Ain Shams University
Faculty of Engineering

An Experimental and Theoretical Investigation of Ice Slurry Flow and Thermal Behavior in Circular Pipes

By
Eng. Tarek Adel Abdul-Ghaffar Mouneer
M. Sc. in Mechanical Engineering, Mechanical Power Engineering, 2004
B. Sc. in Mechanical Engineering, Mechanical Power Engineering, 2000

A Thesis Submitted
in Partial Fulfillment for the Requirements of
the Degree of Doctor of Philosophy
in Mechanical Engineering

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Examination Committee

The undersigned certify that they have read and recommended to the Faculty of Engineering, Ain Shams University for acceptance a thesis entitled **"An Experimental and Theoretical Investigation of Ice Slurry Flow and Thermal Behavior in Circular Pipes"**, submitted by **Eng. Tarek Adel Abdul-Ghaffar Mouneer,** in Partial Fulfillment for the Requirements of the Degree of Doctor of Philosophy in Mechanical Engineering.

Date: 29 / 9/ 2012

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Statement

This thesis is submitted in partial fulfillment for the degree of Doctor of Philosophy in Mechanical Power Engineering to Faculty of Engineering, Ain Shams University. The work included in this thesis is carried out by the author, at the laboratories of Mechanical Power Engineering Department, Ain Shams University, from March 2007 to December 2009.

No part of this thesis has been submitted for degree or qualification at any other University.

Tarek Adel Mouneer

Signature

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Date: 29/09/2012

Abstract

The application of ice slurry as secondary refrigerant is limited up to now. The main objective of this research is to study the thermal and hydro behavior of an ice slurry system during different operational processes of the ice slurry such as: Generation Process inside different types of ice slurry generators, Transportation process inside straight circular pipes, Melting process in heat exchanger and inside straight circular pipes, and Thermal storage process inside the thermal storage tank. Other objective is to compare the super-cooled water jet type as ice slurry generator with competitive scraped surface traditional ice slurry generator. A final objective is to study the thermal behavior and the hydro behavior of produced ice slurry in other ice slurry system components. A test rig with all the necessary measuring instrumentation has been set up to carry out the different kinds of the experiments performed. The generation process focus on the influence of ice slurry generator parameters on the prevention of ice scaling in tested ice slurry generators at different conditions. The transportation process of ice slurry in circular straight pipes is thoroughly studied and investigated. Pressure drops, and friction factors, and flow coefficients across flow meters are evaluated. The melting process of ice slurry in artificial heat exchanger is thoroughly investigated in the present work. Heat transfer coefficients and superheating were measured during ice slurry melting process experiments in a tube-in-tube heat transfer electrical heating coil. Historical pictures were taken during the thermal storage experiments demonstrate the developing of the ice layers inside the thermal storage tank of cylindrical shape. A comparative CFD Study

for two different type of ice slurry generators is presented and demonstrated using commercial CFD Package. A comparison between the experimental work results, and the CFD results obtained, was performed to validate the tested numerical model and the tested ice slurry generator of super-cooled water jet type. The conclusions from the different experiments are summarized to give the integral conclusions.

Acknowledgement

First of all I would like to thank my supervisors:

Prof. Dr. Mahmoud Abdel-Rasheed Nosier,

Prof. Dr. Nabil Abdul-Aziz Mahmoud,

Assoc. Prof. Mohamed Saad El-deen El-Morsi, for their support and help along the way. Many thanks are due to their continuous guidance, support, and their appreciated help to finish this thesis.

Special thanks are due to :

Prof. Dr. Samir F. Moujaes, for all the good discussions, suggestions, and answers on ice slurry systems, comparisons and economical study, and CFD questions! I am also very grateful to him who carefully corrected my English.

I wish to express my sincere appreciation to:

Prof. Dr. Salah El-Haggar, for all the good discussions and answers on super cooling phenomena and ice slurry systems, and his appreciated help.

I want to thank all my dear colleagues at the Mechanical Power Dept., Faculty of Engineering, Ain Shams University. Also, I would like to thank the technical group who shared me the effort in the laboratory. I want to thank my friends, my family, and my son Adel Tarek Adel, who encouraged me every now and then along the way! Also, I would like to thank my beauty daughter Joudy Tarek ; and my lovely son Zyad Tarek.

And finally, I am deeply grateful to my great mother.

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