Experimental Ivestigation of Hydraulic Oil Cooler with Longitudinal Fins:A Review

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Abstract

Heat pipes are very useful and effective devices for the heat transfer with no moving parts. Power packs which are used in various industrial hydraulic systems contain hot oil .Due to heating of oil, hydraulic system gets overheated and its basic properties get deteriorated. In such applications by using heat pipe heat can be removed by evaporating and condensing to pipe ends having longitudinal fins exposed to air with working fluid as water .By forced convection ambient air is drawn over exposed pipe by using blower, causing working fluid to condensed and return to heat source to repeat process. This paper reviews development of heat pipe for various applications like power pack, chemical industries, etc.

Keywords:*Heat pipe,Power pack,Working fluid,Blower,Longitudinal fins***.**

1.Introduction

Hydraulic oils are used as operating fluids in a wide variety of technical devices, including hydraulic systems. They determine the functionality, durability, and reliability of such systems. The present-day hydraulic systems are characterized by increasing exertion and decreasing overall dimensions; they comprise less and less hydraulic fluid, have smaller and smaller cooling systems, and operate at higher and higher pressures. In consequence, the hydraulic oils undergo increasingly difficult mechanical, thermal, and chemical conditions of operation, which conduce to ageing and fast deterioration in functional properties of the oils unless they are of adequately high quality and are appropriately used in the hydraulic systems.[1] To better understand the operating principles and design features in a hydraulic power unit, it may be helpful to look at the basic components of a standard model used in industrial hydraulic systems. As the temperature of hydraulic oil increases, input power falls – and if the total loss of power is greater than the heat dissipated, the hydraulic system will eventually overheat. And if oil overheats, it loses its lubricating properties and increases friction and wear on hydraulic components, meaning hardened seals and increased wear to the system. Another problem caused by high oil temperatures is reduced oil viscosity – which often leads to oil leakages.[2] In investigation of heat transfer, heat pipes plays very important role. It is enclosed, passive two phase heat transfer device. Evaporation and condensation are two processes which are carried out in heat pipe to increase the thermal conductance between heat source and heat sink. Also heat pipe are proven to be very effective, low cost and reliable heat transfer devices for heat recovery systems. The heat pipes are used in many applications i.e. baking oven, heat exchanger, water heater, solar energy systems, etc. The basic Principle of the heat pipe is shown in fig 1.

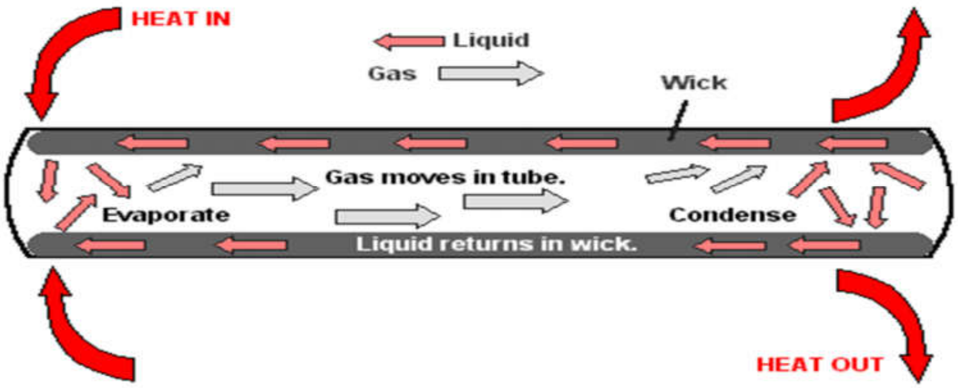

Figure 1. The Working Principle of Heat Pipe

2. Literature Review

Lot of research work is done in past on to increase the heat transfer rate of hydraulic applications, few of them are sited as follows.

Sercan Dogan et al[1] designed an experimental setup to investigate offset-offset fin oil cooler. The main objective of study was to determine thermal and hydrodynamic performance of commercially used oil coolers. To achieve this aim mass flow rate of ST42 oil in heavy duty machinery were detected. During experimentation oil circulated via a gear pump and heated with electrical resistance. Experiment were conducted at six different oil entrance temperature, three different cooling air mass flow rate and nine different oil mass flow rate. Results were given by the terms of total heat transfer, pressure drop and effectiveness values. Offset-offset fin oil cooler configuration was found to be good alternative among commercial competitors.

C.R. Kamthane et al[2] did the investigation of cross flow heat pipe hydraulic oil cooler. Experiments show that with evaporator section, fluid is evaporated as it absorbs an amount of heat equivalent to latent heat of vaporization, while in condenser section fluid vapour are condensed. Return of the liquid to evaporator is provided by the wick structure. Also heat pipe is capable to transform more heat as compared to simple copper rod.

M.K. Chopra et al.[3] performed analysis of cross flow unmixed heat exchanger by the variation of volume fraction of hot fluid. The objective of this project was to determine at what percentage of water coolant mixture the performance of unmixed cross flow heat exchanger deteriorates and at what percentage obtained maximum heat exchanger rate. An experimental analysis has been performed on unmixed cross flow heat exchanger which was automobile radiator using air and water coolant as fluids. Where air serves as cold fluid and water as hot fluid. Automobile radiator was connected with variable speed petrol engine to vary the mass TH flow rate of air.

Beata Niezgoda et al.[4] experimentally studied the heat transfer process on the outer surface of longitudinally finned tubes. Experimental values of heat transfer coefficient under free and forced convection conditions were calculated for low air flow velocities. Two air flow patterns were analyzed. i.e. air flow parallel and perpendicular to the axis of the pipe. The mean values of heat transfer coefficients were obtained during the study for forced convection and free convection. In this research they listed the dimensionless relationship which can be used to calculate the values of heat transfer coefficient under free and forced convection conditions, with transverse and longitudinal air flow around the outer surface of vertical longitudinal finned tubes.

P.G. Anjankar et al.[5] investigated the effect of condenser length, coolant flow rate and heat load on the performance of two-phase closed heat pipe. The heat pipe was a closed copper tube of length 1000mm (evaporator length-300, condenser length-450mm/400mm/350mm) and internal and external diameter of 26 and 32mm respectively. Thermal performance of a heat pipe was higher at flow rate of 0.0027kg/s and heat input 500W with a condenser length of 450mm.

Wongtom Sompon et al[6] investigated inclined heat transfer rate of heat pipe under sound wave. The heat pipe was a closed copper tube of length 1000mm (evaporator length-450mm, adiabatic length-100mm, condenser length-450mm) with external diameter of 22.3 and 1.3mm thickness. Inlet hot air temperature ranged between 50, 60, 70, 80 and 90^{O}C and R-123 was the thermosyphon working fluid.

Parinya Pongsoi et al.[7] reviewed approximately 40 published articles related to spiral fin and tube heat exchangers were briefly described. More over the air side performance correlations of spiral fins and circular fin and tube heat exchanger were compiled for practical industrial applications.

Sachindra Kumar Rout et al.[8] performed numerical analysis of mixed convection through an internally finned tube. Wall temperature of an internally finned tube had been computed numerically for different fin number, height and shape by solving conservation equation of mass, momentum and energy using FLUENT 12.1 for steady and laminar flow of fluid inside a tube under mixed flow condition.

Sameer H. Ammen et al.[9] experimentally studied double pipe heat exchanger which was constructed from copper alloy with inclined parabolic fins fixed over the outer surface of its inner pipe with different angles. The experimental part of the current work was carried out and it gave a coefficient of convection. While the numerical part was achieved using ANSYS package. Both structural and thermal investigation was considered in the numerical analysis which is required for developing a factor called heat transfer coefficient. The parabolic fins improved the local heat convection to about 2.42 percent more than pipes without fins.

Leonard L. Vasiliev, et al[10] reviewed heat pipes in modern heat exchanger. Objective of study was to review on miniature, micro heat pipe, pulsating heat pipes, sorption heat pipes and its application in modern heat exchangers. These heat pipes were very efficient heat transfer device, which can be easily implemented as thermal links and heat exchangers in different systems to ensure the energy saving and environment protection.

R.K. Andrews et al.[11] had performed an experimental and mathematical investigation about heat transfer in the evaporator of an advanced two-phase heat pipe loop. Study includes influence of heat flux, system pressure, mass flow rate, vapour fraction, diameter of evaporator channel and tubing distance between evaporator and condenser. The heat transfer coefficient of an advanced two phase heat pipe loop was reported. The tested evaporators were made from small blocks of copper with 7, 5, 4, 3 and 2 vertical channels with the diameters of 1.1, 1.5, 1.9, 2.5, and 3.5 mm, respectively and the length of 14.6 mm. Tests were done with isobutene at heat fluxes ranging between 28.3 to 311.5 kW/m^2

Arun Balkrishna Kulkarni et al.[12] concluded that there is improvement in the total heat transfer rate when material of the tank changes from mild steel to Aluminium but limitation is that it is having low pressure bearing capacity than mild steel.

3. Experimental Setup

To enhance the heat transfer rate heat pipe with longitudinal fins are used in this experiment. The heat pipe module consists of a base aluminium block with oil inlet and outlet at the top face. This module is used to transfer heat from hot oil to longitudinal fins which are mounted on evaporator section of heat pipe which is pressed fitted in aluminium block and condenser section is fitted in cavity of longitudinal fins. The heat pipe used in the module has following specifications:

- Material: Copper
- Type: Short cylindrical heat pipe
- Working fluid : Distilled water
- Wick structure: Sintered copper

Table 1. Specification of Heat Pipe

r. no	Parameter	Dimensions (mm)
1	Total Length	12
2	Condenser length	6
3	Evaporator length	6
4	Internal dia of pipe	26
5	Outer dia of pipe	32
6	Working fluid	Distilled water

In this experiment longitudinal fins are used as heat transfer enhancement device as it offers maximum surface area in given space. The aim is to cool the oil with longitudinal fins attached on heat pipe containing four modules of heat pipe with radial blower. The blower is of 12 volts DC which gives cold air to modules in radial direction .Hot oil flows in four modules through the inlet and at outlet it is collected in the tank. This tank is mounted externally on the system so that it ensures that operation is with free contamination. The heat pipe modules are connected in parallel.

4.Conclusion

Review work has been carried out to study the application of heat pipe for cooling the hot oil from cylinder outlet .In future experimental research work will be carried out to find out how the heat pipe will be useful to enhance heat transfer rate. The computational analysis of heat pipe application will also be performed and finally the comparison will be done between experimental and computational results.

5.References

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