An Experimental Performance & Emission Analysis of Turbocharged Two Wheeler Engine

Vivek Velachhawala[1] Avesh Khan[2]
[1]Research Student [2]Assistant Professor
[1]Parul Institute of Technology, Vadodara, India [2]Parul Institute of Engineering and Technology, Vadodara, India

Abstract— the progress of two wheeler for transportation has been intimately integrated with the progress of civilization. The two wheeler of today is the result of the gathering of many years of pioneering research and development. An attempt has been made in this project; the exhaust gas is used to rotate the turbine with blower arrangement. Exhaust gas is used to rotate the blower and this compressed air is given to the ignition input supply. Our fore most aim in selecting this project is to use an efficiency of turbocharging. It is also good with regard to economic considerations, environmental considerations and engine efficiency. The problems such as low horse-power, shutting down of engine, low torque, etc. It is known that the output of horse-power of an engine is enlarged with the rise in amount of air or mixture in the cylinder and turbocharger plays important role in increasing the amount or air. The numbers of two wheelers are increasing day by day. Therefore the pollution is a major problem which we are facing. So, using turbocharged engine we can reduce the pollution by providing more air to engine, makes fuel combustion easier. Thus the turbocharged engines produce approximately up to 50% less NOX and HC emissions than conventional IC engines.

Key words: Performance Analysis, Exhaust Gas Emissions, Turbocharged Engine (TE), Spark Ignition Engine (S.I. Engine)

I. Introduction

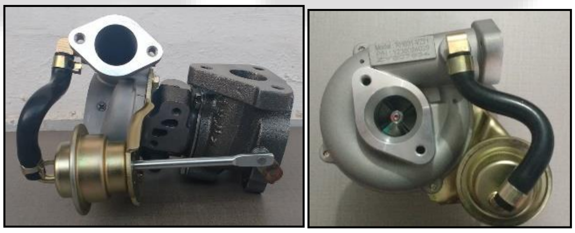
From the past decades the uses of two wheeler in India have been grown at very faster rates. Due to this increase of the two wheeler, the fuel consumption and an exhaust gas emissions increases rapidly so it is needed to use of alternative fuels. The unadulterated power to protect the natural resource is supposed to be the electric and solar energies that best suit the automobiles. These energies produce zero emissions. But it is the only easily attainable alternate source with less efficiency. Hence to get relieved from the incorrigible air pollution the concept of turbocharger was evolved. In this project an attempt has been made to use the exhaust gas energy of engine to rotate a turbine, which is coupled with a compressor arrangement and compressor produces the compressed air is given to the engine air intake. Emission can be reduced by using exhaust energy and providing compressed air into the intake of engine cylinder. That is simply increases the volumetric efficiency of the engine. This makes the combustion easier. Hence more horse power is produced and emission can be reduced by batter combustion happens in engine. In this project we are using a 200cc engine for the installation of turbocharger. We mounted the turbocharger in front of the engine very near to the exhaust of engine to minimize heat losses and improve turbo response.

II. Purpose of Turbocharger

A turbocharger is a device utilizes exhaust gas energy to allow more power to be produced for an engine of a given configuration. A turbocharged engine can be more powerful and efficient when compared to a naturally aspirated engine because of more intake air, proportionately more fuel into the combustion chamber than if atmospheric pressure alone is used.

- The main objective of turbocharging is to raise the air charge per cycle and permit the burning of a larger amount of fuel and thus increase the power output of the engine.
- Another aim of turbocharging is to increase the volumetric efficiency and above that it can be obtained by normal configuration.

The engine is use an air compressor driven by exhaust gases. Increasing the air consumption permits greater quantities of fuel to be added, and results in a greater potential output. The indicated power produced is almost directly proportional to the engine air consumption. While brake power is not so closely related to air consumption, it is nevertheless, dependent upon the mass of air consumed. It is desirable, then, that the engine takes in greatest possible mass of air.



(a) Front View (b) Side View
Fig. 1: Different Views of Turbocharger

III. Summary and Problem Definition

Today's high demands two wheeler engine cause increasing in uses of petroleum products. This results into higher rate of pollution. This needs the use of turbocharged engine. Turbocharged engine is also produces more power and reduces brake specific fuel consumption. This results into fuel economy. Thus, the turbocharged engine in two wheeler is need of developing country like India. The vast potential and comparative performance of turbocharged engine makes fuel economy.

From the literature review, it is concluded that, the increasing the brake thermal efficiency and decreasing the specific fuel consumption for petrol engine with turbocharger compared to the normal engine. There was increasing the brake thermal efficiency for turbocharged petrol engine compared to normal engine. However there was decreasing the brake specific fuel consumption turbocharged petrol engine compared to standard normal engine.

However there was decreasing into emission parameters like CO, NO_X and HC emissions for petrol engine with turbocharger compared to the standard engine.

IV. EXPERIMENTAL SETUP

A Single Cylinder, four stroke, petrol engine is used for the purpose of experimentation. The engine is then coupled to a rope brake dynamometer. Cooling water is circulated separately to the rope brake pulley. Necessary provisions are made to measure the flow rates of fuel. The block diagram of experimental setup is shown in figure 2.

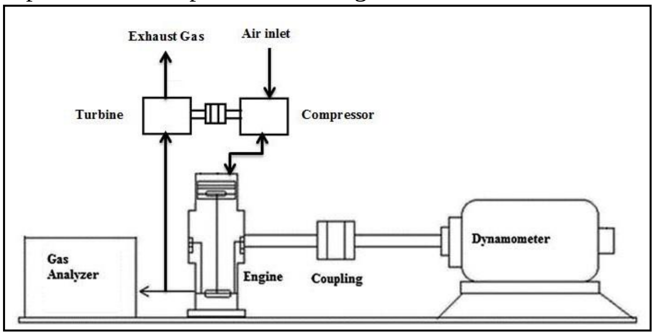


Fig. 2: Engine Test Rig Block Diagram

The engine Performance analysis has included the following features: brake specific fuel consumption and brake thermal efficiency and Emission analysis includes the measure of volume of exhaust gases such as CO, CO_2, NO_X and HC Emissions. The specifications of the SI Engine and Turbocharger are listed in Table 1 and the experimental set up is shown in Figure 3.

Engine Type	Oil cooled, 4 – stroke, single cylinder
Displacement	198.8 cc
Max. Power	13.24 kW @8000 rpm
Max. Torque	17.2 N-m @6000 rpm
Bore	67.0 mm
Stroke	56.4 mm
Compression Ratio	9.9 : 1
Oil Grade	SAE 10
Turbocharger model no.	RHB31-VZ21
Dynamometer	Rope type, water-cooled with loading unit

Table 1: Engine Test Rig Specification

Fig. 3: Engine Test Rig

For an experimental purpose RHB31-VZ21 turbocharger is used with the 200cc SI engine. This is the world's smallest turbocharger. This turbo is ideal for turbo charging of Motorcycle, scooter, dirt bike, ATV, go kart, buggy, and snowmobiles. This turbo is suitable for 125cc to 600cc engines. Engines that are too small would not have enough air flow to push the turbo to generate meaningful boost.

The turbocharger can increase the air flow of engine intake, and add the power and hp, improve the performance of engine.

V. EXPERIMENTAL PROCEDURE

Experiments are carried out at constant engine speed of 2500 RPM and at different load variations like at neutral (No load), 25% load, 50% load and 75% load (Maximum load) condition.

Performance is varied by standard normal engine to turbocharged engine. Observations are taken at time when exhaust gas is utilized to run the turbocharger. Various performance and emission parameters are measured at each varying condition and test parameters are mentioned below.

Using the apparatus described in table 2 the different testing parameters is Brake Thermal Efficiency, Brake Specific Fuel Consumption and exhaust gas analysis.

Apparatus	Purpose
Rope Brake Dynamometer	To Measure Torque
Burette	To Measure Fuel Consumption of 10ml.
Stop Watch	To Measure Time Required To Consume 10ml Fuel.
Thermo Couple	To Measure Temperature
Exhaust Gas Analyser	To Measure Volume of Different Exhaust Gases
Stroboscope	To Measure RPM

Table 2: Performance Measuring Apparatus

Steps for carried out an experiment are as follows.

- Time taken for 10ml fuel consumption for BSFC.
- Load on Dynamometer.
- Carbon Monoxide.
- Carbon Dioxide.
- Nitrous Oxide.
- Hydro Carbon.

Performance of Standard Normal Engine (SNE) is measured first and then Turbocharged Engine (TE). Again engine performance is measured with standard normal engine and turbocharged engine with surfactant as in manner mentioned above. Data measured and calculated thus used for comparison with Turbocharged Engine.

A. *Calculation Procedure*

N = Engine speed (RPM)

W= Load on Dynamometer (kg)

t = Time Required for 10 ml Fuel Consumption (Sec)

Mass of Fuel (mf) = Sample Vol. × Density = 0.010 × 0.742 = 0.00742 kg

Calorific Value of Fuel (CV) = 44000 kJ / kg

Dynamometer Constant = 6000

R = Radius of Pulley (m) = 0.217 m

σf = Specific Density of Fuel = 0.742 kg/L

Torque (T) = W × R = (Nm)

Brake Power (BP) $= \frac{2\pi \times N \times T}{60000}$ (kW)

Total Fuel consumption (TFC) = 0.010×σf×3600/ t (kg/h)

Brake specific fuel consumption (BSFC)= $\frac{TFC}{BP}$ (kg/kWh)

Brake thermal efficiency (%) = $\frac{BP \times 3600}{mf \times CV} \times 100$

VI. RESULTS AND DISCUSSIONS

In this work, the turbocharging performance of a turbocharged gasoline engine was discussed on the basis of experimental investigation. Turbocharging of intake air can increase the combustion characteristics and engine power by increasing the intake pressure above atmospheric pressure. The result showed the comparison of different performance parameter of turbocharged engine (TE) with the naturally aspirated engine (NA).

A. Engine Performance Parameters

Performance test is done on the 4-stroke, single-cylinder petrol engine to study and compare its performance under various loads with and without turbocharger. The test rig consists of a 200 cc SI engine (pulsar DTS-i) which is fitted with loading arrangement using rope brake drum dynamometer with drum diameter 0.217 m and rope diameter is negligible. A digital weight hanger is provided to add the weights and is connected to a rope and the other end of the rope is connected to a spring balance. The engine is load due the friction produced between the rope and drum. The engine is started on no load and allows to run at a speed of 2500 rpm. Then the time taken to consume 10 ml of fuel is taken from the burette which is connected to carburetor with small hose and is recorded. Then load the engine step by step up to a particular load below its maximum capacity. The time for 10 ml fuel consumption is noted for each load at a speed of 2500rpm. The experiment is repeated with and without turbocharger at different loads.

The tables 3 and 4 shows the data obtained during the performance test of the engine with and without turbocharger. From the tables it is clear that the total fuel consumption and break specific fuel consumption decreases with the usage of turbocharger. More over the implementation of turbocharger results in an increase in brake thermal efficiency. As load increases mass of fuel consumption per hour increases but in turbocharged engine, it is less than the naturally aspirated engine due to increase in air flow rate. There is following graphs shows the effect of turbocharger on the different performance parameters as shown as follows.

B. Brake Specific Fuel Consumption

It is observed that the turbocharged engine has higher fuel consumption as compared to normal aspirated engine but brake specific fuel consumption is higher of normal aspirated engine than turbocharged engine.

Sr. No.	Weight added	Spring balance reading	Torque	Break power	Time for 10cc fuel consumption	Total fuel consumption	Brake specific fuel consumption	Brake thermal efficiency
	W	S	T	BP	t	TFC	BSFC	BTH
	kg	kg	Nm	kW	Sec	kg/h	kg/kWh	%
1	0	0	0	0	40.79	0.655	-	0
2	4	1.34	2.83	0.741	37.94	0.704	0.95	10.01
3	8	3.20	5.105	1.34	35.65	0.749	0.559	18.1
4	12	4.79	7.67	2.008	32.46	0.822	0.409	27.13

Table 3: Performance Analysis of NTE

Sr. No.	Weight added	Spring balance reading	Torque	Break power	Time for 10cc fuel consumption	Total fuel consumption	Brake specific fuel consumption	Brake thermal efficiency
	W	S	T	BP	t	TFC	BSFC	BTH
	kg	kg	Nm	kW	Sec	kg/h	kg/kWh	%
1	0	0	0	0	43.65	0.612	-	0
2	4	1.04	3.15	0.824	41.84	0.638	0.774	11.13
3	8	2.73	5.6	1.47	39.42	0.677	0.46	19.86
4	12	3.95	8.56	2.24	37.23	0.717	0.32	30.27

Table 4: Performance Analysis of TE

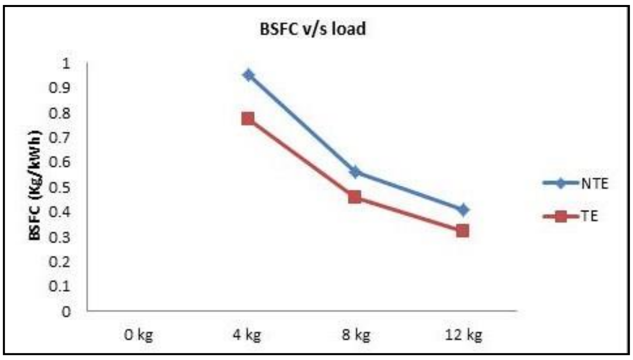


Fig. 4: Variation of BSFC for non-turbocharged engine and turbocharged engine

As at neutral condition there is some indicated power but on the shaft end there is no break power is available due to disengagement of gears. So theoretically power can't be measure. Hence, BSFC can't be determined at neutral condition. The variations of break specific fuel consumption (BSFC) with load is shown in figure 4.

On the basis of this Graph, at low load condition the BSFC is higher up to certain limit then it is somewhat constant, but in turbocharged engine it is less than non-turbocharged engine.

C. Brake Thermal Efficiency

It is to be observed that the brake thermal efficiency of naturally aspirated engine was less than that of turbocharged engine. This was because of the more amount of air given to the engine cylinder which makes combustion easier. The variations of break Thermal Efficiency (BTE) with load is shown in figure 5.

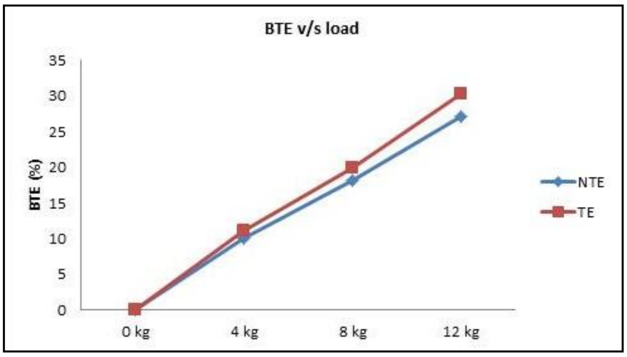


Fig. 5: Variation of BTE for non-turbocharged engine and turbocharged engine

D. Engine Emission Parameters

The levels of hazardous materials that released from a motor vehicle during combustion have been checked with the aid of emission test. Although emissions in new vehicles have been greatly reduced over the last few decades, the threat to human safety and the environment remains a great concern. The turbocharging process is also concerned with emission control due to proper and batter combustion.

Figure 6 shows the image of the exhaust gas analysis test of engine. This includes a measure of carbon dioxide (CO_2), nitrogen oxides (NO_X), carbon monoxide (CO) and hydrocarbons (HC's) at different speeds of engine.

The emission test is done by AVL 444 DIGAS Exhaust Gas Analyser with the comparison of different emission parameter of turbocharged engine (TE) with the naturally aspirated engine (NA). The table 5 and 6 is as follows at different speeds (rpm).

Fig. 6: The Exhaust Gas Analysis Test

Sr. No.	Speed	CO	CO_2	NO_X	HC
	RPM	% volume	% volume	ppm volume	ppm volume
1	2000	5.23	2.19	69	497
2	4000	5.9	3.24	81	314
3	6000	7.12	4.07	84	290
4	8000	8.96	5.04	89	305

Table 5: Emission Analysis of NTE

Sr. No.	Speed	CO	CO_2	NO_X	HC
	RPM	% volume	% volume	ppm volume	ppm volume
1	2000	4.24	2.58	21	132
2	4000	4.92	3.87	41	183
3	6000	6.47	5.29	48	112
4	8000	7.23	6.37	52	197

Table 6: Emission Analysis of TE

E. Carbon Monoxide (CO)

It is to be observed that the CO emission in general was found to be decreased significantly with turbocharged engine tested.

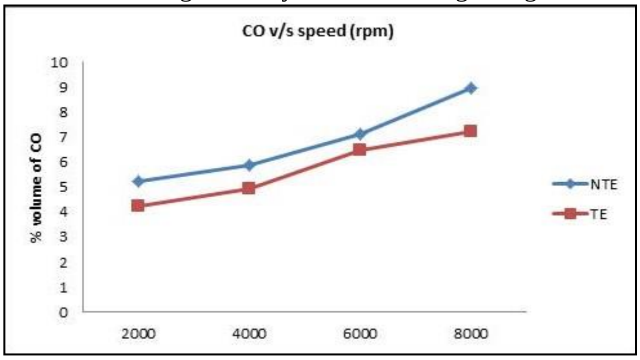


Fig. 7: Variations of CO emissions for non-turbocharged engine and turbocharged engine

Figure 7 shows CO variations depending on the speed of the engine. CO emission from SI engine is related to the properties of fuel as well as characteristics of combustion. It was experimentally that SI engine with turbocharger causes reduction in CO emission up to 15%. This is due to the fact that application of turbocharger provides increased air in the engine and enables mixing of fuel and air easily in the combustion chamber, thereby causing better combustion and lower CO emission values.

F. Carbon Dioxide (CO_2)

It is to be observed that the CO_2 emission in general was found to be increased significantly with turbocharged engine tested.

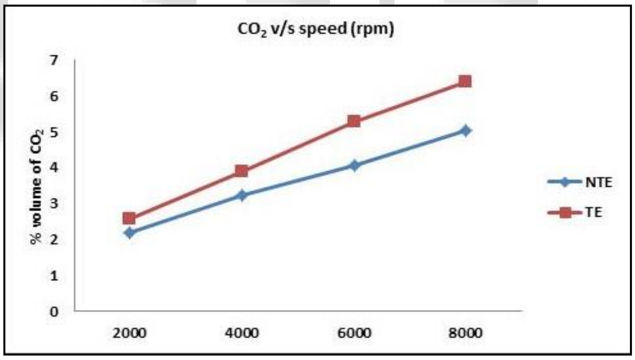


Fig. 8: Variations of CO_2 emissions for non-turbocharged engine and turbocharged engine

Figure 8 shows CO_2 variations depending on the speed of the engine. CO_2 emission from petrol engine is related to the fuel properties as well as combustion characteristics. It is well known that better fuel combustion usually resulted in higher the CO_2 emission. It was experimentally determined that in turbocharged engine CO_2 emission up to 10 to 15% is increased. This is due to the fact that application of turbocharger provides increased air in the engine and enables mixing of fuel-air easily in the combustion.

G. Oxides of Nitrogen (NO_X)

It is to be observed that a NO_X emission of turbocharged engine was found to less than normally aspirated engine.

Figure 9 shows NO_X variations depending on the speed of the engine. All factors facilitating and accelerating the reaction between oxygen and nitrogen increase NO_X formation. The main factor in the NO_X formation is temperature. However, engine speed, combustion chamber content, combustion chamber homogeneity, and mixture density in the combustion chamber are also affects. Figure also shows NO_X emission increases with increasing engine speed. The increase of NO_X for in the SI engine may be a result of an increase in after-combustion temperature.

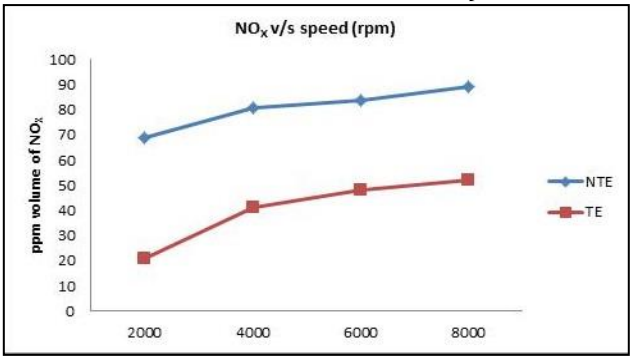


Fig. 9: Variations of NO_X emissions for non-turbocharged engine and turbocharged engine

Most of the earlier investigations showed that NO_X emission from normally aspirated engines is generally higher up to 50%. This is due to higher combustion temperature and longer combustion duration. A considerable decrease in the NO_X emission was observed in the SI engine with the turbocharger operation.

H. Hydrocarbon (HC)

It is to be observed that the turbocharged engine was having low HC emission as compared to normally aspirated engine. Turbocharged engine can be seen highest reduction in emission as compared to normal engine. This is due to improvement of air fuel mixing, which improves the combustion process and hence makes a reduction in HC emissions.

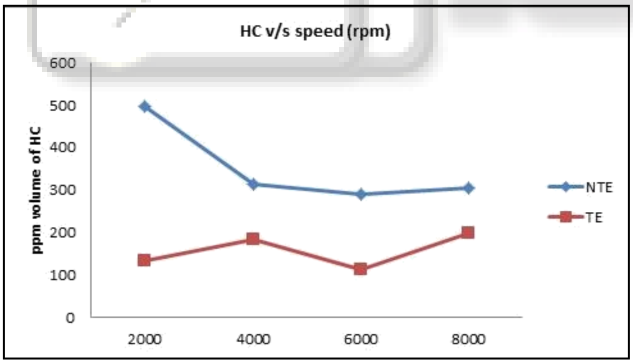


Fig. 10: Variations of HC emissions for non-turbocharged engine and turbocharged engine

Figure 10 shows variations of HC emissions depending on the speed of the engine. HC emission is low in the petrol engine with turbocharger compared with the standard engine. The decrease in HC emission in the petrol engine with turbocharger may be due to an increase in after-combustion temperature as a result of the decrease in heat losses causing less unburned HC to be added to the combustion. Thus, the emission of unburned hydrocarbon from the petrol engine with turbocharger is more likely to be reduced up to 50%. The higher temperatures in the gases and at the combustion chamber walls of the petrol engine assist in permitting the oxidation reactions to proceed close to completion.

VII. CONCLUSION

An Experimental investigation is carried out using four stroke single-cylinder SI engine. By modifying naturally aspirated engine, turbocharged application get influences in all field of internal combustion engine to obtain more power from given size of the engine. With different performance parameter, its effect of turbocharging and without turbocharging was analysed. The result can be summarized below:

Sr. No.	Performance Parameter	Result
1.	Brake specific fuel consumption	Decrease
2.	Brake thermal efficiency	Increase
3.	CO emission	Decrease
4.	CO_2 emission	Increase
5.	NO_X emission	Decrease
6.	HC emission	Decrease

Table 7: Result Analysis Table

Thus, above experimental results were obtained by implementation of turbocharger in Single Cylinder SI Engine which ensures the conclusion that Turbocharged engine were better and seems more efficient in terms of all parameters (except CO_2 emissions) as compared to non-Turbocharged engine.

REFERENCES

[1] P Balashanmugam1*, E Elakiya1 and Sunayana Sharma1, “PERFORMANCE ANALYSIS ON A TURBOCHARGED TWO WHEELER ENGINE”.
[2] P. N. Shrirao1, A. N. Pawar2, “Evaluation of Performance and Emission characteristics of Turbocharged Engine with Mullite as Thermal Barrier Coating”.
[3] Sujith G 1, Jishnu S Nair 2, Mohammed Jezry Faruq 3, Muhammad Ameer M 4, Nithin P Nair 5, “Modification and Analysis of 125 cc Petrol Engine with Turbocharger”.
[4] S. Shaaban and J. Seume, “Impact of Turbocharger Non-Adiabatic Operation on Engine Volumetric Efficiency and Turbo Lag”, International Journal of Rotating Machinery, Vol. 2012, Article ID 625453, 11 pages, 2012.
[5] Ashish Jain#1, Jikisha Patel#2, Asst. Prof. K.P.Trivedi#3, “Heat Recovery & Performance Characterization Of 4-Stroke C.I. Engine Using Turbocharger & Intercooler”.
[6] Yashvir Singh, Nishant Kr. Singh, Rakesh Prasad and Hemant Kr. Nayak, “Performance Analysis of Supercharging of Two Wheelers” International Journal of Mechanical Engineering and Technology, ISSN 0976 – 6359 Vol. 2, Issue 2, pp. 63-69, 2011.
[7] Bangal D.B., Tathe D.W., Patil P.C. – 2010, “Methods of Improving Performance of I.C. Engine by Turbocharging”, National Conference on “Recent Trends in I.C. Engines & Automobile”, pp. 182-185.
[8] Mohd Muqeem, Dr. Manoj Kumar, “Turbocharging of IC Engine: A Review”, International Journal of Mechanical Engineering and Technology, Vol. 4, Issue 1, pp. 142 – 149, 2013.

