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Analysing the Causes of Overheating of Heavy Duty Truck Engines and Heat Flux of Radiator Using Pareto Principle Ansys Software

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ABSTRACT

Today's heavy duty engines demand more from coolant than ever before and the reason is the higher exhaust gas recirculation gas rate produce more heat, increasing pressure on the coolant performance capabilities. The Cooling system plays an important role to control the temperature of the engine. The overheating of the engine usually occur due to an inefficient cooling system and the failure of cooling system component results in overheating of an engine. This paper presents the analysis conducted to find out the causes of heavy duty engine overheating. The factors which were frequently affecting the engine temperature are found to be the coolant, radiator, fan and the water pump. The mentioned factors are found by using the pareto analysis technique, a survey is also conducted on various heavy duty trucks for the possible causes. The cause and effect diagram is presented to have a clear idea of the causes and its sub causes and the thermal analysis of the radiator is done using Ansys software.

Keywords- *Cooling system, cylinder liner, Engineoverheating, Thermal analysis, Pareto analysis*.

I. INTRODUCTION

The heavy duty engine in the heavy vehicles usually produce more heat than the commercial vehicles engines it because of their high capacity to carry loads and to maintain a constant speed. The energy produce by these heavy duty engines are enormous, which is a match to its capacity but the problem with these engines are these energy that are produced are not efficiently utilised only 40 % of the energy is utilised by the engine and the remaining 60% is wasted in the form of heat. This waste heat in the engine should be eliminated from the engine in order to avoid the engine from attaining the permissible heat limit.

Every engine has a capacity to cover a certain distance especially the heavy duty truck engines are designed to cover distance in terms of thousands of kilometres, during this journey they need to run in an optimum condition without any failure. In order to attain this condition the excess heat from the engine has to be eliminated so that the permissible limit of the engine is not attained during the journey of the vehicle.

The elimination of the excess heat from the engine is done by the coolant through the cooling systems, the prime objective of the cooling system is to reduce the excess heat generated from the engine. It does its job by leveraging the coolant, the cooling system is complex that circulates the coolant all around the engine through the passage that are produced with in the engine, the coolant which is sent inside the engine will absorb the heat that is generated from the engine, the heat generated by the engine is very high about 2200°C-2500°C and if it continues to be then it may result into seizing.

Therefore, the temperature of the engine should be reduced up to 200°C in order to make the engine more efficient. The cooling of the engine should not go beyond certain limit as it may affect the thermal efficiency of the engine so, the main objective of the cooling system is to keep the engine in a most optimum condition without affecting the efficiency of the engine.

The cooling systems are designed in such a way that when the engine is in a cold state condition they do not cool the engine further more as it will lead to inefficiency so, it will allow the engine to get warm up to the maximum operating temperature, then it starts cooling engine. If the cooling system do not do its job properly then the efficiency of the engine is affected, as it was said earlier especially in the case of the heavy duty engines this is the problem so, we have did some sort of analysis and found the root cause of problems in the cooling systems with the help of pareto analysis.

Pareto analysis is a mathematical technique which is also called as the 80/20 rule which assumes that the 80% of what we achieve is a direct result of only 20% of the action what we take. It is a statistical technique which is used in the decision making process to isolate of a limited number of actions that produce maximum overall effect. The technique helps in finding out the 20% of the cause which is responsible for the 80% of the problems in a domain so, that is the reason why we have chosen this technique to resolve our problem. By using this technique the top portion of the cause is identified and then the identified causes are resolved by using the tools like cause and effect diagram or fish bone diagram. The results of this analysis are represented in the form of the charts or graphs. The representations usually have bar graph which is in a descending order and predicts the major factor which is the reason for the most causes by superimposing a line graph that cuts at 80% and it also indicate the factors which have least amount of benefits. We have used this pareto analysis to study the data which we have collected regarding the causes of the heavy duty engine overheating and to identify the critical causes.

II. COMPONENTS OF THE COOLING SYSTEM

1. VALVE

It is one of the crucial part of the engine which tends to control the flow of fuel entering the combustion chamber and release of the exhaust gas to the exhaust manifold. It is usually controlled by the Cam which is driven by the crank shaft.

2. COOLANT PUMP

The water pump is a centrifugal pump driven by the crankshaft of the engine through the driver belt. Whenever the engine runs the water pump circulate the coolant throughout the engine. It utilises the centrifugal force to force the coolant to circulate around the cylinder in order to bring down the engine temperature below the permissible limit.

3. CYLINDER LINER

A cylinder liner is a cylindrical component which is present at the inner side of the cylinder. It is used to reduce the excess heat generated during the combustion.

4. TURBO CHARGER

A turbocharger, is a turbine-driven forced induction device that increases an I.C. engine's efficiency and power output by forcing extra air into the combustion chamber. Turbochargers were originally known as turbo superchargers where the other forced air induction devices were known as superchargers. Compared to an engine driven supercharger, turbochargers tend to be more efficient, but less responsive. Radiator:

5. RADIATOR

Radiator is a heat exchanging device used to transfer thermal energy from one medium to another for the purpose of cooling and heating. Radiator used in the tank has aluminium cores, these aluminium cores often save money and weight by using plastic headers. This construction is more prone to failure and less easily repaired.

6. THERMOSTAT VALVE

The thermostat is a device that automatically activates the valve whenever the temperature is reaches to a certain limit. Usually in the diesel engines this thermostat is used to regulate the flow of the coolant from the engine to the radiator to maintain the temperature of the engine near its permissible range. The thermostat operates using a sealed chamber containing a wax pellet that melts and expands at a set temperature.

7. WATER PUMP

Internal combustion engine cooling uses either air or a liquid to remove the waste heat from it. The coolant, which is circulating the cylinder, improves heat transfer from internal parts of the engine. Engines for watercraft may use open-loop cooling.

8. FAN

It is driven by the engine output shaft through same belt that drives the pump.

9. WATER JACKET

Cooling jackets are the essential component which is used to guide the coolant, which is required to absorb the excess heat from the engine, around the cylinder.

10. ANTIFREEZE MIXTURE

The following properties are possessed by the antifreeze

a) Anti-corrosion property.
b) Easily dissolvable in water.
c) Should not get evaporated.
d) It should not contain any unwanted debris.

Advantages of the cooling system

a) It maintain the engine efficiency.
b) It provides a uniform cooling effect.
c) It improves the specific fuel consumption of the engine.

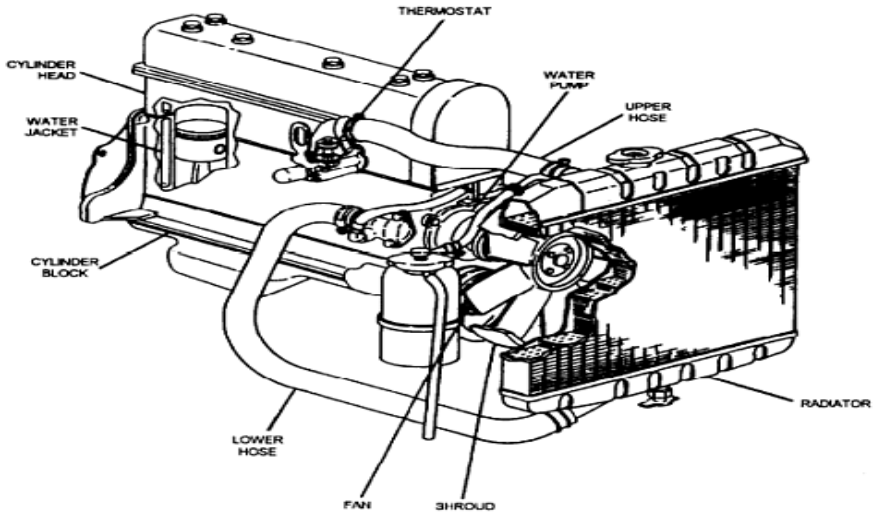

Figure 3.1 Components of cooling system

III. DATA COLLECTION

We have collected the data from heavy duty trucks repair shed. The data about eighteen trucks are list below with the major and the minor problems that are usually faced by the trucks. From the below table 4.1 we can get a clear idea and identify the major and sub causes of the overheating of the engines.

Table 4.1. Causes of overheating of engines.

S no.	**Engines**	**Causes of overheating**	**Sub causes**
1	MAN CLA 25.280	Radiator	Rusted tubes
2	MAN CLA 31.280	Fan	Less friction
3	MAN CLA 31.280 tipper	Fan	Fan blade
4	TATA LPK 3118 9S	Water pump	Damaged ring
5	TATA LPK 3118 9S RMC	Coolant	Improper concentration
6	Cummins	Radiator	Rusted tubes
7	Cummins	Coolant	Inadequate level
8	TATA PRIMA 4938.P	Fan	Less friction
9	TATA PRIMA LX 2523.T	Gasket	Installation
10	TATA PRIMA LX 3123.TTS	Coolant	Improper concentration
11	Eicher 4585	Coolant	Inadequate level
12	Eicher 4085	Gasket	Heating
13	Cummins	Radiator	Improper fitting
14	ASHOK LEYLAND 3118 IL	Radiator	Improper fitting
15	ASHOK LEYLAND 3118 IL XL	Fan	Fan blade

16	Eicher 4056	Coolant	Improper concentration
17	MAN CLA 49.280	Gasket	Installation
18	ASHOK LEYLAND U 3518 IL	Gasket	Heating
19	MAN CLA 36.5	Coolant	Inadequate level
20	Cummins	Radiator	Rusted tubes
21	Cummins	Coolant	Improper concentration
22	ASHOK LEYLAND UL 3508 IL	Fan	Less friction
23	Eicher 4085	Radiator	Rusted tubes

IV. ANALYSIS OF PROBLEM

Root cause analysis: The path of analysis is given in the form of cause & effect diagram and brain storming as shown in fig 5.1.

BRAINSTORMING:

1. Radiator efficiency
2. Coolant level
3. Coolant Additives
4. Driving Technique
5. Cooling fan efficiency
6. Water Pump
7. Turbo charger

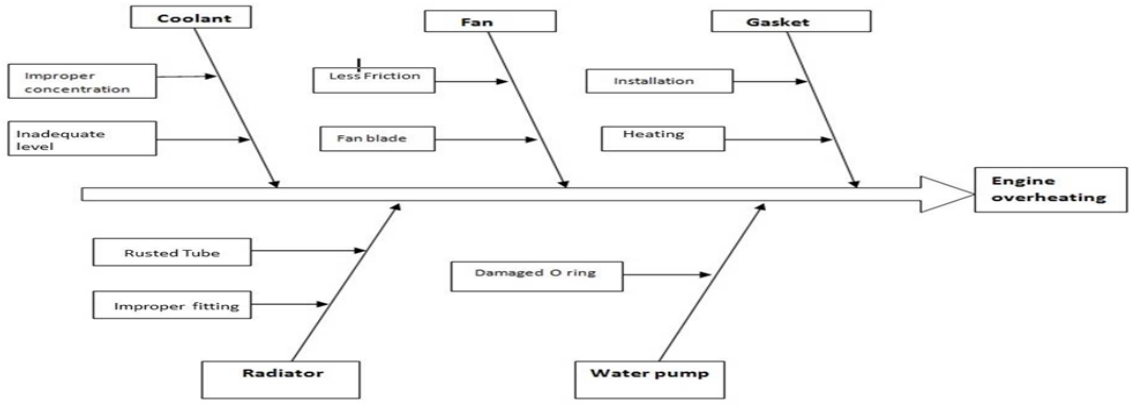

Figure 5.1 cause & effect diagram

V. ANALYSIS

ANSYS is a common purpose finite element analysis (FEA) software tool for structural analysis, linear, non-linear and dynamic studies. A numerical method of dismantling a complex structure into small pieces called elements, is known as Finite Element Analysis. This software governs the behaviour of these elements and solve them all by using the equations that are generated by them. These software can be also used to perform the thermal analysis. In this paper we have utilized this ansys to thermally analysis the radiator of the engines.

ANALYSIS OF THE RADIATOR

Table 6.1 Materials of analysis

S.NO.	COMPONENT NAME	MATERIAL
1	Radiator Tubes	Aluminium Alloy
2	Liner	Stain Steel

S.NO.	PARAMETERS	DIMENSIONS
1	Length	210mm
2	Diameter	10mm
3	Property	Aluminium alloy 6061

Radiator model:

The model of the radiator is done by using the solid works software tool. It is a computer aided design used to produce solid modelling. The radiator is done by integrating various parts that is made from solid works modelling. The radiator cooling plates are designed by using the patent command tool. And the tubes are modelled by using brushed aluminium material as shown in fig. 6.1.

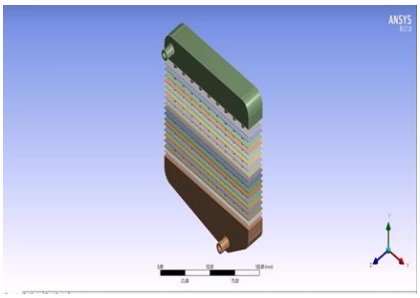

Figure 6.1model of the radiator

By using the size controls command of lines the Generate Mesh Meshing is done, the outer structure of the model is divided to get the mesh. After that mesh area is selected as shown in fig 6.2

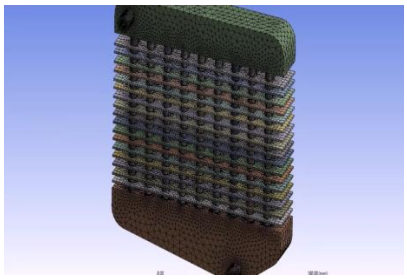

Figure 6.2 mesh model of radiator

The temperature of the coolant at the inlet is give as 110°C and the outlet temperature is 48°C are shown in fig 6.3.

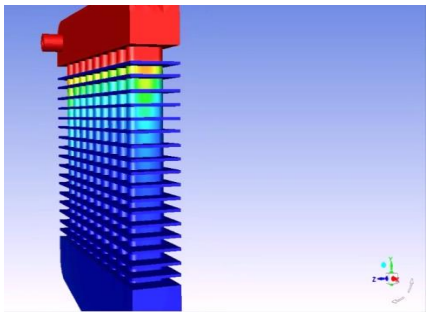

Figure6.3 Radiator analysis

VI. RESULT

From the data which is analysed using pareto technique which is based on the pareto principle of 80/20 rule, it is observed that the major causes of the engine overheating are coolant, radiator and pump as the graph shows in fig 7.1 that the line passes over the percentage line at 83% therefore, the left hand side shows the critical causes.

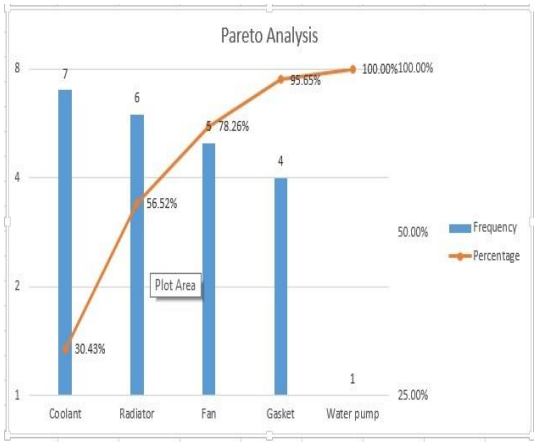

Figure7.1 pareto graph

The thermal analysis of the radiator is done in the ansys software and the behaviour of the aluminium material with the water mixed additive is studied, the data is enclosed in the below table 7.1

Table 7.1 Critical causes of engine overheating

S.No.	Causes	Contribution
1	Coolant	69.57%
2	Radiator	43.48%
3	Fan	21.74%

VII. CONCLUTION

The causes of the overheating of the heavy duty engines were studied by considering the 23 engine that was recorded in the workshop. And the causes of the overheating were found by using the Pareto technique, the critical causes of the overheating of the engine is found to raise from the coolant, radiator and fan. When considering the coolant, in most of the engine they are either in improper concentration or inadequate level. The radiator tubes were rusted and this disturbs the turbulent flow of the coolant which will ultimately reduce the heat transfer rate and the improper fitting leads form leaks in the radiator which reduce the level of the coolant. Some engines have a damaged fan blades which is a result of inappropriate material selection and the friction between the fan rotor and the belt was found wearing out. From the thermal analysis of the radiator by using the aluminium alloy 6061 as the material of the tubes, the value of heat flux which is obtained, is found to be more which implies that the heat transfer rate of the radiator is also more and it is recommended to use aluminium alloy 6061 as tube material.

VIII. REFERENCES

Prof. J.A. Doshi, J.D. Kamdar, Prof. S.Y. Jani, Prof. S. J. Chaudhary / " Root Cause Analysis Using Ishikawa Diagram For Reducing Radiator Rejection" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 6, November- December 2012, pp.684-689

Gogineni. Prudhvi, Gada.Vinay, G.SureshBabu " Cooling Systems in Automobiles & Cars" International Journal of Engineering and Advanced Technology (IJEAT) ISSN: 2249 – 8958, Volume-2, Issue-4, April 2013

TanuSinghai 1, Abhishek Mishra 2 , Rajiv Saxena 3 , Sanjay Chhalotre 4 "Analysis and Performance of Automobile Engine Components Considering Thermal and Structural Effects" International Journal of Innovative Research in Science,Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 3, Issue 1, January 2014

QuaziMohd. Jawed Ali ** Dr.SuwarnaTorgal "Failure Analysis of Engine over Heating Issues Observed in Vibratory Compactor Powered by Air Cooled Diesel Engine (Part-01)" Indian journal of research Volume : 3 | Issue : 5 | June 2013

Shantkumar.B..Bocharrei "Improving the performance of engine block by varying cooling fluids" Proceeding of NCRIET-2015 & Indian J.Sci.Res. 12(1):408-416, 2015 ken nelson " engine overheating" Shade tree A's volume 36 No 7 july 2009