

Performance Testing and Emission measurement of Turbocharged Exhaust of Multi-cylinder CI Engine.

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ABSTRACT

Turbochargers are used all through the automotive industry as they can improve the outcome of an internal combustion (IC) engine exclusive of the require to amplify its cylinder capability .The importance today is to present a practical engineering resolution to built-up economics and “Ecofriendly” road vehicles. However, the amount of concert growth for a exacting engine should be studied so that the advantages and drawbacks of turbo charging will be clarified. The testing is done on multi cylinder four strokes C.I .engine. This learns is mainly troubled on the result of bypassing the drain which is going away to turbine. Wastegate valve is used for this reason. The engine is practised under diverse Wastegate valve positions. Exhaust release is the main constraint in comparing the recital indifferent conditions as it influences the engine torque, power, and exhaust emissions. The use of a Wastegate operated turbocharger on this experiment engine has clearly enlarged its performance compared to its stock naturally aspirated form. This turbocharger can lend a hand to create engines with improved performance, smallest amount exhaust emissions.

Keywords— Turbocharger, Ecofriendly, Bypass, Wastegate, Exhaust emissions.

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I INTRODUCTION

A turbocharger is device as important part of all multicylinder diesel engines. Turbocharger is an exhaust gas driven induction device used in I.C. Engine to improve engine performance. This is done by forcing compressed air into the combustion chamber allowing more fuel to be burned resulting in a large air fuel ratio, large power & the method is called turbo charging. These devices use the energy of exhaust gases out from engine to run the turbine that in turns the air-compressor that provides. Now a day’s Wastegate operated turbocharger are also becoming popular now a days. Waste gate valve bypasses the flow that is coming from exhaust so that we can vary speed of turbine. It

has certain effect of emissions that is being studied here in paper.

I. LITERATURE SURVEY

The comparison engine was first equipped with a standard (Standard) and waste-gate (WG) turbocharger was done. [1]Attention was paid to the exhaust emissions that are CO, HC and CO₂.The engine was tested at three speeds within the entire load range. The results shows that the Wastegate TC is have fewer emissions than normal TC that is wastegate TC is advantageous at high loads at low and medium speeds. At rated speed, however, the Standard TC

proved better than the WG one.[1]How Boost pressure influences the engine torque, power, and efficiency and exhaust emissions was studied by Sriharrajoo [3].It mentioned that the incorporation of intercooler to the turbocharger system increases the performance even further. As per conclusion it is mentioned that addition of the turbocharger increased the maximum output of the engine and reduction in emission at the speeds above 2000 rpm.Also HC and CO emissions are reduced when the engine is turbocharged compared to its stock naturally aspirated condition [3].The effects of turbocharger on the performance of a diesel engine using diesel fuel and biodiesel in terms of BP, torque, BSFC and thermal efficiency, as well as CO and NO emissions was also investigated[2] For this used biodiesel was rapeseed oil methyl ester, at full load condition at the speeds between 1200 and 2400 RPM. Emissions of CO in the operations with biodiesel were less than those in the operations with diesel fuel, whereas NO emission in biodiesel operation was found higher [2].Effects of different opening ranges of waste-gate on the exhaust soot emission of a turbo-charged DI diesel engine was investigated [5].How Waste-Gate Turbo charging Controlled in Automotive SI Engines and its Effect on Steady and Unsteady Turbine Performance is studied [4].

II. EXPERIMENTAL SETUP & PROCEDURE

The multi cylinder, four strokes 27.6 KW Mahindra, water-cooled DI diesel engine with a bore of 88 mm and stroke of 101 mm and a compression ratio of 18.1:1 is used for the experiment. The engine load is applied with help of eddy current dynamometer.



Fig.1 Multi cylinder CI Engine setup

Engine specification of current set up is as tabulated below.

TABLE I
ENGINE DETAILS

Make	Mahindra
Model	MDI 3200 TCI
Rated power	27.6 KW @ 5000 rpm
Bore	88.9
Stroke	101.6
Compression ratio	18.1:1
Type	4 stroke 4 cylinder water cooled turbocharged Diesel engine

As per above mentioned title engine is tested for modified turbocharger which is provided with waste gate at turbine end And intercooler at compressor end. Wastegate is for controlling emissions purpose and intercooler is obviously for improving volumetric efficiency and reduction of NOx emissions.

The Wastegate:-The Wastegate is a valve that bypasses the turbine flow. When the Wastegate is opened the gases do not flow through turbine. This results in lesser power to the turbine and the turbine speed decreases, which in its turn results in a lowered intake manifold pressure, In the long run this influences the torque, but the effect is delayed and there is no direct connection between the Wastegate and the torque produced. One way the Wastegate is used is to avoid that the turbine spins to fast. Another purpose of the Wastegate is to avoid a phenomenon called knocking. Knocking occurs when the air/fuel mixture auto ignites and burns before the flame front, which can cause damages to the engine. There is a larger risk for knocking when a turbocharger is used because of the boost pressure. Today the Wastegate is a mechanical valve opened by the difference in compressor pressure and ambient pressure. If an electrical valve would be used instead this would not be an issue.

Wastegate fitted at current work is provided with three various positions. Firstly it is at 20 % closed position, it means 20% of valve position is open that is bypasses 80 % exhaust through Wastegate valve and remaining 20% is allowed towards the turbine. After rotating the turbine it is directed towards the atmosphere. Secondly it is at 50 % closed position, it means 50% of the valve position is open that is bypasses 50 % exhaust through Wastegate valve and remaining 50% is allowed towards the turbine. Lastly it is at 80 % closed position, it means 80% of the valve position is open that is bypasses 20 % exhaust through Wastegate valve and remaining 80% is allowed towards the turbine. After rotating the turbine it is directed towards the atmosphere. After rotating the turbine it is directed towards the atmosphere Emissions are measured at both the ends using Gas Analyser. Gas analyser gives in details about emissions of CO, HC and CO₂.

Setup with Wastegate operated turbocharger and installed intercooler at compressor end is as shown in pictures below. All modified setup is installed at exhaust line coming from the turbine end.



Fig.2 Turbocharger with Wastegate valve and intercooler installed at exhaust line

The engine is tested as per above three mentioned conditions of Wastegate positions, at various engine speed and at various engine load. The engine is kept firstly at 50 % load. Then it is set at speed of 1000 RPM and this condition three Wastegate valve positions are tested for emissions. Then keeping same 50 % load, engine speed is changed to 1500 RPM and same procedure is repeated of Wastegate position. Lastly again at same load speed is increased up to 2000 RPM and same procedure for Wastegate.

Now load is changed from 50 % to 100% and again engine speed is varied from 1000 RPM to 2000 RPM at this condition Wastegate position is varied from 20% closed, 50% closed and 80% closed. At above these all conditions emissions are measured at both ends that is Wastegate outlet and turbine outlet. Wastegate outlet is treated as unused exhaust and turbine outlet is treated as used exhaust.

Also at compressor end we have intercooler as modification. The temperature of air entering at compressor end, temperature behind the intercooler and temperature after the intercooler is measured at all these various condition so as to calculate intercooling effect and its effect on volumetric efficiency and reduction of NO_x emissions. Another purpose of this setup to evaluate quality of air entering the engine.

III. OBSERVATION AND DISCUSSIONS

As per project title here effect of various Wastegate opening of turbocharger on engine emissions is identified. Multi cylinder four stroke CI engine is available for testing. Engine is already turbocharged one. Exhaust coming from engine is passed through turbine which makes it to rotate. Turbine rotates common shaft which is connected to compressor. Now exhaust coming out from the turbine which is going to atmosphere is used for the further work which is modified setup with new turbocharger and Wastegate setup. Also after compressor the intercooler is fitted for medication purpose. Use of intercooler improves the volumetric efficiency and reduces NO_x emissions. Now Wastegate fitted is modified setup for turbocharger. This Wastegate provided with facility of bypassing the exhaust through turbine.

Wastegate fitted provides facility of bypassing the exhaust at various positions. For further mentioned work we have selected three types of opening as stated below,

a) 20 % closed position of Wastegate

At this position 20 % of total exhaust is bypassed, it means 80 % of Wastegate valve is open and 80 % of total exhaust is bypassed to atmosphere.

b) 50 % closed position of Wastegate

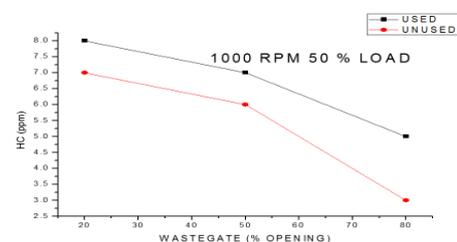
At this position 50 % of total exhaust is bypassed, it means 50 % of Wastegate valve is open and 50 % of total exhaust is bypassed to atmosphere.

c) 80% closed position of Wastegate

At this position 80 % of total exhaust is bypassed, it means 20 % of Wastegate valve is open and 20 % of total exhaust is bypassed to atmosphere.

Engine is maintained at fix RPM and above three conditioned are tested and emissions at both ends that is passing through Wastegate and which is not passing through Wastegate valve. For mentioned work engine speed is maintained at 1000 RPM, 1500 RPM, 2000RPM. Also engine is maintained at 50 % and 100 % load. This is done with dynamometer provided. The observations taken at this all conditions which is tabulated below.

Graphical presentation of observations is presented below

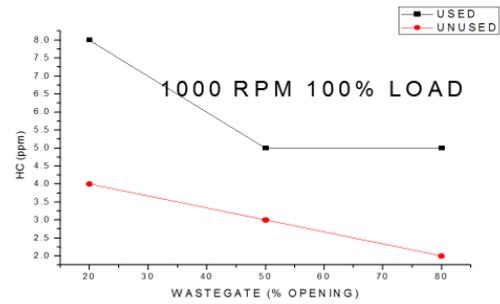


Graph 1-HC emissions at various wastegate opening

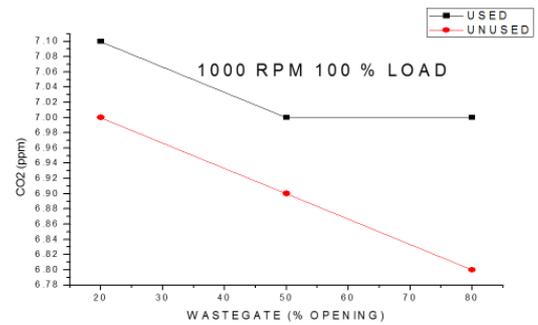
TABLE 2
Turbine reading

At Speed of 1000 RPM		Used exhaust emission			Unused exhaust emission		
Load	Wastgate position	CO	HC	CO ₂	CO	HC	CO ₂
50	X1=20% closed	0.04	8	3.9	0.04	7	3.8
	X2=50% closed	0.03	7	3.8	0.03	6	3.7
	X3=80% closed	0.02	5	3.7	0.02	3	3.6
100	X1=20% closed	0.02	8	7.1	0.02	4	7
	X2=50% closed	0.03	5	7	0.03	3	6.9
	X3=80% closed	0.03	5	7	0.03	2	6.8
At Constant Speed of 1500 RPM							
50	X1=20% closed	0.02	6	3.7	0.02	6	3.6
	X2=50% closed	0.02	7	3.6	0.02	4	3.5
	X3=80% closed	0.02	4	3.5	0.02	3	3.4
100	X1=20% closed	0.01	5	6.2	0.01	3	6.1
	X2=50% closed	0.01	3	6.1	0.01	2	6
	X3=80% closed	0.01	2	6.0	0.01	1	6.1
At Constant Speed of 2000 RPM							
50	X1=20% closed	0.01	6	3.2	0.01	4	3.1
	X2=50% closed	0.01	5	3.1	0.01	3	3
	X3=80% closed	0.01	3	3	0.01	2	2.8

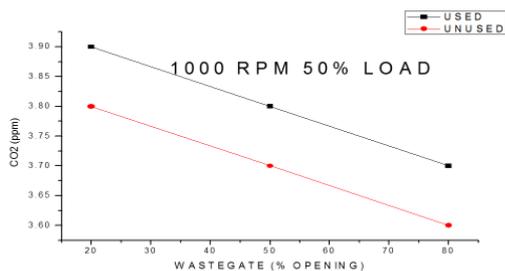
Graph 2-CO₂ emissions at various wastegate opening



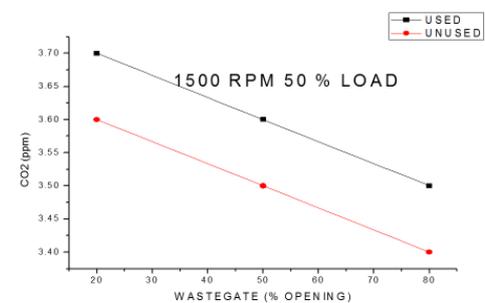
Graph 3- HC emissions at various wastegate opening

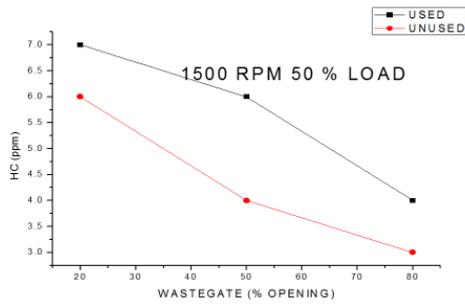


Graph 4- CO₂ emissions at various wastegate opening

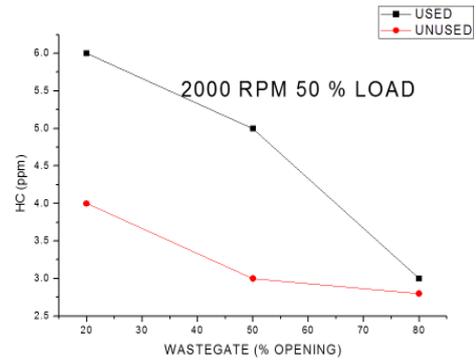


Graph 5- CO₂ emissions at various wastegate opening

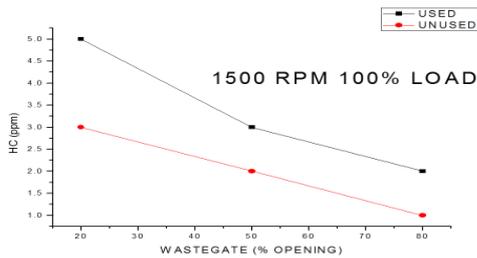




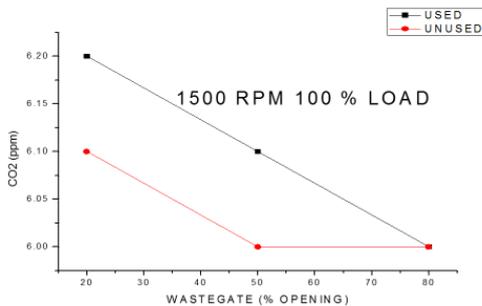
Graph 6- HC emissions at various wastegate opening



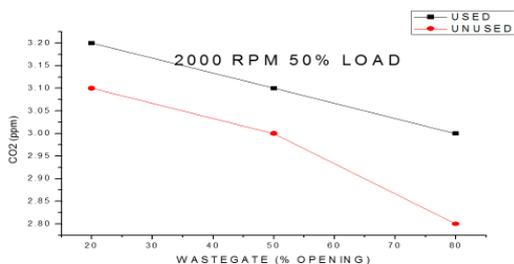
Graph 10- HC emissions at various wastegate opening



Graph 7- HC emissions at various wastegate opening



Graph 8- CO₂ emissions at various wastegate opening



Graph 9- CO₂ emissions at various wastegate opening

All above graphs explains the effect on emissions for current wastegate modification. Graph 1 and 4 to explains about HC and CO₂ emission at 1000 rpm and 50 %, 100% load. It shows continuous reduction in emission when opening is increased gradually from 20% to 80%.also it can be seen that emissions are less at unused (wastegate outlet) comparatively than used (turbine outlet).

Graph 5 and 8 to explains about HC and CO₂ emission at 1500 rpm and 50 %, 100% load. It shows continuous reduction in emission when opening is increased gradually from 20% to 80%.also it can be seen that emissions are less at unused (wastegate outlet) comparatively than used (turbine outlet).

. Graph 9 and 10 to explains about HC and CO₂ emission at 2000 rpm and 50 %, 100% load. It shows continuous reduction in emission when opening is increased gradually from 20% to 80%.also it can be seen that emissions are less at unused (wastegate outlet) comparatively than used (turbine outlet).

IV. CONCLUSION

Current work represents effect of wastegate operated turbocharger on engine emissions at various speed and load conditions and which is mentioned below.

- When engine speed and load kept constant and wastegate opening changed from 20% to 80%, it is found that both HC and CO₂ emissions are decreasing continuously.
- It is also concluded that wastegate outlet (Unused) has less emissions than turbine outlet (Used).
- When engine load is kept constant and speed is increased gradually it is found in reduction in emissions of CO, HC and CO₂.
- When load is increased and speed condition kept same again there is reductions of CO, HC and CO₂
- Also it is found that when load kept constant and speed increases and wastegate position being 20 % closed, then wastegate outlet has fewer emissions than turbine outlet.

Same phenomenon observed about remaining wastegate positions

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