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Experimental Analysis of Heat Pipe by Using Different Working Fluids

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ABSTRACT: The heat pipe is a simple heat conveying system with very high thermal efficiency. Because of its advantages such as simple structure, high versatility, and lightweight heat piping, they find a wide variety of heat dissipation applications. Heat pipe cooling, air temperature renewal, Western heat recuperation from exhaust gases, etc. are some applications. In order to assess the thermal tube efficiency, an attempt is being made to analyze a thermal tube with various parameters such as fill ratio, focus, and working fluid. The heat pipe, commonly known as a heat exchanger whose basic purpose is centered on a fluid-changeable phase. Capillary action is used for the fluid circulation within the vent. Air, acetone, methanol, and others are the working fluid medium used. The heat pipe process must be analyzed using parameters including temperature, pressure, condensation evaporation, etc. The above-mentioned parameters are examined theoretically and experimentally in the sense of current experimental evidence.

I. INTRODUCTION

Nowadays, the requirements of the world's quick heat transfer are rising quite rapidly. At the hot side of a heat pipe, working fluid in contact with a thermal conducting solid surface becomes a vapour, because of the temperature difference, by absorbing latent heat from that surface. Owing to a pressure difference, a density difference, and condensation, the vapour passes through the heat pipe to the other side of the heat tube. Through the capillary effect, pressure differential, gravity and cycle the fluid are returned to the hot side. Due to the high coefficients of heat transfer for boiling and condensing, heat pipes for heat transfer are especially powerful. Efficient thermal conductivity can vary from 100 kW / mK (35 kW / mK) for long heat pipes to roughly 100 kW / mK.For copper, 0.4 kW/(mK) [1].

Heat pipes are used because of their easy building, high versatility and compactness for the transfer of heat to a different range. Heat is absorbed by evaporation on one end of the heat pipe. The working fluid is transformed into a vapour shape by absorbing the heat and travels to the opposite side because of the difference of temperature and pressure. Vapour moving the other end of the heat pipe heat extracts heat and begins the phase condensation of the working fluid on the second end of the heat pipe vapour. The fluids are converted vapour to liquid during the condensation process, and this fluid travels with the aid of wick to another side [2].

Heat piping consists of a screened vacuum pipe or a material consistent with working fluids and materials such as acetone, copper is suitable for the use of methanol- methane water, aluminium nickel and steel are suitable for ammonia. For sucking the air out of the empty heat pipe a vacuum pump is used. And afterwards, the liquid was partially filled and sealed. The heat pipe is calculated so that vapour and liquid are present over the operating tempo [3].

1 Working of Heat Pipe

In the heat pipe, heat is absorbed by the evaporator at one end of the heat pipe. The heat absorption converts the working fluid into a type of vapour and transfers to the other part due to the difference in density and pressure. Latent heat is removed from the central heat tube on the side of the vapour on the condenser, which is the other end of the heat tube. During the condensation phase, fluids are converted into fluid vapour, which with wick materials is going on to another side. During the thermal pipe phase, various areas such as the evaporation area, adiabatic area and condensation zone are present [4].

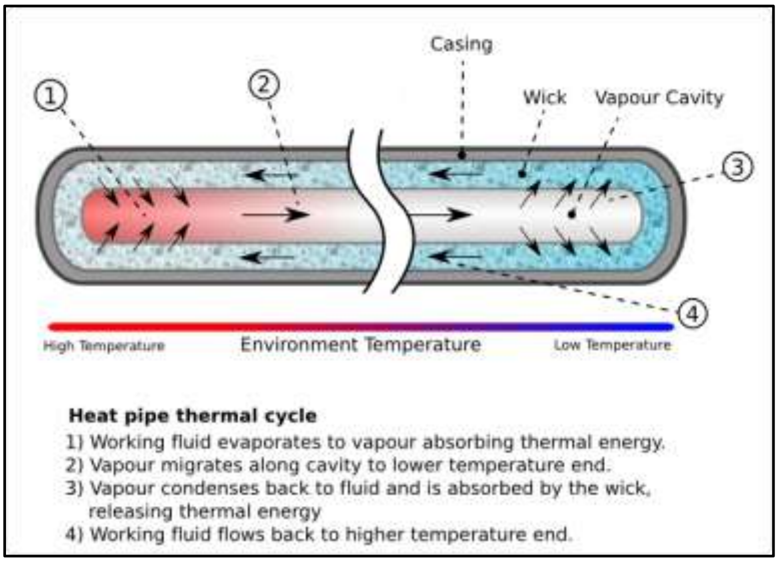

Figure 1: Components and Mechanism for a Heat Pipe

The heat from the hot interface and the saturated work fluid vaporised phase change is absorbed by the evaporation zone and transferred into the condenses zone, where the heat is lost and the evaporator zone with the help of saturated liquid materials is reverted to the evaporator zone. The latent heat is released into the condensation region and transferred from the saturated vapour to a saturated liquid shape. HP is used as heat is moved from one spot to another. For the transmission of heat from a chipset to an external heat sink, the example is the electronics device [5].

This paper refers to study the existing problems of heat pipe like gas generation, corrosion, material transportation etc. and give a probable solution of regarding problems.The Objectives of this research is to enhance the heat transfer performance of heat pipes using the different working fluids with the theoretical and experimental analysis.

II. METHODOLOGY

2.1 Apparatus

The Experimental Apparatus design enables a vertically suspended wing structure to lift work fluid, which is water from the internal liquid pool to the heated area where the fluid is evaporated in all cases considered for this article. The vapour then moves on the inner surface of the external cylinders wall to condensing areas where heat is thrown away and the vapour condenses. The condensates that develop along the walls are deposited in the annulus. The weight and height of the additional water in the annulus were determined in the mass approach. The cross-sectional area was determined based on the density of water. The volume and height of the additional water were determined in the volume-based method, then divided into the cross-sectional area. For calculating condensate volume, the average cross-sectional area calculated by these two methods was used. Using the set holder to tighten the HP.

2.2 Working Fluids and TemperatureRanges

Table 1 lists several widely used working fluids, their melting and burning points at atmospheric pressure and their useful ranges. Each HP application has a specific temperature range under which HP must function [6-7].

Table 1: Working fluids and Temperature ranges of Heat Pipes

Working fluid	Melting point, K at 1 atm	Boilingpoint, K at 1 atm	Usefulrange, K
Methane	90.6	111.4	91-150
Ethane	89.9	184.6	150-240
Freone 21	138.1	282.0	233-360
Acetone	180.0	329.4	273-393

Water	273.1	373.1	303-350
Sodium	371.0	1151	873-1473
Silver	1234	2485	2073-2573

In a HP, type of material and working fluids selection is major factor be- cause, some materials are not compatible with all working fluids due to some chemical properties. So, choose the which type of material is compatible with working fluid [8].

Table 2: Experimental Compatibility of Material and Working Fluids

Working fluid	**Compatible Material**
Water	Stainless Steel, Copper, Silica, Nickel, Titanium
Ammonia	Aluminium, Stainless Steel, Iron, Nickel
Methanol	Stainless Steel, Iron, Copper, Brass, Silica, Nickel
Acetone	Aluminium, Stainless Steel, Copper, Brass, Silica
Freon 21	Aluminium, Iron
Sodium	Stainless Steel, Nickel, Niobium
Silver	Tungsten, Tantalum

2.3 Working FluidSelection

Working fluids selection process is most important method of HP. In this method working fluid is selected with the help of compatible material table. From thetable we identified that material and working fluids. For selection of working fluids, the meritnumbermethodisusedmeritnumberisidentifyth atwhichworkingfluidhave moreefficientbytheoreticalcalculation.Ifmeritnumbe rishighofthefluidithasa more efficiency compare to other. Formula of merit number is givenby the following expression [9].

Merit number = $(\rho\sigma hfg/\mu)$ (1)

1.4 Capillary Wick Designs andStructures

2.4.1 CapillaryDesign

A fluid-filled porous structure provides solid-liquid-vapor contact lines in the intersti- tialvolumes between the solid particles where large capillary forces can be developed frominterfacialtensions.Liquidcanbedrawn through porous media as a result of these capillary forces. This relationship, referred to as the capillary limitation, can be expressed mathematically asfollows [10].

$$\Delta P_{max} = \Delta P_{liq} + \Delta P_{vap} - \Delta P_{hyd} \quad (2)$$

2.4.2 WickStructure

The condensed fluid from condenser to the evaporator is returned from Wick Structure. When small pores in the HP are required for the design of high capillary pressures on the liquid-vapour interface, large pores are taken into the wick structure so that fluid movement is not limited too strongly.There are 3 properties of wicks that are important in HP.

Effective thermal conductivity: If large value of this parameter gives small temp drop that is most effective condition of HP?

Minimum capillary radius: This parameter for a long HP should be less if a large capillary pressure difference is necessary, in such types of problems when evaporator above the condense.

Permeability: This parameter should be large in order to have a small liquid pressure drop. Different Homogeneous Wick Structure is Show in figure.

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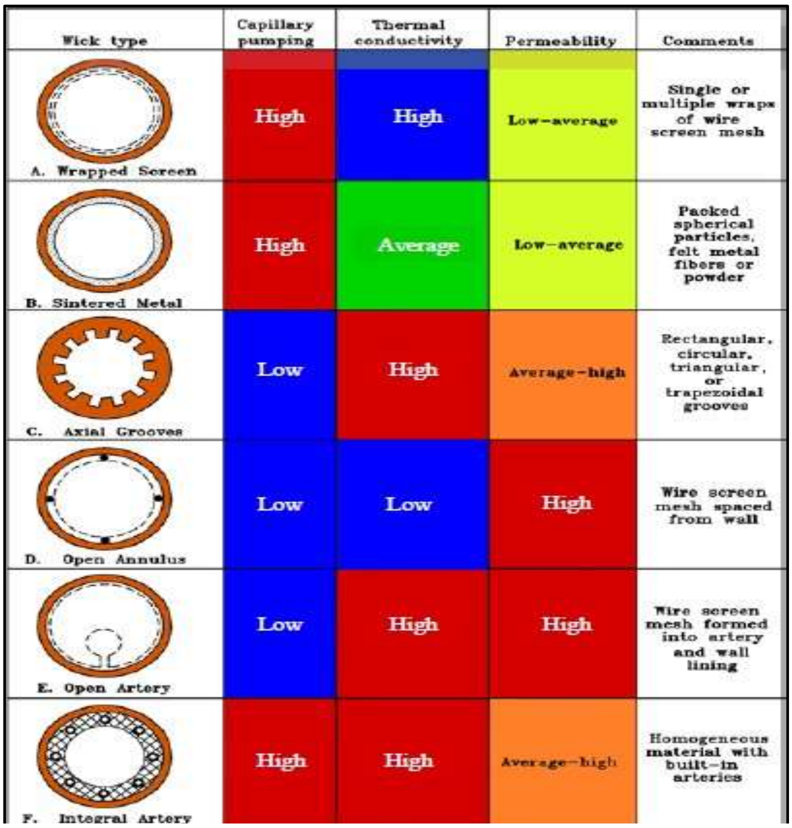

Wick type	Capillary pumping	Thermal conductivity	Permeability	Comments
A. Wrapped Screen	High	High	Low-average	Single or multiple wraps of wire screen mesh
B. Sintered Metal	High	Average	Low-average	Packed spherical particles, felt metal fibers or powder
C. Axial Grooves	Low	High	Average-high	Rectangular, circular, triangular, or trapezoidal grooves
D. Open Annulus	Low	Low	High	Wire screen mesh spaced from wall
E. Open Artery	Low	High	High	Wire screen mesh formed into artery and wall lining
F. Integral Artery	High	High	Average-high	Homogeneous material with built-in arteries

Figure 2: Typical Homogeneous Wick Designs

III. CONCLUSION

The various types of HP and Wick Structures and Working Fluids used in thermal pipes can be justified here. The consistency with the respective wick materials is evaluated. For acetone, methanol, ethanol and so on, the maximum HT is higher. The angle of tilt affected wall temperatures in the wickless HP significantly. For all of the HPs with water, methanol, ethanol, acetone, this effect has been observed. To validate changes needed for the heat pipe in the current years during its formation.

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