PERFORMANCE TEST ON 4 STROKE SINGLE CYLINDER DIESEL ENGINE BY PRE HEATING OF THE FRESH CHARGE WITH EXHAUST GAS

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ABSTRACT: Present IC engines are having the thermal efficiency around 28% for diesel engine and 25% for petrol engine (terms and conditions are applied). The remaining efficiency has been lost by the way of heat energy to the surroundings. In this paper we done an analysis on 4 stroke diesel engine which have the heat exchanger at exhaust manifold to recover the some amount of heat energy from exhaust gas to inlet fresh gas. This is the process name as pre-heating of the fresh charge.

IndexTerms–IC engine, heat exchanger, Pre-heater, thermal efficiency, exhaust gas, fresh charge.

1. INTRODUCTION

Present IC engines have the maximum efficiency of only around 28% for diesel engine and 25% for petrol engine. The remaining efficiency has been lost by heat energy to the surroundings. The main thermal losses which occur in the engine in the form of losses through exhaust gases and incomplete combustion of fuel. The incomplete combustion not only reduce the engine efficiency but also leads to form harmful gases like CO, CO2, NOx&SO2 to the atmosphere which leads to causes of greenhouse effect and global warming and also knocking in IC engines. The temperature of the exhaust gas is 400-900 degrees for SI engine and 300-600 for CI engine.

In this paper our main aim is to reduce the heat losses and improve the thermal efficiency of the engine with the attachment of heat exchanger to perform the process of pre heating of the fresh charge. By using of the copper tube with convective mode of heat transfer we gone to exchange the heat from exhaust gas to inlet fresh charge gas, which result the changes in the performances of the IC engine.

2. LITERATURE SURVEY:

P. Balashanmugam et al. [1] Worked on preheating of exhaust gas is giving to input of ignition in two/Four Stroke engine to increase the efficiency. Finally pre-heating the inlet air to the carburetor for a considerable amount, the vaporization can be easier and in turn complete combustion is achieved.

Arjun Shanmukam et al. [2] concentrated to heating the fuel up to an operating temperature for which heat can be extracted from a potential source, namely the Exhaust Manifold to achieve the required atomization, reducing the Surface Tension of the fuel is a potential solution. Finally it is expected to increase power output of the engine by 20-30%. Due to the extreme homogeneity of the air-fuel mixture present in the cylinder during power stroke, the combustion is near ideal and the flame travel is assumed to be steady and uniform.

K.Raja et al. [3] found the method to recover the waste heat from internal combustion engine in order to increase performance and lower the emissions of the internal combustion engine. He achieved the efficiency has been increased nearly 6% with a degree rise in temperature of the fuel.

G.Aravinthkumar et al. [4] He discusses about the variability of using H2 as a fuel along with petroleum with preheat the inlet air to get the more efficient for the performance of engine. From the investigation it has been informed that the efficiency of single cylinder four stroke petrol engines is increased by 2-3% using the hydrogen gas along with the petroleum.

P.Naresh et al. [5] He found the way to reduce the nitrogen oxide emissions of a diesel engine is the use of exhaust gas recirculation, EGR. Here, a part of the exhaust gases is rerouted into the combustion chamber. He conclude that 15% EGR rate is found to be effective to reduce NOx emission substantially without deteriorating engine performance.

Ajinkya B. Amritkar et al. [6] His paper includes formation of NOx in diesel engine, detailed about EGR system and one case study regarding this. He conclude that EGR reduces the rise in temperature by recirculation of exhaust gases, exhaust gas displaces fresh air-entering in the combustion chamber and hence air displacement lowers oxygen amount available for combustion in the intake mixture.

S.K. Mahla et al. [7] objective of this work is to investigate the possibility of decreasing the exhaust emissions and to determine the performance parameters. The use of EGR up to 5% is useful in improving the brake thermal efficiency. Peak cylinder pressure reduced and ignition delay prolonged with 15% EGR substitution.

Amruthraj. M et al. [8] the effect of addition of browns gas to air fuel mixture has been investigated by electrolysis process. The Hydro carbon has reduced by 99.25% and Carbon Monoxide has reduced by 98.668% by volume.

M. M. Shahmardan et al. [9] in this paper, an analytical solution for convective heat transfer in straight pipes with the elliptical cross section is presented based on Nusselt number. The solution indicated that the Nusselt number is increased by changing the geometry of cross section from circular to elliptical shape from 48/11 to 4356/833 for large enough aspect ratios.

Madhu L. Kasturi et al. [10] explained from this paper included that the analysis of preheating intake air on emissions (CO, CO2, HC and NOx) and time required for fuel consumption. Engine exhaust gas temperature is used to preheat the inlet air, heat exchanger is used to transfer heat from exhaust gases to inlet air. They concluded that CO and HC content in the exhaust gas reduces with increase in intake air temperature.

3. COUNTER FLOW OF HEAT EXCHANGE:

Basically there are two types of the heat flow those are counter heat flow and parallel heat flow on those the beat method of heat flow is counter heat flow. That’s why we use the counter way of heat flow in heat exchanger.

4. EXPERIMENTAL SETUP:

Engine specifications:

1.	Made	: Kirloskar
2.	Bore diameter	: 80mm
3.	Stroke	: 110mm
4.	Rated speed	: 1500 rpm
5.	Compression ratio	: 16.5:1
6.	Fuel	: diesel
7.	Density of diesel	: 0.827 gm/ml
8.	Break drum diameter	: 0.3 m
9.	Rope diameter	: 0.015 m
10.	Calorific value of diesel	: 45,350 Kj/kg

In this setup we attached the heat exchanger at the manifold of the engine and in the heat exchanger both the fresh charge and out let pipes are being in contact then the heat transfer can occurs. We use copper material for the tubes because the only copper have the low in cost and best heat transfer coefficient as compare to the other materials.Copper has many desirable properties for thermally efficient and durable heat exchangers. First and foremost, copper is an excellent conductor of heat. This means that copper's high thermal conductivity allows heat to pass through it quickly. Other desirable properties of copper in heat exchangers include its corrosion resistance, bio fouling resistance, maximum allowable stress and internal pressure, creep rupture strength, fatigue strength, hardness, thermal expansion, specific heat, antimicrobial properties, tensile strength, yield strength, high melting point, alloy ability, ease of fabrication, and ease of joining.

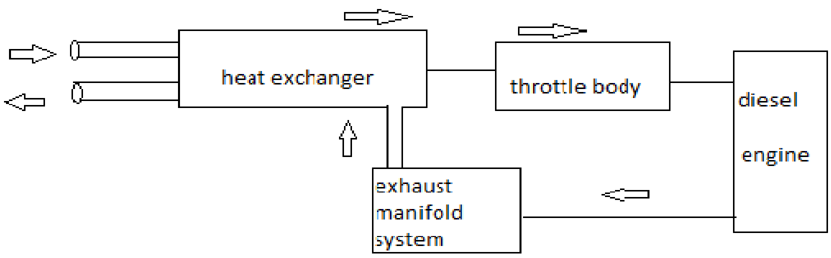


Fig no 4.1 Basic block diagram of the experiment setup

Fig no 4.2 experimental setup

5. RESULTS AND DISCUSSION :

After the attachment of this equipment we just collect the observations has shown in the indicators the observations are

S.NO	SPEED(N)	S1(kg)	S2(kg)	MANOMETER READING(X)	TIME OF FUEL CONSUME	Co level (ppm)
1	1540	0	0	6	39	310
2	1538	1	2	6	38	450
3	1534	2	4	6	36	510
4	1532	4	5	6	31	560
5	1527	5	5	6	25	610

Table no 5.1 Observation table without heat exchanger

S.no	(N) Rpm	S1 (kg)	S2 (kg)	MANOMETER READING(X)	TIME OF FUEL CONSUME	Co level (ppm)	T Exit ˚C	T In ˚C
1	1560	0	0	6	43	425	154	46
2	1554	1	2	6	42	433	154	48
3	1542	2	5	6	40	450	155	49
4	1538	3	6	6	36	470	159	50
5	1535	4	7	6	33	560	162	52

Table no 5.2 Observation table with heat exchanger

The formulas which we were used to analysis the performance of the diesel engine based on the above data are:

1. Break power
   $BP = (2\pi n\ (s1+s2)\ ((D+d)/2))/60000$
2. Indicative power
   IP= B.P+ frictional power
3. Mass of fuel consumption
   $mf = (X*sg*3600)/\ (1000*t)$
4. Break mean effective pressure
   $bmep = (BP*1000)/\ (10^5*(\pi d^2/4)*l*N/\ (120))$
5. Indicative mean effective pressure
   $imep = (IP*1000)/\ (10^5*(\pi d^2/4)*l*N/\ (120))$
6. Mechanical efficiency
   $\eta=BP/IP.$
7. Indicative thermal efficiency
   $\eta\ i\ th= (Ip*3600)/\ (mf*cv)$
8. Break thermal efficiency
   $\eta b\ th= (Bp*3600)/\ (mf*cv)$

Based on these formulas we done our performance test and these formulas has been adopted from the published book in the named as INTERNAL COMBUSTION ENGINES by V.GANESHAN.

Finally the obtained by above observation table through formulas are:

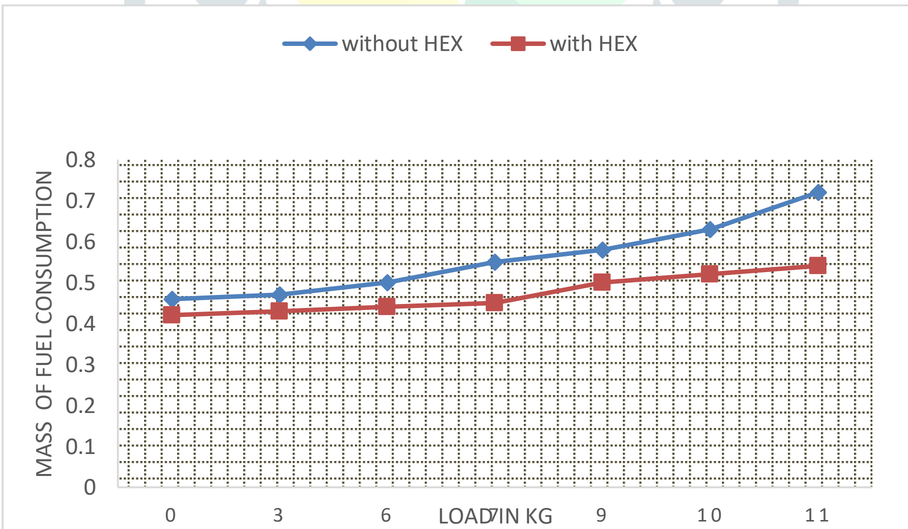
OBJECTIVE	S=0 kg	S=3 kg	S=6 kg	S=9 kg	S=10 kg
BP kw	0	0.3	0.6	0.9	1.0
IP kw	1.6	1.9	2.2	2.5	2.6
Ŋ	0%	15%	27%	35%	38%
Bmep	0	0.24	0.49	0.75	0.8
Imep	1.31	1.56	1.83	2.06	2.15
ŋ B thermal	0%	5.4%	10.2%	13.2%	11.9%
ŋ I thermal	29.3%	34.4%	37.8%	36.1%	30.0%

Table no 5.3Result table without heat exchanger

OBJECTIVE	S=0 kg	S=3 kg	S=7 kg	S=9 kg	S=11 kg
BP kw	0	0.30	0.71	0.97	1.10
IP kw	1.6	1.9	2.31	2.57	2.70
Ŋ	0%	15%	30%	37%	40%
Bmep	0	0.24	0.58	0.79	0.91
Imep	1.29	1.54	1.89	2.10	2.22
ŋ B thermal	0%	5.9%	13.3%	16.5%	17.4%
ŋ I thermal	32%	37%	43%	44%	42%

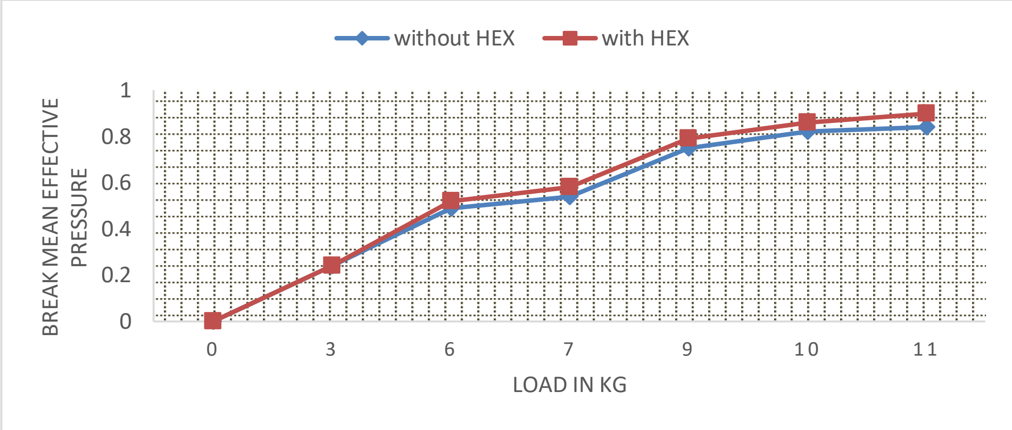
Table no 5.4Result table with heat exchanger

6. GRAPHS:



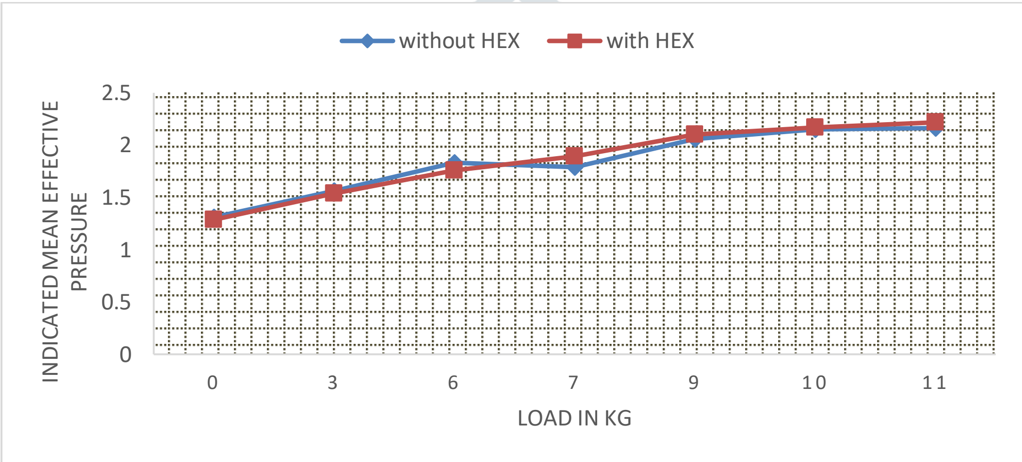
Graph 6.1 Load vs mf

Here we plot the graph between loads in kg vs mass of fuel consumption. There is a significant changes has been occurs as comparison with heat exchanger and without heat exchanger, that changes are occurs mainly due to several reasons the main probable reason is mass of fuel consumption which means the effectiveness to convert the chemical energy contents of fuel into useful work. So this engine index is used rather than thermal efficiency to indicate not only the efficiency of engine combustion process, but also fuel economy. As temperature increasing the fuel combustion is improved due to better mixing of fuel and air. While at high engine load the combustion is improved due to higher in-cylinder temperature after successive working of engine at this load that is would improve fuel atomization and evaporation processes and partially improve fuel air mixing process.



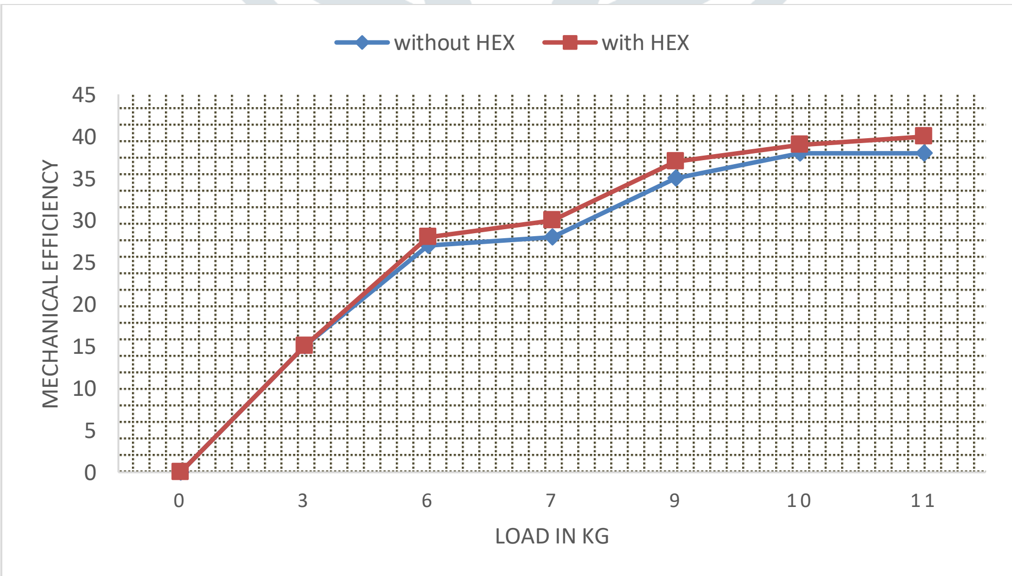
Graph 6.2 Load vs bmep

Here we draw a graph between loads in kg vs break mean effective pressure which leads a moderate changes as compare to the standard engine arrangement. This thing happens due to the applied load on engine at different temperature levels of the fresh charge, which impacts the combustion process in engine, gives to the moderate changes as compare to the standard arrangement of the engine.



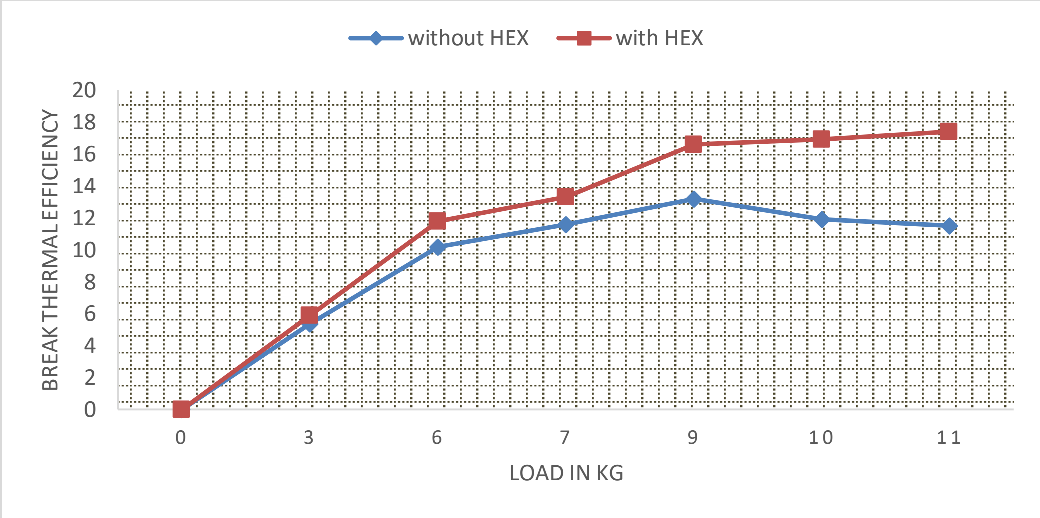
Graph 6.3 load vs Imep

Here the graph is representing the loads vs indicative meant effective pressure at different level of the temperature to the inlet air. The moderate changes has been occurred due to the changes in break power because the indicative power is dependent on the break power and frictional power which is a directly proportional to the break power. Based on that indicative power and speed of the engine with respect the load we can get the indicative mean effective pressure.



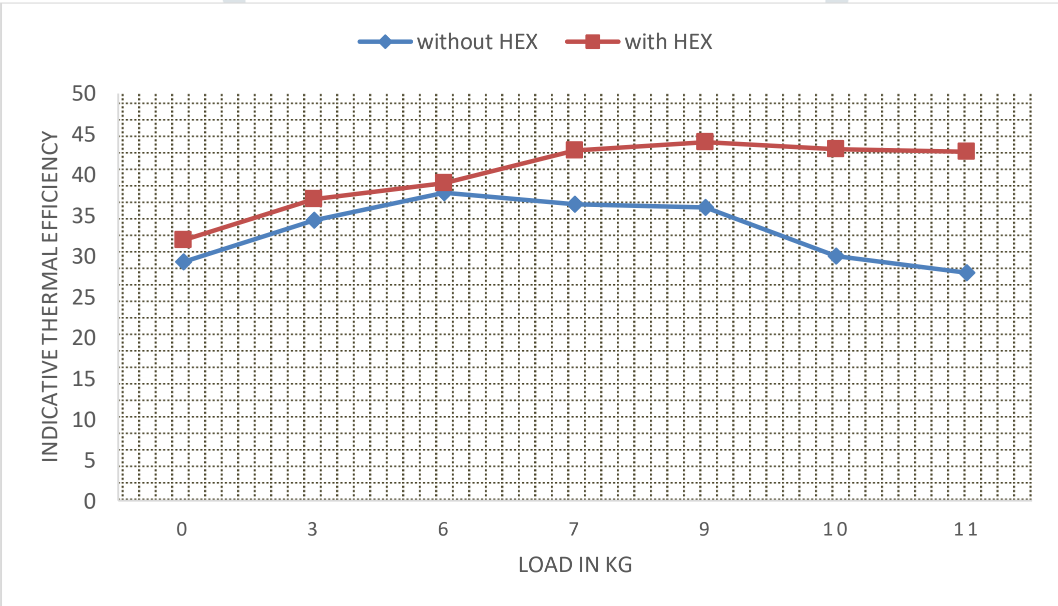
Graph 6.4 load vs mechanical efficiency

Here we draw the graph between loads in kg vs mechanical efficiency. The mechanical efficiency is directly proportion to the break power and inversely proportion to the indicative power. From the data the graph no 6.2 and 6.3 were representing the break power and indicative power of the engine with heat exchanger and without heat exchanger of the engine. At a particular load the efficiency can start decreasing due to several reasons like increasing the wear and tear, mass of fuel consumption is more and inside air temperature can be increases.



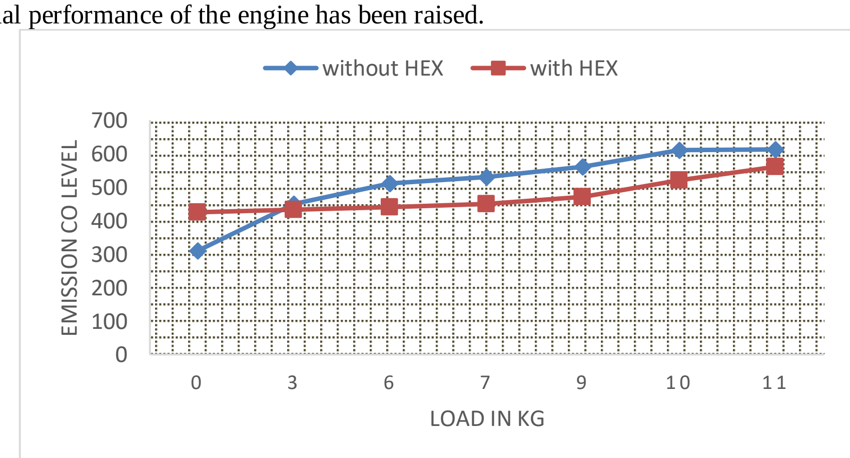
Graph 6.5 load vs break thermal efficiency

Here we draw the graph between loads in kg vs break thermal efficiency. There are significant changes have been occurred in the break thermal efficiency with the comparison of the engine with heat exchanger and to the standard engine arrangement. These changes are occurs by influencing the major factors like break power and mass of fuel consumption.



Graph 6.6 load vs indicative thermal efficiency

Here we draw the graph between loads in kg vs indicative thermal efficiency of the engine. These major significant changes are also obtained due to the factors influencing like indicative power and mass of fuel consumption, which these are indicating that the thermal performance of the engine has been raised.



Graph 6.7 load vs emission (CO)

Here the graph is representing that loads vs emission levels. These are the predominant role played in this analysis because at different loads the emission is obtaining but we got very major difference in the level and we have reduced the emission because when we pre heat the charge the temperature level of the air has raised which leads to complete combustion of the fuel so finally we get less pollute gas from exhaust.

From the graphs and results from the tables we conclude that the thermal efficiency has been increased and the mass of fuel consumption is reduced and the emission level also reduce.

7. CONCLUSION:

By this paper we gain some effective parameters those are

1. Utilizing the waste heat reduces the amount of greenhouse gases.
2. CO content in the exhaust gas slightly reduces by 50 ppm with increase in intake air temperature at 52˚c.
3. The heat input required for the engine reduces with increase in intake air temperature up to 52˚c
4. The inlet air temperature increase and indicated thermal efficiency also increase to 8%
5. Fuel consumption reduces to 0.18 and brake thermal efficiency increases to 5%.
6. It will reduce the ignition delay while cold start of the engine when it is in cold conditions
7. Pre heating leads to homogeneous mixture in the combustion chamber to combust.
8. Finally the mechanical efficiency has been raised to 2% with respect to load.

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