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AN EXPERIMENTAL PERFORMANCE ANALYSIS OF A HEAT PIPE WITH n_HEXANE AS WORKING FLUID.

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Abstract Heat pipe, a simple and very efficient heat transfer device, which is considered as a super thermal conductor that transmits heat by evaporation and condensation of a working fluid. Many working fluids have been reported in the literature for the heat pipes, which are intended for a particular range of temperature. In this paper the performance of a heat pipe with n_Hexane (which was not reported in the literatures) as working fluid has been presented. The experiments were conducted for two different combination of container and wick materials Viz., copper- stainless steel and stainless steel – stainless steel respectively. Heat transfer rate and efficiency in each case are reported and compared. Also the temperature rise with respect to various heat input are also presented.

INTRODUCTION

Heat pipe is a heat transfer device, in which heat is transferred through four processes, that is evaporation of the working fluid at the evaporator, vapour flowing from the evaporator to the condenser, condensation of the vapour at the condenser and liquid flowing from the condenser to the evaporator[1],[2]. Now a days heat pipe is proving to be a effective tool in the heat transfer industry. In recent years there has been a growing interest in terrestrial application of the heat pipe. Working fluid is one of the basic component of heat pipe , besides wick structure and container. One has to consider a number of factors to select a suitable combination of these components. The working fluid of the heat pipe should satisfy some prime requirements so as to get smooth heat pipe operation and long life. Many fluids were tried and its useful temperature range were reported[1]. But so far in the literature n_Hexane has not been reported as working fluid. Merit number is considered as a convenient means for quick comparison of the working fluids. The merit number for the hexane is found to be 8.2×10^6at an operating temperature of 345 K. On comparing the merit number of n_Hexane with that of other fluids, it is found that it is quiet higher than some fluids such as CCl_5,C_2H_5OH,CH_3OH. So a heat pipe with hexane as working fluid had been designed fabricated and tested for its performance.

TEST HEXANE HEAT PIPE

The test heat pipes were fabricated with stainless steel and copper as container material with a bore of 38 mm, 40 mm respectively and 700 mm in length. Wrapped screen wick structure with one layer of 120 mesh screen was selected as capillary structure. The length of the evaporator and condenser were 100mm respectively and the adiabatic length was 500 mm. Heat pipe design details are shown in table –1. The angle of tilt was $6^o$to the horizontal.

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Table : 1

Working fluid	Hexane (40g)	
Container material	Copper	Stainless steel
Overall length	700mm	700mm
Evaporator	100mm	100mm
Condenser	100mm	100mm
Adiabatic	500mm	500mm
Diameter	40mm	38mm
Wick material	Stainless steel-120mesh-one layer	Stainless steel-120mesh-one layer

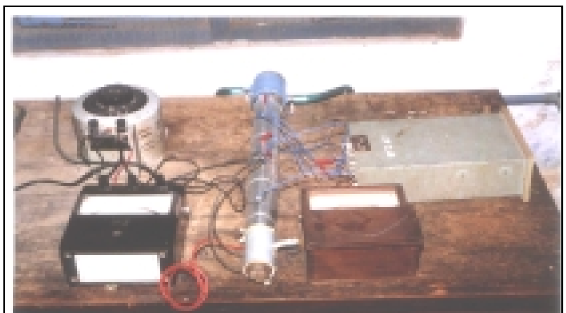

Fig-1. Experimental setup

Schematic diagram of experimental set up is shown in Fig-1. Heat pipe had thermocouples attached to their external surfaces to estimate the axial heat conduction and the thermocouples inserted in container in order to measure the hexane vapour temperature. The inlet and exit temperature of the condenser water were also measured using thermocouples. Copper Constantan thermocouples with a nominal accuracy of 0.5°C was used. The evaporator of heat pipe was fitted with an electrical resistance heater that was fixed permanently to the pipe.

TESTING OF HEAT PIPE

Performance tests were conducted for different heat input and different flow rate of cooling water in the condenser. Heat input were tried for 90W,100W,110W,&120W. The flow rate of water were kept at 0.1kg/min and 0.13 kg/min for each case. Vapour temperature in the adiabatic section, coolant inlet and exit temperature, and container wall temperature were measured and recorded. Table 2-5 Axial heat conduction through container was estimated. The net heat transferred was determined from the condenser fluid temperature difference and flow rate. The efficiency of the heat pipe to the given heat inputs were found out and reported.

Table-2
Container : Copper m_w = 0.13 ml/min

Input in W	Temperature in °C T_1	T_2	T_3	Q_{max}	η in %
90	85	85	83	51.1	56.73
100	90	90	85	60.0	60.0
110	92	92	90	78.0	70.93
120	97	97	94	105.0	87.29

Table-3
Container : Copper m_w = 0.10ml/min

Input in W	Temperature in °C T_1	T_2	T_3	Q_{max} W	η in %
90	85	85	83	24.3	27
100	90	90	88	45.23	45.23
110	94	94	92	58.71	53.37
120	98	98	96	93.83	78.19

Table-4
Container: Stainless steel m_w = 0.13 ml/min

Input in W	Temperaturein °C T_1	T_2	T_3	Q_{max} W	η in %
90	89		83	72.19	80.21
100	92		90	81.3	81.3
110	94		92	108.5	98.64
120	98		92	117.6	98.01

Table – 5
Container: Stainless steel m_w = 0.10 ml/min

Input in W	Temperature in °C T_1	T_2	T_3	Q_{max}	η in %
90	90		85	62.42	69.36
100	90		89	83.41	83.41
110	92		90	104.3	94.86
120	97		94	118.3	98.36

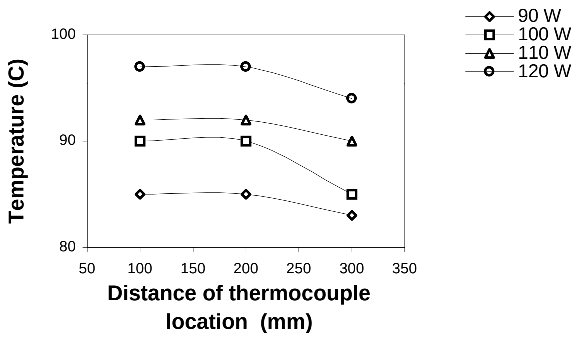

Fig-2 Temperature distribution of Adiabatic section for Cu-SS heat pipe m_w =0.13 ml/min

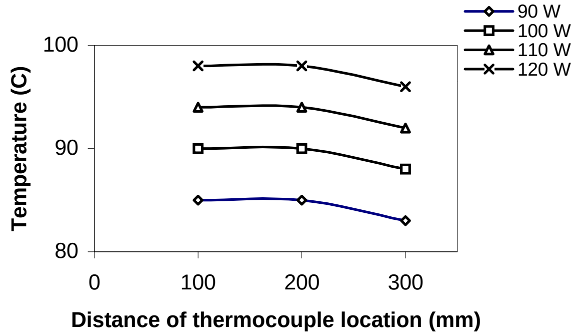

Fig-3 Temperature distribution of adiabatic section for Cu-SS heat pipe m_w=0.1 ml/min

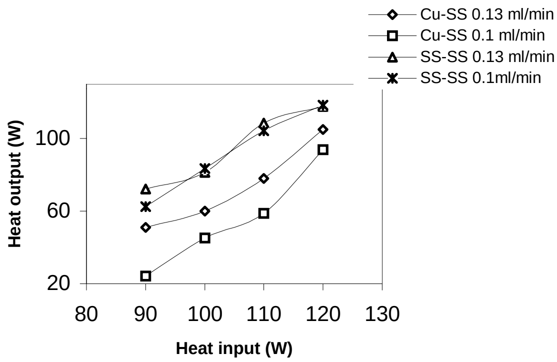

Fig-4 Heat output Vs heat input for various flow rate

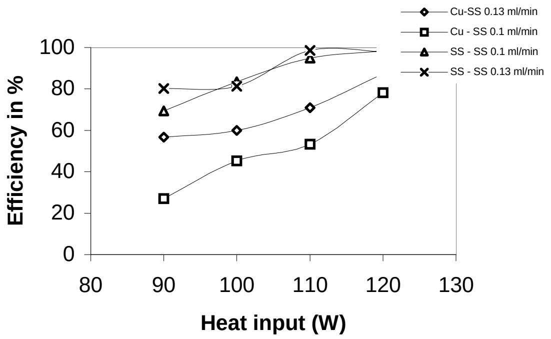

Fig-5 Efficiency curve for various heat pipes

RESULTS AND CONCLUSION

Fig 2 & 3 gives the temperature distribution along the adiabatic section for the Cu-SS heat pipe. As it has been reported in the literature [1]&[2] the temperature drop in the adiabatic section is within the limit of 5^oC in both the cases. Since one thermocouple fails to respond in the cases of SS-SS heat pipe, temperature plot has not been plotted. However from the table 4 & 5 it is clear that the temperature drop is also within the limit. Fig – 4 gives the heat output for various input of all the heat pipes. Fig – 5 clearly shows that the SS-SS heat pipe is having higher efficiency compared to the other pipe. Also the test result reveals clearly that the n_Hexane can be used as a working fluid in the heat pipes. Life test of this heat pipe have to be taken up to study about the compatibility of the working fluid & container materials. Even some more combination of container and wick materials could be taken up to study the performance of heat pipe with n_Hexane as working fluid as future work.

REFERENCE

Chi.S.W.1976 “Heat Pipe Theory Practice”, McGraw Hill, New York.

Dunn PD and Reay D.A “Heat Pipes” Third edition May, 1982 Pergamon Press