Implementation and Testing Of Turbo Charger on a Diesel Engine

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Abstract: Turbo chargers are used throughout the automotive industry to enhance the output of an internal combustion engine without increasing the cylinder capacity. The application of such a mechanical device enables automotive manufacturers to adopt smaller displacement engines, commonly known as engine downsizing. Turbochargers were often used to increase the potential of an already powerful IC engine, example those used in motorsport. The emphasis today is to provide a feasible engineering solution to manufacturing economics and "greener" road vehicles. It is because of these reasons that turbochargers are now becoming much more popular in automotive industry applications. The aim of this paper is to installation and testing of a turbo charger to a diesel engine and to improve the engine performance (power of the engine). It is observed that by installing a turbo charger to a diesel engine the power of the engine increases for the same engine capacity as compared to naturally aspirated engine.

Index Terms - Turbo Charger, Internal Combustion (IC), Efficiency, Diesel Engine, Implementation, Power output**.**

I. INTRODUCTION

Forced induction systems, like a turbocharger or supercharger, compress the air flowing into your engine and offer the greatest performance increase. It's not uncommon to increase horsepower and torque by over 50% with the aid of forced induction. By adding more air, the engine can also mix in more fuel, so a charged engine produces more power overall, which significantly improves acceleration. While a supercharger's powered by a belt that connects directly to the engine, a turbocharger gets its power from the exhaust system. Turbochargers are considered more efficient since they use "wasted" energy from the exhaust stream as their power source, but by nature present a greater delay (or turbo lag) until you feel power. Superchargers, on the other hand, offer almost instant power when you step on the gas and are usually easier to install.

WHAT IS A TURBO CHARGER?

Have you ever watched cars buzzing past you with sooty fumes streaming from their tailpipe? Its obvious exhaust fumes cause air pollution, but it's much less apparent that they're wasting energy at the same time. The exhaust is a mixture of hot gases pumping out at speed and all the energy it contains—the heat and the motion (kinetic energy)—is disappearing uselessly into the atmosphere. Wouldn't it be neat if the engine could harness that waste power somehow to make the car go faster? That's exactly what a turbocharger does.

Car engines make power by burning fuel in sturdy metal cans called cylinders. Air enters each cylinder, mixes with fuel, and burns to make a small explosion that drives a piston out, turning the shafts and gears that spin the car's wheels. When the piston pushes back in, it pumps the waste air and fuel mixture out of the cylinder as exhaust. The amount of power a car can produce is directly related to how fast it burns fuel. The more cylinders you have and the bigger they are, the more fuel the car can burn each second and (theoretically at least) the faster it can go.

One way to make a car go faster is to add more cylinders. That's why super-fast sports cars typically have eight and twelve cylinders instead of the four or six cylinders in a conventional family car. Another option is to use a turbocharger, which forces more air into the cylinders each second so they can burn fuel at a faster rate. A turbocharger is a simple, relatively cheap, extra bit of kit that can get more power from the same engine.

HOW DOES A TURBOCHARGER WORK?

If you know how a jet engine works, you're halfway to understanding a car's turbocharger. A jet engine sucks in cold air at the front, squeezes it into a chamber where it burns with fuel, and then blasts hot air out of the back. As the hot air leaves, it roars past a turbine (a bit like a very compact metal windmill) that drives the compressor (air pump) at the front of the engine. This is the bit that pushes the air into the engine to make the fuel burn properly. The turbocharger on a car applies a very similar principle to a piston engine. It uses the exhaust gas to drive a turbine. This spins an air compressor that pushes extra air (and oxygen) into the cylinders, allowing them to burn more fuel each second. That's why a turbocharged car can produce more power (which is another way of saying "more energy per second"). A supercharger (or "mechanically driven supercharger" to give it its full name) is very similar to a turbocharger, but instead of being driven by exhaust gases using a turbine, it's powered from the car's spinning crankshaft. That's usually a disadvantage: where a turbocharger is powered by waste energy in the exhaust, a supercharger actually steals energy from the car’s own power source (the crankshaft), which is generally unhelpful.

II. EXPERIMENTAL SETUP

First standard engine is fully instrumented and connected to the dynamometer. The experiments are conducted at constant speed and the experiment is conducted at different loads(1kg,2.5kg).The experiment is first conducted without turbocharger with the stock engine and the readings are taken ,then the experiment is conducted with turbocharger and the reading are taken then afterward both the values are compared and the graphs are being plotted.

Figure1: Experimental Setup (DIESEL E/N)

Table 1: Engine Specifications

S.No	ENGINE PARAMETERS	SPECIFICATIONS
1	Engine make	Kirloskar
2	Engine type	4-stroke diesel engine
3	No. of cylinders	Single cylinder
4	No. of strokes	4-stroke
5	Rated power	3.5KW(5hp)@1500RPM
6	Bore size	85mm
7	Stroke length	110mm
8	Cubic capacity	553cc
9	C.R	16.5:1
10	Rated speed	1500RPM
11	Type of cooling	Water cooled
12	Type of fuel	Diesel
13	Starting engine	Hand cranking

Table 2: Turbocharger Specifications

SI.NO	TURBO PARAMETER	SPECIFICATIONS
1.	Turbo made	Garret
2.	Car	Tata Indica CR4
3.	Engine	1.2 litre Diesel Engine
4.	Model	M53 Garet 033

5.	Position	Engine Area

Figure 2: Turbo Charger

Figure 3: Modified Intake System (Intake from Turbo)

A. MODIFIED INTAKE SYSTEM:

The intake system should be modified so that the compressed air from the turbo charger must enter the combustion chamber of the engine. We have used plastic pipes for joining the engine intake to the turbo charger.

B. MODIFIED EXHAUST SYSTEM:

The exhaust system should be modified so that the exhaust gas coming from the engine enters the turbo charger and strikes the blades of the turbine of the turbo charger and rotate the turbine. We have used G.I pipe, because the exhaust gas coming from the engine has the temperature of 300 ^{0}C to 400 ^{0}C. The exhaust gases after rotating the turbine it must exit from the turbo to the atmosphere.

Figure 4: Modified Exhaust System (Exhaust to Turbo)

III. SAMPLE CALCULATIONS FOR TURBO CHARGER:

Mass of fuel consumed in kg/min

$$M_F = \frac{Fuel\ consumed\ in\ ml * density\ of\ diesel * 60}{1000 * time\ taken\ in\ seconds} \quad \text{Kg/min}$$

Total Fuel Consumption in kg/hr.

TFC=M_F*60 kg/hr

Air Consumption in kg/hr.

m=0.6*A_o*V_a*1.29*60 kg/hr

Where, A_o= area of orifice.

D= diameter of orifice.(20mm)

Air Fuel Ratio

$$\frac{A}{F} = \frac{M_a}{M_f}$$

Break Power (B.P) in kW

$$B.P = \frac{2 * \pi * N * (F2 - F1) * 9.81 * 0.19}{60000}$$

Where, N= Speed of the engine in RPM.

F_1&F_2= Force on the spring balance, kg.

0.19= Radius of the break drum.

Specific Fuel Consumption (SFC)

SFC = SFC=0.69 kg/ kW-hr

Heat Input in kW

$$Heat\ input = \frac{TFC * CV}{60 * 60}$$

Break Thermal Efficiency

$$\eta_{bth} = \frac{BP}{Heat\ input}$$

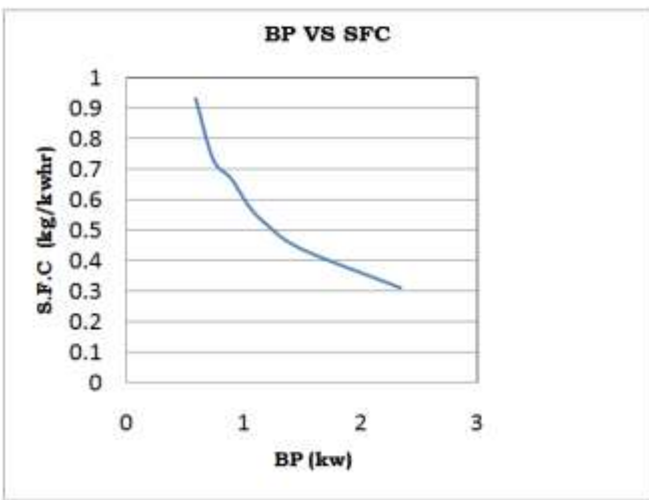
Table 3: Data without installing Turbo

S. No	Spring Balance Load in 'kg'		Engine Speed 'rpm'	Fuel Consumption for 10ml 'sec'	Air Flow Reading 'mm'		Temperature '°C'						
	F1	F2			H1	H2	Air inlet	E/N water inlet	E/N water outlet	Calorimeter water inlet	Calorimeter water outlet	Exhaust water inlet	Exhaust water outlet
1	0	2	1450	78	5	5	34	30	50	50	50	231	45
2	0	2.5	1450	77	5	5	34	30	52	52	54	243	46
3	0	3	1450	76	5	5	35	30	52	52	55	247	47
4	0	3.4	1450	73	5	5	35	30	53	53	55	253	48

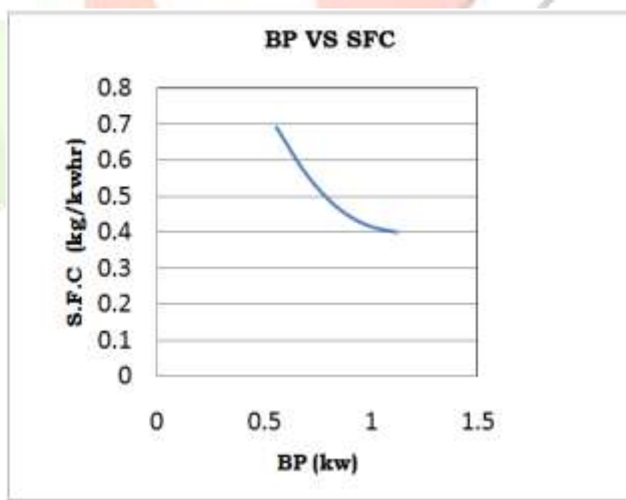
5	0	4	1450	68	5	5	35	30	53	53	56	260	48

Table 4: Data obtained by installing Turbo

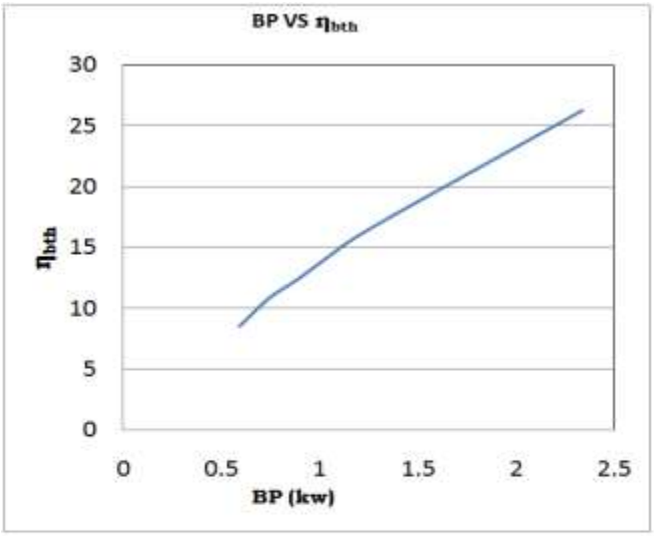
S. No	Spring Balance Load in 'kg'		Engine Speed 'rpm'	Fuel Consumption for 10ml 'sec'	Air Flow Reading 'mm'		Temperature '°C'						
	F1	F2			H1	H2	Air inlet	E/N water inlet	E/N water outlet	Calorimeter water inlet	Calorimeter water outlet	Exhaust water inlet	Exhaust water outlet
1	0	2	1530	55	4.8	5.5	33	32	45	38	103	239	35
2	0	2.5	1530	53	4.8	5.5	33	33	47	40	121	261	37
3	0	3	1530	51	4.8	5.5	33	33	48	43	130	276	38
4	0	3.5	1530	50	4.8	5.5	33	33	50	59	143	284	40
5	0	4	1530	49	4.8	5.5	33	33	50	63	154	288	40



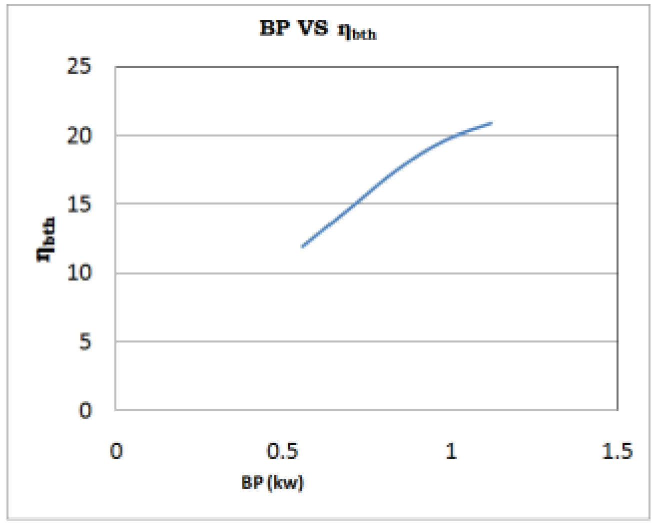
Graph-1: BP vs. SFC WITH TURBO



Graph -2: BP vs. SFC WITH TURBO



Graph -3: BP vs. η_{bth} WITH TURBO



Graph -4: BP vs. η_{bth} WITH OUT TURBO

IV. RESULTS & CONCLUSION

The main objective of this paper is to install and testing of a turbo charger on a Kirloskar diesel engine. The turbocharger was selected by the engine specification. We have successfully installed the turbo charger on the diesel engine. We have tested the engine before installing the turbocharger and the readings were being taken, we have tested engine after installing the turbocharger and the readings were being taken.

Calculations have been done and we have compared both the results, we have found that the power has been increased up to 15%.

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