A Review: Analysis of Two Phase Closed Loop Thermo Syphon Cooling System by Changing Operating Pressure

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Abstract— Two phase closed loop Thermosyphon is proved to be a good heat transfer device. In this project, the heat transfer of two phase thermosyphon is analyzed experimentally with different thermosyphon length and operating pressure. The influence of affecting parameters on the performance TPT such as geometry, the filling ration, the working fluid, operating temperature & pressure analyzed by various researchers is discussed . In this system heat is transferred as a heat of vaporization from evaporator to condenser in closed loop with relative small temperature difference by natural convection method.

Key words: Closed Loop, Two Phase, Thermosyphon, Operating Pressure

I. Introduction

Thermosyphon is a method of passive heat exchange, based on natural convection, which circulates the fluid without the necessity of mechanical pump. Thermosyphoning is used for circulation of liquids and volatile gases in heating and cooling applications such as heat pumps, water heaters, boilers and furnaces. Its purpose is to simplify the transfer of liquid or gas while avoiding the costand complexity of a conventional pump. As heat generation from various systems increased and there is limit on heat transfer rate in air cooling system the interest for using liquid cooling for high heat flux applications has risen. Thermosyphon cooling is an alternative liquid cooling technique in which heat is transferred as heat of vaporization from evaporator to condenser with a relatively small temperature difference. The thermosyphon has been proved as a promising heat transfer device with very high thermal conductance. Packaging and thermal management of electronic equipment has led to the demand for new and reliable methods for electronic cooling. Because of increased power levels and miniaturization of the electronic devices, typical cooling techniques such as conduction and forced convection are not able to cool such a high heat flux. The increasing integration of electronic systems requires an improved cooling technology. Thermosyphon can be designed either as a single tube or as a closed loop. An advanced loop thermosyphon consists of an evaporator, where liquid boils and a condenser, where vapor condenses back to liquid; riser and down comer connect these parts. The thermosyphon is a passive heat transfer device, which relies on gravity for the liquid return to the evaporator.[1]

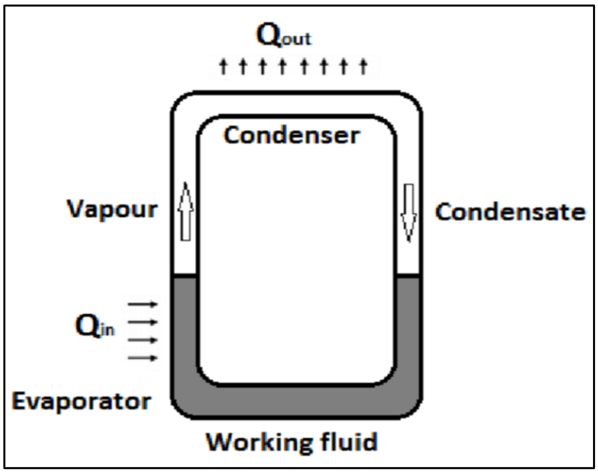

Fig. 1.1: two phase closed loop thermosyphon

Heat is transferred as heat of vaporization from the evaporator to the condenser. Thermosyphon cooling is one of the most promising, being capable of dissipating high heat fluxes with minimal temperature differences. The thermosyphon has been proved as a promising heat transfer device with very high thermal conductance. In practice, the effective thermal conductivity of thermosyphon exceeds that of copper 200500 times. A two-phase closed thermosyphon is a high performance heat transfer device which is used to transfer a large amount of heat at a high rate with a small temperature difference. This is achieved by evaporation of the working fluid (A) in the evaporator section (B) and condensing in the condenser section (C) and return of the condensate (D), as shown in the two-phase closed thermosyphon is widely used because of their simple structure when compared with other types of heat pipes. Therefore, thermosyphon are being used in many applications such as: heat exchangers (air pre-heaters or systems that use economizers for waste heat recovery), cooling of electronic components, solar energy conversion systems, spacecraft thermal control, cooling of gas turbine rotor blades, etc.[8]

II. Factors affecting the thermal performance of thermos phone

1) Properties of working fluid
2) Filling ratio
3) Heat load
4) Inside vacuum pressure
5) Length of various sections
6) Mass flow rate

III. Literature survey

Main objective of this paper is to replace cooling system of aircraft which run by the forced convection which is done by Ekkehardlohse and Gerhard scmitzand given experimental results of an inherently safe liquid cooling system. This cooling system uses a dielectric working fluid (a fluorinated polyether of the H-Galden series by solvaysolexis) for cooling of modern civil aircraft by natural circulation in a looped thermosyphon operating in both one- and two-phase mode. The test shows that passive liquid cooling, operating on buoyancy forces without active components like pump, is possible for electronic components. Also show the influence of three different parameters: the heat flux density, the heat sink temperature and system angle with respect to gravity. Additional work is needed to improve the heat transfer to the main cooling loop, while considering maintainability in aircraft application.[1]

Rahmatollah Khodabandeh and Richard Furberg both work for to predict and control the oscillation during different loads, also investigate heat transfer, flow regime and the problem of oscillating behavior during unstable operation of a two phase closed loop thermosyphon system. This study shows that flow and thermal instability increases as channel height decreases and also heat transfer coefficient increases with increasing channel height and heat flux. The two largest channel diameters trigger less fluctuations. Boiling delay or intermittent boiling characterized the heat transfer at low heat fluxes where low heat load in combination with backflow and poor heat transfer gives both low mass flow and vapor fraction in thermosyphon system. Due to this the net liquid head caused density difference between riser and down-comer is not enough to lift the vapor-liquid to the condenser for sufficient circulation.[2]

The paper presented by A.A. Chehade, H. Louahlia-Gualous, S. Le Masson, I. Victor and N. Abouzahab-Damaj under the title of “Experimental investigation of thermosyphon loop thermal performance” is the review of experimental investigation of two phase closed loop. The experimental setup consists of an evaporator and a condenser connected by two insulated tubes. Using water as a working fluid, the experiments were conducted to evaluate the performance of a thermosyphon: the effects of fill charge ratio, the condenser jacket coolant inlet temperature and the mass flow rate. Finally, the results show that the optimal fill charge ratio is between 7% and 10%, the cooling system has the optimal performance when controlling the condenser jacket water temperature and flow rate at 5°C and at0.7 l/min respectively. System, loop, evaporator, vapor line, condenser, and liquid line thermal resistance sanalysis is directed additionally to the pressure and temperature evolutions for the better understand of the main parameters affecting the cooling system performance.[3]

The paper presented by Ali Chehade, HasnaLouahlia-Gualous,, Stephane Le Masson, Eric Lepinasse under the title of “Experimental investigations and modeling of a loop thermosyphon for cooling with zero electrical consumption”. This paper presents an analytical model for a thermosyphon loop developed for cooling air inside a telecommunication cabinet. The proposed model is based on the combination of thermal and hydraulic management of two-phase flow in the loop. Experimental tests on a closed thermosyphon loop are conducted with different working fluids that could be used for electronic cooling. Correlations for condensation and evaporation heat transfer in the thermosyphon loop are proposed. They are used in the model to calculate condenser and evaporator thermal resistances in order to predict the cabinet operating temperature, the loop's mass flow rate and pressure drops. Furthermore, various figures of merit proposed in the previous works are evaluated in order to be used for selection of the best loop's working fluid. The comparative studies show that the present model well predicts the experimental data. The mean deviation between the predictions of the theoretical model with the measurements for operating temperature is about 6%. Besides, the model is used to define an optimal liquid and vapor lines diameter sand the effect of the ambient temperature on the fluid's mass flow rate and pressure drop.[4]

The paper presented by Mehmet Esen, HikmetEsen under the title of “Experimental investigation of a two-phase closed thermosyphon solar water heated”.In this paper experiments were performed to find out how the thermal performance of a two-phase thermosyphon solar collector was affected by using 3 different refrigerants viz. R-134a, R407C, and R410A. The basic aim of the experiments conducted was to determine the thermal performance of thermosyphonheat-pipe solar collector under real operating conditions. This study can be useful to system designers in the selection of an appropriate working fluid.[5]

The paper presented by C.Chang,S.-C.Kuo,M.-T.Ke&S.L. Chenunder the title of “Two-Phase Closed-Loop Thermosyphon for Electronic Cooling”. In this paper they experimentally investigated the thermal performance of a two-phase closed-loop thermosyphon with a thermal resistance model for electronic cooling. The experimental parameters were the evaporator surface type, fill ratio of working fluid, and input heating power. Thermal resistance decreases asin put heating power increase & thermal resistance increases with increasing fill ratio. The input heating power has a major effect onthe evaporator and condenser thermal resistance. The performance of the two-phase closed-loop thermosyphon at a high fill ratio and low input heating power is characterized by unsteady operation due to intermittent boiling.[6]

The paper presented by Lazarus Godson Asirvatham, Somchai Wongwises, Jithu Babu under the title of “Heat Transfer Performance of a Glass Thermosyphon Using Graphene–Acetone Nanofluid”. In this paper, they studied that enhancement in the heat transfer performance of a glass thermosyphon using graphene–acetone nanofluid with 0.05%, 0.07%, and 0.09%volume concentrations. This experimental work reported that the use of low volume concentration of graphene nanoparticles in acetone enhances the heat transfer performance of the thermosyphon effectively. The higher thermal performance of thermosyphon working with nano fluid proved its potential as a substitute for conventional fluids and makes nano fluid attractive as an advanced heat transfer fluid for electronic cooling applications.[7]

The paper presented by Alessandro Franco and SauroFilippeschi under the title of “Experimental analysis of Closed Loop Two Phase Thermosyphon (CLTPT) for energy systems”. In this paper the authors designed and realized an experiment test rig for the analysis of CLTPT of small dimensions where the heat flow rate up to 1.7 kw can be furnished. The setup was consisting of an evaporator and water cooled horizontal condenser placed above 1m over the evaporator. The purpose of this analysis is to investigate the correlation between mass flow rate and heat flow rate. The results of an experimental analysis by using water and ethanol as tested fluids at different operating conditions are shown discussed and analyzed. The influence of several parameters on the performances was studied experimentally: in particular heat load, operating pressure and fluid filling. The limits in the heat and mass transport are evidenced together with the unstable behavior at the high heat input. From the results they concluded that the quantitative prediction of the performance of CLTPT appears to be quite difficult: the individual and the inter-correlative effects of the various variables are very difficult to be exactly identified even if it possible to establish a hierarchical level of the various variables. It is possible to recommend using water in thermosyphons for use at heat flow rate higher than 1000 W, while for heat flow rate below 1000W the use of ethanol could be advantageous.[8]

The paper presented by Mohite Sanket R. , Kumbhar Vaibhav S. , Kumbhar Vaibhav V. , Mahamuni Shubham R. , and Prof. Kare K.M. the title of “A review Paper on Closed loop two phase thermosyphon system”. In this paper experiment were performed to find out different thermosyphon lengths and heat input. As used Acetone, Methanol and Ethanol for analysis. For this project, thermosyphon setup with lengths 100, 500 and 800 mm, inner diameter 32 mm and outer diameter 40 mm is used. System was charged with different fill charge ratio of working fluid with an evaporator length of 600 mm and condenser length of 600 mm.It is found that, thermal resistance is indirectly proportional to the heat input also, heat transfer coefficient increases with heat input. Acetone has good heat transfer coefficient.[9]

IV. CONCLUSION

This research reviews the closed loop two phase thermosyphon cooling systems for various applications. This review report thoroughly studies different parameters for increasing the performance of system according to applications. After reviewing this paper one can get idea about the areas of research for advancement of system.

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