International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

REGENERATION OF ELECTRICITY USING THERMOELECTRIC GENERATOR WITH POLLUTION CONTROL

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Abstract - *In automobile engines almost 30% of the fuel energy is wasted in exhaust gases. That wasted energy can be reused to charge battery. By using Thermoelectric module waste heat can be recycled. If this waste heat energy is converted into usable energy, the fuel efficiency of an engine could be improved. Thermoelectric modules are semiconductor devices which could convert thermal energy to electrical energy from a temperature difference. Thermoelectric Module works under principle of Seebeck effect. Heat exchanger is used with cooling circuit to maximize the temperature difference. To reduce pollution catalytic convertor is employed. The catalytic convertor decreases gases like HC, CO, NO_x produced during combustion of the automobile engine. This allows to reduce amount toxic gases into atmosphere. This total system at end allows to reduce amount of heat energy and pollutant gases emitted by an automobile engine can be reduced.*

KEYWORDS: Automobile engine, Waste heat recovery, Thermoelectric Generator, Heat exchanger, Exhaust gases; Catalytic convertor.

1.INTRODUCTION

Pollution nowadays increased all over world which cause numerous problems to humans as well as to the environment. Thus, new technology has to be found to reduce pollution. One of technology is Thermoelectric Generator which uses the heat from exhaust gas and convert it into usable energy like electrical energy. Thermoelectric Generator uses Thermoelectric Cooling Module (TEC) to generate electricity. Thermoelectric Module works on the principle of Seebeck effect. The Seebeck effect or Thermoelectric effect produce electrical energy from temperature difference. The automobile engine is one of major reason for pollution in the world. Catalytic Convertor with Thermoelectric generator can reduce wastage of energy and pollution. Thermoelectric module made of semiconducting materials which when placed in a temperature gradient between the two faces produce electricity. The semiconducting material consist of p and n side. When p side is heated electron get excited and move towards n side which produce electricity. That's why temperature difference is produced between the faces of thermoelectric module to obtain electricity.

The work done in [1] Coatings 2018, 8, 45 Performance Investigation of an Exhaust Thermoelectric Generator for Military SUV Application uses the TEG in SUV to produce energy which gave good outcome and show TEG can be used with Catalytic convertor. [2] Design and Fabrication of Silencer Waste Heat Power Generation System Using Thermo-Electric Generator M G Jadhav1 and J S Sidhu2, ISSN 2250-3234 Volume 7, Number 1 (2017), their conclusion was TEG used in series connection could run other battery operating system in automobile. But they did not use cooling system. [3] Effect of a Thermoelectric Generator on the Fuel Economy of a Vehicle Operating in a Real-world Environment Nikolay Anatolyevich Khripach1, Boris Arkadyevich Papkin1, Viktor Sergeevich Korotkov1, Alexander Sergeevich Nekrasov1 and Dmitriy Vladimirovich Zaletov2 BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, September 2015. Vol. 12(Spl. Edn. 2). They concluded suitable thermoelectric conductor could produce 1kW power and fuel efficiency can be reduced. [4] Generation of Electricity by Using Exhaust from Bike S.Vijaya, Vol. 4, Special Issue 6, May 2015 Kumar used turbine to generate electricity from exhaust gas

The global warming is major significance problem faced by humanity. If any steps aren't taken to reduce pollution. It may lead to tripping point of our world. If tripping point is crossed devastating things will happen. The automobile engine reasons more pollution. Catalytic convertor is major component to reduce pollution in automobile engines. Catalytic convertor is of two types Two-way catalytic convertor and Three-way catalytic convertor. The catalytic convertor traps toxic gases like (CO, NOx, HC) into harmless gases. The honeycomb structured catalytic convertor is best efficient to reduce gases. Honeycomb structure has minute pores which will reduce gases. The cooling reduces gases and in honeycomb structure cooling is better than any other structures.

2.EXPERIMENTAL SETUP

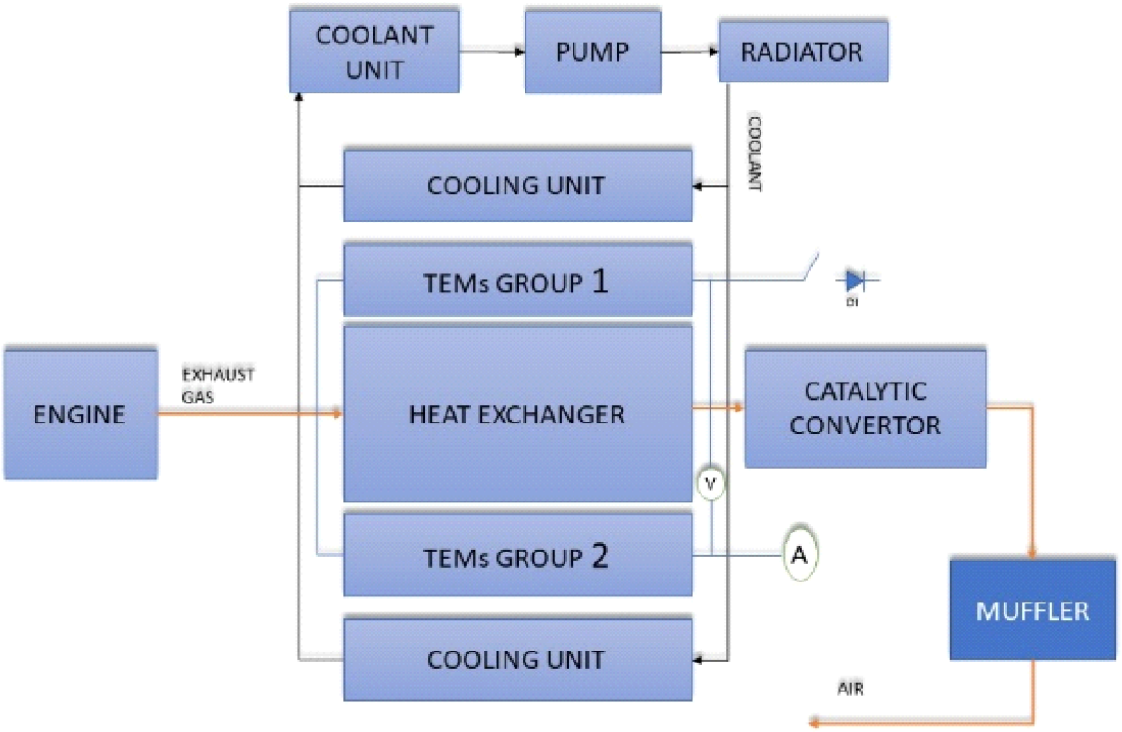


Fig -1: Architecture of TEG with Catalytic Convertor

The components of this experiment are

- Bike
- TEG Module (TEC1-12706)
- Aluminum silencer
- Cooling Unit
- Catalytic Convertor

The architecture of this project is shown in figure 1

2.1. Bike

In this experiment we used Bajaj platina 110cc for conducting real world experiment

2.2. TEG Module (TEC1-12706)

Thermoelectric module cooling module used in this experiment is TEC1-12706 as shown in fig 2. This cooling module has 138°C maximum operating temperature. This module could produce about 6 amperes at 130°C with cooling. Totally 6 number of Module is used. TEC are grouped into two groups with three modules on each group. The TEG are connected in series within group and two groups are connected in parallel. Then TEG is connected to battery using wire

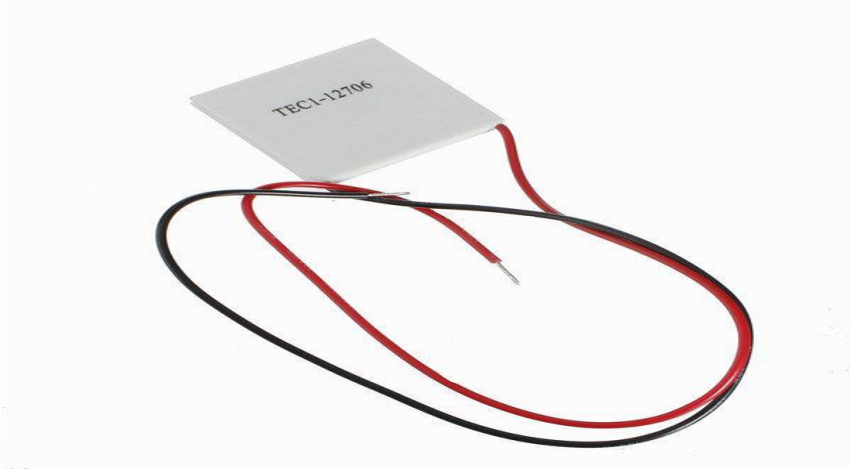


Fig -2: TEC1-12706

2.3. Aluminum silencer

Aluminum silencer is used to obtain maximum temperature gradient. The aluminum silencer is designed and fabricated as shown in fig 3 and fitted to engine exhaust.

Fig -3: Silencer fabricated

2.4.Cooling Unit

Cooling unit consist of circulating pump and radiator. Radiator is used to cool water to obtain maximum temperature difference. The circulating tube is fitted at back side of TEG groups. The water circulated into tube from coolant storage to tube using pump is shown in fig 4.

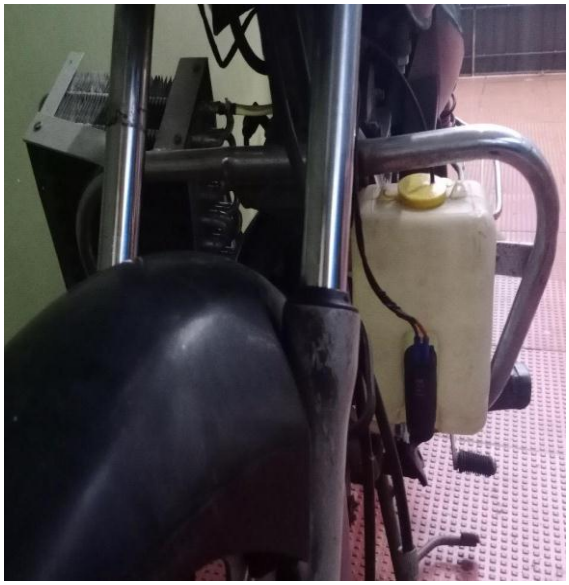


Fig -4: Colling system

2.5.Catalytic Convertor

Catalytic convertor reduces toxic gases (CO, HC, NOx) in exhaust gas into nontoxic gases. Catalytic convertor used in project is from tata Indica. The part of catalytic convertor is placed inside the aluminum silencer at end. The catalytic convertor used is three-way type in which reduction and oxidation takes place in order.

3.RESULT

3.1.Road test

Working condition 1(No load - Idling)

The vehicle is operated on idle condition without any load. The temperature is increased constantly and the characteristic values of the system is noted down in following table. Two types of values are taken during the experiment. One is without cooling system and the other is with a cooling system unit. The coolant medium used in cooling system is water.

Table -1: Without cooling

LOAD	T1	T2	ΔT = (T1– T2)	Voltage	Ampere	Power
Kg	℃	℃	℃	Volt	Amp	W/hr
NO LOAD	50	46.8	3.2	13.18	0.18	0.88
	60	55.6	4.4	13.25	0.21	0.96
	70	61.6	8.4	13.29	0.34	1.43
	80	69.7	10.3	13.33	0.42	1.98

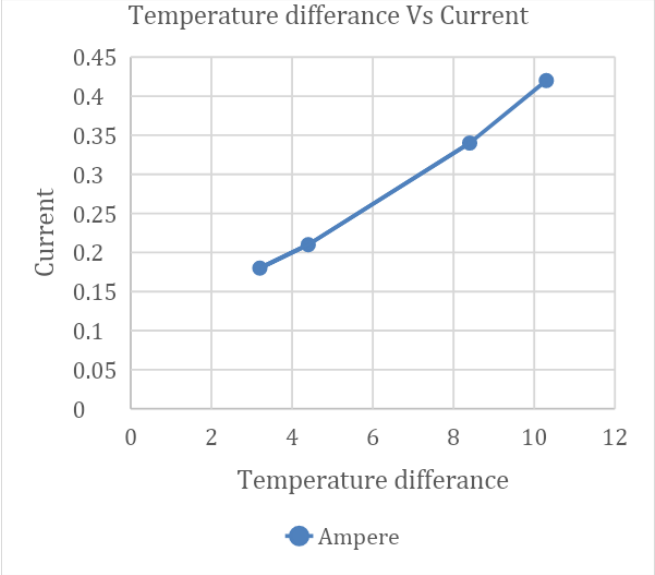


Chart -1: Temperature Difference Vs Current

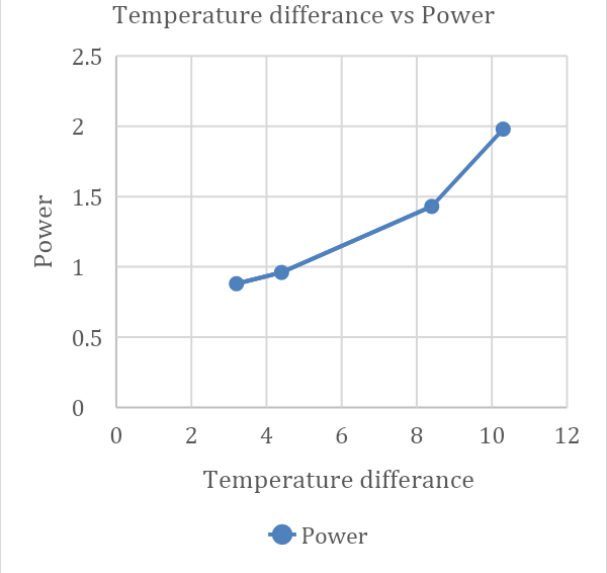


Chart -2: Temperature Difference Vs Power

Table -2: With forced cooling (Water cooled)

LOAD	T1	T2	ΔT = (T1– T2)	Voltage	Ampere	Power
Kg	℃	℃	℃	Volt	Amp	W/hr
NO LOAD	50	37.00	13	13.11	0.56	6.68
	60	38.01	21.99	13.15	0.66	8.62
	70	39.10	30.9	13.20	0.81	10.63
	80	40.50	39.5	13.26	0.89	11.62

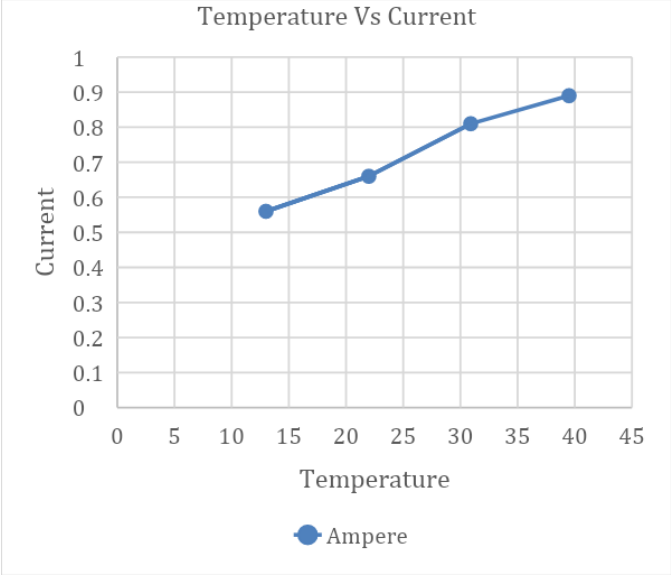


Chart -3: Temperature Vs Current

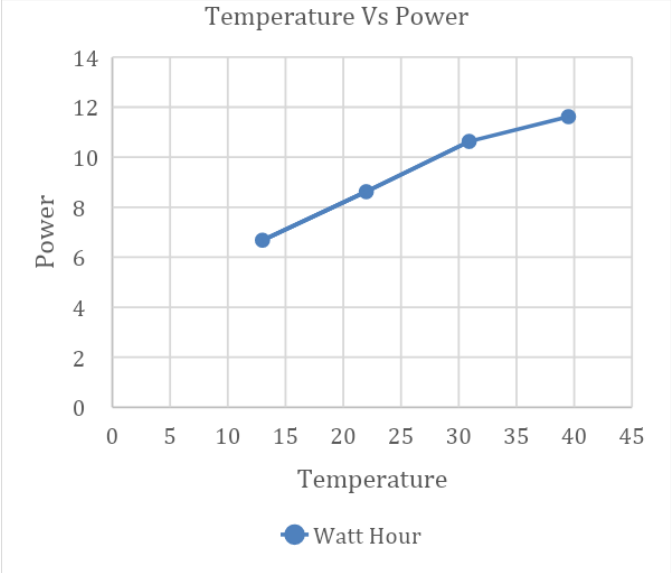


Chart -4: Temperature Vs Power

Working condition 2(With Load-Running)

The vehicle is driven on with two persons which adds an approximate load of 120kg to the system. The characteristic values of the system are noted down in following tables. Two types of values are taken during the experiment. One is without cooling system and the another is with cooling system. The coolant medium used in cooling system is water.

Table -3: Without cooling

Load	Speed	Time	T1	T2	ΔT = (T1–T2)	Voltage	Ampere	Power
Kg	KM/hr	min	℃	℃	℃	Volt	Amp	W/h
120	30	1	45.25	39.32	5.93	13.01	0.26	2.95
		2	50.30	42.75	7.55	13.12	0.31	3.85
		5	51.30	41.87	9.43	13.18	0.38	4.76
	40	1	59.70	48.75	10.95	13.25	0.40	4.98
		2	60.5	47.98	12.52	13.31	0.43	5.33
		5	65.00	51.79	13.21	13.39	0.48	5.97
	50	1	70.00	56.11	13.89	13.44	0.51	6.44
		2	74.00	59.4	14.60	13.68	0.53	6.93
		5	79.75	64.48	15.27	13.85	0.55	7.22

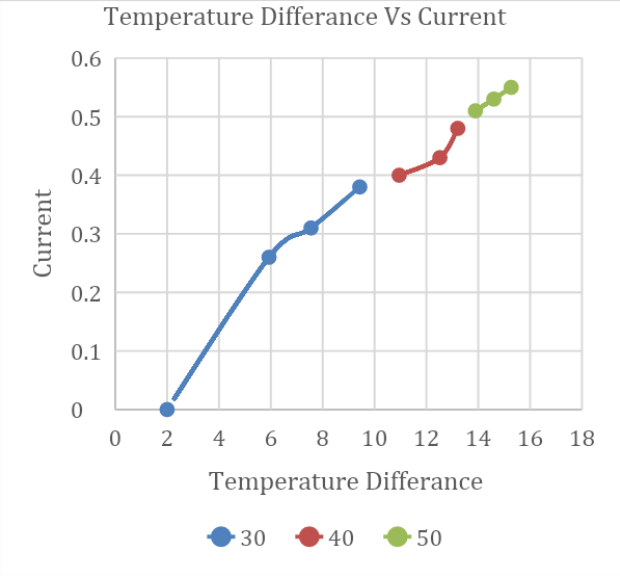


Chart -4: Temperature Difference Vs Current

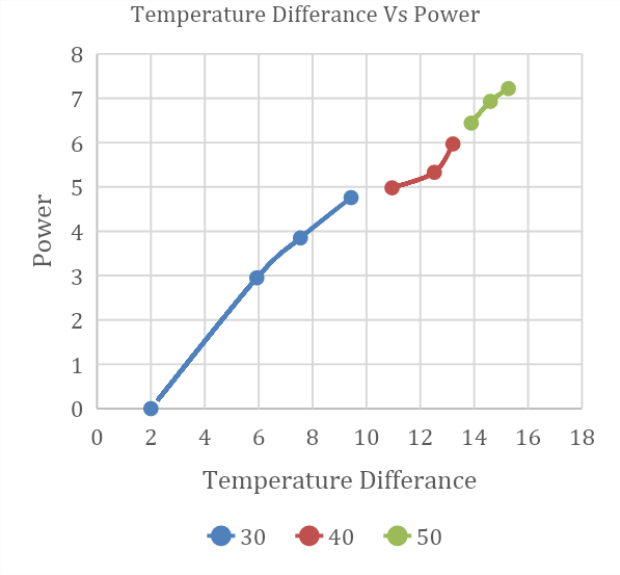


Chart -5: Temperature Difference Vs Power

Table -4: With forced cooling (Water cooled)

Load	Speed	Time	T1	T2	ΔT = T1–T2	Voltage	Ampere	Power
Kg	KM/hr	min	℃	℃	℃	Volt	Amp	W/h
120	30	1	45.25	32.10	13.15	13.23	0.52	7.70
		2	50.30	33.00	17.3	13.30	0.54	7.91
		5	51.30	33.50	17.8	13.71	0.66	8.06
	40	1	59.70	33.81	25.89	13.78	0.74	9.76
		2	60.5	33.98	26.52	13.80	0.81	10.10
		5	65.00	34.19	30.81	13.85	0.89	11.83
	50	1	70.00	36.56	33.44	13.89	1.03	12.64
		2	74.00	37.00	37	13.90	1.11	14.62
		5	79.75	37.44	42.31	14.00	1.78	15.56

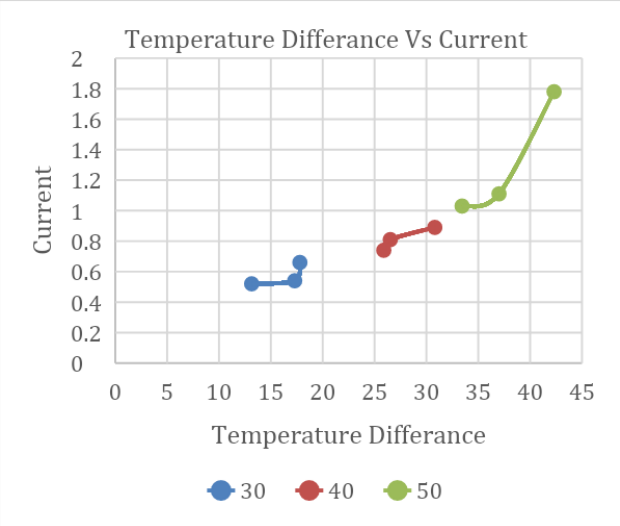


Chart -6: Temperature Difference Vs Current

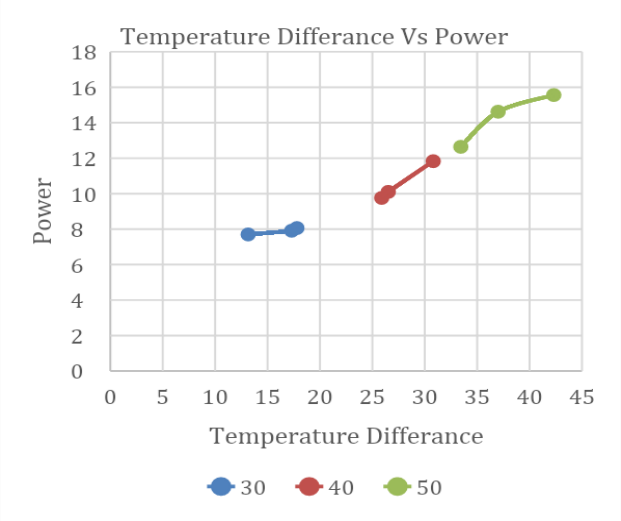


Chart -7: Temperature Difference Vs Power

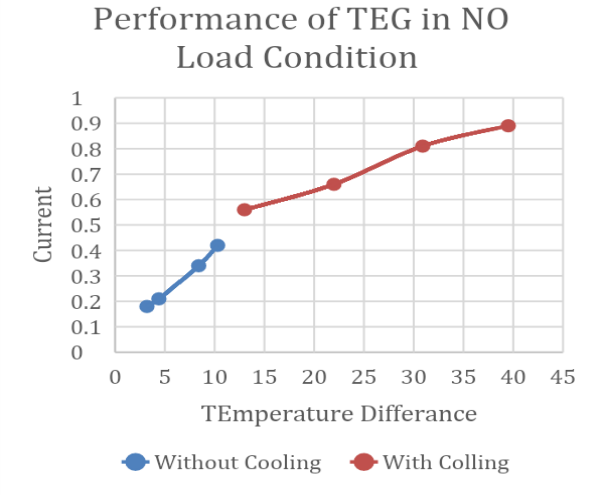


Chart -8: Performance of TEG in No Load Condition

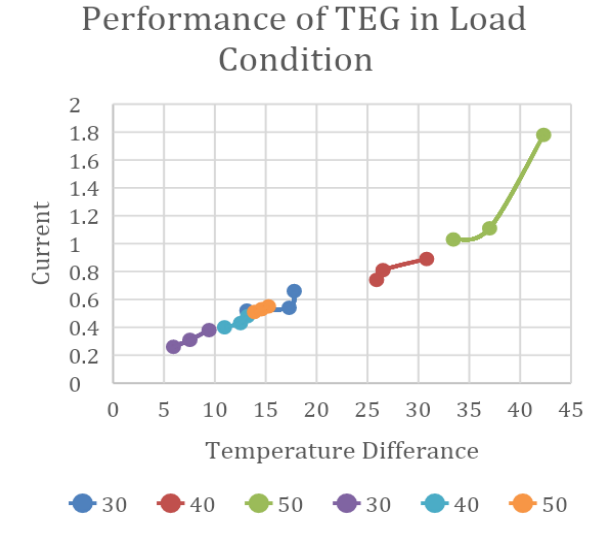
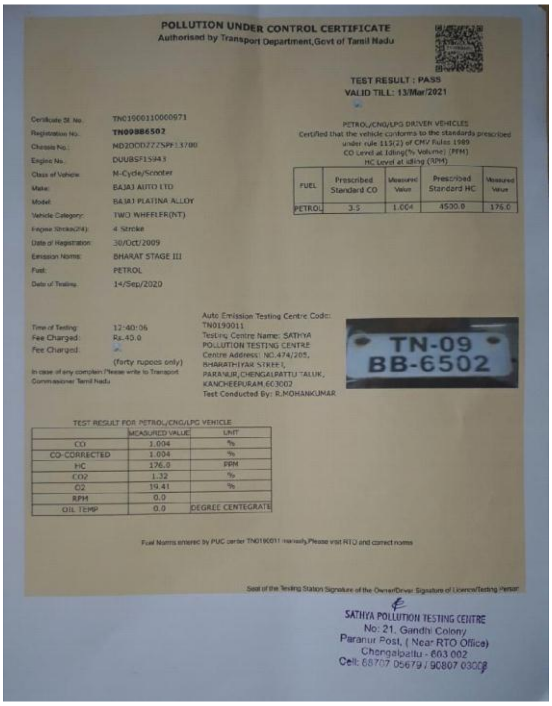


Chart -9: Performance of TEG in Load Condition

3.2. Pollution Test

To test the working of catalytic converter pollution test is carried out on the vehicle. First bike is started and given acceleration. Then the rod is fitted inside the muffler to collect a sample of gas. The collected gas is tested and compared with existing value. The pollution Certificate is shown in fig 5


POLLUTION UNDER CONTROL CERTIFICATE
Authorised by Transport Department,Govt of Tamil Nadu

TEST RESULT : PASS
VALID TILL: 13/Mar/2021

Certificate Sl. No. TNC1900110000971
Registration No. TN09BB6502
Chassis No. MD2DDD27ZSPF13700
Engine No. DUUBSF15943
Class of Vehicle M-Cycle/Scooter
Make BAJAJ AUTO LTD
Model BAJAJ PLATINA ALLOY
Vehicle Category TWO WHEELER(NT)
Engine Stroke(2/4) 4 Stroke
Date of Registration 30/Oct/2009
Emission Norms BHARAT STAGE III
Fuel PETROL
Date of Testing 14/Sep/2020

PETROL/CNG/LPG DRIVEN VEHICLES
Certified that the vehicle conforms to the standards prescribed under rule 115(2) of CMV Rules 1989
CO Level at Idling(% Volume) (PPM)
HC Level at idling (RPM)

FUEL	Prescribed Standard CO	Measured Value	Prescribed Standard HC	Measured Value
PETROL	3.5	1.004	4500.0	176.0

Time of Testing 12:40:06
Fee Charged Rs.40.0
Fee Charged (forty rupees only)
In case of any complain Please write to Transport Commissioner Tamil Nadu

Auto Emission Testing Centre Code: TN0190011
Testing Centre Name: SATHYA POLLUTION TESTING CENTRE
Centre Address: NO.474/205, BHARATHIYAR STREET, PARANUR,CHENGALPATTU TALUK, KANCHEEPURAM.603002
Test Conducted By: R.MOHANKUMAR

TN-09 BB-6502

TEST RESULT FOR PETROL/CNG/LPG VEHICLE

	MEASURED VALUE	UNIT
CO	1.004	%
CO-CORRECTED	1.004	%
HC	176.0	PPM
CO2	1.32	%
O2	19.41	%
RPM	0.0	
OIL TEMP	0.0	DEGREE CENTEGRATE

Seal of the Testing Station Signature of the Owner/Driver Signature of Licence/Testing Person

SATHYA POLLUTION TESTING CENTRE
No: 21, Gandhi Colony
Paranur Post, (Near RTO Office)
Chengalpattu - 603 002
Cell: 88707 05679 / 90807 03008

Fig -5: Pollution Test Result

4. CONCLUSION

The regeneration of exhaust heat energy was successful and gave good performance. Catalytic Convertor gave less emission value which makes this eco-friendly vehicle. In this project we removed conventional battery charging methods through dynamo which in turn increases fuel efficiency. Battery is charged directly by exhaust energy and used to run the auxiliary systems of the bike such as lighting and horn. Due to improved cooling systems can get more output. We concluded that further development of this project and new development in TEG system can lead to converting this project into a hybrid vehicle.

5. REFERENCES

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[2] Design and Fabrication of Silencer Waste Heat Power Generation System Using Thermo-Electric Generator M G Jadhav1 and J S Sidhu2, ISSN 2250-3234 Volume 7, Number 1 (2017).

[3] Effect of a Thermoelectric Generator on the Fuel Economy of a Vehicle Operating in a Real-world Environment Nikolay Anatolyevich Khripach1, Boris Arkadyevich Papkin1, Viktor Sergeevich Korotkov1, Alexander Sergeevich Nekrasov1 and Dmitriy Vladimirovich Zaletov2 BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, September 2015. Vol. 12(Spl. Edn. 2).

[4] Generation of Electricity by Using Exhaust from Bike S.Vijaya, Vol. 4, Special Issue 6, May 2015