DESIGN AND DEVELOPMENT OF TEST-RIG TO EVALUATE PERFORMANCE OF HEAT PIPES IN DIFFERENT ORIENTATIONS FOR MOULD COOLING APPLICATION

Ms.M.M. Shete¹, Prof.Dr.A.D.Desai²

¹PG Student in Heat power Engineering, Modern College Of Engineering, Pune University, India, email-meghashete1@yahoo.co.in

²Professor in Mechanical Engineering, Modern College Of Engineering, Pune University, Pune, India

ABSTRACT

Heat pipes are enclosed, passive two phase heat transfer devices. They make use of the highly efficient thermal transport process of evaporation and condensation to maximize the thermal conductance between a heat source and a heat sink. They are proven to be very effective, low cost and reliable heat transfer devices for applications in many thermal management and heat recovery systems. In this paper the total heat transfer of heat pipes in different orientations with different flow rate to mould cavity has been investigated experimentally. There are three orientations of heat pipe horizontal, vertical and inclined. It is found that the total heat transfer in case of heat pipes in horizontal, vertical and inclined orientations 18.65 watt, 23.60 watt and 38.83 watt respectively. The objectives of the present work are to study the new design of heat pipe for mould cooling application.

Keywords: Heat pipe, horizontal orientation, vertical orientation, inclined orientation

I. INTRODUCTION

A heat pipe is a simple device that can quickly transfer heat from one point to another. They are often referred to as the "superconductors" of heat as they possess an extra ordinary heat transfer capacity & rate with almost no heat loss. The idea of heat pipes was first suggested by R.S.Gaugler in 1942. However, it was not until 1962, when G.M.Grover invented it that its remarkable properties were appreciated & serious development began. It consists of a sealed
aluminum or copper container whose inner surfaces have a capillary wicking material. Heat pipes have an effective thermal conductivity many thousands of times that of copper. The heat transfer or transport capacity of a heat pipe is specified by its "Axial Power Rating (APR)". It is the energy moving axially along the pipe. The larger the heat pipe diameter, greater is the APR. Similarly, longer the heat pipe lesser is the APR. Heat pipes can be built in almost any size and shape.

Figure 1 illustrates working of heat pipe. Inside the container is a liquid under its own pressure, that enters the pores of the capillary material, wetting all internal surfaces. Applying heat at any point along the surface of the heat pipe causes the liquid at that point to boil and enter a vapor state. When that happens, the liquid picks up the latent heat of vaporization. The gas, which then has a higher pressure, moves inside the sealed container to a colder location where it condenses. Thus, the gas gives up the latent heat of vaporization and moves heat from the input to the output end of the heat pipe.

Injection moulding and Die-casting moulds are cooled by the conventional water jacket method, where in water jackets or runners are provided all around the mould to effect the cooling. Mould cooling is absolutely essential considering the quality of parts and cycle time. The conventional water jacket method used in conjunction with bubbler, baffles, fountains or blades offers many disadvantages. Heat Pipe is a heat transfer device specifically designed for optimal performance in plastic injection molds and dies for the die casting industries. The Heat Pipe consists of a vacuum-tight tube containing a wick and a non-toxic working fluid. The two ends of the Heat Pipe perform distinct functions – one end is an evaporator, the opposite end is a condenser. Thermal energy is gathered at the evaporator end, vaporizing the working fluid. This vapor then travels through the Heat Pipe to the condenser end. At the condenser end the vapor condensates back into a liquid, giving up its latent heat in the process. To complete the cycle the condensed liquid then travels along the wick, via capillary action, back to the evaporator section. This process repeats itself continuously, transferring heat many times faster than pure copper.

Heat pipes are available in two temperature ranges. Heat pipes having temperature range from +5 °C to + 200 °C. The main applications of these types of heat pipes are in injection moulding, compression / transfer moulding and rotation moulding. Heat pipes having temperature range from +5 °C to + 350 °C. The main application of these types of heat pipes is in die-casting,
plastic moulding. It is advisable to order the heat pipes suitable to the applications temperature range. If the heat pipe gets heated above its operating temperature, it releases a small amount of non-toxic gas and becomes inoperative. The material of construction is either Copper or Stainless Steel.

II. OBJECTIVE OF OUR WORK

To design and development of test-rig to evaluate performance of heat pipes in mould cooling applications installed in different orientations namely; horizontal orientation, inclined orientation, vertical orientation. To find heat transfer rate of heat pipe and effectiveness of heat pipe. The trial is conducted on the heat pipe system to determine the temperature difference at cold water outlet and cold water inlet for three orientation i.e. horizontal orientation (heat pipe placed in 0° orientation), inclined orientation (heat pipe installed in inclined direction), vertical orientation (heat pipe installed in 90° orientation).

III. EXPERIMENTAL SET-UP DESCRIPTIONS

The experimental set up includes mould cooling apparatus with the heat pipe installed in the horizontal orientation, the mould cooling apparatus with the heat pipe installed in the Vertical orientation mould cooling apparatus with the heat pipe installed in the Inclined orientation, casing, mould cavity, heater and water flow control valve. The photograph of experimental set-up is shown in figure 2.
IV EXPERIMENTAL RESULT ANALYSIS

Using the data obtained from theoretical analysis and experimental results graph of mass flow rate versus temperature difference has been plotted.

Figure 2: Photograph of experimental set up

Figure 3: Mass flow rate vs temperature difference for heat pipe in different orientations
From the graphs of temperature difference between water outlet temperature and water inlet temperature versus mass flow rate for heat pipe in different orientations it is noticed that the temperature difference for heat pipe in inclined orientation is greater as compared to temperature difference for heat pipe in vertical and horizontal orientation. From the graph between temperature difference versus mass flow rate for heat pipes in different orientation we see that the temperature difference for heat pipe in inclined orientation is $30.6^\circ C$ and respective mass flow rate is $0.0078$ kg/sec. The temperature difference for heat pipe in vertical and horizontal orientations is $18.6^\circ C$ and $14.7^\circ C$. For the mass flow rate $0.014$ Kg/sec the temperature differences between water outlet temperature and water inlet temperature for heat pipe in inclined orientation, heat pipe in vertical orientation and heat pipe in horizontal orientation are $25.6^\circ C$, $14.4^\circ C$ and $11.5^\circ C$. For the mass flow rate $0.0265$ Kg/sec the temperature differences between water outlet temperature and water inlet temperature for heat pipe in inclined orientation, heat pipe in vertical orientation and heat pipe in horizontal orientation are $16.5^\circ C$, $9.4^\circ C$ and $3.5^\circ C$.

Figure 4: Heat transfer vs temperature difference for heat pipe in different orientations

From the graphs of temperature difference versus heat transfer for heat pipe in different orientations it is noticed that the heat transfer rate for heat pipe in inclined orientation is greater as compared to heat transfer rate heat pipe in vertical and horizontal orientation. From the graph between temperature difference versus heat transfer rate for heat pipes in different orientation we
see that the heat transfer rate for heat pipe in horizontal orientation is 18.65 watt at temperature difference of 14.7 °C, for heat pipe in vertical orientation heat transfer rate is 23.60 watt at temperature difference of 18.6 °C and for heat pipe in inclined orientation the heat transfer rate is 38.83 watt at temperature difference of 30.6 °C. The heat transfer rate for heat pipe in horizontal, vertical and inclined orientation is 14.59 watt, 18.27 watt and 32.48 watt for respective temperature difference of 11.5 °C, 14.4 °C and 25.6 °C.

V CONCLUSION

Some key findings of the theoretical and experimental analysis of heat pipe system are as follows:

1. The experimental results indicated that total heat transfer in case of heat pipe of in horizontal orientation is 18.65 watt. The total heat transfer in case of heat pipe in vertical orientation is 23.60 watt. The total heat transfer in case of heat pipe in inclined orientation is 38.83 watt.
2. It is seen that the heat transfer enhancement of heat pipe in inclined orientation is more when it is compared with other two heat pipes in horizontal and vertical orientations. Heat pipe in inclined orientation is 2.08 times effective than heat pipe in horizontal orientation and 1.64 times effective than heat pipe in horizontal orientation.
3. It is seen from the graph that at 0.0078 kg/sec the temperature difference is 30.6 °C which is the highest.

VI FUTURE SCOPE

Experimental test is conducted to evaluate performance of heat pipes in different orientations. By changing the heat pipe material, dimensions of heat pipe better heat transfer rate can be achieved.

REFERENCES