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BOILING HEAT TRANSFER IN CONCENTRIC
TUBE THERMOSYPHON

BY

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TO:

MY PARENTS and WIFE
With Respect and Love

PREFACE

This thesis is submitted to Ain Shams University for the degree of Master of Science in Mechanical Engineering.

The work included in this thesis was carried out by the author at the research laboratory, Energy and Automotive Department, Faculty of Engineering, Ain Shams University in the period from March 1984 to March 1989.

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

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ABSTRACT

BOILING HEAT TRANSFER IN CONCENTRIC TUBE THERMOSYPHON

In this study , the characteristics of the boiling heat transfer for single tube and concentric tube open thermosyphons are examined experimentally. Fluorocarbon R - 11 refrigerant was the working fluid.

The present work investigates the effect of the heat flux, operating pressure, and the diametric ratio of the internal and the external tube diameters of the concentric tube open thermosyphon on the heat transfer. The temperature along the outer heated surface of the tube was maintained uniform.

Several experimental runs have been done under the following operating conditions :

- * Heat flux : ranges from 500 to 7000 W / m² ;
- * Pressure : ranges from 1.7 to 4 bar ;
- * Internal tube outer diameters : 50, 40, 25 mm.
- * External tube inner diameter is 64 mm

The experimental results show that the local heat transfer coefficient decreases with the distance measured from the closed end of the thermosyphon until a certain distance and then increases. The average heat transfer coefficient increases with the increase of operating pressure. The average heat transfer coefficient for single

tube open thermosyphon is greater than that for the concentric tube open thermosyphon in the whole range of parameter studied . The average heat transfer coefficient for concentric tube open thermosyphon increases with the decrease of the internal tube outer diameter (i.e. increase of the annulus spaces). These are in agreement with the other published results. The average heat transfer coefficient increases with the increase of the heat flux at constant operating pressure .

Emperical correlations based on the present measurements were developed in the form :

$$\bar{h} = 1.301 (q)^{2/3} (p_c)^{0.18} \quad \text{W / m}^2\text{K.}$$

for the concentric tube open thermosyphon,
and in the form :

$$\bar{h} = 1.74 (q)^{2/3} (p_c)^{0.18} \quad \text{W / m}^2\text{K.}$$

for the single tube open thermosyphon.

A qualitative description of the local heat flux along the thermosyphon tube has been discussed.

CONTENTS

	<u>Page</u>
PREFACE -----	i
ACKNOWLEDGEMENTS -----	ii
ABSTRACT -----	iii
CONTENTS -----	v
NOMENCLATURE -----	vii
CHAPTER (1)	
INTRODUCTION -----	1
CHAPTER (2)	
REVIEW OF PREVIOUS WORK -----	4
CHAPTER (3)	
THE EXPERIMENTAL SETUP AND INSTRUMENTATION --	15
3-1 Experimental setup description -----	15
3.1.1 Thermosyphon tube -----	18
3.1.2 Electric heaters -----	20
3.1.3 Condenser -----	23
3.1.4 Cooling circuit -----	25
3.1.5 Power supply -----	27
3-2 Instrumentation and safety devices -----	29
3.2.1 Temperature measurements -----	30
3.2.1.1 Thermocouples circuit ----	30
3.2.1.2 Thermocouples calibration-	35
3.2.2 Pressure measurements -----	39
3.2.2.1 Pressure gauge calibration	39
3.2.3 Flow rate measurements -----	43

3.2.3.1 Orifice meter calibration-	43
3.2.4 Power measurement -----	47
3.2.5 Liquid level measurements -----	47
3.2.6 Safety and control devices -----	51
 CHAPTER (4)	
EXPERIMENTAL WORK ANALYSIS -----	52
4-1 Experimental work procedure -----	52
4-2 Experimental data analysis -----	56
4-3 Calculation of liquid level -----	60
4-4 Calculation of peak heat flux -----	66
4-5 Determination of power factor -----	67
 CHAPTER (5)	
EXPERIMENTAL RESULTS AND DISCUSSIONS -----	70
5-1 Experimental results -----	70
5-2 Discussions -----	89
5-3 Emperical correlation -----	101
 CHAPTER (6)	
CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE WORK	106
REFERENCES -----	109
 APPENDICES	
A Sample of calculation -----	113
B Experimental results -----	118
C Error analysis -----	122
D Experimental results program -----	130
E Group of photographs -----	133

NOMENCLATURE

Except where it is stated otherwise, the symbols used in this thesis have the following meanings :

SYMBOL	DESIGNATION	UNITS
A	surface area	m ²
a	inner radius of heated tube	m
B,C	constants	-
C _p	specific heat of the working fluid	kJ/kg K
D	diameter of the heated thermosyphon tube	m
d	diameter of the internal tube	m
g	gravitational acceleration	m / s ²
h	heat transfer coefficient	W /m ² K
h _{fg}	latent heat	kJ/kg
I	electric current	A
k	thermal conductivity	W /m K
L	thermosyphon tube length	m
m	mass	kg
P	pressure	bar
PA	actual value of pressure	bar
PR	measured value of pressure	bar
q''	heat flux including heat losses	W / m ²
q	net heat flux	W / m ²
T	temperature	C
V	electric voltage	V

V	volume	m^3
v	specific volume	m^3/kg

GREEK LETTERS

β	coefficient of volumetric expansion	$1/K$
γ	thermal diffusivity	$W / m K$
μ	viscosity	$Pa. s$
ρ	density of working fluid	kg / m^3
ν	kinematic viscosity	m^2 / s
σ	surface tension	N/m
Δ	difference	

SUBSCRIPTS

a	atmosphere
c	condenser
e	entrance
g	gas
i	inner, or each station, or insulation
l	losses, or liquid
o	outer
s	saturation
w	wall

18

SUPERSCRIPTS

- average value
- .
- * normalized by its value at the critical condition

DIMENSIONLESS GROUPS

- Nu Nusselt number ($Nu = ha / k$)
- Pr Prandtl number ($Pr = Cp \mu / k$)
- Ra Rayleigh number ($Ra = g \beta \Delta T a^4 / \mu L$)

CHAPTER -1-