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Experimental Analysis of Twin Mode Heat Transfer on Rotating Heat Pipe

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***Abstract* — The analysis is done in the heat pipe with the new installation of an active and passive technique. The heat transfer rate have been improved under the working state with the working fluid of ammonia in aluminium heat pipe. The operating temperature is maintained below 80^{0}C as a moderate level, so that the pressure loss can be neglected. The experiments were conducted with rotation active technique and stand still conditions of inserts passive technique. From the experimental observation the results were plotted and the improvement in heat transfer due to the rotation of heat pipe is justified and discussed.**

***Keyword:* Aluminium Heat Pipe, Rotating Technique, Twisted Tape Inserts, Over-all Heat Transfer.**

I. INTRODUCTION

Whenever, there is a temperature difference occurs between the two conduction and non conducting surface there is exchange between the two surface either by conduction or by convection. The heat pipe will have the tendency to increase the thermal heat transfer rate of the material. This can be reached by minimizing the pressure loss and increasing the heat power in the pipe. In the current scenario, the heat exchanger in exhaust system is the newest technology to reduce the waste heat and recovering the availabilty of energy is commonly known as exergy. The heat transfer rate will be maximum at passive mode of heat transfer because of the heat transfer co-efiicient 'h' improves the rate of heat transfer over the surface.

A.Passive Mode

The secondary flow on the heat pipe fluid is made by fixing the inserts into it. This permises the swirl flow of the working fluid alternatively increasing the heat transfer during the phase changing process. The different geometric shapes of the inserts were commonly used are Twisted tape, Helical vane, static mixer etc.,

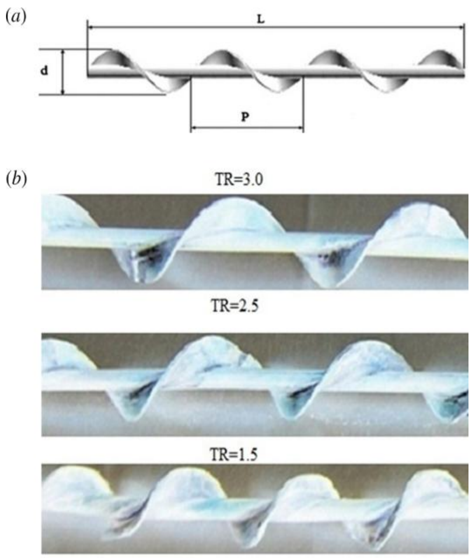

Figure 1. Twisted Inserts

The displaced inserts are the devices into the flow channel which improves the energy transmission the spaced disk insert and space streamline inserts were functioning by mixing it in the main flow of the fluid with the wall region transmission but in the wire coil inserts only the main flow fluid mixing alone which inhibits and eliminating the loss of heat transfer in the wall region.

B.Active Mode

The active technique involves the heat transfer is done by the external source. This is achieved by the surface vibration, electrostatic field, jet impingement etc., among them the mechanical aid by the rotation of the heat pipe through the external supply of induction motor. This creates the rapid kinetic moment on the working fluid which improves the rate of the heat transfer by external cause.

C.Hybrid Mode

In this method the combined state of the active and the passive techique is used to increase the over all heat transfer rate by decreasing the area. The attainment of the thermal equilibrium state on the shaft at aerospace application were improved by this hybrid mode. The time to reach the thermal equilibrium is simply made easy by this twin mode implementation. The construction of the pipe is made quite easier only by chosing the combination of two techique in adoptable manner. Thus the recent development on obtaining the thermal equilibrium is rapidized only by hybrid mode.

II. Over-all Heat Transfer Co-efficient

From the first law of thermodynamics that the quantity of the heat can be transferred from the heat zone to the cold zone has been calculated. The over all heat transfer rate has been measured only after the setup is made after reaching the steady nature of gradual decreasing or increasing of the temperature line up on utilisation of turbulence and mechanical aid of the working fluid. Now, the overall heat transfer co-efficient of the heat pipe can be calculated by the following equation.

$$\mathbf{U} = \frac{Q}{A\,\Delta Tlm} \qquad \text{(II.1)}$$

Where,

ΔT_{lm} – is the Logarthemic mean temperature

$$\Delta T_{lm} = \frac{(T1-t2)-(T2-t1)}{ln\frac{(T1-t2)}{(T2-t1)}} \qquad \text{(II.2)}$$

T_1 – Temperature at Evaporator

T_2 – Temperature at Condensor

t_1 - temperature at Adiabatic Inlet

t_2 - temperature at Adiabatic Outlet

For the working fluid on the heat pipe is chosen that the following properties were creamed for the phase change mechanism during the rotation of the heat pipe and Turbulence action by twisted tape. so that, the heat transfer enhancement on the heat pipe is evaluated for the analysis using Ammonia solution with respect to their property explained in the Tabulation.

Tabulation I Properties of Ammonia Solution

S.No	Description	Value
1.	Liquid Density	935.6kg/m^3
2.	Boiling Point Temperature	-33.3^{0}C
3.	Specific gravity	0.6
4.	Operating Temperature Range	0-100^{0}C
5.	Specific Heat Capacity	4.91 kJ/mol.K
6.	Chemical Formula	NH_3
7.	Molecular Weight	17.03g/mol
8.	Latent Heat of Vapourization	1369.5kJ/kg

These are the criterias for chosing ammonia as a working medium for the aluminium heat pipe for biactionary mode of operation.

III. Experimental Setup

This setup has an arrangement of following sections as follows

A. Heat Pipe.

It is a device which works under the condition of lower temperature gradient for transmitting the heat. It is also known as the thermal super conductor. In most of the industries will have the exhaust temperature from their output is lower then the moderate level of temperature at 100^{0}C. So that the heat pipe is chosen for the operation to bring more effectively with reduced pressure drop, high heat transfer rate and in the economic range. Therefore, the Aluminium material is chosen for the heat pipe where it is economic and the thermal stability of the heat pipe is made more quicker than other materials. Due to the higher thermal conductivity of Aluminium material 210 W/mK, it has been selected for the heat exchanging process with ammonia as a working fluid.

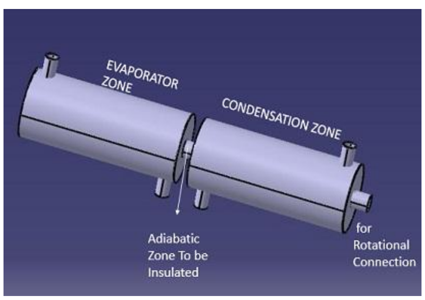

Figure 2. Experimental Setup

B. Phase Exchange Section.

It works under the state of two phase change mechanism that the liquid phase of the working fluid transmitting the heat from the evaporator to the condensor area by the vapourisation of the working fluid. Which is then cooled and backed into the liquid state in the heat pipe for the continuous chain process. The two phase chaning process involves for the effectve heat transfer by 1) Latent Heat of vapourization and 2) Sensible Heat Rejection. The latent heat of vapourisation of the ammonia will be active at a temperature from the 30^{0}C and absorbing heat to the maximum of 80^{0}C. At this state the liquid ammonia solution would change its state into the vapour form and transform the heat from the evaporator area to the other end condesor area. Now, the sensible heating process emits the heat to the condensor unit at the constant pressure. Due to these heat transfer from the vapourisation state of the working fluid to the liquified state, there would be a reasonable increament in the condensor zone temperature. From this phase transistion the centrifugal force and turbulence in fluid will impact on the heat pipe to replace the ammonia solution into the evaporator zone for further thermodynamic cyclic process.

C. Connecting parts.

The connecting parts for the heat pipe were bearings, oil seal, asbestoes rope, and housings for providing smoothness. The asbestoes rope which is wounded over the heat pipe commonly known as the adibatic zone which is used for insulation purpose to avoid the heat transfer loss to the surrounding atmosphere. The Bearings and its housing were kept aligned to minimise the vibration and matching defects on surroundings during their operation. The oil seal is provided for separting the motion between the heat pipe and the heat exchanging chambers. This seal will also eliminate the leakage of water from the two chambers to the outside environment.

D. Measurements system.

The measurement system is provided with the Laser interfero thermometer which provides the ease of measurement on rotating devices. The Temperature zones to be measured at Inlet and Outlet of the Adiabatic Zone and the Temperature of the

Evaporator and the Condensor Zones for the Overall Heat Transfer Measurement.

IV. Result and Discussion

A. Heat Tranfer at Evaporator

The evaporator is the region in which the heat transfer of the hot fluid passes into the heat pipe with the lower temperature. In this the heat from the evaporator region will emits its heat to the working fluid in the heat pipe by the latent heat of vapourisation and transmits its heat to the condensor region. And it is gradually reduced to the thermal stability region on the Twin mode condition as quicker in the time period than the other due to its higher heat conductivity by two modes. This also states that the Figure3. Explains about the performance of the heat transfer on the different modes of the heat pipe among them the most efficient and highly performed twin mode will increase the utilization of the exergy source of energy from the waste heat recovery systems.

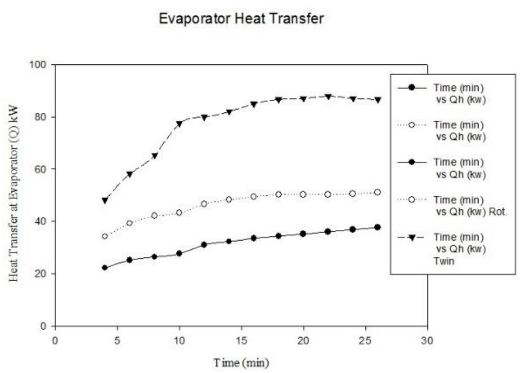

Figure 3. Comparison of Heat Transfer on Evaporator Zone

The twin mode is complicated to install in the heat pipe but now a days the regular combination of the twin mode analysis will improve in ease of installation and the performance of the heat pipe without the defects.

B. Heat Transfer at Condensor

In the condensor section the heat is being absorbed from the sensible heat rejection from the heat pipe due to the phase transmission of the ammonia solution inside the heat pipe. This variation of the phase change will also have the changes in the temperature between the heat pipe and the condensor region in general.

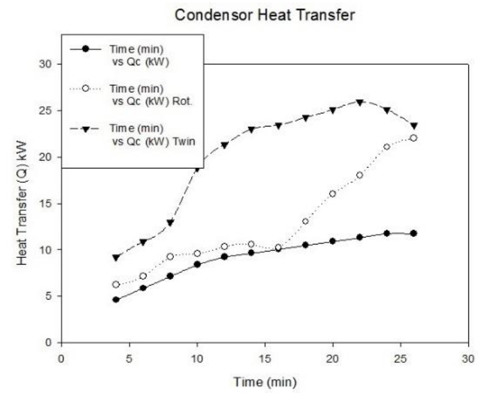

Figure 4. Comparison of Heat Transfer on Condensor Zone

The Figure 4. explains about the performance of the heat transfer at the condensor zone. Here, it is clearly shows that the heat transfer rate at rotational state will have a drop at the initial state finally leads to the thermal equilibrium with some improvement in its performance. But by the twin mode of analysis the heat loss is minimised and the utilization of the power increases the effectiveness and the efficiency of the system. The objective of thermal equilibrium is as nearer to the evaporator zone temperature.

C. Thermal Equilibrium

The thermal equilibrium is the state to attain the constant temperature will maintain over the surface with the negligible heat transfer. The over all heat transfer co efficient over the heat pipe is maintain at zero value so that the heat pipe will reach its equilibrium state as soon as possible. This system has a valid application in the aerospace thermal equilibrium in the turbine shaft so as to keep away the destruction of the sus radiational temperature changes.

V. Conclusion

Therefore, the heat pipe by holding the phase change mechanism with the twin mode of heat transfer. The system reaches the thermal equilibrium condition as quicker than the other modes such as active or passive mode. The combination of the two technique on the aluminium heat pipe having ammonia as a working fluid is literally improved in the overall heat transfer rate. Once, its application in the gas turbine on jet engines will increase the efficiency and performance of the engine. The pay back period of this technique is achieved through its usage of exergy on 3/4th of one year after their installation.

References

[1] Dominic O'Connor, John Kaiser S. Calautit, Ben Richard Hughes, A review of heat recovery technology for passive ventilation application, Renewable and Sustainable Energy Review 54 (2016) 1481-1493.

[2] Mustafa AliErsoz, AbdullahYıldız, Thermoeconomic analysis of thermosyphon heat pipes, RenewableandSustainableEnergyReviews 58 (Dec-2015)666–673.

[3] John M. Gorman, Kevin R. Krautbauer, Ephraim M. Sparrow, Thermal and Fluid Flow First-Principles Numerical Design of an Enhanced Double Pipe Heat Exchanger (Accepted on Jun-2016).

[4] Amir Amini, Jeremy Miller, Hussam Jouhara, An investigation into the use of the heat pipe technology in thermal energy storage heat exchangers, Energy, (Feb-2016)1-10.

[5] J.H. Wagner, B. V. Johnson, T.J. Hajek, Heat Transfer in Rotating Passages with Smooth Walls and Radial Outward Flow, the American Society of Mechanical Engineers 345 E, 1989, 89GT-272.

[6] Patrik NEMEC, Jozef Huzvar, Mathematical Calulation of Total Heat Power of the Sodium Heat Pipe, University of Zilina, Department of Power ISBN 13, 978- 2006 UK.

[7] Jingyu cao, Jing Li, Pinghui Zhao, Dongsheng Jiao, Performance evaluation of controllable separate heat pipes, Applied Thermal Engineering 100 (2016) 518-527.

[8] R.J. Golddtein, E.R.G.Eckert, W.E. Ibele, T.E. Simon, Heat transfer- a review of 2001 literature, International Journal of Heat and Mass Transfer 45 (2003) 1887-1993

[9] Gokhan Arslan, Mustafa Ozdemir, Correlation to predict heat transfer of an oscillating loop heat pipe consisting of three interconnected columns, Energy Conservation and Management, Jan- 2008

[10] Haynes, Boone, LLP, Heat Sink Assembly with Rotating Heat Pipe, US006125035A, Patent No. 6,125,035, Sep 26, 2000.

[11] Gokhan Arslan, Mustafa Ozdemir, Correlation to predict heat transfer of an oscillating loop heat pipe consisting of three interconnected columns, Energy Conservation and Management, Jan- 2008.

[12] Hosny Z. Abou-Ziyan, Abdel Hamid B. Helali, Mohamed Y.E. Selim, Enhancement of forced convection in wide cylindrical annular channel using rotating inner pipe with interrupted helical fins, International Journal of Heat and Mass Transfer 95 (Jan-2016) 996–1007.