Experimental Investigation of Water-Stainless Steel Heat Pipes

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Abstract. *Heat pipes are a closed tube or chamber of different shapes whose inner surfaces are lined with a porous capillary wick. The wick is saturated with the working fluid, able to transport large quantities of heat with little temperature difference between the evaporation and condensation sections, presenting a highly efficient heat transfer process. This work aims to present experimental results of heat pipes operation designed and manufactured in stainless steel and using water as working fluid, operating at temperatures up to 200 ^oC destined for industrial applications.*

Keywords: Heat Pipes, Thermal Control, Industrial Application.

1. Introduction

Basically heat pipes are built by three components: The external enclosed structure (container), the working fluid and wick structure. Capillary pressures in heat pipes tends to be higher as while as pores of wick structure goes smaller, on the other hand, larger pores are preferred so the liquid movement within wick structure will not be greatly restricted. There are three most relevant wick properties to be check out during the concept design phase: Minimum capillary radius, permeability and effective thermal conductivity so that each chosen mesh of wick structure will bring different challenges and results in terms of their capillary limit, boiling limit, entrainment limit, vapor pressure limit, etc [FAGHRI, 1995; PETERSON, 1994; CHI, 1976].

2.Metodology

The laboratory tests were conducted with the test bench with the heat pipes was placed with no inclination (0°), the heat was applied to the evaporator by a controlled electric heater. Upon using the testing power cycles, the heat source was applied to each heat pipe to observe, at first, the start-up effect. Once the temperatures for the start-up power have reached stability, power was changed according to the testing profile, following the sequence to temperature stabilization.

3. Results and Discussion

With the tests performed for the power cycles of 25, 50, 75, 100 and 125 W (Table 1) it was possible to verify the temperatures along the heat pipes to obtain the temperature profile for cycle 2 (Figure 1a), where the heat pipes have their startup with the power of 125 W, and check the capacity of each heat pipe in supporting the different power to the steady state condition. For a better analysis cycles, the thermal conductivity was calculated for HP1, HP2 and HP3, using the experimental results obtained with 5 cycles shown in Table 1.It is defined as the ratio of the heat applied (Q) to the device by the temperature difference between the evaporator (T_e) and condenser (T_c), being given by the following relation (with uncertainties below 10%):

Table 1. Test Cycles.

Cycle 1	50 W - 100 W - 75 W - 125 W - 25 W
Cycle 2	125 W - 50 W - 100 W - 25 W - 75 W
Cycle 3	100 W - 25 W - 50 W - 75 W - 125 W
Cycle 4	75 W - 125 W - 25 W - 100 W - 50 W
Cycle 5	25 W - 75 W - 125 W - 50 W - 100 W

$$G = \frac{Q}{T_e - T_c} \quad (1)$$

Figure 1b presents the results of the thermal conductance obtained from Eq. (1) for a better analysis of the heat pipes thermal operation. With the results for thermal conductance, the HP2 presented higher thermal conductance at all cycles compared with HP1 and HP3 due to low temperature differences between the evaporator and the condenser. The highest thermal conductivity was 19 W/°C obtained where the heat pipes have your startup with the power of 125 W operating at zero degree.

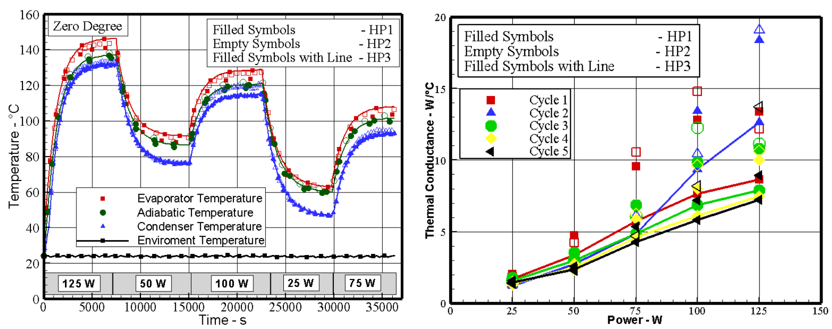

Figure 1. (a) Temperature profiles, (b) Thermal Conductance for HP1, HP2 and HP3

4. Conclusion

Following the presented data, the conclusions that can be obtained from this investigation are the folowing:HP3presented higher thermal conductance compared to HP1 which was somehow expected, based upon the temperature profile graphs demonstrated in the Figure 1; HP2 presented higher conductance values from 75W and above due to lower end to end temperature drop between the evaporator and the condenser in this region already mentioned in the temperature profile graphs;

References

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