POROSITY AND PERMEABILITY STUDIES OF WIRE WICK STRUCTURES

M.VENGATESH, P.RAJENDRAN ,R.TITUS , M.E.DHIVYA,

Abstract— **This article is about heat transport limitation is used to porosity and permeability of the construction of wire wick heat pipes and screen mesh wick heat pipe and DI water is working fluids operating temperatures from 30°C to 120°C.The wick is the very important material of heat pipes. The porosity is low in wier wick heat pipe compare to screen mesh wick heat pipe.The calculations of the various variants of the wick structure of the heat pipe and the working fluid are presented in the diagrams as a dependency of the heat transport limitations on the working temperature. At the conclusion, the effect of these limits on the cooling power of the heat pipe is evaluated.**

Key words: heat pipe, wire wick, DI water, porosity,permeability, cooling power.

I. INTRODUCTION

The heat pipe is a vapor – liquid phase change device that transfer heat from an evaporator to a condenser using capillary forces generated by a wick or porous medium and a working fluid. The heat pipe is composed of a container lined with a wire wick structure that is filled with a working fluid near its saturation temperature. The vapor – liquid interface, usually found near the inner edge of the wick, separates the liquid in the wick from an open vapor core.Heat flowing into the evaporator is transferred through the container to the liquid-filled wick materials causing the liquid to hot reservoir and vapor to flow into the open cope portion of the evaporator. The vapor in the open core flows out of the evaporator through the adiabatic region and into the condenser[1]. The vapor then condenses, generating capillary forcibly similar, although much less in magnitude, to those in the evaporator. The heat released in the condenser passes through the wet wicking material and container out into the condenser. The condensed liquid is then pumped, by the liquid pressure difference due to the net capillary force between the evaporator and condenser, out of the condenser back into the evaporator[2]. Proper selection and design of the pipe container, the working fluid, and wick structure are essential to the successful operation of a heat pipe. The limitations of effective thermal conductivity, and the axial temperature difference defines the operational characteristics of the heat pipe[3].

Due to the two phase characteristics, the heat pipe is ideal for transferring heat over long distances with a very small temperature drop and for creating a nearly isothermal surface for temperature stabilization[4]. As the working fluids operates in a thermodynamic saturated state, heat is transferred using latent heat of vaporization instead of sensible heat or conduction where the heat pipe then operates in a nearly isothermal condition[5].Additionally,no mechanical pumping systems are required due to the capillary-driven working fluid.Given the wide range of operating temperature for working fluids,the high efficiencies,the low relative weights,and the absence of external pumps in the heat pipes,these systems are seen as attractive options in a wide range of heat pipe heat transfer applications[5].

II. MATHEMATIC MODEL

2.1 HEAT PIPE PARAMETERS

Heat pipes undergo various limitations depending on the working fluid,the wick structure, the dimensions of the heat pipe,and the heat pipe operational temperature.

2.2 POROSITY

Porosity is the gap between two wires or mesh,the porosity is large the flow will reduced and deveated through the vapor flow area.the vapor are also disturb and performance is low in the time.porosity is denoted by ε

$$\varepsilon = 1 - 1.05\pi N d_w / 4$$

PERMEABILITY

The permeability of the wick structure is calculated from the equations.It is denoted by k.

$$K = d_w^{2} . \varepsilon^{2} / 122(1-\varepsilon)^{2}$$

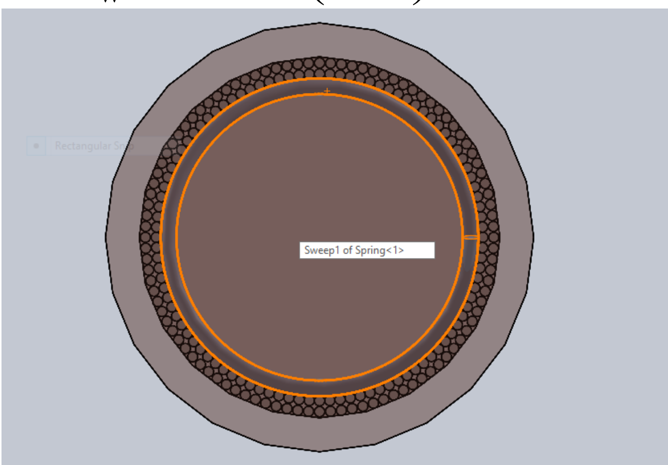

Fig 2.1.**wire wick structure heat pipe**

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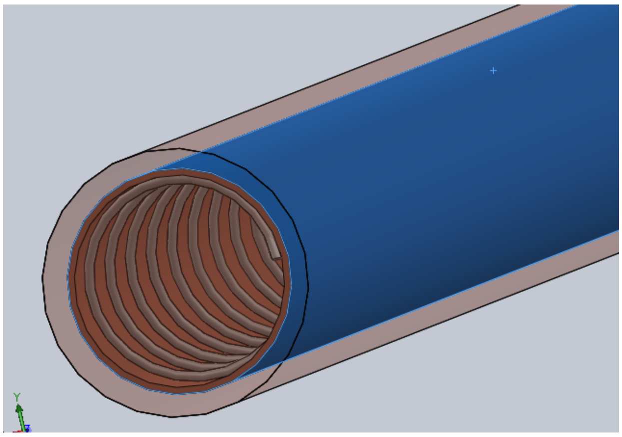

Fig 2.2.Screen mesh wick heat pipe

III. CALCULATIONS OF HEAT PIPE PERFORMANCES

For calculation,heat transport limitations are needed in order to know the thermophysical properties of working fluid in the heat pipe (Table 1 shows the thermophysical properties of DI water in the temperature range),heat pipe paramters (shown in Table 2), the thermal conductivity of heat pipe material (λ_m of copper is 387.6 $W.m^{-1}.k^{-1}$),the working condition of heat pipe (t is 40^0 c), and axial orientation of heat pipe is 45^o.

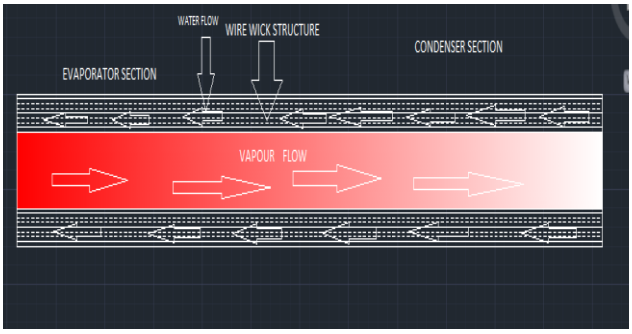

Fig.3.1.HEAT PIPE

Wire diameter (m) d_w	= 0.00045
Porosity (-) ε	= 0.99
Width of capillary structure (m) h	= 0.009
Permeability (m^2) k	= 1.62 x 10^{-5}
Effective radius of capillary structure (m) r_{eff}	= 0.000094
Effective thermal conductance (w $.m^{-1}$ $.k^{-1}$) λ_{eff}	= 1.69

Table.3.1.Parameters of wick capillary structure.

Cross-sectional radius of vapor core(m) r_v	= 0.007
Inner container radius(m) r_i	= 0.008
Evaporation length of heat pipe(m) l_e	= 0.1
Adabatic length of heat pipe(m) l_{ad}	= 0.1
Condensation length of heat pipe(m) l_c	= 0.15
Total length of heat pipe (m) l_t	= 0.35
Effective length of heat pipe (m) l_{eff}	= 0.225
Cross-sectional area of the vapor core(m^2) A_v	= 0.000153
Wick cross-sectional area(m^2) A_w	= 0.000197

IV. RESULT AND DISCUSSION

4.1 GRAPHIC DEPENDENCIES OF THE MATHEMATICAL MODEL

Based upon verification of the mathematical model with the measuring of heat pipe performance, some interesting dependencies of heat pipe performance and geometric parameters of the heat pipe's capillary structure are obtained. Knowledge from results may be used in optimization of sintered wick heat pipe design applications. The lines in the graphs represent dependencies and maximal heat flux area of the heat pipe from working temperatures. In the influence of groove dimensions on total heat pipe performance is shown. Heat transport limitations of wick heat pipe with Screen mesh capillary structure and dimensions (high 0.3 mm, width 0.2 mm and pitch 0.3) created by the mathematical model. In the influence of groove height from 0.3 to 0.9 mm on total heat pipe performance is shown. It can be seen that pipe performance rises with an increase in groove height. However, increasing the groove height from 0.7 to 0.9 is the boiling limitation, shown as a main limitation, and at working temperatures from 80 °C to 130 °C decreases heat pipe performance. A wire wick height of 0.09 as a optimal height for this specific type of wire wick heat pipe.

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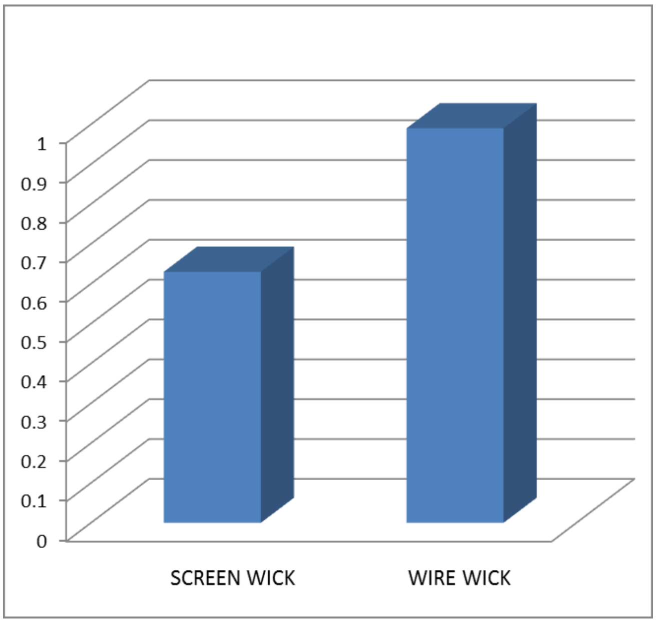

Fig.4.1.POROSITY OF SCREEN MESH WICK AND WIRE WICK

The graphic dependencies of heat pipe performance are created from a mathematical model for ethanol wick heat pipe with sintered capillary structure and various porosities, WIRE diameter of copper heat pipe, capillary structure width and heat pipe position. In the influence of porosity on heat pipe performance is shown. There is an obvious rise in heat pipe performance with increasing the porosity of the capillary structure. With the higher permeability of the capillary structure, the heat pipe transfer demonstrates increased flux. The increasing permeability of the capillary structure can however cause entrainment of liquid flow to the evaporator by vapor flow. This may cause dryout of the heat pipe's evaporation section and decrease total heat pipe performance.

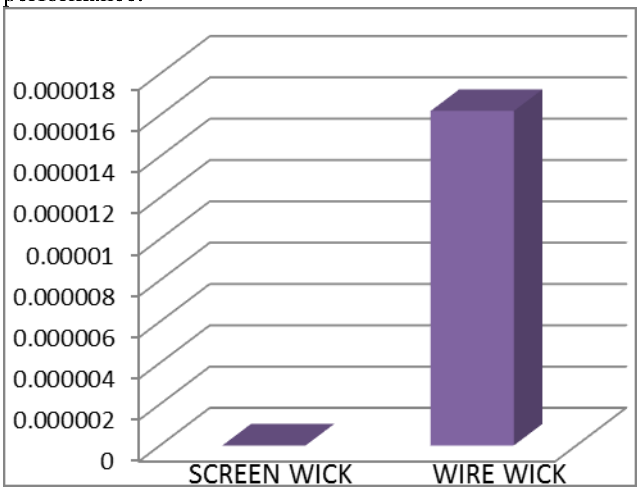

Fig.4.2.PERMIABILITY OF SCREEN WICK AND WIRE WICK

V. CONCLUSION

Graphic dependencies are expressly defined which heat transfer limitations are the biggest influence on the total performance of the heat pipe. Generally, the limitation values depend on heat pipe parameters, wick structure parameters and the thermophysical properties of the working fluid. The values of porosity and permeability is different from wire wick heat pipe and screen wick heat pipe.

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M.VENGATESH, PG SCHOLAR, M.E.THERMAL ENGINEERING, RVS COLLEGE OF ENGINEERING AND TECHNOLOGY,COIMBATORE.TAMIL NADU,INDIA.641402

Dr. P. RAJENDRAN, M.TECH, Ph.D, DEAN AND PROFESSOR, DEPARTMENT OF MECHANICAL ENGINEERING,RVS COLLEGE OF ENGINEERING AND TECHNOLOGY,COIMBATORE,TAMIL NADU,INDIA.641402.

R.TITUS, M.E, ASST.PROFESSOR, DEPARTMENT OF MECHANICAL ENGINEERING, RVS COLLEGE OF ENGINEERING AND TECHNOLOGY,COIMBATORE.TAMIL NADU,INDIA.641402.

M.E.DHIVYA, PG SCHOLAR, M.E.THERMAL ENGINEERING, RVS COLLEGE OF ENGINEERING AND TECHNOLOGY, COIMBATORE.TAMIL NADU,INDIA.641402 .

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