal resistance compare to original glass wool which is around 35% improvement. In addition TGA reveals that Maerogel® can retard material decomposition of blanket from 270°C to 287°C. Moreover SEM and FTIR clearly show that there is a good bonding between $SiO_2$

particles that make a strong network to tolerate high temperature and to be flexible blanket. Furthermore Maerogel® blanket structurally was simulated then was validated by experiment result that showed good agreement; there is a well matching between the data that were extracted from simulation and experiment.

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

**PENILAIAN TERMA DAN SIMULASI GLASS WOOL / MAEROGEL® SELIMUT**

Oleh

**BAHADOR DASTORIAN JAMNANI**

**Jun 2014**

**Pengerusi: Mohd Roshdi Hassan,PhD**
**Fakulti: Kejuruteraan**

Selimut Aerogel adalah dihasilkan dari komposit zarah silika aerogel yang tersebar dalam matriks serat yang kukuh, yang bertukar aerogel yang rapuh menjadi penebat bagi tikar agar tahan lama dan fleksibel. Walaupun selimut aerogel dihasilkan daripada bahan sama ada organik atau bukan organik, ia masih ada beberapa kebimbangan mengenai isu-isu semasa alam sekitar di seluruh dunia iaitu pemanasan global , kesan rumah hijau dan perubahan iklim. Oleh itu, kebimbangan alam sekitar ini telah membawa kepada peningkatan dalam usaha untuk memperbaharui bahan sisa pertanian seperti RHA ( abu sekam padi ). Sebagai sebahagian daripada kajian ini , untuk menghasilkan penebat, kapas kaca telas diubahsuai dengan menggunakan beberapa kaedah kimia bagi fabrikasi aerogel selimut yang fleksibel. Untuk penilaian rintangan haba bagi selimut aerogel, plat panas telah digunakan. Mikrostruktur selimut aerogel diselidiki untuk lebih memahami proses pembuatannya. Pengetahuan tentang sifat haba dan mekanikal adalah penting untuk pengoptimuman reka bentuk untuk bahan yang berlainan. Dalam usaha untuk menilai selimut aerogel , beberapa teknik seperti analisis terma gravimetrik (TGA) , pengimbasan elektron mikroskopik ( SEM ) dan Fourier Transform sinaran Inframerah ( FTIR ) telah dilakukan.Model mikro berangka yang mudah telah dibangunkan untuk meramalkan pengaliran haba yang efektif bagi selimut aerogel fleksibel , yang terdiri daripada serat , zarah aerogel dan poket udara. Simulasi ini mempunyai dua bahagian. Dalam bahagian pertama simulasi , pengaliran suhu yang berkesan bagi komposit aerogel dikira dengan zarah aerogel berbeza dan nisbah jumlah yang berbeza dengan menggunakan kaedah unsur terhingga . Analisis berangka pengaliran suhu dijalankan dengan menjana model 3D mikrostruktur selimut aerogel itu. Dalam bahagian kedua model, hasil yang diekstrak daripada model mikro dimasukkan kepada model bersaiz sebenar untuk meramalkan suhu permukaan atas. Akhirnya semua data eksperimen disahkan oleh model berangka bersaiz sebenar.Dalam kajian ini, selimut aerogel fleksibel menunjukkan rintangan haba yang sangat baik berbanding dengan bulu kaca asal iaitu peningkatan kira-kira 35%. Tambahan pula, TGA mendedahkan bahawa Maerogel® boleh memperlahankan penguraian bahan selimut dari 270 °C ke 287 °C. Selain itu SEM dan FTIR jelas menunjukkan bahawa terdapat

hubungan baik antara zarah SiO2 yang membuat rangkaian yang kukuh untuk berubah dengan suhu yang tinggi dan menjadi selimut yang fleksibel. Disamping itu, struktur selimut Maerogel® telah disimulasi dan kemudian telah disahkan oleh hasil eksperimen yang menunjukkan perasamaan yang baik; ada juga yang hampir sama antara data yang dipetik daripada simulasi dan eksperimen.

## ACKNOWLEDGEMENT

First of all, I would like to extend my deepest praise to GOD who has given me the patience, strength, determination and courage to the complete this thesis.

I would like to take this opportunity to express my utmost gratitude to my supervisor, Dr. Mohd Roshdi Hassan, for his invaluable guidance throughout the course of this study. It is only with his patience and guidance that I have been able to complete this process and I am grateful for all of the opportunities that he has provided me. I also would like to acknowledge associated Prof. Madya Dr. Sa'ari Bin Mustapha, my co-supervisor for his invaluable support, constructive comments, continuous support and advice. My appreciation goes especially to Dr. Soraya Hosseini, for her guidance and advice throughout the project. Special thanks also go to my friends at the Department of Mechanical Engineering who helped me throughout this period. Sincere thanks to Mohammad Izadi for his help.

Moreover, my greatest appreciation will always go to my loving parent for their sacrifices, love, patience, and supports. My mother and father for their unending support from distances far away from me, this dissertation would not have been possible without their love and encouragement during this tedious journey. I would like to thank my dear spouse, Sepideh, for her love, warm-heartedness and support.

At last but not least, I would like to dedicate this thesis to my daughter Diana. You will always be the source of my inspiration and a part of me.

I certify that a Thesis Examination Committee has met on 24 June 2014 to conduct the final examination of Bahador Dastorian Jamnani on his thesis entitled "Thermal Evaluation and Simulation of Glass Wool/Maerogel® Blanket" 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:

**Barkawi bin Sahari, PhD**
Professor Ir.
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

**Nur Ismarrubie binti Zahari, PhD**
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

**Azmah Hanim binti Mohamed Ariff, PhD**
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

**Zuraida Ahmad, PhD**
Associate Professor
International Islamic University Malaysia
Malaysia
(External Examiner)

**NORITAH OMAR, PhD**
Associate Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 19 September 2014

This thesis was submitted to the Senate of University Putra Malaysia and has been accepted as fulfillment on the requirement for the degree of Master of Science. The members of the supervisory committee were as follows:

**Mohd Roshdi Hassan, PhD**
Senior Lecturer
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

**Sa'ari b. Mustapha, PhD**
Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

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Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

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## DECLARATION

**Declaration by the student**

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## TABLE OF CONTENTS