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Study of Parameters Affecting the Thermal Performance of Heat Pipe

Yogesh Ramdas Mahulkar, C. M. Sedani

Abstract- The heat pipes are widely uses in many applications specially for cooling of electronic part industry and heat transfer industry. The need to study the capacity of heat pipe which changes according to applications and for better identification of the heat pipe for special application. Here we study the unlike heat pipes using dissimilar diameter, wire mesh layer and adiabatic section for diverse application of heat pipe. The heat pipe identified for use in special application with respect to its capability and limitation of heat pipe. Some heat pipe results in use for high capacity, low and high inclination, also according to limitations of heat pipe such as capillary limit, entrainment limit. The result detect the double wrapped screen wire mesh affords better result for each pipe diameter and adiabatic section. Also some modify in size of heat pipe diameter and adiabatic section have better than other heat pipe as changes observed in capillary limit and entrainment limit.

Keyword: heat pipe, capillary limit, entrainment limit, wrapped screen mesh, adiabatic section.

I. INTRODUCTION

R.Manimaran, K.Palaniradja, N.Alagumurthi, J.Hussain [1] elaborated the filling ratio in a range of heat pipes with the changeable filling ratio at different inclination for high thermal conductivity, high efficiency and reduced thermal resistance. Addition of the supplementary nanoparticles with based working fluids shows the better heat transfer performance, reduced thermal resistance, increase heat transfer rate, increase thermal efficiency but proportion of nanoparticles should be proper with low temperature gradient at different inclination and not make higher viscous fluid. Leonard L. Vasiliev [2] clarified the various types of heat pipes with examples as it distinguishes from the conventional heat pipe. Miniature and microheat pipes, thermosyphons, loop heat pipe, pulsating heat pipes, sorption heat pipes experimentally shown the application range of heat pipe, basic principle, features, a variety of design and developed mathematical model include various parameters for the better explanation of the operation of heat pipe. Per Wallin [3] attentive on the selection of working fluid, describe various operation limits, compatibility with wick and case materials.

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Sonic limit, boiling limit, entrainment limit and capillary limit results with working fluids acetone, methanol and water for copper case material show water provide best results. GEORGE FRANCHI and XIAO HUANG [4] demonstrate the use of composite wick structure over number of heat pipe than the homogenous wick structure heat pipe.

The four configuration used of zero, one two and four layers of composite wick of heat pipe with experimental results. The use of composite wick structure enhance the capillary limit, increase heat input rate and minimize the liquid pressure drop with the increase in the layers of composite wick of heat pipe. D. Somasundaram, A. Mani, M. Kamaraj [5] analyzed effects of wick columns on the thermal performance of flat heat pipe and validate with CFD simulation. The CFD simulation done with top wall temperature, bottom wall temperature, evaporator temperature, condenser temperature, thermal resistance and vapor velocity. The effects of wick column are reduction in thermal resistance, enhancement in fluid return mechanism, temperature of the bottom wall at the centre increases, the top wall surface temperature decreases, increasing heat flow, increasing capillary effect, increasing vapor velocity and improve heat transfer effects. Zesheng LU, Binghui MA [6] established the relation of heat transfer of heat pipe using equivalent thermal conductivity for reduction in the thermal distortion of motorized spindle, increase in the life of machine tool and increase in the machining precision. Calculation of thermal conductivity, thermal resistance of the operation of heat pipe and heat transfer rate based on the theoretical and test value of experimental data. The setup of reducing thermal distortion of motorized spindle tested with screen wick pipe, gravity pipe and rotation heat pipe through equivalent thermal conductivity of theoretical value and test value. The results shown for thermal stabilization, the temperature difference of screen wick pipe is more than that of the gravity heat pipe and for rotation heat pipe temperature difference reduces with increase in the speed. Enertron engineer [7] paying attention on the selection of heat pipe describe through operational parameters, pipe material, wick structure, working fluid, length, size and shape of heat pipe. The design of maximum heat transport and heat pipe operational temperature for different diameters of copper water groove heat pipe at vertical orientation show maximum heat transport at maximum diameter. The design of thermal resistance and length shows the maximum thermal resistance occurred with groove wick structure in horizontal and maximum thermal resistance occurred with fiber spiral wick structure in vertical at same heat input and diameter of heat pipe.

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Mohamed H.A. Elnaggar, M.Z. Abdullah, M. Abdul Mujeebu [8] studied the U shape heat pipe with fin for PC cooling with numerical analysis and FEM simulation. The heat pipes have fins on the condenser side to improve heat transfer rate and reduce the thermal resistance. Increase in the heat transfer rate with reducing thermal resistance can be achieved with increasing number of heat pipe, fins and forced convection velocity.

II. EXPERIMENTAL RESULTS

Here we study the unlike heat pipes using dissimilar diameter, wire mesh layer and adiabatic section for diverse application of heat pipe. The configuration of cooling jacket and heating jacket on condenser section and evaporator section such as size of jacket is same and flow rate of hot and cold water through jacket is same. The manufacturing of pipe using copper material with annular shape, also wrapped screen mesh used as wick structure with phosphorus bronze as wick material for all heat pipes. The result of different heat pipes elaborate in figures with mostly used water as working fluid in all heat pipes. Also the results show the temperature of condenser inlet water and condenser outlet water with different inclinations.

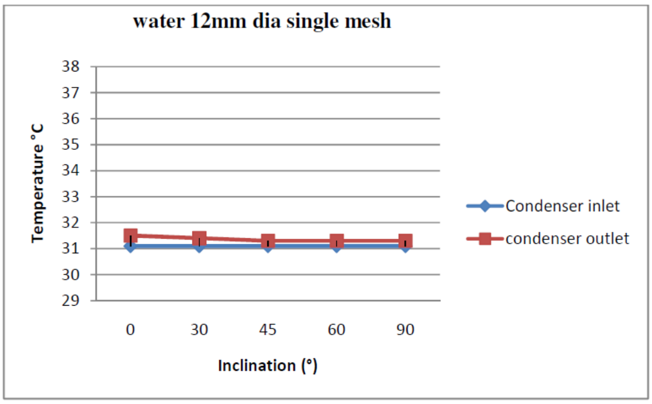

Fig. 1a) Water as working fluid with 12 mm diameter of pipe, 10 % adiabatic section and wick structure single wrapped screen mesh.

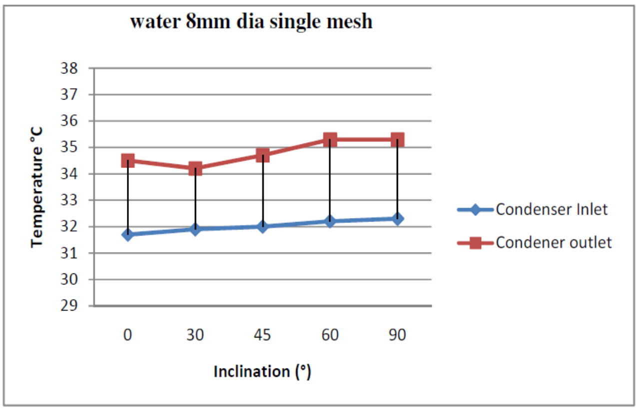

Fig. 1b) Water as working fluid with 8 mm diameter of pipe, 10 % adiabatic section and wick structure single wrapped screen mesh.

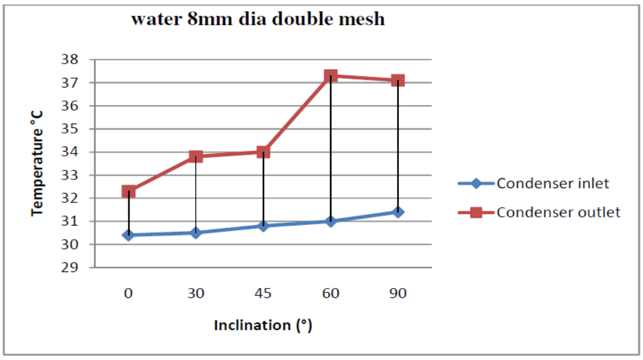

Fig. 1c) Water as working fluid with 8 mm diameter of pipe, 10 % adiabatic section and wick structure double wrapped screen mesh.

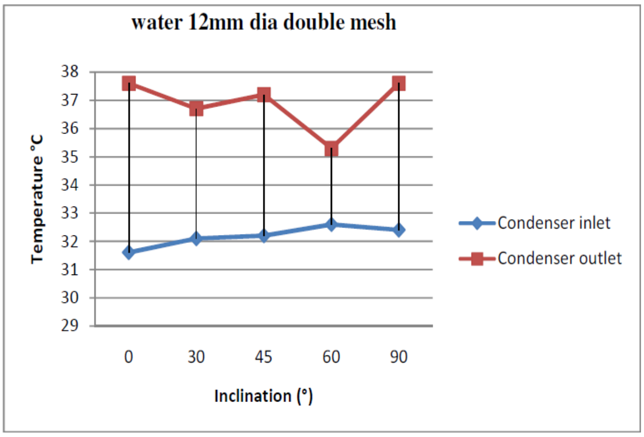

Fig. 1d) Water as working fluid with 12 mm diameter of pipe, 10 % adiabatic section and wick structure double wrapped screen mesh.

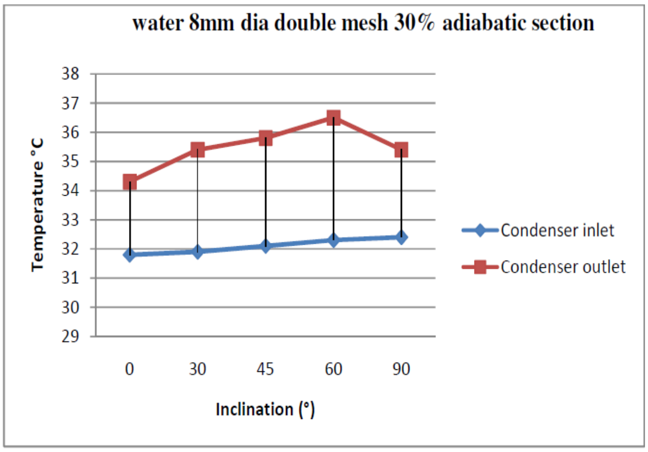

Fig. 1e) Water as working fluid with 8 mm diameter of pipe, 30 % adiabatic section and wick structure single wrapped screen mesh.

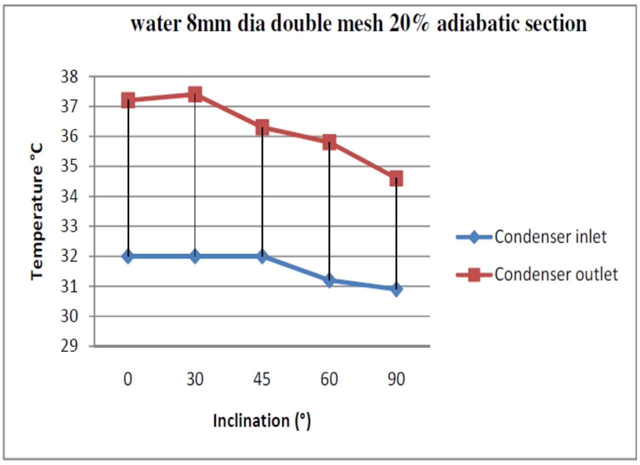

Fig. 1f) Water as working fluid with 8 mm diameter of pipe, 20 % adiabatic section and wick structure double wrapped screen mesh.

In figure 1 a) heat pipe using water as working fluid, 12 mm diameter and single mesh of wrapped screen mesh is used with 180 mesh, adiabatic section 10 percent of total length and remaining length equally distributed in evaporator and condenser section. The figure shows not too much difference in condenser inlet temperatures and condenser outlet temperatures, it marks major at 0° and 30° of inclination of heat pipe. In figure 1 b) heat pipe using water as working fluid, 8 mm diameter and single mesh of wrapped screen mesh is used with 180 mesh, adiabatic section 10 percent of total length and remaining length equally distributed in evaporator and condenser section. The figure shows difference in condenser inlet temperatures and condenser outlet temperatures over the all inclinations, it marks major at 60° and 90° of inclination of heat pipe. The results are better at single mesh by means of reducing diameter than previous heat pipe of diameter 12 mm single mesh as capillary limit sustain such less diameter heat pipe. In figure 1 c) heat pipe using water as working fluid, 8 mm diameter and double mesh of wrapped screen mesh is used with 180 mesh and 100 mesh, adiabatic section 10 percent of total length and remaining length equally distributed in evaporator and condenser section. The figure shows better difference in condenser inlet temperatures and condenser outlet temperatures, it marks major at 60° and 90° of inclination of heat pipe as entrainment limit not provide such problems which observed at small inclinations. In figure 1 d) heat pipe using water as working fluid, 12 mm diameter and single mesh of wrapped screen mesh is used with 180 mesh and 100 mesh, adiabatic section 10 percent of total length and remaining length equally distributed in evaporator and condenser section. The figure shows better difference in condenser inlet temperatures and condenser outlet temperatures, it marks major at 0° and 45° of inclination of heat pipe as capillary limit and entrainment limit are proper with this double mesh and 12 mm diameter of heat pipe than 8 mm diameter, double mesh heat pipe of same adiabatic section. In figure 1 e) heat pipe using water as working fluid, 8 mm diameter and single mesh of wrapped screen mesh is used with 180 mesh and 100 mesh, adiabatic section 30 percent of total length and remaining length equally distributed in evaporator and condenser section. The figure shows better difference in condenser inlet temperatures and condenser outlet temperatures, it marks major at 60° of inclination of heat pipe as entrainment limit not provide such problems which observed at small inclinations. In figure 1 f) heat pipe using water as working fluid, 8 mm diameter and single mesh of wrapped screen mesh is used with 180 mesh and 100 mesh, adiabatic section 20 percent of total length and remaining length equally distributed in evaporator and condenser section. The figure shows better difference in condenser inlet temperatures and condenser outlet temperatures, it marks major at 0° and 30° of inclination of heat pipe as capillary limit and entrainment limit are proper with this double mesh and 8 mm diameter with 20 % adiabatic section of heat pipe than the 12mm diameter double mesh heat pipe with 30 % adiabatic section.

III. CONCLUSION

The selection of the wick should be proper to provide capillary action at any inclination for proper operation of the heat pipe with low temperature gradients. Also the adiabatic selection of the heat pipe should be proper to provide entrainment action at any inclination for proper operation of the heat pipe with low temperature gradients. The results are of heat pipes with different heat pipe diameter, wick mesh and adiabatic section discussed in details,

1) It provide as 8mm diameter with single mesh provide better results than the 12mm diameter with single mesh as according single mesh provide less capillary action.
2) It provide as 8mm diameter with double mesh provide better results at high inclination of heat pipe by means of capillary action and poor results at low inclination of heat pipe by means of entrainment limit. And 12mm diameter heat pipe provide better results at all inclinations of heat pipe.
3) With 20 % adiabatic section length double mesh heat pipe provide better results at all inclinations than the heat pipe of 30 % adiabatic section double mesh, as best result observed at high inclination in case of the heat pipe of 30 % adiabatic section double mesh.

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