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IMPROVING ENGINE OIL COOLING PERFORMANCE FOR VEHICLE USAGE

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ABSTRACT

This article provides the means of improving engine oil cooling systems in automobiles. The need for the improvement arises due to the frequent breaking down of automobiles as a result of congestion, temperature and nature of the Nigerian roads. In automobiles, the engine is either cooled by air using oil to air heat exchanger or by water using oil to water systems. For the engine to be cooled by air there must be sufficient air flow obtained at high speed. In order to provide solution to this problem, other method of cooling has to be used. Larger plate heat exchanger, Copper as heat exchanger material, additional radiator (oil to air) and a separate cooling circuit (water to air) were the examined factors adding to the cooling performance of the engine oil. Results from the simulation of this methods using Gamma Technology Suite (GTS) software shows that heat transfer rate above 26kW is achieved using any of the four methods. In the cause of this work, only the cooling system was considered.

KEYWORDS: Engine oil, heat exchanger, cooling performance, heat transfer.

1. INTRODUCTION

The rate at which automobiles breakdown due to overheating is becoming alarming more especially in the Northern part of the country. The problem of overheating which leads to several fault like burning of gasket, damaging piston and rings is commonly experience by the road users (personal interview). The fault is trance to the nature of the roads, holdups and weather conditions. Over the years, vehicles that are used in the Nigeria are imported from

Europe, North America and other Asian countries. The vehicles are manufactured to move on good roads. The cooling capacity of the vehicles depends on the speed at which the vehicle moves (Finlay, 2003), the nature of Nigerian roads and the congestions causing slow movement that makes the cars to overheat (Klien, 2003). The problems with the cooling could be traced back to the following reasons:

i. Increased engine power generates more heat to both the oil and water coolant.
ii. Desire to allow a higher maximum towing weight.

The maximum heat transfer rate of the oil cooler in the current engine is 21kw for the high performance petrol engine and 26kw for high performance diesel engine (Chanfreau et al, 2015). Overheating of the vehicles could only be control if the cooling capacity in the current engine could be improve.

When the internal combustion engine is operating at a full throttle the maximum temperature reached by the burning gas is as high as 2700^{o}C (pulkrabek,1997). The system produced to control the temperature in the vehicle could no longer function well because of the exposure to the dust and dirt on the radiator which might result in to other malfunction of other accessories. Beside, the fact that most of the cars were produced to operate in Europe where the weather is unlike that in Nigeria. The aim of this work is therefore, to provide a general technical description and performance calculations in order to provide possible methods that improved the oil cooling performance in automobiles.

2. METHODOLOGY AND DATA ANALYSIS

I. Idea generation
II. Information gathering from journals, car magazine, documentaries and other literature.
III. Calculation using the GT SUITE, each concept was simulated and result obtained were compared to the ones presently used in most automobile which shows that the maximum heat transfer rate in the current engine is 21kw for high performance petrol engine and 26kw for high performance diesel engine.

2.1 Larger Plate Heat Exchanger

The existing Oil to Water (OTW) Engine Oil Cooler (EOC) is scale to a larger size by adding more plates; the added plate will result to a larger surface contact area and reduce the pressure drop compared to the existing EOC at a given flow of both coolant and oil.

The goal of this concept is to get sufficient heat transfer by changing the present oil cooling as little as possible.

2.2 Copper as Oil to Water Heat Exchanger Material

The thermal properties of aluminum will be compared with that of copper to see if copper heat exchanger will offer more cooling effect than the aluminum heat exchanger.

The goal of the concept is to get a better heat transfer per physical volume than the present aluminum heat exchanger.

2.3 Additional Radiator Oil to Air (OTA)

Oil to Air cooler (OTA) is added to the oil cooling system. The OTA was connected from the oil output to the standard OTW and pump through the OTA for additional cooling of the oil. The cooling rate is controlied using a Thermal Bypass Valve(TBV) that was activated by the oil temperature, the OTA is now positioned to get sufficient air flow.

The goal of the concept was to dispatch the heat that the standard OTW could not handle in extreme situation.

2.4 Separate Cooling Circuit Water to Air (WTA)

This concept eliminates the use of the radiator for cooling the oil entirely. The water connection on the OTW was connected to a separate WTA that handled all the heat coming from the oil. The concept was that, the WTA was dimensioned such that a higher water cooling rate was achieved which increased the heat transfer rate of the OTW. An electric pump was used to pump the water through the separate cooling circuit. The goal of the concept is that, since the oil has separate cooling circuit the engine coolant and the oil did not affect each other.

3. RESULT AND DISCUSSIONS

3.1 Larger Plate Heat Exchanger

When the standard size of the heat exchanger was doubled, it created more space for the heat transfer between the oil and water. Hence the size of the plate was increased. The new heat exchanger was simulated and compared with the one in use shown in Figure 3.1. As seen in the figure, the heat transfer rate of 40kw was achieved with the coolant and oil flow of 1kg/s. The flow supplied in the current system is 0.6kg/s for both the oil and the coolant. This system therefore, requires a significant increase. It is possible to replaces the current water and oil pump in favor of pumps with higher capacities. Such a decision would however result in a number of negative side effects. Pumps with higher capacities would be more expensive and require more power.

Table 3.1: Result of the large plate heat exchanger.

Pump capacity	Oil mass flow0.2kg\s	Oil mass flow0.4kg\s	Oil mass flow0.6kg\s	Oil mass flow0.8kg\s	Oil mass flow1.0kg\s	Oil mass flow1.2kg\s
0.2	11	15	17	18	20	21
0.4	12	16	24	27	29	30
0.6	13	20	25	30	33	35
0.8	13	24	26	34	37	41
1.0	14	24	30	35	40	43
1.2	14	24	30	37	42	45

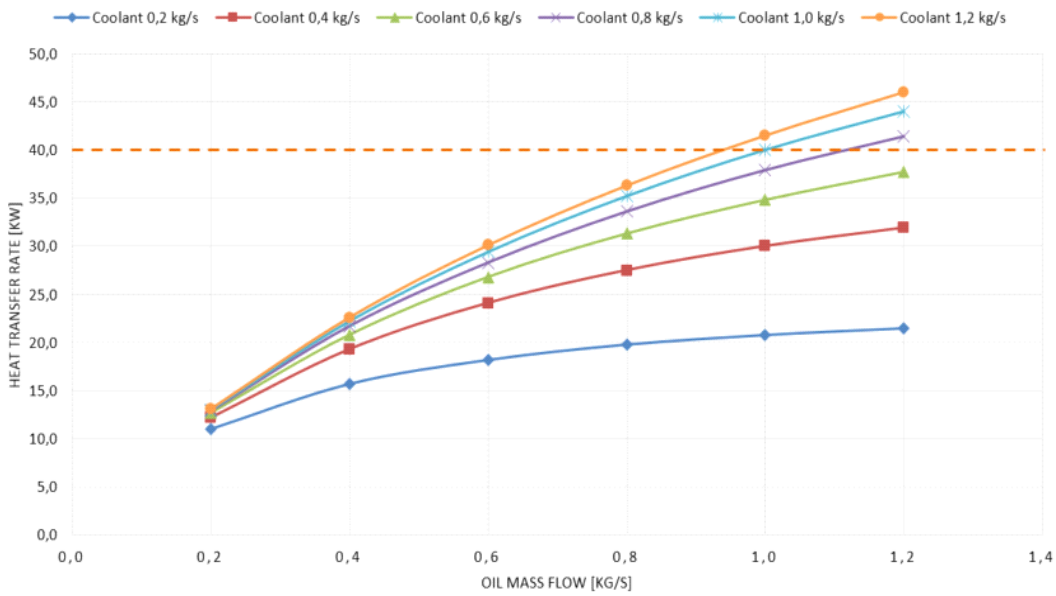

Figure 3.1: Graph of heat transfer rate against oil mass flow.

3.2Additional radiator Oil to Air (OTA)

Result from the simulation of this concept shows that heat transfer rate of 40kw at a relatively low air mass flow rate was obtained, when the air holds a temperature of 38C. 40kw was reached just below air mass flow rate of 0.5kg/s. Fig3.2 shows the combined effect of the OTW and OTA heat exchanger at ambient air temperature of 27^0 and 38^0C compared only to the OTA heat exchanger at 27^0 and OTW heat exchanger at 38C, it shows that 40kw can only be obtained when the oil to water is combine with the oil to air at both 27 and 38^0C with air flow mass of 0.5kg/s. This shows that with the addition of OTW heat exchanger to the present OTA heat exchanger, the 40kw heat transfer rate is obtained at 0.5kg/s air mass flow.

Table 3.2: Result of additional radiator oil to air.

Air mass flow	OTW + OTA AT 27 °C	OTW + OTA AT 38 °C	OTW AT 27\38 °C	OTA AT 27°C	OTA AT 38 °C
0.25	37	36	24	13	12
0.50	42	40	24	17	13
0.75	43	41	24	17	15
1.00	44	42	24	17	15

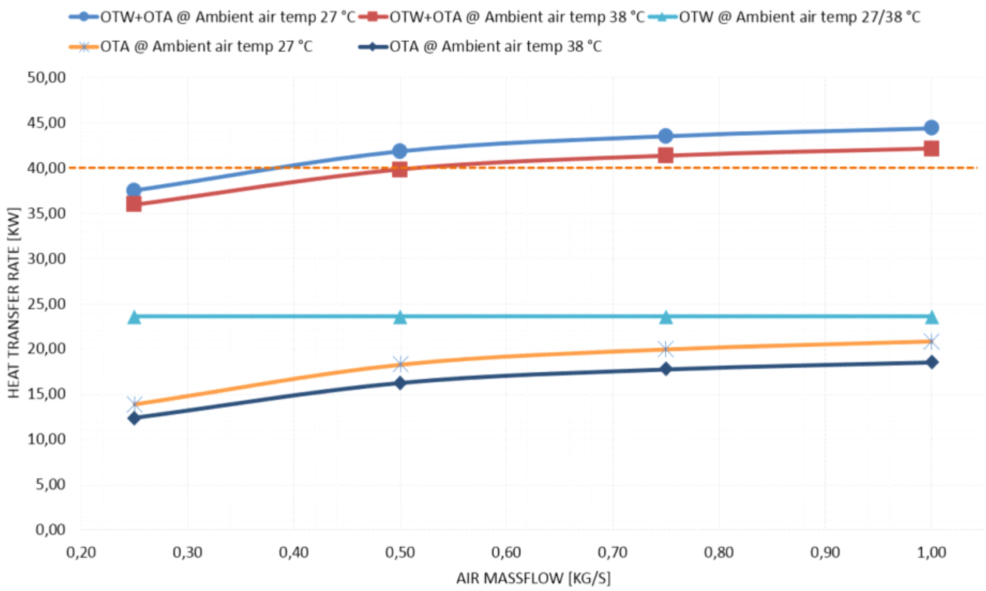

Fig. 3.2: Graph of heat transfer rate against air mass flow.

3.3 Separate Cooling Circuit Water to Air (WTA)

The result from the simulation show that it is possible to achieve a heat transfer rate of 40kw using a separate water circuit for the oil cooling as shown in fig.3.3, hence both the water and the air flow needs to be high, the high air flow could be difficult to achieve at a low speed. The water flow of 50L/min could be achieved by choosing an electric pump with sufficient capacity. The pressure loss in the plate heat exchanger would however be high, at such high flow. A slightly large WTA heat exchanger could most likely achieve the same heat transfer rate at lower air flow rate.

Table 3.3: Result of separate cooling circuit.

Tem °C	Water flow rate	Air mass flow 0.28	Air mass flow 0.50	Air mass flow 0.80	Air mass flow 1.00	Air mass flow 1.20
38	30	17	26	29	33	35
38	40	18	27	30	33	35
38	50	19	28	32	34	36
27	30	20	29	33	34	35
27	40	21	30	34	36	41
27	50	22	31	35	37	42

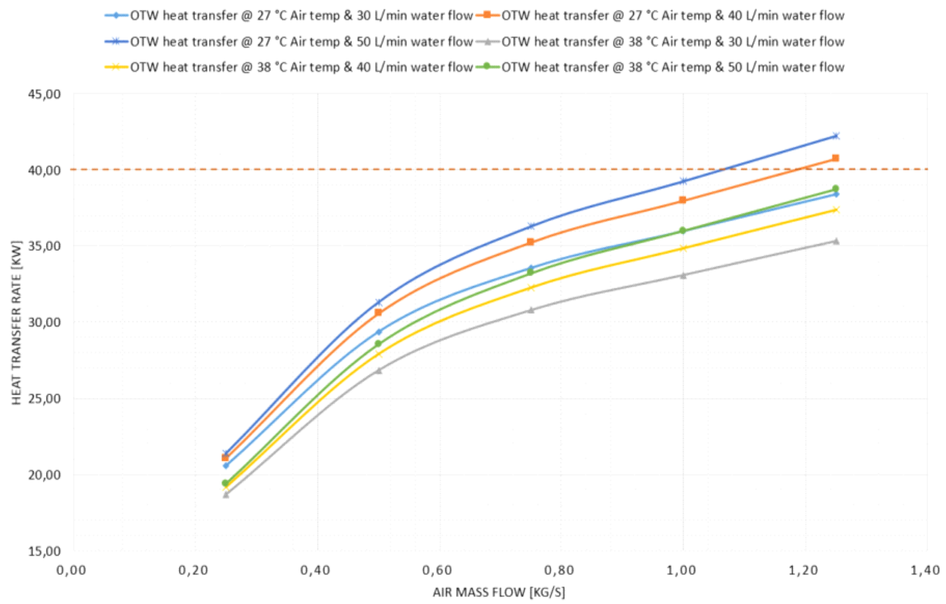

Fig. 3.3: Graph of heat transfer rate against air mass flow with separate cooling circuit.

4. CONCLUSION

At the end of this study four possible concept where discovered to improve the engine oil performance in automobile these are:

i. **Larger plate heat exchanger:** By increasing the surface area of the heat exchanger, which offers large surface area that result to increase in the heat transfer rate. After simulation, the heat transfer rate of 40kw was achieved with a coolant and oil flow of 1kg/s that requires the highest water and oil flow to achieve the desire 40kw heat transfer rate, therefore, the pump for both oil and water needs to be replaced with new one with higher capacity.

ii. **Copper as heat exchanger material:** Using copper as the heat exchanger, it has better thermal properties than aluminum at higher temperature that increases the capacity of the heat exchange.

iii. **Additional heat exchanger OTA:** With additional OTA heat exchanger was used to support the existing plate heat exchanger when it reaches its maximum heat transfer value. From the simulation it show that the direct air cooling of the engine without the addition of water in between as used in concept 3 and 4 proved to be the more realistic and performed much better at low vehicle speed.

iv. **Separate cooling circuit WTA:** The separate cooling circuit that take care of the excess heat from the engine. Results from the performance simulations showed that the desired heat transfer rate of 40Kw was achieved.

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