Study and performance analysis of charging vehicle battery using bike exhaust gas

[1]K. Kumaravel, Assistant Professor, Mechanical Engineering, Annamalai University, Chidambaram, Email:kkapme74@gmail.com, Mobile: 9486457183

[2]P.Balashanmugam, Assistant Professor, Mechanical Engineering, Annamalai University, Chidambaram, Email:Pbsapme1980@gmail.com, Mobile: 9486432546

[3]G.Balasubramanian, Assistant Professor, Mechanical Engineering, Annamalai University, Chidambaram, Email: gbala1972@gmail.com, Mobile: 9442273221

ABSTRACT

Nowadays, the environment as well as their dwellers surviving here have recently been badly influenced by one of the most burning problems, i.e. 'Air pollution, which is caused due to emission of toxic exhaust into the sounding resulted, running the floral and faunal lives. Generally, these toxic gases emit from vehicle exhaust, power plants, small and large scale industries and mixed into atmospheric air and increased the pollution rate. In recent years an increasing concern of environmental issues of emission in particular global warming and the limitations of energy resources has resulted the extensive research in naval technology of generating electrical power. In this study of electrical power generation using IC engines exhaust gas and performance analysis was conducted by presenting the charging vehicle battery by using bike exhaust gas. The experimental investigation shows get converted into how the exhaust gases were utilized and kinetic energy from mechanical energy and further converted it into AC current resulting electrical power generation. The result indicates the electrical power generated by the exhaust gas of IC engine was successfully observed.

Keywords

Exhaust gas, energy conversion system, power generation, burning of fuels.

1. INTRODUCTION

As the oil resources are depleting day by day with a rapid increase demand for energy, research is in progress to identify an alternative source. At the same time the present day equipment is being developed to give maximum output to conserve resources till an alternative is developed. Reciprocating Internal combustion engines being the most widely preferred prime movers give a maximum efficiency range of 27% to 29%. Rotary engines, even though having higher efficiencies up to 45% are restricted to aircrafts due to their very high speeds of 45000 RPM to 90000 RPM. Cogeneration is the method of simultaneous production of heat and other form of energy in a process. Many cogeneration techniques have been employed in IC engines to recover the waste heat. Turbo charging is also a kind of waste heat recovery technique in which the exhaust gases leaving the engine are utilized to run a turbine to produce power.

Waste heat to power (WHP) is the process of capturing heat discarded by an existing industrial process and using that heat to generate power (see Figure 1). Energy intensive industrial processes such as those occurring at refineries, steel mills, glass furnaces, and cement kilns all release hot exhaust gases and waste streams that can be harnessed with well-established technologies to generate electricity .The recovery of industrial waste heat for power is a largely untapped type of combined heat and Power (CHP), which is the use of a single fuel source to generate both thermal energy (heating or cooling) and electricity.CHP generally consists of a prime mover, a generator, a heat recovery system, and electrical interconnection equipment configured into an integrated system. CHP is a form of distributed generation, which, unlike central station generation, is located at or near the energy-consuming facility. CHP's inherent higher efficiency and its ability to avoid transmission losses in the delivery of electricity from the central station power plant to the user result in reduced primary energy use and lower greenhouse gas (GHG) emissions.

The most common CHP configuration is known as a *topping cycle*, where fuel is first used in a heat engine to generate power, and the waste heat from the power generation equipment is then recovered to provide useful thermal energy. As an example, a gas turbine or reciprocating engine generates electricity by burning fuel and then uses a heat recovery unit to capture useful thermal energy from the prime mover's exhaust stream and cooling system. Alternatively, steam turbines generate electricity using high-pressure steam from a fired boiler before sending lower pressure steam to an industrial process or district heating system. Figure 1 shows the waste heat to power diagram.

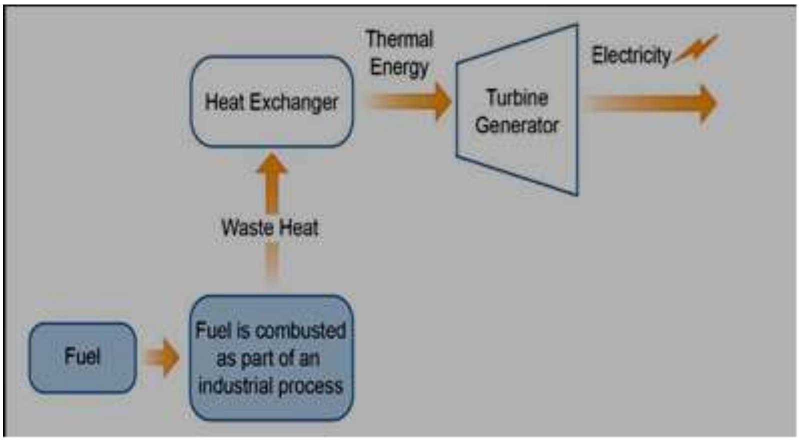

Figure 1: Waste Heat to Power Diagram

Waste heat streams can be used to generate power in what is called *bottoming cycle* CHP—another term for WHP.1 In this configuration, fuel is first used to provide thermal energy in an industrial process, such as a furnace, and the waste heat from that process is then used to generate power. The key advantage of WHP systems is that they utilize heat from existing thermal processes, which would otherwise be wasted, to produce electricity or mechanical power, as opposed to directly consuming additional fuel for this purpose.

2. THERMO ELECTRIC GENERATOR

Thermo-electric generators are all solid-state devices that convert heat into electricity. Unlike traditional dynamic heat engines, thermoelectric generators contain no moving parts and are completely silent. Such generators have been used reliably for over 30 years of maintenance-free operation in deep space probes such as the Voyager missions of NASA. Compared to large, traditional heat engines, thermo-electric generators have lower efficiency. But for small applications, thermo-electric can become competitive because they are compact, simple (inexpensive) and scale able. Thermo-electric systems can be easily designed to operate with small heat sources and small temperature differences. Such small generators could be mass produced for use in automotive waste heat recovery or home co-generation of heat and electricity.

Thermo electrics have even been miniaturized to harvest body heat for powering a wristwatch. A thermo-electric power generator is a solid state device that provides direct energy conversion from thermal energy (heat) into electrical energy based on “Seebeck effect”. The thermo-electric power cycle, with charge carriers serving as the working fluid, follows the fundamental laws of thermodynamics and intimately resembles the power cycle of a conventional heat engine. Advantages of thermo-electric power generators over other technologies.

- They are extremely reliable and they have no mechanical moving parts and require considerably less maintenance.
- They have very small size and weightless.
- They have the capacity to operating at elevated temperatures.
- The source for the power generation is Heat not light, so day and night operation is possible.
- They are mostly used for converting the waste heat so it is considered as a Green Technology.
- We can increase the overall efficiency of the system (4% to &7%).
- They can be alternative power sources.
- When comparing to exciting conventional power system, it require less space and cost
- Less operating cost.

The Drawback of thermo-electric power generator is their relatively low conversion efficiency (typically ~5%) and less power output. Application over the past decade included industrial, instruments, military, medical and aerospace and home reason and applications for portable or remote power generation. Though, in recent years, an increasing anxiety about environmental issues of emissions, in particular global warming has resulted in extensive research into unconventional technologies of generating electrical power. Thermo-electric power generation offers a promising technology in the direct conversion of low-grade thermal energy, such as waste-heat energy, into electrical power. Perhaps the earliest application is the use of waste heat from a kerosene lamp to provide thermo-electric power to power a wireless set. Thermo-electric generators have also been used to provide small amounts electrical power to remote regions for example

Northern Sweden, as an alternative to costly gasoline powered motor generators. The oldest technology behind this technology is the See beck effect on Thermocouple now this tech using in See beck effect on semiconductors so it can eliminate wires, so wireless technology is possible.

An important purpose in thermo-electric power generation using waste heat energy is to decrease the cost-per-watt of the devices. Moreover, cost-per-watt can be reduced by optimizing the device geometry, improving the manufacture quality and simply by operating the device at a larger temperature difference. Analyze the thermoelectric property of the module material is very important. Good thermoelectric material has seebeck property in between 200-300μV/K. Material thermoelectric material figure-of-merit property should be near or more than 3×10-3 for good material. This TEG is used to convert the waste heat emitted from Jet Engine, IC Engines, Furnace, Heat water conveyor tubes.

The basic theory behind this TEG is "seebeck effect". Seebeck effect was discovered by Thomas Seebeck in 1821. When a temperature difference is recognized between the hot and cold junctions of two dissimilar materials (metals or semiconductors) a voltage is generated, this voltage is called Seebeck voltage. Indeed this phenomenon is applied to thermocouples that are extensively used for temperature measurements. When a Thermoelectric material (Thermoelectric Module or Thermocouple) held in-between temperature gradient it generates some voltage. In fact, this phenomenon is applied to thermocouples that are extensively used for temperature measurements. Base on this Seebeck effect, thermoelectric devices can act as electrical power generators.

Thermoelectric Power Generator (TEG) is a solid state device which converts Heat Energy into Electrical Energy. All the exciting conventional power generators convert Thermal Energy into Mechanical Energy then to Electrical Energy. So here no mechanical work (no moving parts). So it produce less noise and no pollution when compare to conventional power generators. TEG is working by Thermo Electric Effect Thermoelectric Power Generator (TEG) is a solid state device which converts Heat Energy into Electrical Energy. All the exciting conventional power generators convert Thermal Energy into Mechanical Energy then to Electrical Energy. So here no mechanical work (no moving parts). So it produce less noise and no pollution when compare to conventional power generators. TEG is working by Thermo Electric Effect. Figure 2 shows the typical waste heat energy recovery system.

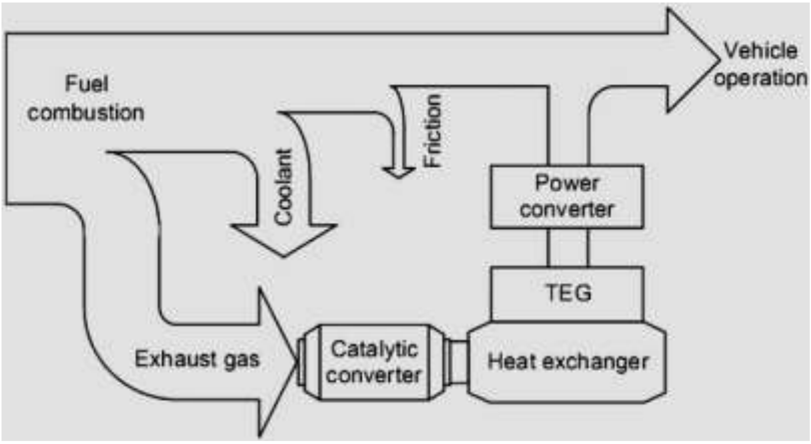

Figure 2: A typical waste heat energy recovery system

3. PREVIOUS WORK

Reciprocating engines remain the dominant power plant for both vehicles and power generation up to a few MW.Yet, circa 30% of the energy in the fuel is lost through the exhaust system. In today's market, it has become essential to attempt to recover some of this “wasted energy” and put it to good use. Exhaust Heat Recovery (EHR) systems are playing an increasingly important role in the Emissions and Fuel Consumption challenges facing today's Heavy Commercial Vehicle (HCV), Off-Highway and Power Gen markets globally.

Exhaust heat recovery using electro turbo generators by Patterson, **A., Tett, R., and McGuire, J.** puts forward an argument in favour of Electro-Turbo compounding as a system that is technically mature enough to benefit the above markets today. Only a part of the energy released from the fuel during combustion is converted to useful work in an engine. The remaining energy is wasted and the exhaust stream is a dominant source of the overall wasted energy. There is renewed interest in the conversion of this energy to increase the fuel efficiency of vehicles. There are several ways this can be accomplished. This work involves the utilization thermoelectric (TE) materials which have the capability to convert heat directly into electricity. A model was developed to study the feasibility of the concept. A Design of Experiment was performed to improve the design on the basis of higher power generation and less TE mass, backpressure, and response time. Results suggest that it is possible to construct a realistic device that can convert part of the wasted exhaust energy into electricity thereby improving the fuel economy of a gaselectric hybrid vehicle.

Thus the Various possible exhaust heat recovery methods have been discussed by **Husain,Q., Brigham, D., and Maranville,C** in Thermoelectric Exhaust Heat Recovery for Hybrid Vehicles Considering heavy truck engines up to 40% of the total fuel energy is lost in the exhaust. Because of increasing petroleum costs there is growing interest in techniques that can utilize this waste heat to improve overall system efficiency.

Leising, C., Purohit, G., DeGrey, S., and Finegold, J., examines and compares improvement in fuel economy for a broad spectrum of truck engines and waste heat utilization concepts.

4. TURBOCHARGER

Turbo battery charging system converts the pressure energy into electrical power. This system uses the pressure and temperature of the exhaust which is sent through a or a set of nozzles and generates high velocity gases at the exit. This high velocity gas is being utilized to drive a turbo generator (turbine coupled with dynamo) which powers the auxiliary units such as car batteries, air conditioner headlight etc. So fuel economy is greatly saved which is the need of the hour. Figure 3 shows the symmetric diagram of Turbo Batter Charging System.

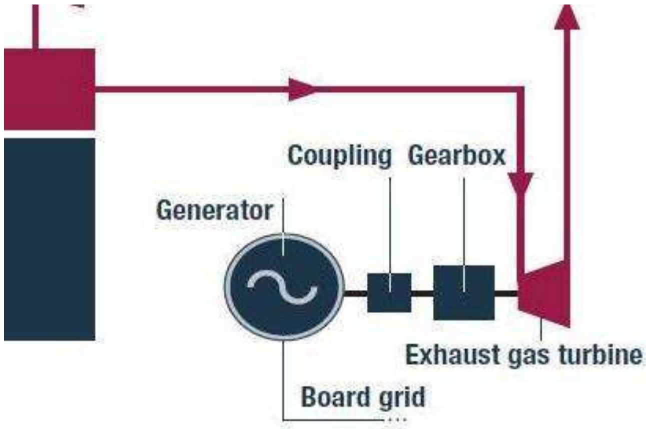

Figure 3: Symmetric diagram of Turbo Batter Charging System.

In this turbo model we have used a single stage impulse turbine. This project incorporates the simple design of axial flow impulse turbine whose results are better than radial flow (proved by the researchers).

4.1. Benefits of Turbo Battery Charging System.

Now a day's battery is charged through crankshaft. So a part of its energy is utilized in charging. We are using exhaust gas to charge the battery which is generally not used in any other purposes and simply wasted. So a part of energy is being saved as well as the overall power output got increased.

By using this device we can generate the electricity which can be used to charge the battery. And can also be used to run air conditioner and to glow the head lights.

4.2. Limitations of Turbo Battery Charging System.

This device consists of a converging nozzle because of which a small back pressure may be generated. This back pressure can be harmful for engine for engine and an engine can work improperly.

5. INTERNAL COMBUSTION ENGINE

The principle behind any reciprocating internal combustion engine: If you put a tiny amount of high-energy fuel (like gasoline) in a small, enclosed space and ignite it, an incredible amount of energy is released in the form of expanding gas. You can use that energy to propel a potato 500 feet.

In this case, the energy is translated into potato motion. You can also use it for more interesting purposes. For example, if you can create a cycle that allows you to set off explosions like this hundreds of times per minute, and if you can harness that energy in a useful way, what you have is the core of a car engine!

Almost all cars currently use what is called a **four-stroke combustion cycle** to convert gasoline into motion. The four-stroke approach is also known as the **Otto cycle**, in honor of Nikolaus Otto, who invented it in 1867.

6. BATTERY

An electric **battery** is a device consisting of one or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell contains a positive terminal, or cathode, and a negative terminal, or anode. Electrolytes allow ions to move between the electrodes and terminals, which allows current to flow out of the battery to perform work.

Primary (single-use or "disposable") batteries are used once and discarded; the electrode materials are irreversibly changed during discharge. Common examples are the alkaline battery used for flashlights and a multitude of portable devices. Secondary (rechargeable batteries) can be discharged and recharged multiple times; the original composition of the electrodes can be restored by reverse current. Examples include the lead-acid batteries used in vehicles and lithium ion batteries used for portable electronics. Batteries come in many shapes and sizes, from miniature cells used to power hearing aids and wristwatches to battery banks the size of rooms that provide standby power for telephone exchanges and computer data centers.

According to a 2005 estimate, the worldwide battery industry generates US$48 billion in sales each year, with 6% annual growth. Batteries have much lower specific energy (energy per unit mass) than common fuels such as gasoline. This is somewhat offset by the higher efficiency of electric motors in producing mechanical work, compared to combustion engines.

Batteries are classified into primary and secondary forms.

- *Primary* batteries irreversibly transform chemical energy to electrical energy. When the supply of reactants is exhausted, energy cannot be readily restored to the battery.
- *Secondary* batteries can be recharged; that is, they can have their chemical reactions reversed by supplying electrical energy to the cell, approximately restoring their original composition.

Some types of primary batteries used, for example, for telegraph circuits, were restored to operation by replacing the electrodes. Secondary batteries are not indefinitely rechargeable due to dissipation of the active materials, loss of electrolyte and internal corrosion.

6.1. Primary batteries

Primary batteries, or primary cells, can produce current immediately on assembly. These are most commonly used in portable devices that have low current drain, are used only intermittently, or are used well away from an alternative power source, such as in alarm and communication circuits where other electric power is only intermittently available. Disposable primary cells cannot be reliably recharged, since the chemical reactions are not easily reversible and active materials may not return to their original forms. Battery manufacturers recommend against attempting to recharge primary cells. In general, these have higher energy densities than rechargeable batteries,[22] but disposable batteries do not fare well under high-drain applications with loads under 75 ohms (75 Ω).Common types of disposable batteries include zinc–carbon batteries and alkaline batteries.

6.2. Secondary batteries

Secondary batteries, also known as *secondary cells*, or *rechargeable batteries*, must be charged before first use; they are usually assembled with active materials in the discharged state. Rechargeable batteries are (re)charged by applying electric current, which reverses the chemical reactions that occur during discharge/use. Devices to supply the appropriate current are called chargers.

The oldest form of rechargeable battery is the lead–acid battery. This technology contains liquid electrolyte in an unsealed container, requiring that the battery be kept upright and the area be well ventilated to ensure safe dispersal of the hydrogen gas it produces during overcharging. The lead–acid battery is relatively heavy for the amount of electrical energy it can supply. Its low manufacturing cost and its high surge current levels make it common where its capacity (over approximately 10 Ah) is more important than weight and handling issues. A common application is the modern car battery, which can, in general, deliver a peak current of 450 amperes.

The sealed valve regulated lead–acid battery (VRLA battery) is popular in the automotive industry as a replacement for the lead–acid wet cell. The VRLA battery uses an immobilized sulfuric acid electrolyte, reducing the chance of leakage and extending shelf life. VRLA batteries immobilize the electrolyte.

7. OBJECTIVES

The objective of the project work is to design and analysis of charging vehicle battery using bike exhaust gas.

- Assembling of setup components properly in order to direct conversion of kinetic energy of exhaust gases (thermal energy) in to electrical power
- Charging of battery is to indicate the supply of electric current produced by a setup.

Figure 4 and 5 shows the schematic diagram of experimental setup.

8. METHODOLOGY

- Check the fuel in measuring tank before starting the engine.
- Check the assembling of setup properly for no defects.
- The test engine is running with constant speed of 1600RPM, 1800RPM and 1900RPM the battery is charged in the exhaust gases.
- Now take the voltage readings and fuel consumption are taken.
- Turbine rpm was noted

- The battery is utilized the CLF bulb using inverting unit (figure 6).
- Tabulated the power achieved. Table 1 shows the Test engine specification.

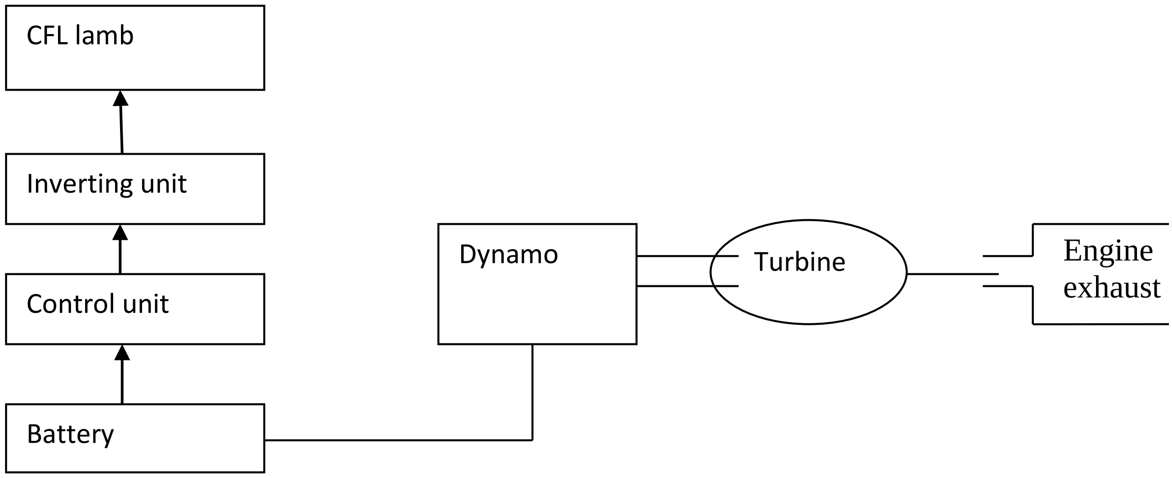

Figure 4: Schematic diagram of experimental setup

Figure 5: Photographic view of experimental setup

Figure 6: Photographic view of inverting unit with CLF bulb

Table1: Test engine specification

Engine	Honda CD 100,4 stroke, single cylinder, air cooled
Displacement	97.2cc
Transmission	4 speed constant mesh
Ignition	Electronic
Starting	Kick starter
Maximum power	5.1Kw or7 PS @8000rpm
Maximum speed	8000RPM

9. RESULTS AND DISCUSSION

The figure 7 shows our practical conclusion that if we are increasing the speed of the engine the electrical power output will also increase. Increasing engine speed means increasing the mass flow rate of exhaust gas or increasing the speed of the turbine.

The experimental results of the present work are on the expected lines and encouraging .As shown in figure 8 the engine speed results in 1600 RPM, 1800RPM and 1900RPM thermal sufficiency enhancement.

Figure 9 shows the thermal efficiency of the engine .It is seen from the graph that there is no appreciable change in the brake thermal efficiency with and without fixed fabricated battery charger. It is evident that the back pressure developed across the turbine is well within the acceptable limits.

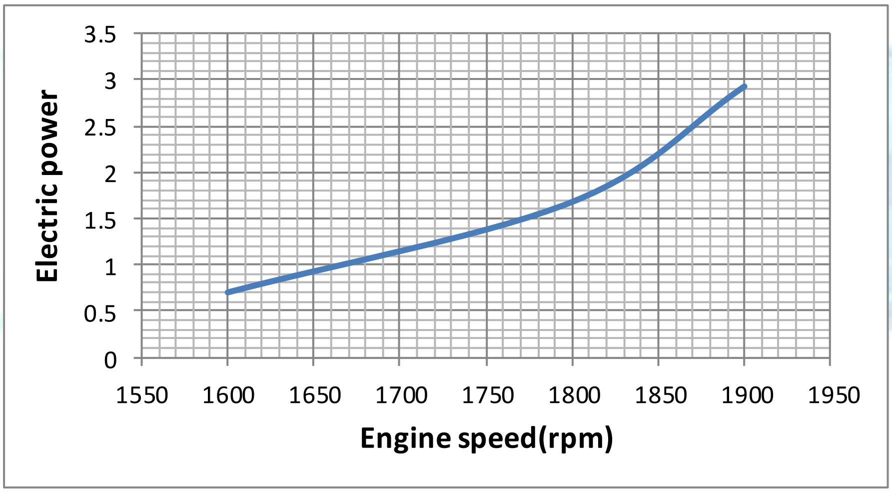

Figure 7: Electrical power against engine speed

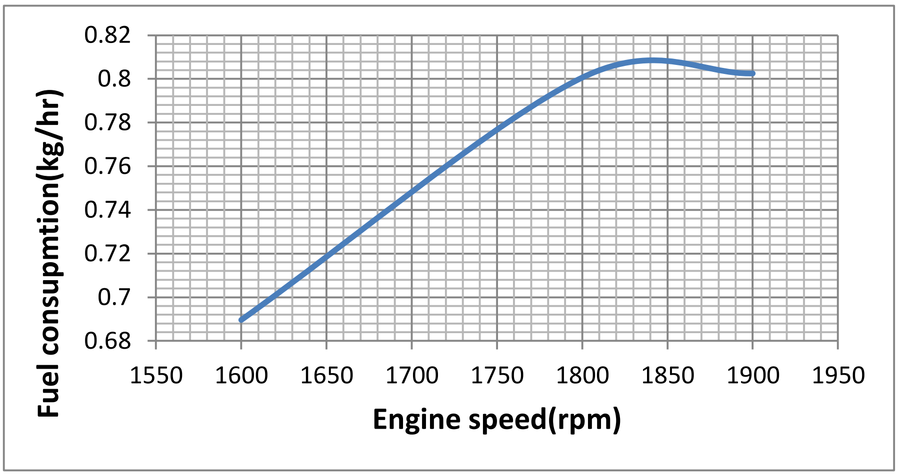

Figure 8: Fuel consumption against engine speed

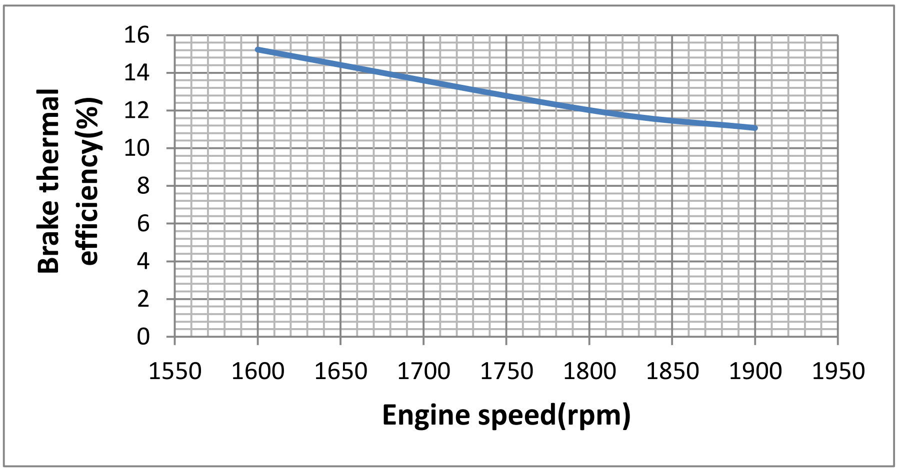

Figure 9: Brake thermal efficiency against engine speed

10. CONCLUSION

We have done different studies according to our practical inputs. We have approached the problem with different engine RPM. Practically for different engine speeds for different turbine power output were observed.

However the efficiency of the turbine is less, but in optimum design best results can be achieved.Batterty charging system from exhaust gas is better idea to save the power. In general the battery is charged through flywheel in which we lost some amount of power. From the experimental investigation, we have observed that the fuel economy can be saved up to a greater extent. The engine performance is almost same in with and without battery charger.

REFERENCES

[1]. A., Tett, R., and McGuire, *J.*2009. "Exhaust Heat Recovery using Electro-Turbo generators," *SAE Technical Paper* 2009-01-1604, doi: 10.4271/2009-01-1604.

[2]. Husain, Q., Brigham, D., and Marienville, C.2009. "Thermoelectric Exhaust Heat Recovery for Hybrid Vehicles," *SAE Int. J. Engines* 2(1):1132-1142, doi: 10.4271/2009-01-1327.

[3]. Leising, C., Purohit, G., DeGrey, S., and Feingold, J.1978. "Waste Heat Recovery in Truck Engines," *SAE Technical Paper* 780686, doi: 10.4271/780686.

[4]. Alberto, 2012. “Improving the Efficiency of Turbocharged Spark Ignition Engines for Passenger Cars through Waste Heat Recovery” *Boretti Missouri University of Science and Technology* Date, Published: 2012-04-16Paper Number: 2012-01-0388 DOI: 10.4271/2012-01-0388.

[5]. P.Balashanmugam, E.Elakiya, Sunayana Sharma,(2013), Performance Analysis on a Turbocharged Two Wheeler Engine, *International Journal of Engineering Research and Science & Technology*,, Issue 2, Volume11, ISSN 2319- 5991 ,Vol. 2, No. 4, pp-29-41.

[6]. Natkrita Prasoetsopha, Supree Pinitsoontorn, Vittaya Amornkitbamrung, Department of Physics, Faculty of Science, Khon Kaen University, Khon Kaen 40002, Thailand

[7]. D. Flahaut, T. Mihara and R. Funahashi, N. Nabeshima, K. Lee, H. Ohta and K. Koumoto.2006. *Journal of a pplied physics* 100, 084911.

[8].Il-Ho Kim1, Soon-Mok Choi, Won-Seon Seo and Dong-Ik Cheong, Kim et al. Nanoscale Research Letters 2012.

[9]. Driss Kenfaui, Guillaume Bonnefont , Daniel Chateigner , Gilbert Fantozzi ,Moussa Gomina.2010,*Jacques Guillaume Noudem, Materials Research Bulletin* 45, 1240–1249

[10]. Basel I. Ismail, Wael H. Ahmed, 2009, *Recent Patents on Electrical Engineering, 2*, 27-39

[11]. R. Saidur, M.Rezaei, W.K.Muzammil, M.H.Hassan, S.Paria, M.Hasanuzzaman.2012.*Renewable and Sustainable Energy Reviews* 16, 5649–5659

[12]. Nicolas Bailly, Jean-Marie Dilhac, Christophe Escriba, Claude Vanhecke, Nicolas Mauran1,Marise Bafleur.2008. "*8th International Workshop on Micro and Nanotechnology for Power Generation and Energy Conversion Applications* (PowerMEMS 2008), SENDAI : Japan

[13]. Ganni Gowtham, Ksitij Kumar, S.S Charan, K Manivannan.2012.*International journal of mechanical engineering and technology* (ijmet) ISSN 0976 – 6340 (Print) ISSN 0976 – 6359 (Online) Volume 3, Issue 3, September - December , pp. 471-482