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ZAGAZIG UNIVERSITY (BENHA BRANCH)
SHOUBRA FACULTY OF ENGINEERING

Influence of Fuel Cladding Material Surface Condition on Heat Transfer Coefficient in ETRR-2 Research Reactor

By

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A Thesis Submitted In Partial Fulfillment of
The Requirements for the Degree of

MASTER OF SCIENCE
IN MECHANICAL ENGINEERING

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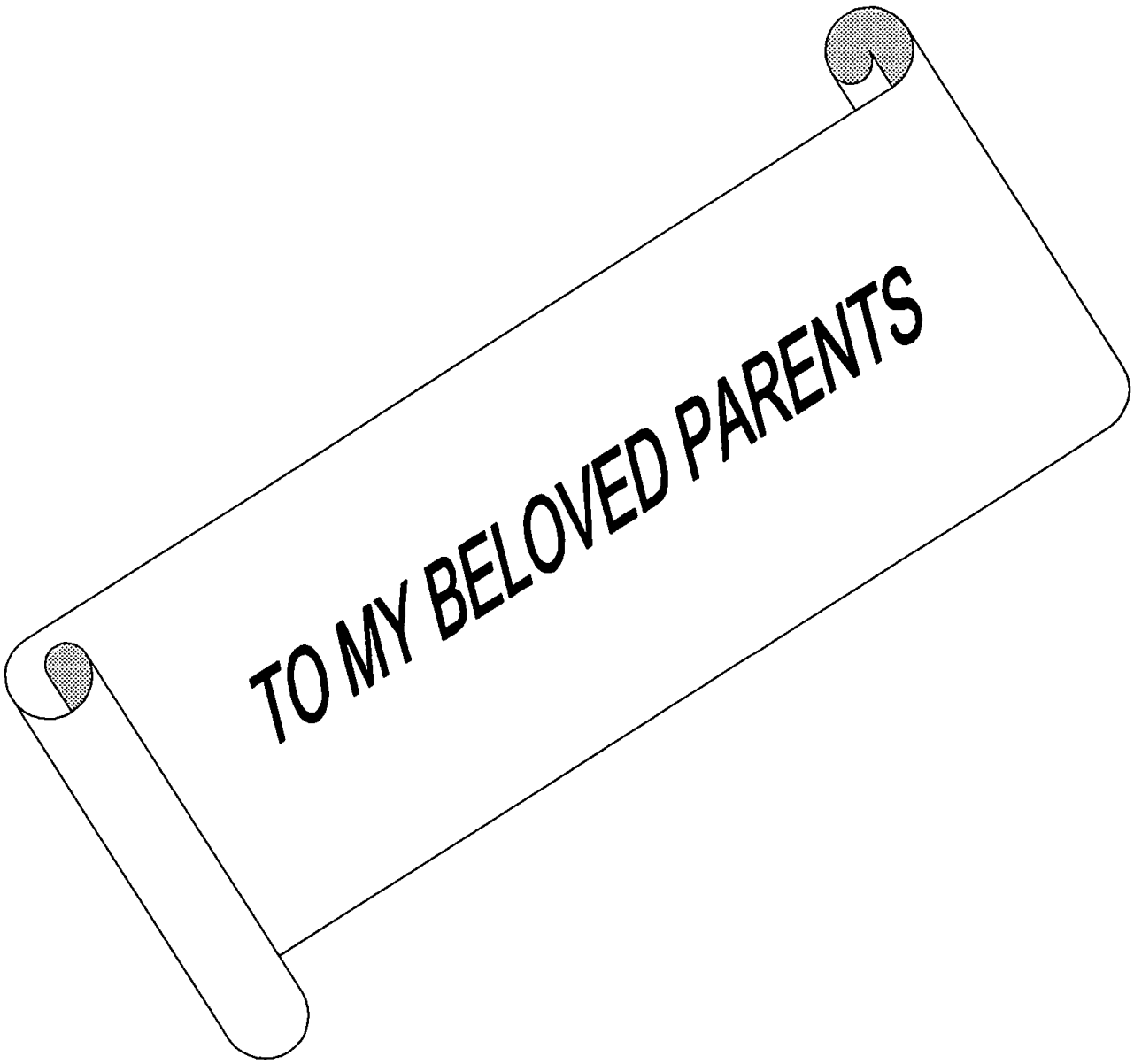
TO MY BELOVED PARENTS

PREFACE

This dissertation is submitted to Zagazig University (Benha Branch) for the degree of Master of Science in Mechanical Power Engineering.

The work included in this thesis was carried out by the author in the Department of Mechanical Engineering, Shoubra Faculty of Engineering, Zagazig University, from January 1996 to May 2001.

No part of this thesis has been submitted for a degree at any other university.

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SUMMARY

In this work both the effects of surface conditions and type of boiling fluid on the pool boiling heat transfer coefficient from upward aluminum alloy 6061 heating surfaces are investigated. For this purpose, a test apparatus has been designed and constructed to achieve heat transfer measurements from seven horizontal aluminum alloy 6061 plates.

The first four plates are treated mechanically using different grained emery papers, while the remaining three plates are treated chemically by HCl acid .Demineralized water and acetone are used as the boiling fluids. Experiments are carried out under the condition of saturated pool boiling, under constant boiling pressure of 0.7 bar for both demineralized water and acetone, which corresponds to boiling temperature 90 °C and 46 °C respectively.

A detailed analysis of the experimental results ensures that the influence of the different surface conditions achieved, either mechanically by different grained emery papers or chemically by HCL acid, on the absolute value of the heat transfer coefficient (h) can not be correlated by one of the roughness parameters used in literature within the whole range of heat flux.

A three parametric distribution functions N (r) for the size of the stable vapor bubble in active nucleation sites are obtained for the seven tested plates using the heat transfer measurements. An attempt has been made to find the relationship between the distribution functions constants and the surface roughness parameter (R_p) measured directly by a profilometer.

The experimental results showed that:

1- It is not possible to correlate the influence of surface roughness on the absolute value of the heat transfer coefficient (h) by a single roughness parameter in the form $h \sim R_p^{0.133}$ or $h \sim R_z^{0.2}$ through a wide range of heat flux and roughness.

2-The results showed a pronounced effect of plate's surface condition on the pool boiling heat transfer coefficient.

3-The heat transfer coefficient increases with increasing surface roughness.

4-The reactor cooling fluid (demineralized water) has more significant effect on heat transfer coefficient than acetone.

5-It should be possible to deduce the distribution function of the size of stable vapor bubbles in active nucleation sites of the heat surface from pool boiling heat transfer data.

6-The three-parametric constants for each tested surface (N_{max}/A, r_{st} & m) showed a significant trend with the surface roughness parameter (R_p).

7-For specific wall superheat, the enhancement in the nucleate pool boiling heat transfer coefficient reached up to 600 % due to the variation in the roughness of the boiling surface.

8- Based on the present results, the three- parametric distribution function constants (N_{max}/A, r_{st} & m) are correlated with the surface roughness parameter (R_P) measured directly by a profilometer.

Nomenclature

Except where it is stated otherwise, the symbols used in this thesis have the folloing meaning .

A	Cross section area of the heated surface	m^2
c	Constant	- - -
$C^{\backslash}$	Specific heat capacity	J/kg °C
D	Bubble diameter	m
f	Bubble frequency	1/s
Gr	Grashoff number	- - -
g	Acceleration of gravity	m/s^2
h	Heat transfer coefficient	$W/m^2°C$
h (r)	Distribution function for the radii of stable nuclei	- - -
h_{fg}	Latent heat of vaporization	kJ/kg
Δh_v	Specific latent heat of vaporization	KJ/kg
I	Current	ampere
K	Constant	- - -
K_{AL}	Thermal conductivity of aluminum alloy 6061	W/m°C
m	Exponent	- - -
N	Number of active nucleation sites.	sites
Nu	Nusselt number	- - -
n	Exponent	- - -
P	Saturation pressure	bar
P_c	Critical pressure	bar
P^*	Normalized pressure	- - -
ΔP	Excess pressure	bar
Pr	Prandtl number	- - -
Q	Power	W