Experimental Ivestigation of Hydraulic Oil Cooler with Longitudinal Fins

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Abstract

Generally for cooling and lubrication purpose oil is the most important fluid used in various industrial hydraulic systems. Hydraulic fluid temperature above 82°C damages most of the seal compounds and accelerates degradation of the oil.To overcome this problem in this experimental work heat pipe and longitudinal fins mounted on it has been used. The working fluid in the heat pipe respond to the application of heat by boiling, changing into a gaseous state and transporting the heated gas to the heat pipe ends that is exposed to air for condensation.Temperature of oil is maintained by increasing the heat transfer area using longitudinal fins. According to the experimental results, it has been concluded that experimental setup can be effectively used for determining thermal performance of practically used oil cooler.

Keywords: Heat pipe,Degradation,Working fluid,Condensation,Longitudinal fins**.**

1.Introduction

In hydraulic systems oils are used as operating fluids in a wide variety of various devices for cooling purpose When excessive heat was applied to hydraulic fluids, materials may lose their discriminating properties or system elements may be damaged. Hydraulic systems utilize sealing to avoid leaking. Those sealing mostly lose their shapes at high temperatures and consequently leaking occurs in the system.Therefore heat exchanger called as oil cooler with heat pipe is used in experimental work to reduce the temperature of oil. Heat transfer is the transfer of energy across a system boundary caused by a temperature difference.Fundamental of heat exchanger principle is to facilitate an efficient heat flow from hot fluid to cold fluid. This heat flow is a direct function of the temperature difference between the two fluids, the area where heat is transferred, and the conductive/convective properties of the fluid and the flow state. This relation was formulated by Newton and called Newton's law of cooling, which is given in equation

$$Q = h*A*\Delta T$$

The main requirement for any heat exchanger is that it should be able to transfer the required amount of heat with a very high effectiveness. In order to increase the heat transfer the heat transfer coefficient cannot be changed, the area or the temperature differences have to be increased. Usually, the best solution is that the heat transfer surface area is extended.So in this work extended fins are used to increase the heat transfer.

2.Selection of components

To conduct experiment various components are needed.The different components are used for performing specific function in oil cooling system. Table 1.1 shows function of each component of hydraulic oil cooler with longitudinal fins.

Table 2.1 Functions of cooling system components

Sr. No.	Component	Function
1.	Heat pipe heat exchanger	Heat exchange with the ambient and to reduce thermal load of system.
2.	Closed Tank	To create pressure for oil flow.
3.	Air Regulator	To regulate the oil mass flow rate.
4.	Fan or blower	Air through modules of oil cooler for forced convection.
5.	Cooling fluid	Heat transfer to surrounding.
6.	Fins	Increase rate of heat transfer by adding surface area of heat exchanger.
7.	AC to DC converter	To convert 230V power supply to 12V DC power supply to run blower.
8.	Temperature controller with thermocouple	To control the temperature of the heater as required.

3.Experimental Work

In this experimental analysis cooling of oil was carried out by using four modules which were connected in series one after another means outlet of first will be the inlet of second. Each module consists of separate short cylindrical heat pipe having 32 mm diameter and 12 mm length. By the application of basic principle of heat pipe i.e. latent heat of vaporization heat was extracted from inlet oil and transfer to the surrounding. Evaporation section of heat pipe was fixed into aluminum base block and spiral radial fins were mounted on the condenser section of heat pipe. Fins were used to increase surface area to increase heat transfer rate.

Test rig was constructed for the analysis of enhanced cross flow heat pipe hydraulic oil cooler.Oil is heated in closed tank with help of heater and maintainted at required temperature then it is passed through four heat modules and collected into beaker.Various temperatures at inlet,outlet,on the surface of fins are measured with help of thermocouple. heat transfer coefficient and corresponding Nusselt numbers are calculated for various temperatures.The photograph for experimental set up is shown as below,

Figure 1.Experimental set up of Hydraulic Oil Cooler

4.Results and discussion

Following results are obtained while performing the experimental work.The readings are taken and shown in following observation table for various temperatures and mass flow rate of oil.

Sample calculation for heat transfer rate

$Q= mCp\Delta T$

ΔT= Temperature difference

m = Mass flow rate

C_p = Specific heat capacity

Q = Heat transfer rate

Properties of oil used SAE 20W40

C_p = 1964 J/kg K

$\rho = 876\ kg/m^3$

k = 0.1442W/mK

$Q_{avg} = 0.00930\times1964\times16.4= 299.542W$

Table 1.Observation table for heat transfer rate at various temp and mass flow rate

Sr No	Flow rate (kg/s)	Inlet Oil Temperature T_i (^{0}C)	Outlet Oil Temperature T_o(^{0}C)	Temperature Difference ΔT (^{0}C)	Q (W)
1	0.0093	80	63.64	16.36	299.54
2	0.0093	85	66.2	18.8	343.40
3	0.0093	90	68.37	21.63	395.09
4	0.0116	80	63.1	16.9	308.69
5	0.0116	85	65.6	19.4	354.36
6	0.0116	90	67.9	22.1	403.67

The temperature drop of module 1 to module 4 at various mass flow rate is shown in figure below,

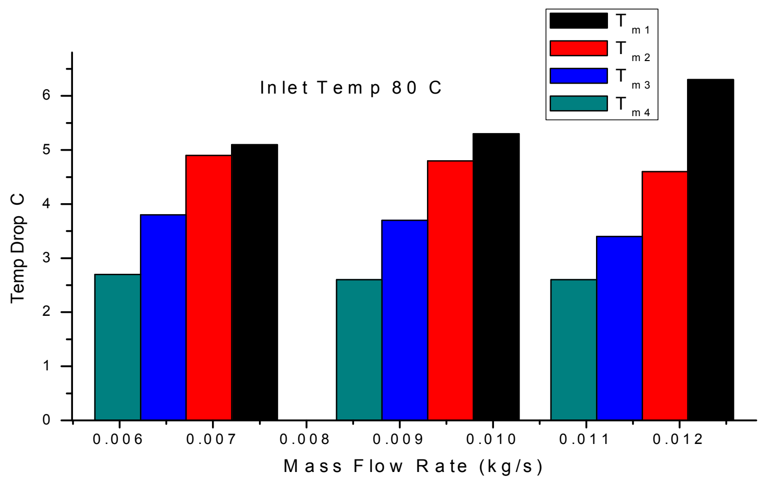

Figure 2.Mass flow rate Vs temperature drop

5.Conclusions

From above results it is cocluded that,

1) Increase in the inlet temperature of the system temperature difference also increased.
2) By changing mass flow rate of oil cooling capacity of oil cooler changes i.e. at lower mass flow rate it was lower and at higher mass flow rate it is higher.
3) Increasing inlet temperature of fluid from 80˚C to 90˚C can enhance Nusselt number.
4) Increase in mass flow rate of fluid circulating in devices temperature difference decreases about 5.47 ˚C.

6.References

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