



A PROJECT REPORT
ON
TURBOREGENERATOR - regeneration of waste exhausts energy

SUBMITTED BY

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**Submitted in partial fulfillment of the requirement for the degree, Bachelor of technology in
Automotive Design Engineering of University of Petroleum and Energy Studies, Dehradun**

UNDER THE GUIDANCE OF
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DECLARATION

We, **Mr. Deepanshu Dwivedi(R140206020)** and **Mr. Siddhath Tripathi (R140206058)**, students of B.Tech (Automotive Design Engineering), University of Petroleum and Energy Studies, Dehradun hereby declare that the dissertation entitled **"TURBO REGENERATOR - regeneration of waste exhausts energy"** embodies the report of our project work carried out at University of petroleum & Energy Studies from 01st October to 08th may, 2010 under guidance of **Mr. R.K. Tripathi Faculty of Engineering, UPES, Dehradun**. This work has been submitted for the partial fulfillment of the requirement for the award of the honorable degree **'Bachelor of Technology in Automotive Design Engineering'**.

Date: 15/05/10



R.K. Tripathi



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ABSTRACT

In this project, we propose a method in which the energy of exhaust is being used to produce electrical energy. As the present scenario of oil & gas sector is showing that automotive world will have to face a big problem of the energy or fuel. Hence the automotive sector is moving towards hybrid technology in which two sources of energy (gasoline and electricity) are used together for running an automobile. This project is a step towards the technology by producing electricity using waste energy of an automobile in running condition of engine. The principle of this project is based on law of conservation of energy. As the exhaust has a substantial part (approx 30%) of total energy produced in an automobile which gets wasted in atmosphere, hence its kinetic energy and pressure energy can be utilized to generate electricity by using a modified setup. In this setup, a turbocharger, a torque converter, an epicyclical gearing system and an alternator are being used. The turbocharger will be run by exhaust, which will convert the kinetic energy of exhaust in mechanical energy. The turbocharger will be coupled with the torque converter. The torque converter will transfer (through the epicyclical gear system) this mechanical energy to the alternator which will convert this mechanical energy into electrical energy. Calculation of various mechanisms and power (electric) output of the setup has been done. It has been found that a good amount of power is generated, which can be used for running an automobile by using hybrid technology. Offline simulation of power obtained is modeled in SIMULINK/MATLAB Package.



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CHAPTER 1

INTRODUCTION



1.1 Introduction of Hybrid Electrical Vehicle:

Hybrid electric vehicles (HEVs) have two or more sources of energy or two or more sources of power on-board the vehicle. The sources of energy can be battery, Flywheel, and so on. The sources of power can be engine, fuel cell, battery, ultra capacitor, and so on. Depending on the configuration of the vehicle, two or more of these power or energy sources are used. These hybrid vehicles can reduce the air pollution significantly through increased fuel economy, use of alternative fuels, improved power unit, and after-treatment technology. Hybrid vehicles offer the following benefits:

- Greatest potential for improved fuel efficiency and performance in the mid-term, hence, potential improvements to fuel economy.
- Eliminates idle fuel consumption during deceleration and stops.
- Operates engine at more efficient points.
- On-board power generation using auxiliary power units; hence, improved accessory power generating efficiency.
- Addresses carbon dioxide emission reduction through improved fuel efficiency and reduced hydrocarbons and nitrogen oxides, using smaller internal combustion engines.
- Uses regenerative braking to recover the kinetic energy of the vehicle.
- Enables engine size reduction with the same vehicle performance due to additional power available from the electric motor.
- Incorporates technologies that are well known and can move into production quickly.
 - Electric motors.
 - Internal combustion engines (ICE).
 - Batteries.
- Added customer features and benefits including customer differentiation and adaptation



Hybrid vehicles are generally classified as series hybrids and parallel hybrids. In a Series hybrid vehicle, generally, an engine drives the generator to produce the power to charge the batteries and to provide power to the propulsion motor. In a parallel hybrid vehicle, the engine and the electric motor are used to drive the vehicle.

The series hybrid vehicle provides more possibilities for the development of low fuel consumption and low emission vehicles but it needs higher power and more efficient motors, an additional generator, a smaller IC engine, and a battery with a high power rating. Adding the cost of all these items could result in an expensive vehicle. The parallel hybrid can offer the lowest cost and the option of using existing manufacturing capability for engines, batteries, and motors. But the parallel vehicle needs complex control systems. Series hybrid vehicles offer lower fuel consumption in the city driving cycle, and parallel hybrid vehicles have lower fuel consumption in the highway driving cycle. There are various configurations of the parallel hybrid vehicles depending on the role of the electric motor/generator and the engine. Hence, hybrid vehicles are also classified as mild hybrids, power hybrids, and energy hybrids depending on the role played by the engine and the electric motor, and the mission that the system is designed to achieve.

1.1.1 Series Hybrid Propulsion System:

A typical series hybrid propulsion system configuration is shown in Figure. A typical series hybrid vehicle is essentially an electric vehicle with an on-board source of power, also called auxiliary power unit (APU), for charging the batteries. Generally, an engine is coupled to a generator to produce the power to charge the batteries. It is also possible to design the system in such a way that the generator could act as a load-leveling device providing propulsion power. In this case, the size of the batteries could be reduced but the size of the generator and the engine need to be increased. The power electronic components required for a typical series hybrid vehicle system are a converter for converting the generator output to DC for charging the batteries and an inverter for converting the DC to AC to power the propulsion motor. A DC-DC converter is required to charge the 12 V batteries in the vehicle. In addition, an electric air-conditioning unit needs an inverter and associated control systems.

The engine driving the generator could be an IC engine, Stirling engine, micro-turbine, diesel engine, or a natural gas engine. The generator is generally a three-phase permanent magnet or an induction-type machine. The output of the generator is converted to DC using a three-phase bridge-controlled rectifier or using an insulated gate bipolar transistor (IGBT) bridge. The control system for the engine and the generator has to be designed in such a way that the engine operates at the optimum speed to obtain the highest possible efficiency. Depending on the state of charge of the batteries, the output of the converter has to be controlled. Generally, the state of charge of the batteries is kept below about 80% to allow room for the batteries to be charged using regeneration. Also, it is desirable to turn off the engine in the urban areas to operate as a zero emission vehicle.

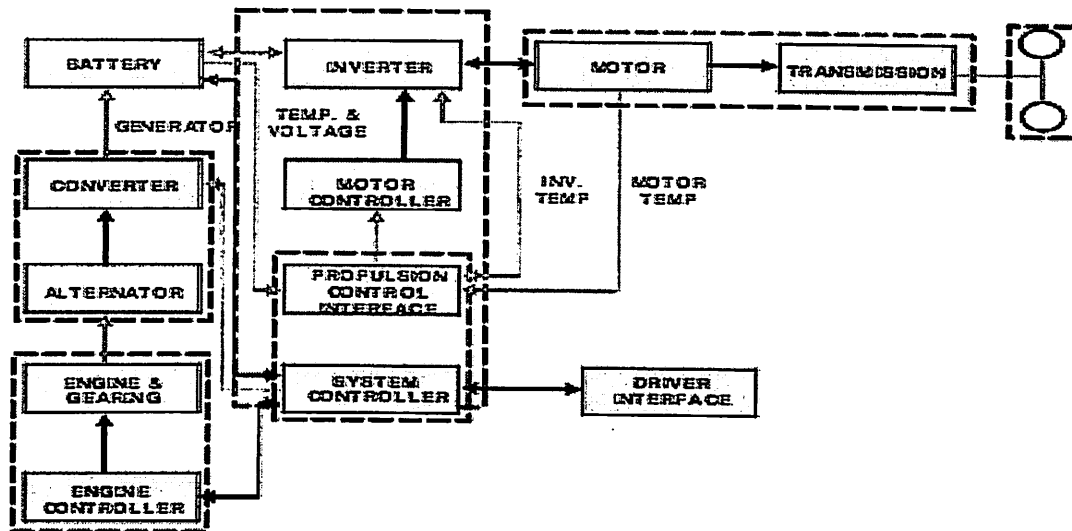


Fig1.0 : Series Hybrid Vehicle Propulsion System

- The power required for a prime mover (or engine) to perform the APU function is much lower than that required to perform the propulsion function.
- The power required for an APU unit is about 25 kW to 40 kW depending on the size of the vehicle.
- The prime mover should emit lowest possible emissions.
- The rating of the alternator (or generator) depends on whether the system is range extender type series vehicle or the load leveling type vehicle, where the propulsion power is obtained both from the battery and the APU.



1.1.2 PARALLEL HYBRID VEHICLE PROPULSION SYSTEM:

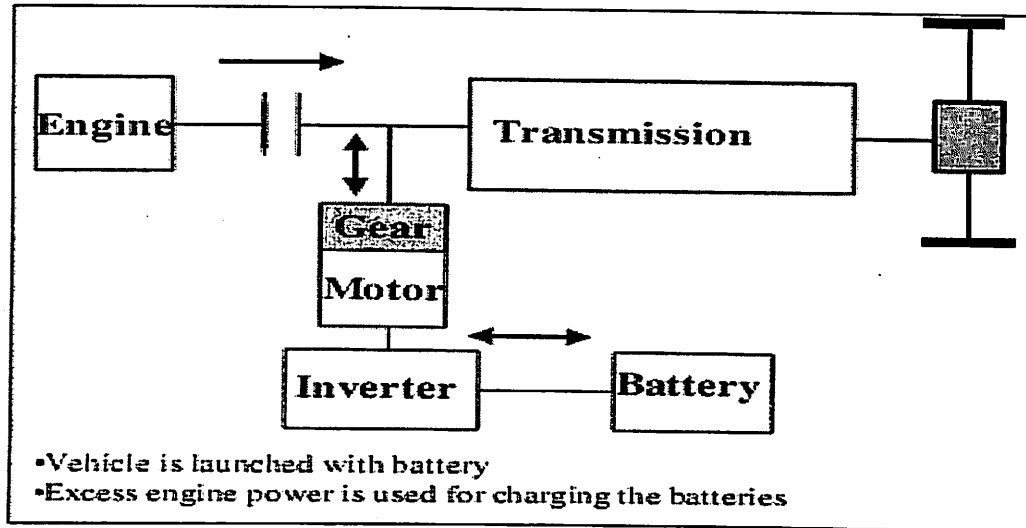


Fig1.1: A Typical Parallel Hybrid propulsion System

In the parallel hybrid vehicle, the engine and the electric motor can be used separately or together to propel a vehicle. In this system, the engine is disconnected during starting and deceleration, and vehicle is run using the electric motor. The electric motor, powered by the battery, also assists the engine when the transmission is in high gear. When the engine has excess power, the motor acts as a generator and charges the batteries. [1]The Toyota Prius and the Honda Civic are two examples of parallel hybrid systems that are commercially available [2]. The parallel hybrid can offer the lowest cost and the option of using existing manufacturing capability for engines, batteries, and motors.

So from the above discussion we can see that for the Hybrid vehicle we need Onboard Electricity Generation. As there are many ways to generate the electricity onboard i.e. from the engine, Regenerative Braking System. So this Idea can be implemented to generate the electricity onboard from the waste exhaust energy for Hybrid Vehicle.



CHAPTER 2

LITERATURE REVIEW



2.1 Background

As the present scenario of the world is showing that the automotive world will have to face a great difficulty in the prospect of energy (fuels). Even at present fulfilling of energy requirements is a great challenge in front of the world. Hence the automotive sector is moving towards hybrid technology in which two sources of energy (gasoline and electricity) are used together for running an automobile. Hybrid technology is a mile stone for the automotive world in terms of efficiency and less emission ambition, which is knocking the doors of the coming future.

2.2 Energy Challenge

The worldwide demand for energy is growing at an alarming rate, world energy technology and climate policy outlook (WETO) predicts an average growth rate of 1.8 % per annum for the period 2000-2030 of primary energy worldwide. While in international energy outlook reference (IEO2009), world marketed energy consumption is projected to grow by 44 percent over the 2006 to 2030 period. Total world energy use rises from 472 quadrillion British thermal units (Btu) in 2006 to 552 quadrillion Btu in 2015 and then to 678 quadrillion Btu in 2030.

The most rapid growth in energy demand from 2006 to 2030 is projected for nations outside the Organization for Economic Cooperation and Development (non-OECD nations). Total non-OECD energy consumption increases by 73 percent, as compared with a 15-percent increase in energy use among the OECD countries. Strong long-term GDP growth in the emerging economies of the non-OECD countries drives the fast-paced growth in energy demand. In all the non-OECD regions combined, economic activity—measured by GDP in purchasing power parity terms—increases by 4.9 percent per year on average, as compared with an average of 2.2 percent per year for the OECD countries.

2.3 Why Hybrid Technology?

A sustainable high quality of life is the basic driver for providing a clean, safe, reliable and secure energy supply in World. To ensure a competitive economic environment, energy systems must meet the following societal needs at affordable prices:

- Mitigate the effects of climate change;
- Reduce toxic pollutants; and
- Plan for diminishing reserves of oil.

Measures should therefore be introduced which promote:

- More efficient use of energy; and
- Energy supply from a growing proportion of carbon-free sources.

And it must aim for the ideal- an emissions-free future based on sustainable energy. Electricity and Gasoline/Diesel together represent one of the most promising ways to achieve this, complemented by Hybrid Technology which provides very efficient energy conversion.



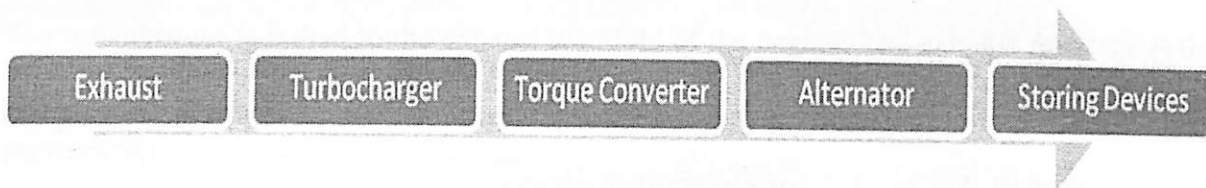
CHAPTER 3

METHODOLOGY



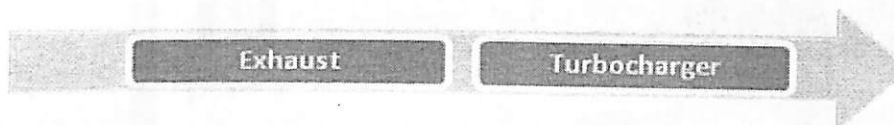
Now days and incoming future there are two main issues for the automotive sector -1) environment, 2) the energy resources .For overcoming the problems related to the issues, a lot of work has been done (or is going on), in Research &Development field. The hybrid technology has come in front of the automotive sector as a satisfactory solution. By using two energy resources together to run an automotive this technology has provided a way to spare the fuel. Many a improvements have been done to produce an alternative source i.e. electricity. In the past the electricity was obtained through various modifications in automotive like (1) Electricity generation from the steam (produce by the exhaust heat). (2) By taking power from the crankshaft to generate the electricity and many others. But in this project we have utilized the exhaust energy to generate the electricity in a different way through the turbocharger (which in itself increases the volumetric efficiency of the engine by increasing the mass flow rate), torque converter and an alternator. In which energy is being transmitted through various stages & converted at last into the electricity. The energy flow path is given below:

3.0 ENERGY FLOW DIAGRAM:



3.1 ENERGY CONVERSION STAGES:

3.1.0 Stage 1.



In this stage the energy flow takes place from exhaust to turbocharger. Here kinetic energy of the exhaust gas is being converted in to the mechanical energy of the turbocharger. Turbocharger is being placed at the exhaust manifold, where exhaust flows out & gets struck to the turbine of the turbocharger. The exhaust having high velocity rotates turbine of the turbocharger at very high rpm & escapes into the atmosphere the turbine is coupled with compressor wheel through a shaft the rotating turbine rotates the compressor on the same rpm this compressor is situated at the intake air manifold. The compressor compresses the intake air and this how increases the mass flow rate of the intake charge. Due to this increase in mass of the intake charge the engine breathing capacity of the combustion chamber the volumetric efficiency of the engine increases.



3.1.1 Working & Principle of Turbocharger:

3.1.2 Turbocharger:

Turbocharger is a type of forced induction system. It compresses the air flowing into the engine. The advantage of compressing the air is that it lets the engine squeeze more air into a cylinder, and more air means that more fuel can be added. Therefore, the more power can be obtained from each explosion in each cylinder. A turbocharged engine produces more power overall than the same engine without the charging. This can significantly improve the power-to-weight ratio for the engine.

In order to achieve this boost, the turbocharger uses the exhaust flow from the engine to spin a turbine, which in turn spins an air pump. The turbine in the turbocharger spins at speeds of up to 150,000 rotations per minute (rpm).

3.1.3 How It Works:

The turbocharger is bolted to the exhaust manifold of the engine. The exhaust from the cylinders spins the turbine, which works like a gas turbine engine. The turbine is connected by a shaft to the compressor, which is located between the air filter and the intake manifold. The compressor pressurizes the air going into the pistons.

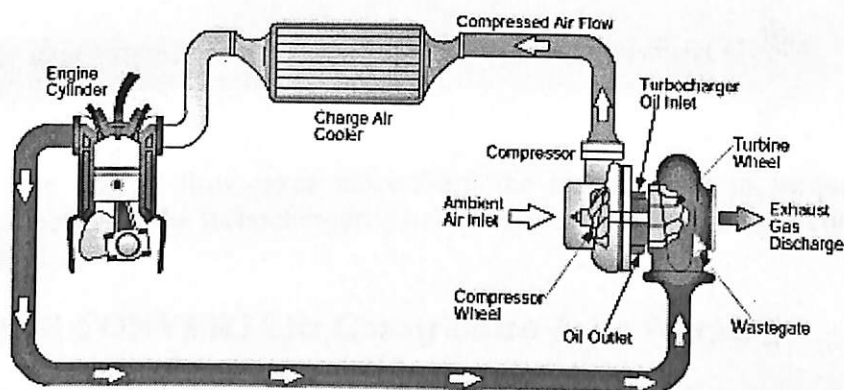


Fig 3.0 : How a turbocharger is plumbed in a car

The exhaust from the cylinders passes through the turbine blades, causing the turbine to spin. The more exhaust that goes through the blades, the faster they spin.

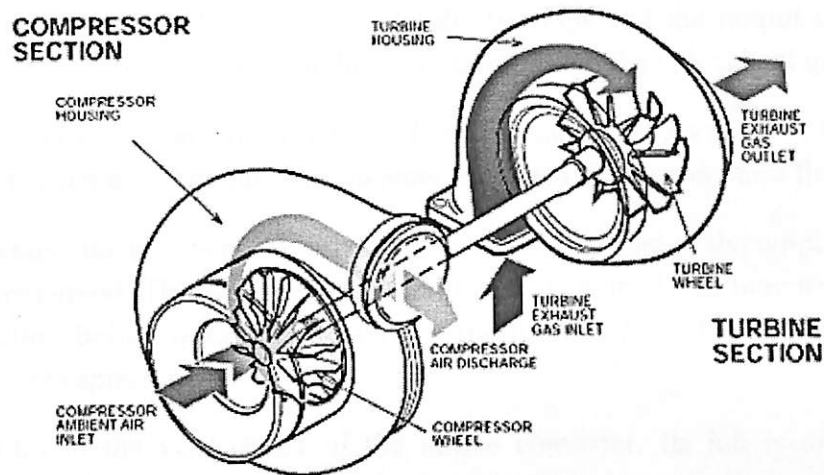
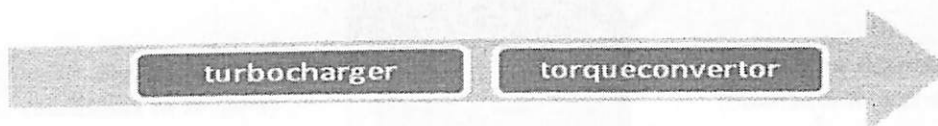


Fig3.1 : Inside a turbocharger

On the other end of the shaft that the turbine is attached to, the compressor pumps air into the cylinders. The compressor is a type of centrifugal pump -- it draws air in at the centre of its blades and flings it outward as it spins.

3.2.0 Stage 2.



In this stage, the energy flow takes place from the turbocharger to torque converter. Here mechanical energy of the turbocharger is being transferred to the torque converter .the torque converter is coupled.

3.2.1 TORQUE CONVERTER: Construction & its Working:

There are four components inside the very strong housing of the torque converter:

- Pump
- Turbine
- Stator
- Transmission fluid

Working:

Torque converter is a torque converting device. In this setup the input is given to the torque converter through the turbocharger. The impeller shaft of the torque converter will be coupled



with the turbochargers shaft through the hydraulic bearings and the output shaft of the torque converter (turbine shaft) is coupled with the alternator through the epicyclical gear system.

The **pump** inside a torque converter is a type of centrifugal pump. As it spins, fluid is flung to the outside. As fluid is flung to the outside, a vacuum is created that draws more fluid in at the center.

The fluid then enters the blades of the **turbine**, which is connected to the output shaft. The blades of the turbine are curved. This means that the fluid, which enters the turbine from the outside, has to change direction before it exits the center of the turbine. It is this **directional change** that causes the turbine to spin.

The stator resides in the very center of the torque converter. Its job is to redirect the fluid returning from the turbine before it hits the pump again. This dramatically increases the efficiency of the torque converter.

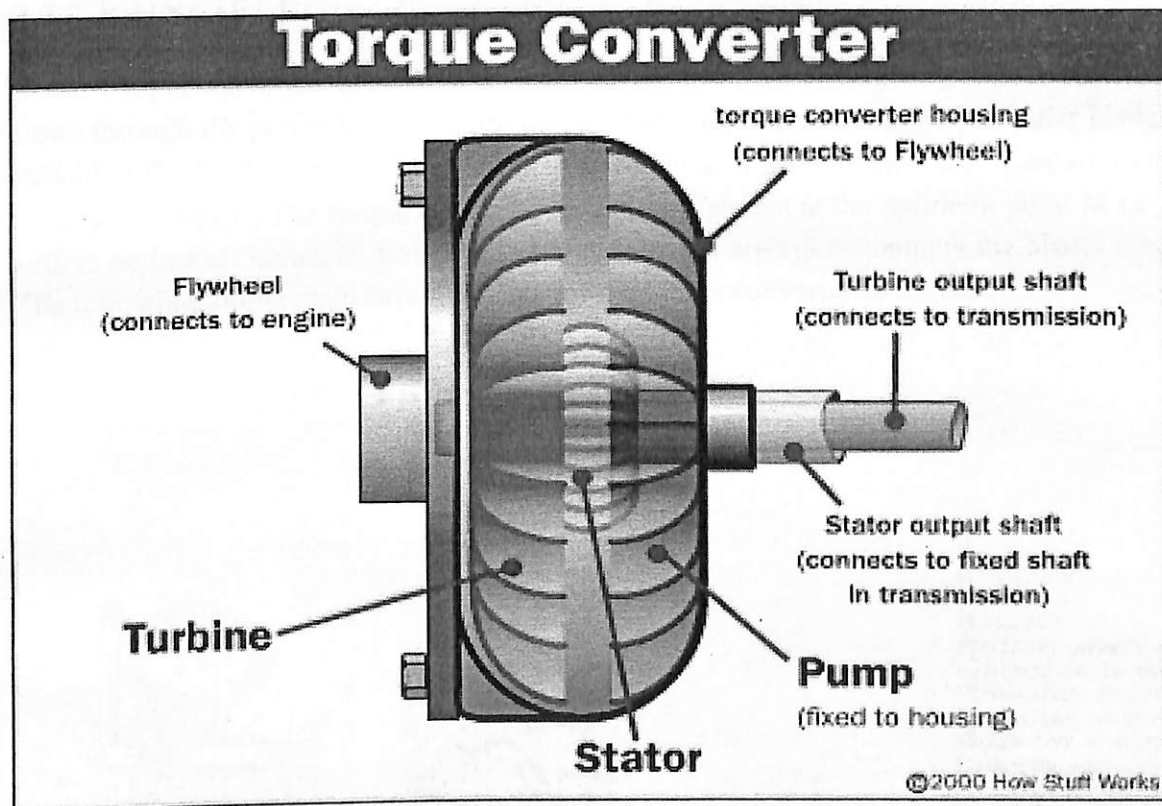


Fig3.2 : Housing of Torque Converter

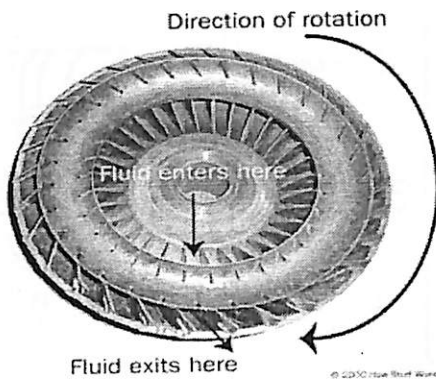


Fig 3.2.1: Pump section of the torque converter.

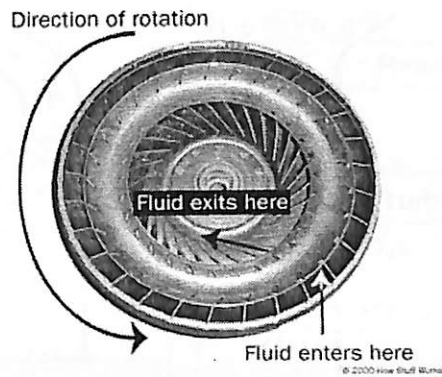


Fig 3.2.2: Torque converter turbine

3.2.2 PRINCIPLE:

In the Torque converter the system uses a transmission fluid having very low viscosity. The fluid flows through the pump, then the turbine, then the reactor, following the particular blade contour, assuming the blades are as close together as required. Fig 1.1 shows the speeds on entering & leaving the Blades. The torque converter operation is shown at the optimum point M i.e. the fluid suffers no impact losses in the operating mode since it always encounters the blades tangentially. The following torque equilibrium applies for the torque converter as a whole

$$T_P + T_T + T_R = 0 .$$

..... (1)

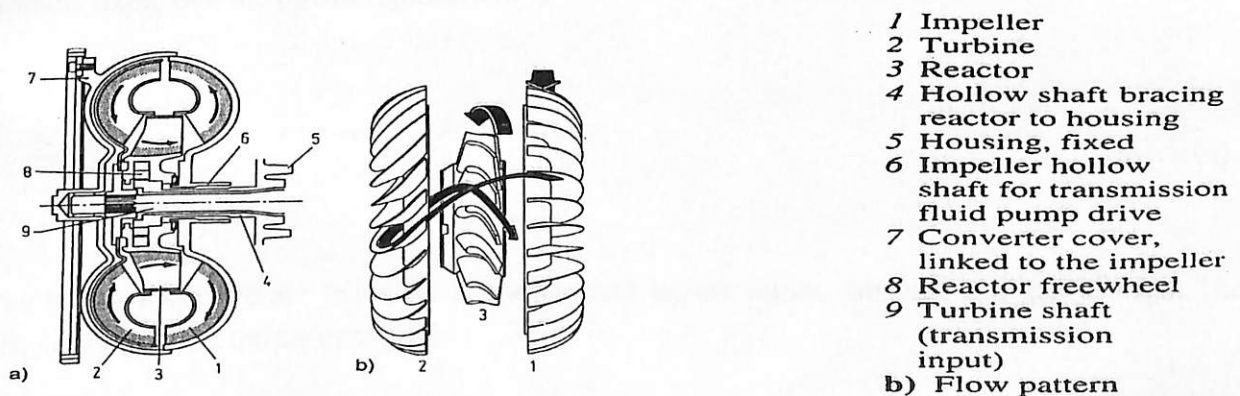


Fig 3.3- Torque Converter

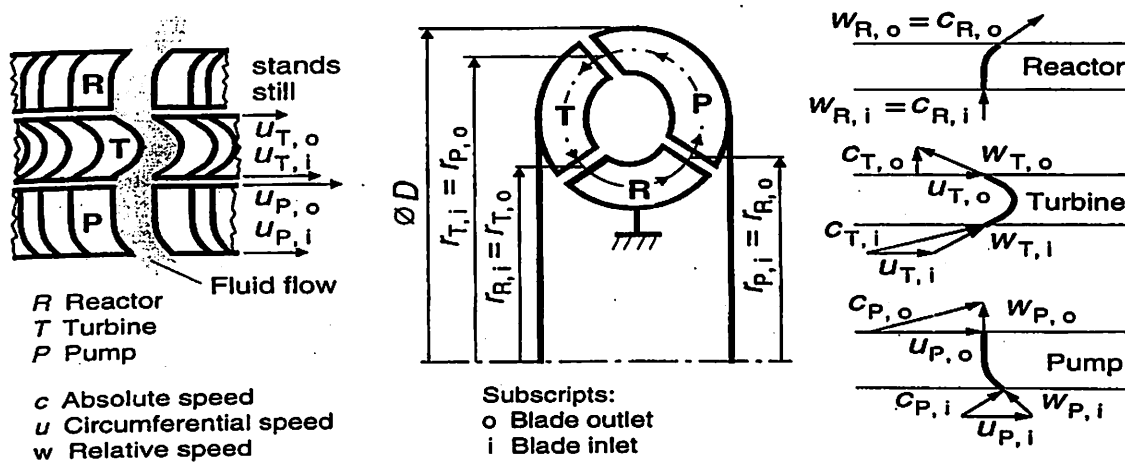


Fig 3.4: Flow cycle in the torque converter with flow speeds for smooth flow

The individual torque values can be determine using Euler's turbine Equation

$$T = Q \rho \Delta(r c_u) . \quad \dots\dots\dots (2)$$

They therefore depend on the flow rate Q, the fluid density ρ and the twist difference $\Delta(r c_u)$ between the blade input and output. The twist is the product of the radius r and the circumferential component c_u of the absolute speed c

$$\dots\dots\dots (3)$$

Since it is a closed system in which the fluids flows passes through all the wheels in a sequence, and there is thus the same mass flow everywhere, the twist balance $\sum \Delta(r c_u) = 0$ results in addition to the torque equilibrium. If the power of one wheel $P = T \cdot \omega$, it follows, given that the reactor remains fixed, that the power Equilibrium is

$$\sum P = P_P + P_T + \sum P_V = 0 . \quad \dots\dots\dots (4)$$

The Power losses P_V are made up of friction and impact losses, windage and gap leakage. The efficiency η_{TC} of a torque converter-

$$\eta_{TC} = \frac{P_T}{P_P} = \frac{T_T \omega_T}{T_P \omega_P} = \mu \nu , \quad \dots\dots\dots (5)$$



Using the torque ratio $\mu = T_T/T_P$ and the speed ratio $v = \omega_T/\omega_P$.

Torque converter is designed according to hydraulic model laws using characteristic values derived by experiment. The following two preconditions must be fulfilled for models to be considered:

Geometrical similarity:

The same linear scale m for all parts relevant to hydraulic design, in this case given as the ratio of the profile diameter of the model, D_M , to that of the original, D

$$m = D/D_M \quad \dots\dots\dots (6)$$

Kinematic similarity:

Matching speeds of the original and the model must be in the same ratio, i.e. the speed triangles must be similar. Using the designations in figure (1.1), the following is true

$$\frac{c}{c_M} = \frac{w}{w_M} = \frac{u}{u_M} \quad \dots\dots\dots (7)$$

Substituting the circumferential speed $u = \omega D/2$, the speed scale m_v is given by

$$m_v = \frac{u}{u_M} = \frac{\omega D}{\omega_M D_M} = m \frac{\omega}{\omega_M} \quad \dots\dots\dots (8)$$

From eq (7), the scale of the twist m_{twist} is

$$m_{\text{twist}} = \frac{\Delta(r c_u)}{\Delta(r c_u)_M} = m^2 \frac{\omega}{\omega_M} \quad \dots\dots\dots (9)$$

The flow rate Q , equal to the product of the speed and area according to the continuity equation, is proportional to the product of the speed scale m_v (equation (6)) the area scale m^2

$$m_Q = \frac{Q}{Q_M} = m_v m^2 = \frac{\omega D^3}{\omega_M D_M^3} \quad \dots\dots\dots (10)$$

Using Eq. (2) the power is given by

$$P = T \omega = Q \rho \Delta(r c_u) \omega \quad \dots\dots\dots (11)$$



By substituting Eq (8), (9), (10) & (11), it follows that

$$\frac{P}{P_M} = \frac{\rho \omega^3 D^5}{\rho_M \omega_M^3 D_M^5} \quad \text{or simply} \quad P \sim \rho \omega^3 D^5 \quad \dots\dots\dots (12)$$

Since $T=P/\omega$ It follows that for the torque

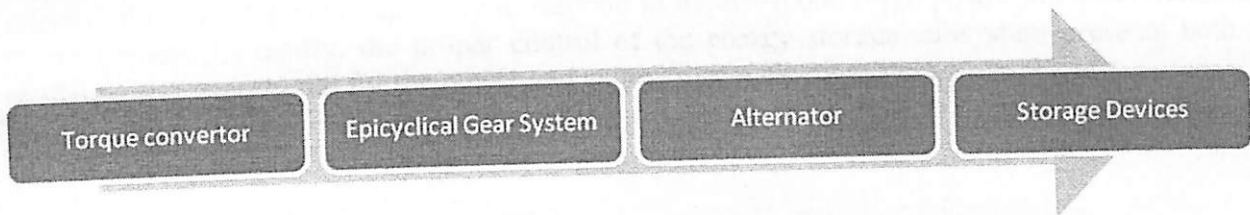
$$\frac{T}{T_M} = \frac{\rho \omega^2 D^5}{\rho_M \omega_M^2 D_M^5} \quad \text{and correspondingly} \quad T \sim \rho \omega^2 D^5 \quad \dots\dots\dots (13)$$

Adding the proportionality factor λ gives the law of similarity

$$T_P = \lambda \rho \omega_P^2 D^5 \quad \dots\dots\dots (14)$$

Where λ is a function of the speed ratio v and is designated a performance coefficient. It can be used to compare various torque converters.

3.3.0 Stage 3:



An **alternator** is an electromechanical device that converts mechanical energy to alternating current electrical energy. In this stage the energy flow takes place from the torque converter to the alternator. The Torque converter is coupled with the alternator through the Epicyclical gearing System (having gear ratio output speed/ input speed = 1:6). Here the mechanical energy of the torque converter is converted into the electrical energy by the alternator; this electrical energy can be stored into the storing devices.

3.3.1 Alternator principal:

Moving bar magnet past a conductor induces a flow of electrons (electric current) in the conductor. The rotating bar magnet supplies a moving magnetic field, as it rotates the magnetic field passes through the two side s of the stationary loop. At the top, as the south pole moves past the upper side of the loop , current is induced in the opposite direction when the north pole is moves the past the upper side of the loop. A similar condition occurs in the lower side of the loop,



but direction of the induced current is reversed .the effect is that an alternating current flows in the loop.

Three conditions will increase the current moving in loop,

1. Increasing the strengths of the magnetic field.
2. Increasing the speed at which the magnetic field rotates
3. Increasing the number of loops.

3.3.2 Storage System:

The main function of the energy storage subsystem is to provide readily available electric power/energy when the primary power sources have no or insufficient power output, and store surplus electric energy generated by the primary power sources or recovered by regenerative braking. The most common energy storage devices are the various types of batteries, ranging from lead acid, and metal-hydride to lithium-ion types. The key consideration for battery selection is specific power (power/weight), specific energy (energy/weight), cost, and cycle lifetime. Other energy storage devices, such as ultra- capacitors, flywheels, and hydraulic/pneumatic accumulators, are normally used along with batteries to compensate for the limited battery power capability. While these devices typically have a limited energy capability, they can greatly improve the system power capability to respond to a burst-mode (high power but short duration) power request. Evidently, the proper control of the energy storage subsystem presents both a challenge and opportunity for the power and energy management system.



CHAPTER 4

CALCULATION



Let's take of the configuration of turbocharger **TD04-13G** for calculation ,this turbocharger runs out of flow at higher RPM(engine RPM) - about 17-18 psi boost max at 7000 RPM and having the turbochargers shaft speed 50,000 at a particular boost.

Now this shaft is connected to the input shaft of the torque converter. So:

Data of Torque Converter:

Rpm of the impeller shaft (input shaft) ω_p	50,000 rpm
Torque ratio of the turbine shaft to the impeller shaft (T_T / T_P)	2.4
Diameter of the impeller D_P	300mm
Diameter of the turbine D_T	170mm

Table: 4.0

Then from the equation 14:

$$T_T / T_P = (\lambda \rho \omega_T^2 D_T^5) / (\lambda \rho \omega_P^2 D_P^5)$$

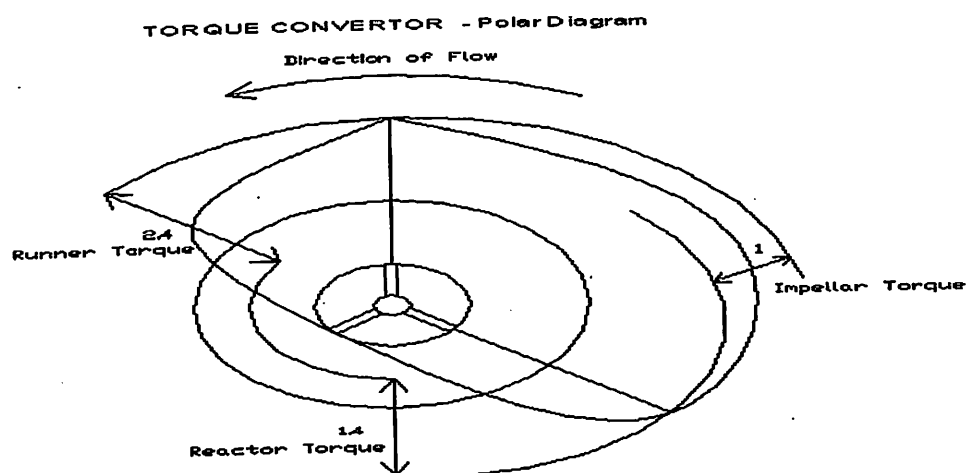


Fig 4.0 Polar Diagram of Torque Converter



Put the values T , ω , & D in the above equation in respect of the turbine & impeller specification

$$2.4 = [\omega_T^2 (.3)^5] / [(50000)^2 (.17)^5]$$

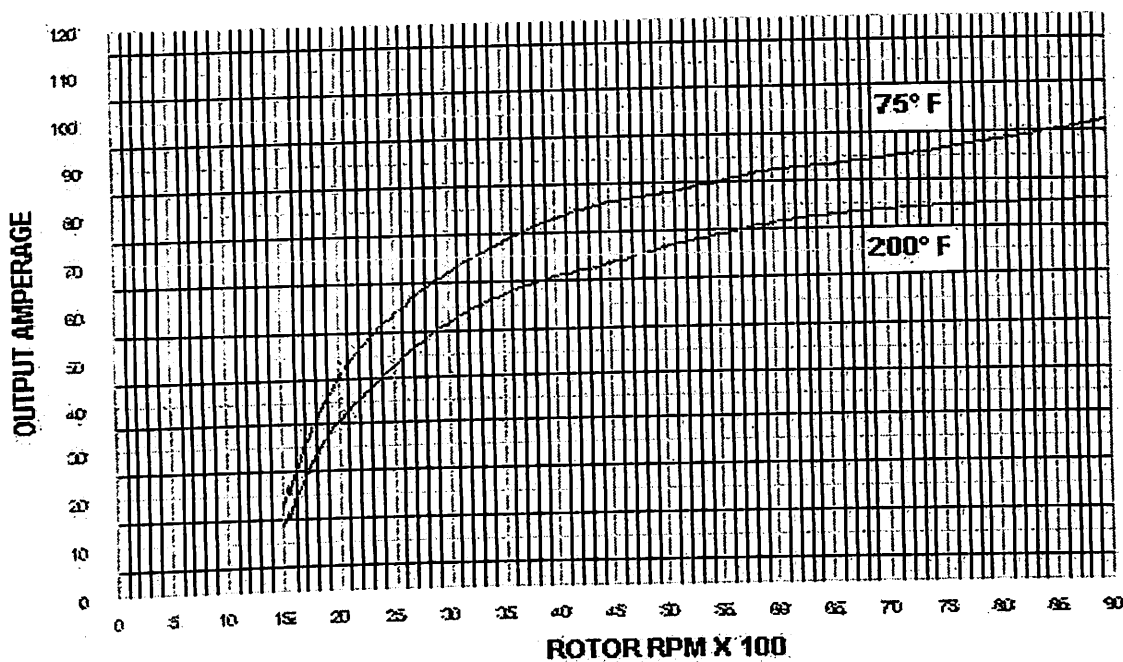
After solving the equation we get

$$\omega_T = 18724$$

Now the Gear Ratio of used Epicyclical gear system = 5:1.

Hence the rpm after reduction through Epicyclical gear system = 3745 rpm

An alternator, at 12V and 200°F, 100 Hz with 2 Poles.



SERIES 23, 100 AMP, 12V

Fig. 4.1 Performance Curve of Alternator

From the performance curve (Fig 1.3 as given below) we get the value of the current at the specified rpm:

Current $I = 70$ amp

Voltage $V = 12$ V

Then , the power output we get, $\text{Power } P = VI = 70 \times 12 = 840 \text{ watts} = 50 \text{ Kw-Hr}$



CHAPTER 5

RESULTS AND DISCUSSION



As from the calculation we can get the output for a static value of rpm, but as the rpm of the turbocharger is not static but variable. Hence we have simulated the calculation and the data to obtain the output for various rpm by doing offline simulation using Excel and Matlab simulation.

Excel Simulation:

Excel table 5.1

impeller rotation ω_P	turbine rpm ω_T
50000	18723.83442
52000	19472.78779
54000	20221.74117
56000	20970.69455
58000	21719.64792
60000	22468.6013
62000	23217.55468
64000	23966.50805
66000	24715.46143
68000	25464.41481
70000	26213.36819
72000	26962.32156
74000	27711.27494
76000	28460.22832
78000	29209.18169
80000	29958.13507
82000	30707.08845
84000	31456.04182
86000	32204.9952
88000	32953.94858
90000	33702.90195
92000	34451.85533
94000	35200.80871
96000	35949.76208
98000	36698.71546
100000	37447.66884
102000	38196.62221
104000	38945.57559
106000	39694.52897
108000	40443.48234
110000	41192.43572
112000	41941.3891
114000	42690.34247
116000	43439.29585
118000	44188.24923
120000	44937.2026



Excel table 5.2

turbine rpm ω_T	alternator rpm
18723.83442	3744.766884
19472.78779	3894.557559
20221.74117	4044.348234
20970.69455	4194.13891
21719.64792	4343.929585
22468.6013	4493.72026
23217.55468	4643.510936
23966.50805	4793.301611
24715.46143	4943.092286
25464.41481	5092.882962
26213.36819	5242.673637
26962.32156	5392.464312
27711.27494	5542.254988
28460.22832	5692.045663
29209.18169	5841.836338
29958.13507	5991.627014
30707.08845	6141.417689
31456.04182	6291.208364
32204.9952	6440.99904
32953.94858	6590.789715
33702.90195	6740.58039
34451.85533	6890.371066
35200.80871	7040.161741
35949.76208	7189.952416
36698.71546	7339.743092
37447.66884	7489.533767
38196.62221	7639.324442
38945.57559	7789.115118
39694.52897	7938.905793
40443.48234	8088.696469
41192.43572	8238.487144
41941.3891	8388.277819
42690.34247	8538.068495
43439.29585	8687.85917
44188.24923	8837.649845
44937.2026	8987.440521



Excel table 5.3

rotor rpm ωR	output amprage i
1500	15
2000	35
2500	45
3000	55
3500	60
4000	65
4500	68
5000	70
5500	75
6000	77
6500	78
7000	79
7500	80
8000	82
8500	84
9000	86

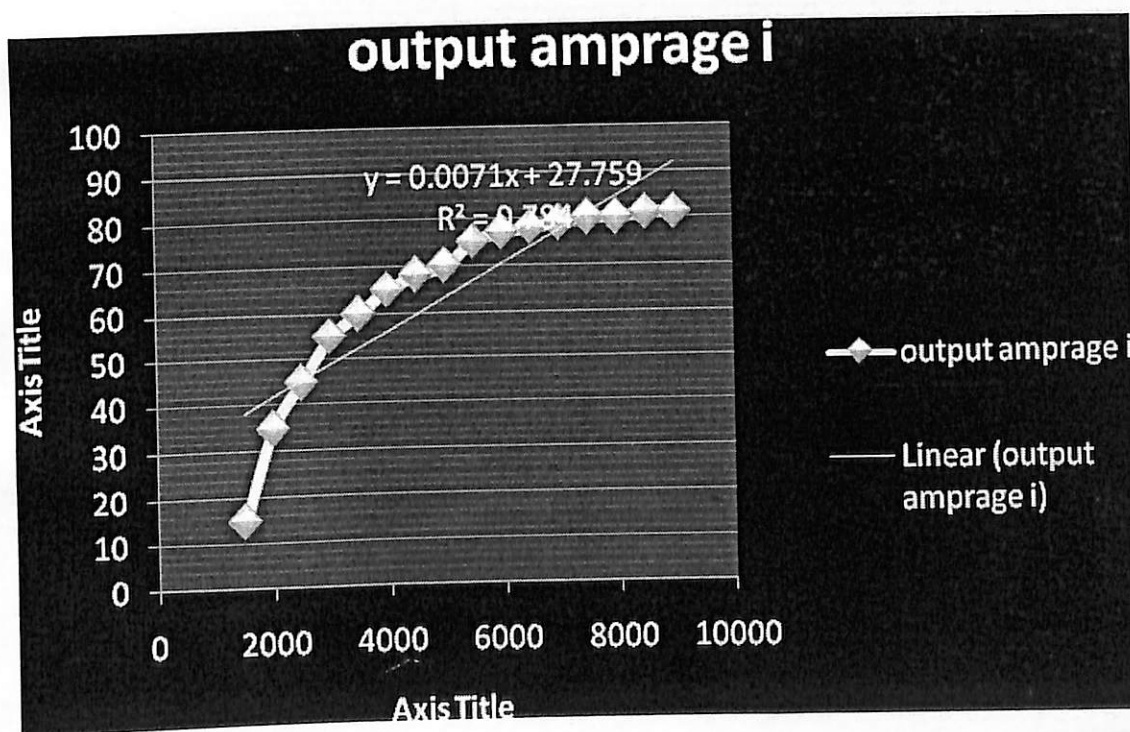


Fig 5.0 excel simulated graph between output amperage and the rpm of alternator



Excel table 5.4

<i>alternater rpm</i>	<i>current value I in amp</i>
3744.766884	69.12554271
3894.557559	71.26703613
4044.348234	73.29657227
4194.13891	75.22020071
4343.929585	77.04397107
4493.72026	78.77393295
4643.510936	80.41613594
4793.301611	81.97662966
4943.092286	83.4614637
5092.882962	84.87668767
5242.673637	86.22835116
5392.464312	87.52250379
5542.254988	88.76519515
5692.045663	89.96247485
5841.836338	91.12039248
5991.627014	92.24499766
6141.417689	93.34233998
6291.208364	94.41846905
6440.99904	95.47943447
6590.789715	96.53128584
6740.58039	97.58007276
6890.371066	98.63184485
7040.161741	99.69265169
7189.952416	100.7685429
7339.743092	101.8655681
7489.533767	102.9897768
7639.324442	104.1472187
7789.115118	105.3439434
7938.905793	106.5860004
8088.696469	107.8794394
8238.487144	109.23031
8388.277819	110.6446618
8538.068495	112.1285444
8687.85917	113.6880074
8837.649845	115.3291003
8987.440521	117.0578729

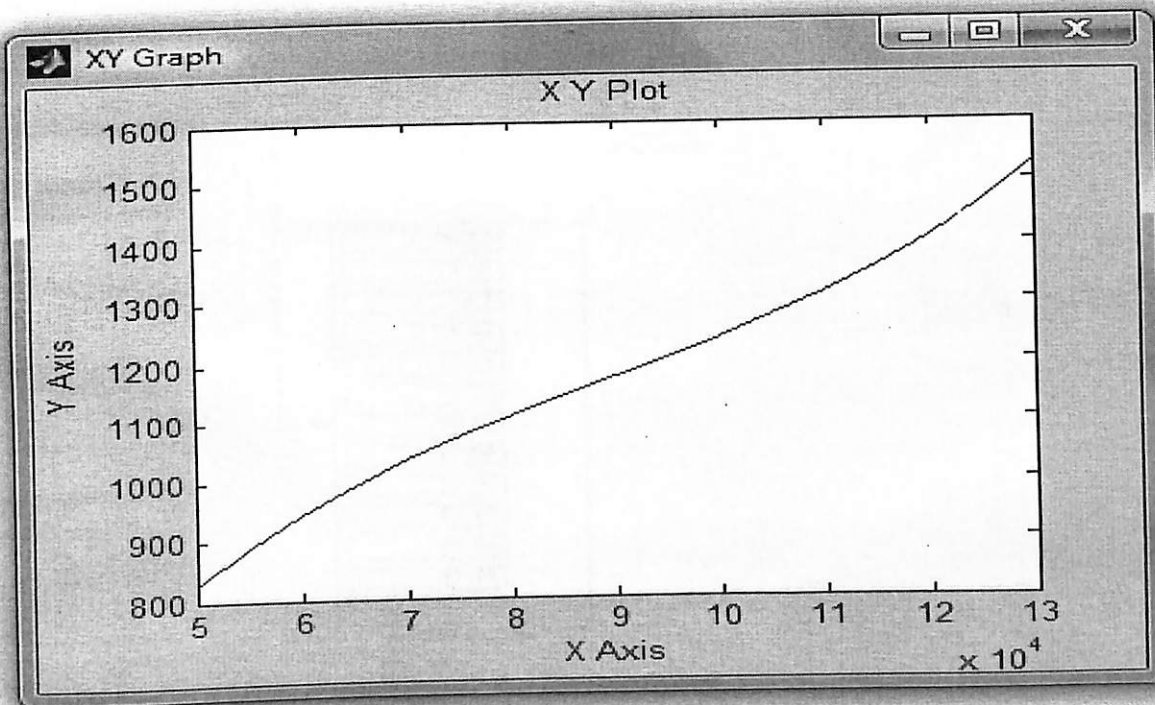
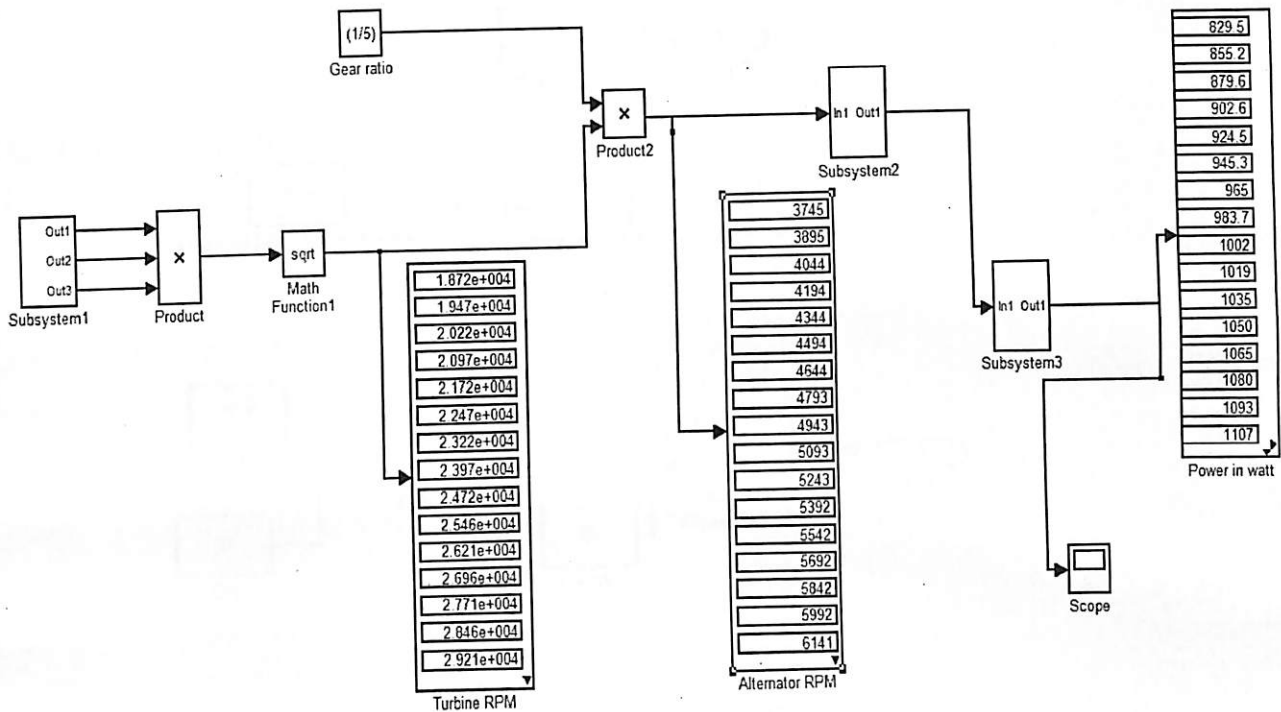


Excel table 5.5

current value I in amp	Power output in watts	output in Kw-hr
69.12554271	829.5065125	49.77039075
71.26703613	855.2044336	51.31226602
73.29657227	879.5588672	52.77353203
75.22020071	902.6424086	54.15854451
77.04397107	924.5276529	55.47165917
78.77393295	945.2871954	56.71723172
80.41613594	964.9936313	57.89961788
81.97662966	983.7195559	59.02317336
83.4614637	1001.537564	60.09225386
84.87668767	1018.520252	61.11121512
86.22835116	1034.740214	62.08441284
87.52250379	1050.270045	63.01620273
88.76519515	1065.182342	63.91094051
89.96247485	1079.549698	64.77298189
91.12039248	1093.44471	65.60668259
92.24499766	1106.939972	66.41639832
93.34233998	1120.10808	67.20648479
94.41846905	1133.021629	67.98129772
95.47943447	1145.753214	68.74519282
96.53128584	1158.37543	69.50252581
97.58007276	1170.960873	70.25765239
98.63184485	1183.582138	71.01492829
99.69265169	1196.31182	71.77870921
100.7685429	1209.222515	72.55335088
101.8655681	1222.386817	73.343209
102.9897768	1235.877321	74.15263929
104.1472187	1249.766624	74.98599746
105.3439434	1264.12732	75.84763922
106.5860004	1279.032005	76.7419203
107.8794394	1294.553273	77.6731964
109.23031	1310.763721	78.64582323
110.6446618	1327.735942	79.66415652
112.1285444	1345.542533	80.73255197
113.6880074	1364.256088	81.8553653
115.3291003	1383.949204	83.03695223
117.0578729	1404.694474	84.28166846

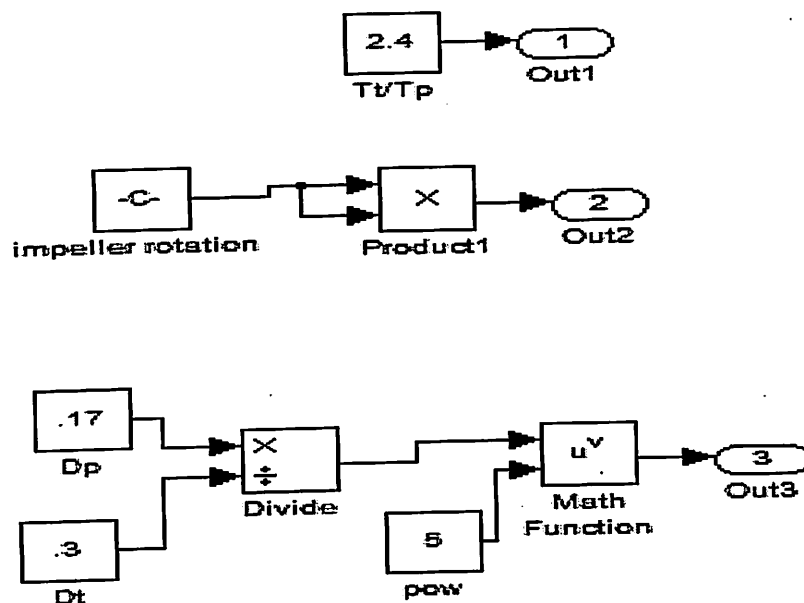


Matlab Simulation:

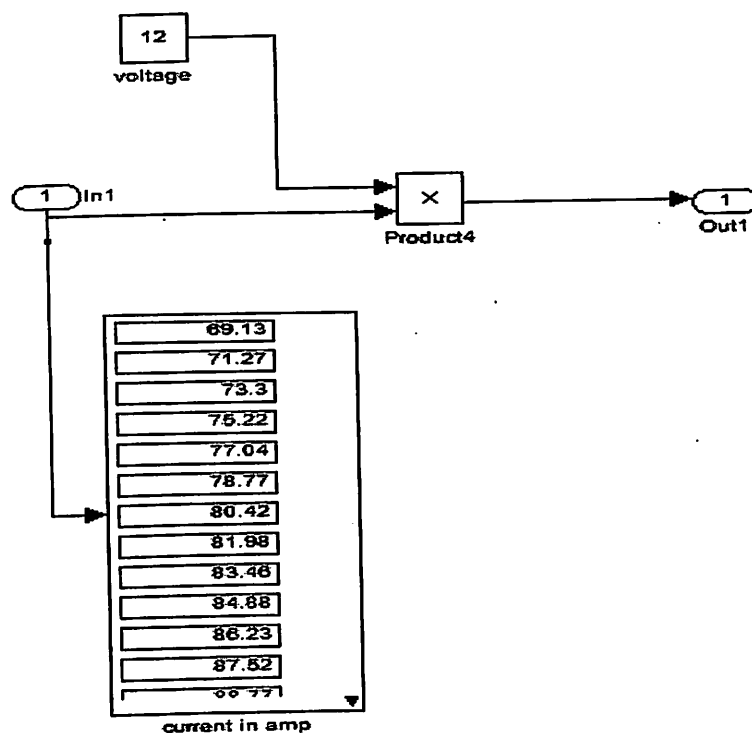




Subsystem1:

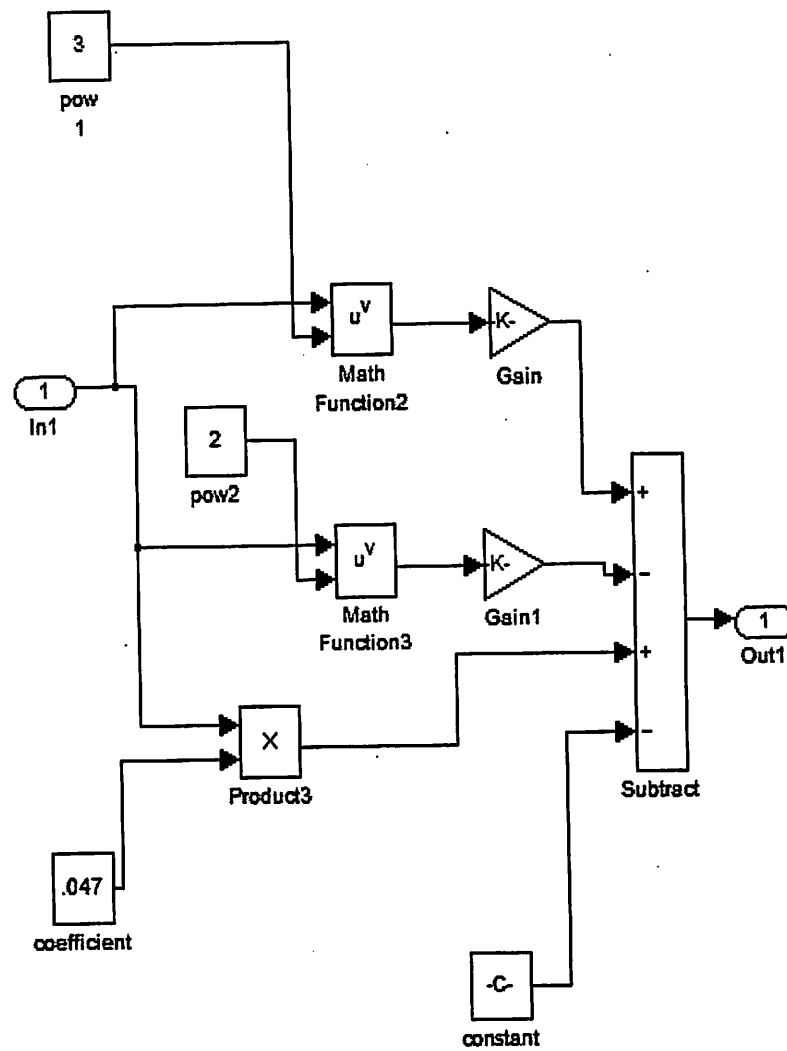


Subsystem 3:





Subsystem 2:





CONCLUSION:

From the above results of simulation for the output of the proposed setup, we can draw the conclusions that the idea can be an efficient tool for the regeneration of the exhaust waste energy in the form of Onboard Electricity Generation for the Hybrid Vehicles. Because of the higher efficiency of the system it would be able to spare a good part of the indicated thermal energy which will lead to the increase in the overall efficiency of the vehicle. It can minimize the well known menaces of global warming by reducing the GHG (Green House Gases) emission like CO_2 , CO , NO_x as well as other environment pollutants like Unburned Hydrocarbons, SO_x etc. The work can be extended further for the practical implementation and testing of the proposed setup and real time simulation would lead better results.



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