AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
MECHANICAL POWER ENGINEERING DEPT.

STUDY OF THE PERFORMANCE OF A LIQUID METAL HIGH TEMPERATURE HEAT PIPE

A THESIS SUBMITTED TO THE FACULTY OF ENGINEERING
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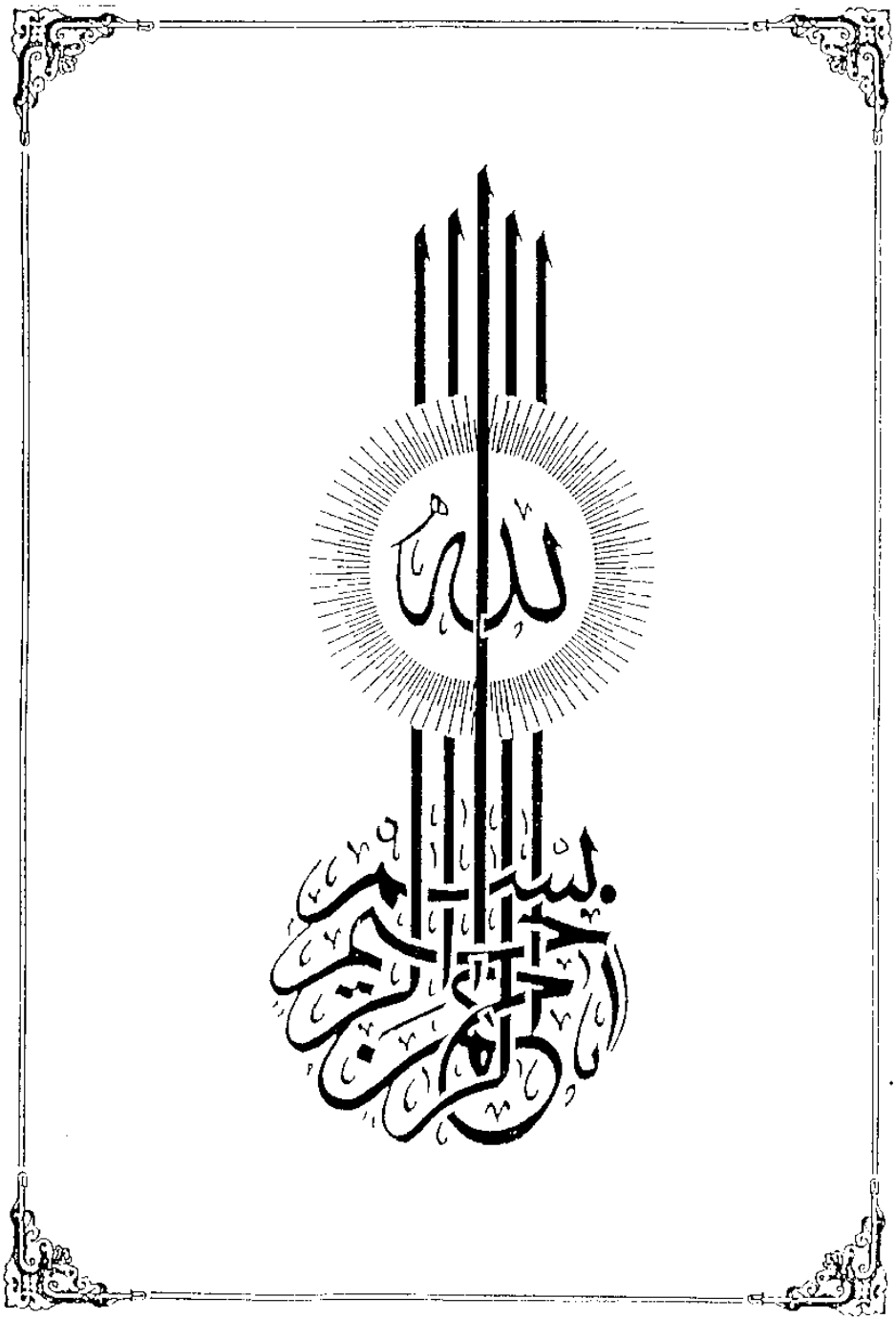

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MECHANICAL POWER ENGINEERING DEPT.

by

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in Fulfillment of Ph. D .Degree

in Mechanical Engineerng (Power)

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TO MY

MOTHER

for her endless assistance, encouragement , patience and support

STATEMENT

This dissertation is submitted to Ain Shams University for the degree of ***Doctor*** of ***Philosophy*** in Mechanical Engineering (Power).

The work included in this thesis is carried out by the author in the ***Reactors Department, Nuclear Research Center, Atomic Energy Authority***, from 1990 to 1996.

No part of this study has submitted for a degree or a qualification at other university or institution.

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ABSTRACT

Heat pipes and thermosyphons are devices capable of transporting high heat rates with isothermal operation, and cover a large active area in the space and terrestrial applications. In this research, the liquid metal thermosyphon is utilized for the first time at relatively moderate operating temperatures.

The study of the behaviour and mechanism of evaporation and condensation processes is very important for the design purpose. The steady-state operation of an inclined ***mercury/stainless steel*** two-phase closed thermosyphon is investigated experimentally. The study aims basically to investigate the effect of varying the heating rate (***heat flux***), evaporator charging quantity (***liquid fill ratio***), operating temperature and the inclination angle, on thermosyphon operation.

A thermosyphon with 21.6 mm inside diameter, 25.4 mm outside diameter and 90 cm long was used. Both the evaporator and condenser lengths are 32 cm, whilst the adiabatic section has 26 cm length. The evaporator section is uniformly heated while the condenser section is convectively cooled. Some special features are introduced in the design of the present thermosyphon. Namely these features include : *a vapour temperature probe*, *distributing blocks for uniform heating*, *cooling block thermal resistor*, *conducting copper powder layer in the evaporator and condenser sections*

to minimize the thermal resistance to heat flow, *baffle structure in the cooling jacket* and *geysering decay mechanism*.

Experiments on the ***mercury / stainless steel*** thermosyphon are performed in the range of: 4.87-22.13 kW/m^2 of radial heat flux, 0.5-1.0 of liquid fill ratio, 252-267°C operating temperature and 0-70° inclination angle. An analysis is performed for the boiling liquid pool, liquid film evaporation and condensation heat transfer coefficients in the vertical position ($\theta = 0°$). In addition, an analysis is performed for the equivalent overall heat transfer coefficient of inclined thermosyphon. In addition, the axial wall temperature distribution of the interior surface of thermosyphon is considered.

Results of the experimental data showed that :

(a) The axial wall temperature distribution is only uniform in the adiabatic and condenser sections. While the wall temperature decreases with the axial distance in the evaporation section owing to the hydrostatic head of mercury pool.

(b) The liquid fill ratio has generally small effect on the heat transfer coefficients in the liquid pool, liquid film and condensation regions. While these coefficients are greatly dependent on the radial heat flux.

(c) The equivalent overall heat transfer coefficient of thermosyphon is affected to a great extent by the axial heat flux and the operating temperature. But, it is slightly affected by the liquid fill ratio.

(d) The effective thermal conductivity of thermosyphon is very high, and reached about 68 and 64 times higher than the copper and silver thermal conductivities.

The experimental results have been assessed and qualitatively compared with previous studies on the low temperature thermosyphon whenever possible. The current results are in good agreement with the previous work , in trend and not quantitatively , due to the difference of the working fluids thermophysical properties. The experimental results of the two-phase closed mercury thermosyphon are formulated in practical applicable correlations for the heat transfer coefficients of evaporation and condensation processes of mercury. These relations are in the form of either individual parameters or dimensionless groups.

Hopefully this work could help in improving the performance of high temperature liquid metal thermosyphons. In addition to initiation series of investigations in future aim to develop super thermosyphons of very high heat rate .