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Modification And Simulation Of Performance Investgation By Repositioning The Intercooler

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ABSTRACT: *In this paper experimental analysis of thermal behaviour of the single phase counter flows through an automotive intercooler. Turbocharger is a integral part of modern IC engines and the major reason that they are able to produce more power. On comparing super charger is driven via belt from the engine but a turbo takes the exhaust that the engine is producing and puts it to good use. As Turbochargers are driven by exhaust, heat is an unwelcome by product and something that wasn't really taken into account in automobiles. Then those intercoolers started to come into play in turbocharged automobiles. The forced air produced by the turbocharger is routed through the intercooler where its temperature is reduced before reaching the engine. The use of intercoolers has made turbocharged vehicles far more reliable, and in the case of today's heavy duty diesel trucks, it is a very important component. The inlet air of an IC engine from radiator, temperature is very much high. And also air with high temperature causes pre-ignition and detonation. So fuel combustion does not take place properly. Inter Cooling of inlet air is very much essential according to performance point of view. Turbo intercoolers are used for cool the inlet air of an IC engine from turbo charger. Moreover cooling of air makes it efficient and contributes for better combustion and the radiators and intercoolers close to eachother reduces air flow. This arrangement affects the performance of both. So in this paper an attempt will be made to increase the efficiency of the intercooler arrangement through design optimization and repositioning of intercooler by taking the* ***TATA MARCOPOLO-Star Bus 909 as a reference.***

KEYWORDS: *Intercooler, Cooling system, Fluid Flow, Optimization, Performance Investigation.*

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I. GENERAL :

Improving the fuel economy for automotive applications has a major priority this decade. The driver of this strong action is concern over Global Warming and the connection between fuel consumptions and emission of the carbon dioxide, greenhouse gas, etc. The European Automotive Manufacturers required the average emissions for new cars reduced to 120 g/km by 2015. This implies a reduction in fuel consumption of more than 24.6% from a 1995 baseline. An even more stringent CO2 target of 96 g/km is under consideration for 2021.

In most cases, especially where boost level exceed 7 PSI, cooling the compressed air with a charge air cooler, often its called an intercooler, increase the air density more than any density losses that occur due to the accompanying pressures drop due to cooling or flow restriction through an intercooler. In other words, intercooling results in a net density increases for the air entering the cylinder shown in **Fig 1.1.**

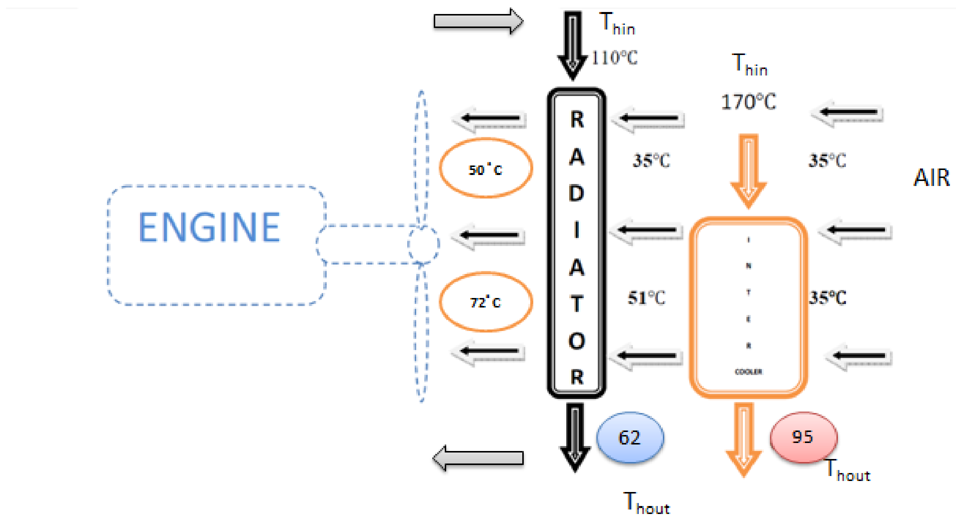


Fig 1.1 Cooling System Arrangement

With the intercooling, exhaust temperature remained manageable for the duration of the Bonneville World Speed Record runs. Without intercooling, the exhaust temperature would have been in the 1800º-1900º F range.

II. CONCEPT OF FLOW

The following **fig 2.1** represented the modified arrangement of intercooler which consists of intercooler core. Turbocharged air is passed through inner finned tubes and atmosphere air is sucked and forced inside the outer tube. Fins welded on inner tube so there is indirect contacts between hot air and normal air. Normal air absorb the heat from inner tube by tube surfaces and fins. So engine inlet air gets cooled by this arrangement. External air blower is connected with engine shaft through belt drive. The intercooler should be repositioned from front of radiator to prevent the thermal radiations. In the optimized arrangement, the intercooler is kept at bottom of the radiator. So the free air flow over the radiator takes place easily. There is no radiation effect from radiator to intercooler. This arrangement is safe and efficient for both engine and cooling system.

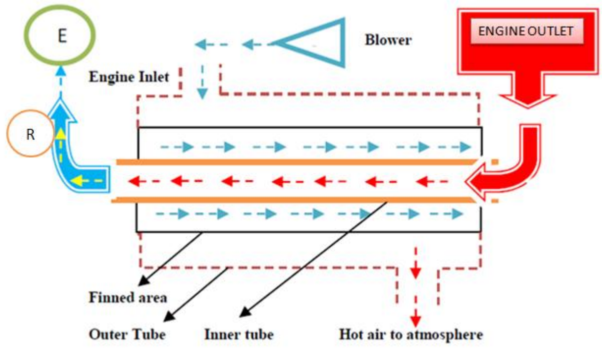


Fig 2.1 Concept of Flow

III. INVESTIGATION OF OLD RADIATOR

The following **table 3.1** shows the difference in temperature and fins efficiency between the upper and the lower half of the radiator due to the presence of intercooler in front of the radiator.

PARAMETERS	**RADIATOR WITH INTERCOOLER**			**RADIATOR ALONE**
	INTERCOOLER	RADIATOR		
		UPPER HALF	LOWER HALF	
U_i (W/m^{2}k)	1229.191	253.050	188.015	207.90
U_o (W/m^{2}k)	146.278	30.46	22.40	24.634

$T_{h\ in}$ (°C)	170	*	*	*
$T_{h\ out}$ (°C)	**62**	99	95	92
$T_{c\ in}$ (°C)	35	**35**	**51**	35
$T_{c\ out}$ (°C)	51	50	72	65
η_{fin} (%)	70	**89**	**80**	89

Table 3.1 Exisiting Arrangement of Cooling system

From above **table 3.1** its observed the intercooler is not present air will flow freely over the radiator resulting in the reduction of coolant temperature difference.

IV. OPTIMISATION OF DESIGN

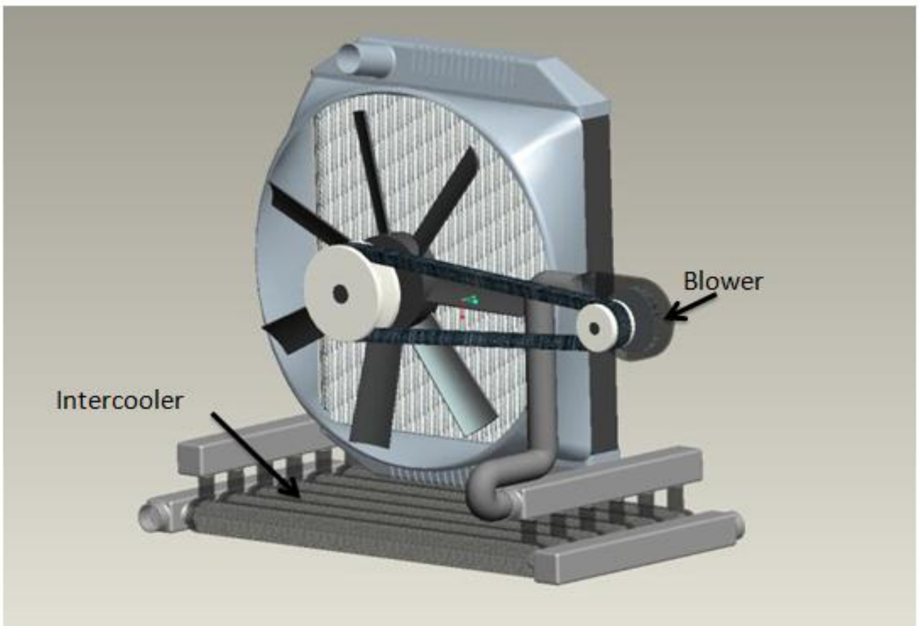
The theortical calculation, different trials were performed for various dimensions and the results are shown below **table 4.1.**

Trials & CFM	Pipe parameters			Fin parameters				Temperatures				Area Calculation		Over all Heat transfer coefficients	
	ID	OD	L	H	L	T	η fin	Inlet		Outlet		Ai	Ao	Ui	Uo
I 100	15	35	550	20	550	1	89%	170	35	72.8	118	0.05	0.40	5.3	2.6
II 200	25	45	650	20	650	1	94%	170	35	51.2	139	0.05	0.51	10	7.9
III 200	**25**	**28**	**700**	**11**	**700**	**1**	**94.97 %**	**170**	**35**	**48.5**	**104**	**0.05**	**0.98**	**4.1**	**4.1**
IV 300	25	28	700	11	700	1	94.63%	170	35	48.5	81.5	0.05	0.98	3.6	3.6

Table 4.1 Summary of Trails

4.1.1 Optimized Design

The conduits for air flow are as shown in the above **fig 4.1** the inner tube consists of a flat fin projecting from the outer surface of the inner tube. The outer tube covers the inner tube there by forming the necessary arrangement.



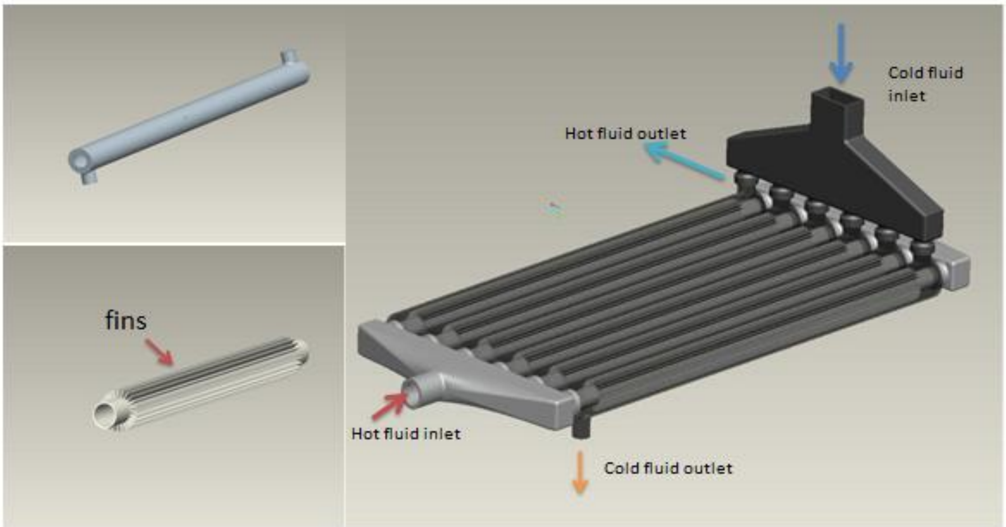


Fig 4.1 New Arrangements

4.1.2 ANALYSIS OF NEW ARRANGEMENT

The analysis result (fluent) shows the temperature contours at various sections of the tube in **fig 4.1.1** the temperature varies from high to low at the end sections of the tube.

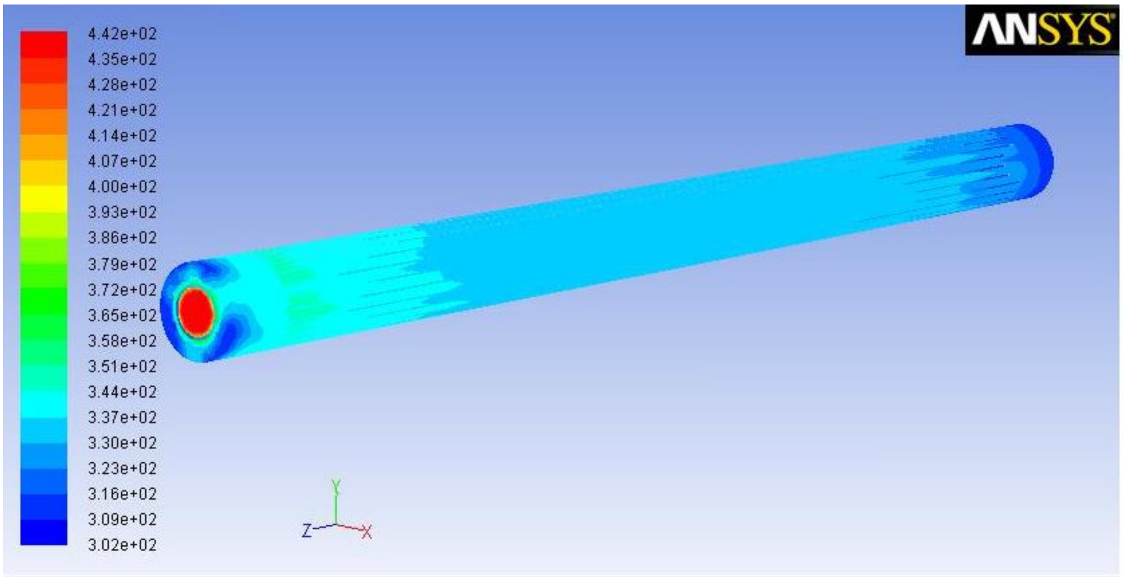


Fig 4.1.1 Temperature Analysis of Counter Flow

4.2 Optimized Arrangement

Using the data of the selected trial 3 from the previous arrangement, a modification is done only to the fins for easy manufacturing. The flat fins from the previous arrangement are changed into pin fins in the form of loops, which increased the area for heat transfer and easy air flow.

4.2.1 Analysis of Optimized Arrangement

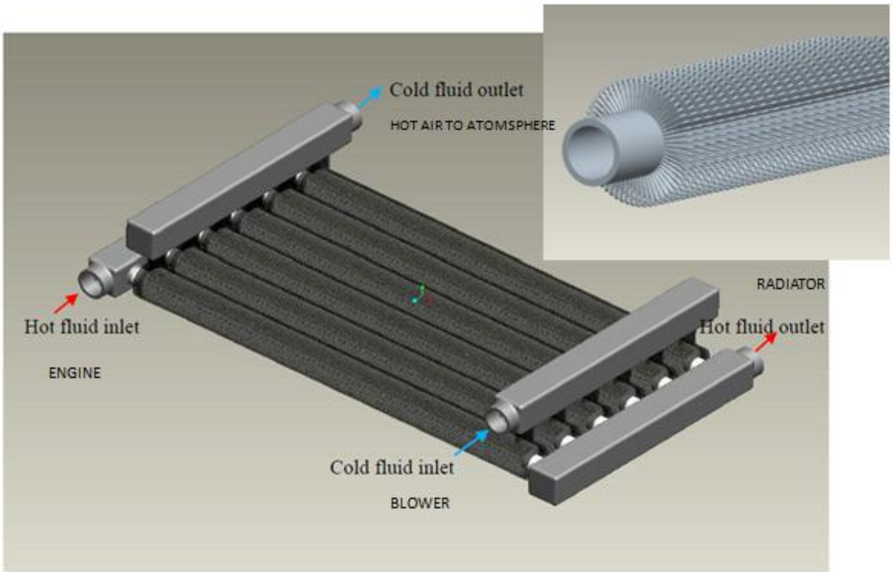


Fig4.2.1 Optimized Arrangement

The contours of the cold fluid are as shown in the below **fig 4.12** the hot fluid heats up the cold fluid. So the cold fluid takes the heat away from the hot fluid, resulting in the increase of temperature from inlet to outlet.

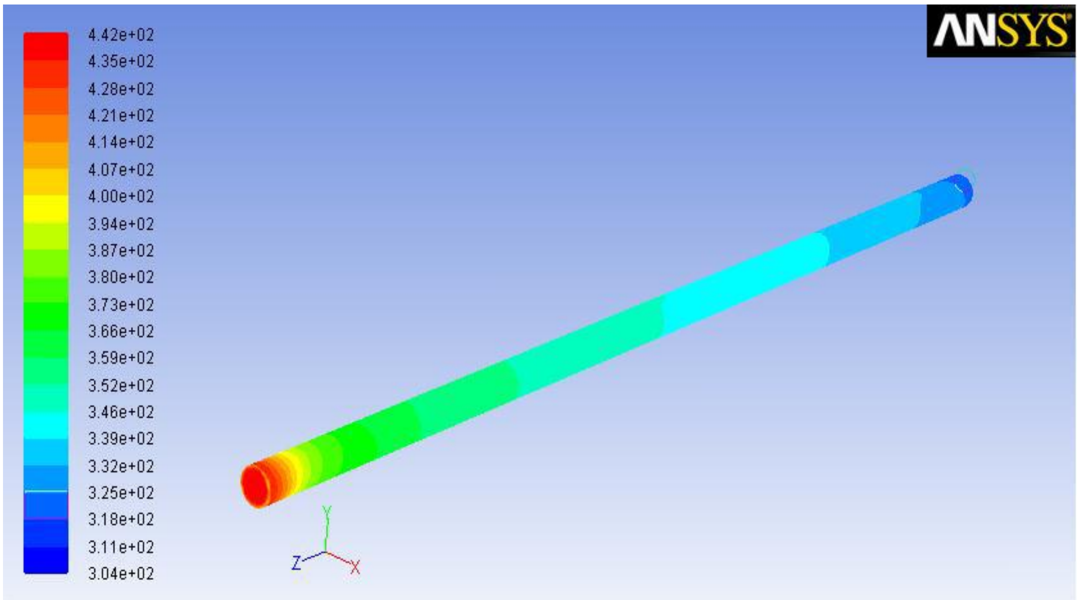


Fig4.2.2 Hot Flow

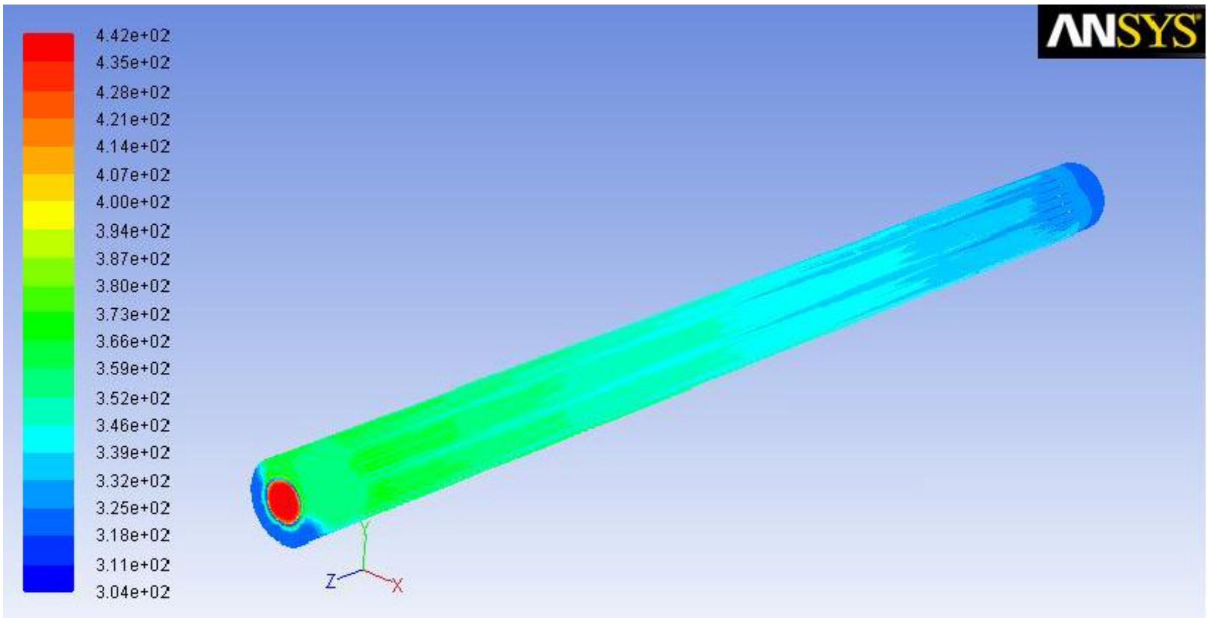


Fig 4.2.3 Temperature Analysis of Counter Flow {Optimized}

V. RESULTS AND DISCUSSIONS

5.1.1 Comparison of the New Arrangement and Optimized Arrangement

The calculated results for the new arrangement and the optimized arrangement are tabulated and are displayed below in the **table 5.1**.

Method	Temperatures ℃					
	Inlet		Outlet			
			New arrangement		Optimized arrangement	
	Thi	Tci	Tho	Tco	Tho	Tco
Theoretical	170	35	48.5	104.72	48.12	110.97
Analysis	170	35	50	99	45	107

Table 5.1 Comparison of Arrangement

The over all comparision of temperature of the hot fluid between the existing and the optimized arrangement is projected. It is clearly seen that there was 14℃ decrease in the hot fluid temperature, which ultimately results in the increase of the compressed air intake (volumetric efficiency), there by leading to increase in the Brake Horse power.

5.2 Enchancement of Engine Power

It‘s obtained from the literature that a 10ºF drop in temperature will improve density and oxygen content by 1% and so the engine power by 1.8%. But in the above optimized arrangement the temperature drop of **14℃** is obtained which actually gives a temperature drop of 57.2º F in Fahrenheit scale. So this ultimately results in the increase of engine power by 9% approximately. The existing Brake Horse Power of the engine was found to be 90BHP (from the engine specification manual) and if the optimized intercooler is used, the BHP would increase up to 98.42BHP approximately. But due to the use of a blower of **0.5HP** and considering transmission losses, approximately 1HP can be deducted and therefore overall brake horse power will increase up to **97.42BHP.**

VI. CONCLUSION

The double pipe counter flow type consists of an inner tube with pin fins attached to it externally and covered by an outer tube. This optimized model was proved better than existing arrangement by theoretical and analytical results, which showed improved cooling effect, increases in BHP efficiency and reduced pressure drop when compared to the conventional model. This increased heat transfer decreases the like hood of detonation by reducing the inlet temperatures and maximizes power output by increasing the density of the air inlet charge, therefore increasing overall horsepower levels as the intake charge is now cooler and denser.

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