International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 09 | Sep -2017 www.irjet.net p-ISSN: 2395-0072

HYDRAULIC OIL COOLING WITH APPLICATION OF HEAT PIPE

Sachin Marjapure[1], Santosh Kumar Bawage[2]

[1 2] Assistant Professor, Mechanical Engineering Department, DYPCOE, Ak. Pune-44, Maharashtra, India

---

Abstract - *The concept of heat pipe can be effectively used in in hydraulic system. The heat pipe heat exchanger has less maintenance cost, space and running cost. The heat pipe equipped hydraulic oil cooler uses heat pipe module comprises of a base metal block with oil channels machined on the top face of aluminum block on which top plate is fitted. The heat pipe used to transfer the heat from the hot oil to the surrounding air through fins is press fitted in the cavity of this metal block. The heat pipe evaporator section is in direct contact with hot oil whereas the condenser section of the heat pipe is fitted in the circular cavity in the spiral radial fin structure. The spiral fins act as heat enhancement method as they offer maximum surface area. The oil cooler can be mounted externally to the oil tank system thereby ensuring contamination free operation as the oil tank is sealed. In this study the purpose is to increase heat transfer rate of oil which prevents the overheating of oil and improves components life. Cooling of oil also helps in saving pumping power of system.*

Key Words*: *Heat Pipe, Hydraulic system, Effectiveness, Capacity ratio…

1.INTRODUCTION

Any hydraulic system gets affected by changing properties of hydraulic oil due to overheating of oil & leakages of oil. Following are the sources of heat generation in hydraulic system .There may be a variety of reason to heat generation in hydraulic component. Heat pipes have high effective thermal conductivities, energy-efficiency, light weight, low cost and the flexibility of many different size and shape options. Heat pipe is a passive heat transfer device, offer simple and reliable operation, with high effective thermal conductivity, no moving parts, ability to transport heat over long distances and quiet vibration-free operation. In heat pipe heat is transferred from hot junction to cold side by vaporizing and condensation of working fluid. The evaporator side is in contact with hot side, the working fluid vaporizes by absorbing the heat. This heat is released in surrounding through condenser side. The fluid returns back to evaporator section by capillary action. This heat pipe concept can be used in hydraulic oil cooler in which hot oil is cooled effectively. In hydraulic system temperature of oil increases during its operation. The temperature of this oil should be lowered before it is return to tank. The increased heat transfer rate of oil lowers the temperature of return oil. As the temperature of oil Overheating ranks No. 2 in the list of most common problems with hydraulic equipment. Unlike leaks, which rank No. 1, the causes of overheating and its remedies are often not well understood by maintenance personnel. Heating of hydraulic fluid in operation is caused by inefficiencies. Inefficiencies result in losses of input power, which are converted to heat. A hydraulic system's heat load is equal to the total power lost (PL) through inefficiencies and can be expressed as:

PL total = PL pump + PL valves + PL plumbing + PL actuators

If the total input power lost to heat is greater than the heat dissipated, the hydraulic system will eventually overheat. Installed cooling capacity typically ranges between 25 and 40 percent of input power, depending on the type of hydraulic system.

2. METHODOLOGY AND WORKING:

Heat pipe enhanced cross flow hydraulic oil cooler: The concept of the heat pipe enhanced cross flow hydraulic cooler is an oil to air cooler that uses four heat pipe modules with a radial blower system as shown in figure below:

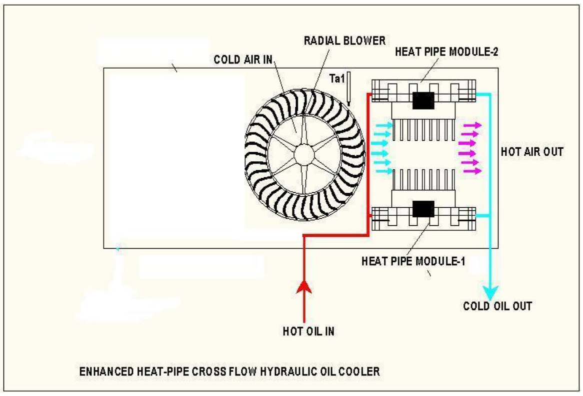

Fig -2.1: Enhanced Heat-Pipe cross flow hydraulic oil cooler

The radial blower is 12 volt DC blower that takes cold air in the system axial and discharges it in radial direction. This cold air is then directed on to the spiral radial fins mounted on the four heat pipe modules. The oil cooler takes in hot oil with help, of hydraulic pump whereas the cold oil from the oil cooler is discharged back to the oil tank. The oil cooler can be mounted externally to the oil tank system thereby ensuring contamination free operation as the oil tank is sealed.

The enhanced heat pipe cross flow hydraulic oil cooler uses four individual heat pipe modules which are connected in parallel and the output oil from each module is then directed back to the oil tank after it is cooler.

Details of the individual heat pipe module are described below

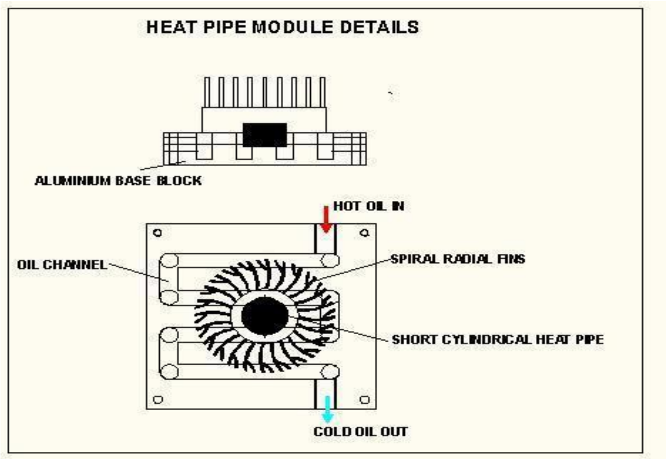

Fig.2.2- Heat pipe Module Details

The heat pipe module comprises of a base Aluminium block with oil channels machined on the top face of the block, and then sealed by top plate. The heat pipe used to transfer the heat from the hot oil to the fins is press fitted in the cavity of the Aluminium block The heat pipe evaporator section is in direct contact with hot oil whereas the condenser section of the heat pipe is fitted in the circular cavity in the spiral radial fin structure.

The heat pipe used in the module has following specifications:

1. Type : Short cylindrical heat pipe
2. Material : Copper
3. Working fluid : OIL
4. Wick structure: Sintered copper the given space.

3. DESIGN & CALCULATION

Oil Grade = SAE 20 W 40
Specific heat of oil = 1.6987 kJ/kg ^{0}C
Oil flow rate = 0.028 liter/s

Mass in kg/sec = (flow rate in liter/s) X (density in Kg/liter)
= 0.0047 X 0.896 kg/liter
= 0.00421 Kg/s

Heat Generated in system = P (Pa) × Q (m3/s))/1000
= $(2\times10^6\times 2.8 \times 10^{-5}) \times/1000$
= 0.056 kW

So based on the above calculations heat generated in the system is calculated. This amount of heat must be delivered into atmosphere. For this heat load suitable heat pipe is selected from standard chart.

3.2: Selection of Heat pipe

Diameter	40 ^{0}C	60 ^{0}C
32 mm	15 Watt	18 Watt

3.3: Hydraulic Pump

Hydraulic pump: vane type electric, 0.5HP
Oil flow at full pressure: 0.6-3.2 lpm

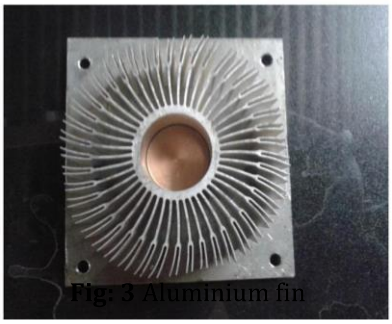

Fig: 3 Aluminium fin

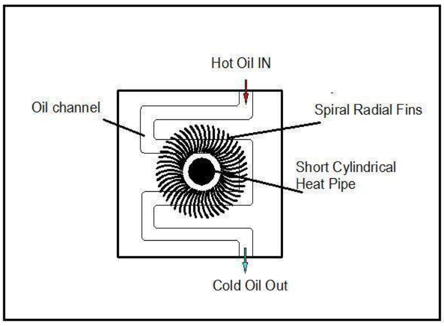

Fig.4- Heat pipe module

4. RESULT

Sr. no	Mass flow of hot oil	LMTD	Overall heat Transfer coefficient	Capacity ratio	Effectivenes s (ε)	Heat Q (w)
1	0.0048	29.28	247.93	0.307	0.645	325.41
2	0.0065	29.65	364.40	0.325	0.689	486.20
3	0.0058	29.75	299.33	0.329	0.655	396.02
4	0.006	29.90	352.25	0.349	0.660	407.61

4.1 Effectiveness:

Actual heat transfer rate is increases with increase in mass flow rate

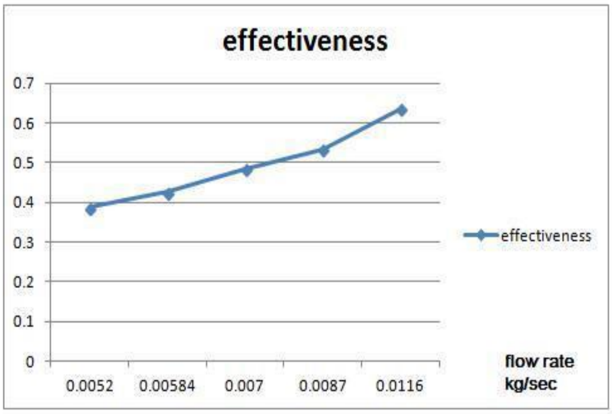

Fig 4.1 Mass flow rate Vs. Effectiveness

The extended surface design of heat pipe has many fins attached on the condenser section. Fins provide more surface area and improve the heat transfer coefficient thereby increasing the effectiveness of oil cooler.

4.2 Capacity Ratio:

The capacity to heat transfer from hot oil to cold is increases with increase in mass flow rate of oil.

Fig no. 4.2 shows the effect of mass flow rate on capacity ratio, from graph it is found that capacity ratio is increasing with the mass flow rate. If capacity ratio is more that means heat capacity rate of cold fluid is less. The low capacity rate for cold fluid is desirable because it shows that there is possibility of transfer more heat.

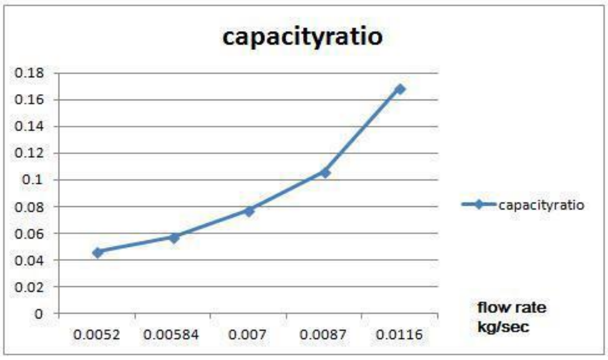

Fig 4.2: Mass flow rate Vs. Capacity ratio

5. CONCLUSION:

Based on the above experimental procedure and literature study, the heat pipe technology can be used in hydraulic system to reduce overheating problems. The increased heat transfer rate helps in saving the pumping power of system. However if the flow rate of oil is made constant it can be effectively used in oil cooling applications compared to conventional natural cooling. The heat pipe with the fins attached improves the heat dissipation and with forced convection it can be further improved.

REFERENCES

[1] Coletti, G., “Impact of Metal Contamination in Multicrystalline Silicon Solar Cells; Case Study for Iron,” IEEE PVSC, June, 2010.

[2] C. R. Kamthane , P. M. Khanwalkar “Development Of Enhanced Cross Flow Heat Pipe Hydraulic Oil Cooler” , Ijpret, 2014; Volume 2 (9): 218-228 Issn: 2319-507x.

[3] Mr.Ashish A. Wankhede ,Dr.Kishor P. Kolhe “Design and Analysis of Hydraulic Oil Cooler by Application of Heat Pipe” International Journal of Science, Engineering and Technology Research (IJSETR), Volume 4, Issue 9, September 2015.

[4] Wei, J., Hijikata, K., and Inoue, T., 1996, ―Fin Efficiency Enhancement Usinga Gravity-Assisted Plannar Heat Pipe Int. J. Heat Mass Transfer, 40(5), pp1045–1051.

[5] Kwan, C. T., Jan, F. S., and Lee, W. C., 2008, ―An Optimum Die Fillet Designfor Minimizing the Difference in Extruded Fin Lengths of Straight-Fin HeatSink Extrusion, J. Mater. Process. Technol., 201, pp. 145–149.

[6] Chen-Ching Ting, Chien-Chih Chen ―Developing the Coaxial DualPipe Heat Pipe for Applications on Heat Pipe Cooler 2011 by ASME,September 2011, Vol. 133/ 092901-1