

Effect of Different Parameter on the Performance of Heat Pipe Heat Exchanger

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Abstract - The thermal management of electronic device or any other thermal device is very important to avoid its malfunctioning. The HPHX is widely used for thermal management in the electronic as well as cryogenic application because of its special features like light weight, low cost of manufacturing, simple structure and most important is the rate of heat transfer which is several hundred times higher than that of other heat exchanger. The heat pipe works on the principle of both phase transition and thermal conductivity to transfer the heat from evaporator to condenser section. In this paper the effect of inclination angle of heat pipe heat exchanger with the horizontal, filling ratio, addition of nano particle in the working fluid, incorporation of fins on the heat pipe heat exchanger have been discuss.

Keyword- Heat pipe heat exchanger, filling ratio, nano particle

I. INTRODUCTION

Thermal management of electronic device or any other thermal devices is very important to avoid malfunctioning of it [2]. To manage the heat dissipation or to transfer the heat from source to sink with a proper device and in optimal way is very important. The heat pipe heat exchanger is one of the compact heat exchanger having multiple advantages which is widely being used for heat dissipation in the electronic device as well as other high temperature thermal devices. The concept of modern heat pipe were first suggested by R.S. Gaugler of General Motors in 1944[1], who patented a light weight heat transfer instrument and added the idea of wick to make the inner fluid returns back to the evaporator instead of gravity but he did not develop it further. In 1963 George Grover independently developed capillary based heat pipes a Los Alamos National Laboratory with his patent of that year being the first to use the term Heat Pipe, and he is often referred to as 'The inventor of the heat pipe'[1]. The heat pipe heat exchanger is widely use in the space and in the cryogenic application because of its special features like it is compact in nature, no electricity is required to function the heat pipe heat exchanger, easy to manufacture, cheaper to manufacture, and no moving parts are there in the HPHX. As the size of the heat pipe heat exchanger is very small the material cost to manufacture it is reduces, the rate of heat transfer is very easy as compared to other types of heat exchanger[5]. The only disadvantage of the heat pipe is that it get dried out if the source temperature rises than that of designed temperature.

II. CONSTRUCTION AND DEATIL OF HPHX

The HPHX combine the principle of thermal conductivity and phase transition to transfer the heat between two solids interfaces. This is the thermal device which is capable of transferring heat and energy several hundred times than the other heat transfer device. Convectional HPHX is the hollow cylinder which is partially filled with working fluid and then sealed at both the ends. The working fluid and material of HPHX should be compatible with each other eg. If the material of HPHX is copper then working fluid in it should be water and if it is aluminium then the working fluid should be ammonia. If both material and working fluid are not compatible then it might react with each other and may cause oxidation and hence HPHX won't work efficiently.

The detail of HPHX is given in the fig. 1.

It consist of

1. Evaporator or high temperature section where the heat is absorb from the source.
2. Adiabatic section where the outer surface of heat pipe is insulated so that no heat can transfer from the surrounding to the heat pipe or vice versa.
3. Condenser section, where the heat transfer by heat pipe heat exchanger to the sink. It is also called as low temperature section.

At the inner surface of adiabatic section of heat exchanger the mesh is provide which is made up of same material as that of the material of HPHX. The function of wick is to return the liquid fluid from condenser to the evaporator section.

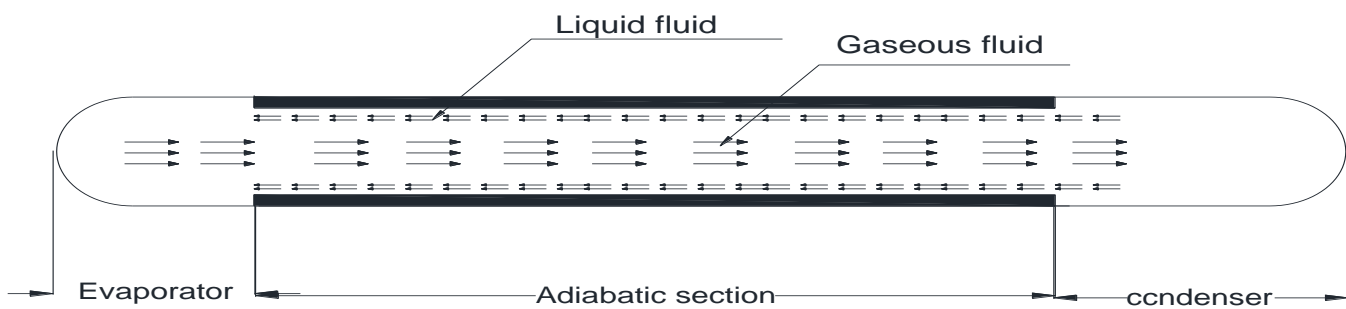


Fig. 1. Working and construction of HPHX

III. MECHANICS OF HEAT TRANSFER

The HPHX work on the principle of both phase transition and thermal conductivity to transfer the heat from the source and liquid in the evaporator section gets vaporized. Once the liquid vaporize it travels along the axis of the tube to the condensers section through adiabatic section. In the condenser section the heat delivered to the sink and the vapor gets condenses and changes the phase from gaseous to the liquid. Once the vapor get condense the liquid fluid flows to the evaporator section with the gravity or with the capillary action through the wick.

IV. EFFECT OF DIFFERENT PARAMERES ON THE PERMORMANCE OF HEAT PIPE

There are some parameters which causes the effect on the performance of heat pipe heat exchanger

A. Effect of wick structure:

The heat pipe can have wick or it can be wickless. Wick is the mesh structure which is use for the return of the fluid from condenser to evaporator section.

It has found that the heat pipe without wick structure shows better performance than that of with wick.

From the study of Lianying zhang, "Experimental investigation of gravity heat pipe exchanger applied in communication base station" it has been found that the gravity heat pipe exchangers used for cooling the communication base station showed the better performance when it is work on gravity [4]. After a several use of heat pipe the wick structure may get block because of deposition and heat pipe may not work efficiently.

B. Effect of incorporation of nano particle in the working fluid.

The performance of heat pipe can enhance with the addition of nano particle in the working fluid. The nonoparticle increases the rate of heat

transfer by heat pipe from evaporator to condenser section [5].

The mass concentration of the nano particle affect on the performance of heat pipe with the power input[6].the main disadvantage of using the nanoparticle in the heat pipe is that after the several use of heat pipe heat exchanger the nano particle start depositing on the inner surface of the heat pipe and on the wick structure. This causes the blockage of the mesh and hence by using the working fluid with nano particle the performance of heat pipe reduces with the several use[7,8].

C. Effect of inclination angle :

The angle of inclination of heat pipe affect on the performance of it, from the literature survey it has found that the heat pipe work efficiently for the angle 30 to 60 degree with the horizontal [6,7,8]

D. Effect of filling ratio

The filling ration does affect on the performance of heat pipe, the heat pipe gives the best performance when the filling ratio is 20% to 30%[9]

V. CONCLUSION

The thermal management of electronic device or any other thermal device is very important to avoid its malfunctioning. The HPHX is widely used for thermal management in the electronic as well as cryogenic application because of its special features like light weight, low cost of manufacturing, simple structure and most important is the rate of heat transfer which is several hundred times higher than that of other heat exchanger.

From the literature survey it has been found that the heat pipe heat exchanger shows better performance when

- The nano particles added in the working fluid which gives the better heat transfer rate than that

- of without nano particles at same working conditions.
- b. Previous study shows that the performance of heat pipe varies with the inclination angle with the horizontal. The pipe shows the better performance when angle of inclination with the horizontal 30 to 60 degree.
- c. Filling ratio ie volume of working fluid to the volume of heat pipe, when it is around 20 to 30 % it shows the best performance.

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