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A EXPERIMENTAL STUDY ON WASTE HEAT RECOVERY IN A 4 CYLINDER 4 STROKE PETROL USING ELECTRO TURBO GENERATION

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ABSTRACT

In a conventional IC engine a considerable heat is carried away by exhaust gases. To recover the waste heat, various methods are being adopted. One of them is turbo charging. In this paper an attempt has been made to explore thes possibilities of waste heat / energy recovery methods in conventional commercial fou wheeler engine.. The heat energy contained in the exhaust gases were used to run a turbine coupled with a electrical generator. Thus the principle of electro turbo generation has been adopted for waste heat recovery.

I. 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 equipments are 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 gives 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.

II. LITERATURE REVIEW

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 “waste d energy” and put it to good use. Exhaust Heat Reco very (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 favor 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 gas-electric 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 systemefficiency. 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.

The engines considered are the Diesel, spark ignition, gas turbine, and Stirling. Principal emphasis is placed on the turbocharged four-stroke Diesel engine. Because of increased exhaust energy and a large potential improvement in performance, the still-to-be-developed "adiabatic" Diesel is also examined.

The waste heat utilization concepts include preheating, regeneration, turbo charging, turbo compounding, and Rankine engine compounding. Predictions are based on fuel-air cycle analyses, computer simulation, and engine test data. All options are compared on the basis of maximum theoretical improvement. The Diesel and adiabatic Diesel are also evaluated in terms of maximum expected improvement and expected improvement over a driving cycle.

The results indicate that Diesels should be turbocharged and after cooled to the maximum possible level. Based on current design practices fuel economy improvements of up to 6% might be possible. It is also revealed that Rankine engine compounding can provide about three times as much improvement in fuel economy as turbo compounding, but perhaps only the same improvement per dollar. By turbo charging, turbo compounding, and Rankine engine compounding, driving cycle performance could be increased by up to 20% for a Diesel and by up to 40% for an adiabatic Diesel. The study also indicates that Rankine engine compounding can provide significant fuel economy improvement for gas turbine and spark ignition engines and regeneration could significantly enhance the performance of spark ignition engines. Because of the low heat content in the exhaust of a Stirling engine it has only a small potential for further waste heat recovery.

III. ELECTRO TURBO GENERATION

Heat balance test conducted in a 4 stroke petrol engine gives the useful output and energy lost in various forms like exhaust heat, cooling water losses, friction losses and other un accounted losses. Energy is lost in several forms. The largest being the heat energy dissipated to the environment via exhaust gases. The EHR system is designed to recover heat energy in the exhaust gases and convert in to useful work for the vehicle. Existing system convert some of the exhaust heat energy in to mechanical energy that is fed back to crank shaft via hydraulic coupling and gear train. The concept of electro turbo generation converts some exhaust heat energy in to electrical energy.The underlying technology is based on integrating compact high speed electrical machines (alternators) with high performance turbo machinery in various combinations.

IV. ELECTRO TURBOGENERATION

In this experimental study an attempt has been made to explore the possibilities of waste heat recovery in 4 cylinder 4 stroke petrol Engine.In a conventional turbocharged engine the exhaust gases are allowed to pass through a turbine stage and expanded.The expansion work is utilized to drive a compressor which compresses the fresh charge before entering the cylinder.In his experimental set up we have removed the compressor unit of the turbocharger and a 24 volt generator is coupled to the turbine shaft.The output of this turbine is given toa DC genarator to produce electrical energy. The electrical power thus produced is tapped into a battery to run a dc motor.A 4 stroke 4 cylinder petrol engine Maruti ALTO 800 was taken and the turbine –genetator unit was attached to the exhaust pipe.The engine is mounted in attest rig containing all measuring equipments to measure the inputs like fuel consumption , speed, cooling water, inlet air and exhaust gas temperatures.

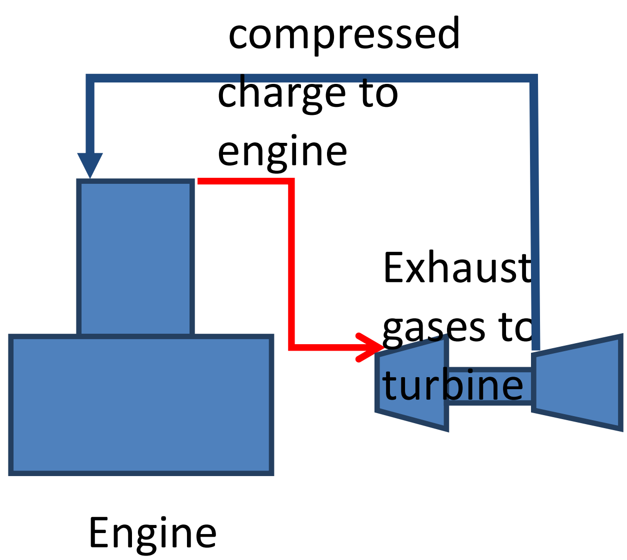

Fig.1. Conventional Turbo charging principle

The test rig used was an electrical dynamometer to measure the performance of a 4 stroke 4 cylinder petrol engine..The various inputs like fuel consumption ,Cooling water temperatures , electrical power produced from the turbine-generator unit were measured by the standard measuring instruments to calculate the energy utilization.

V. EXPERIMENTAL SETUP

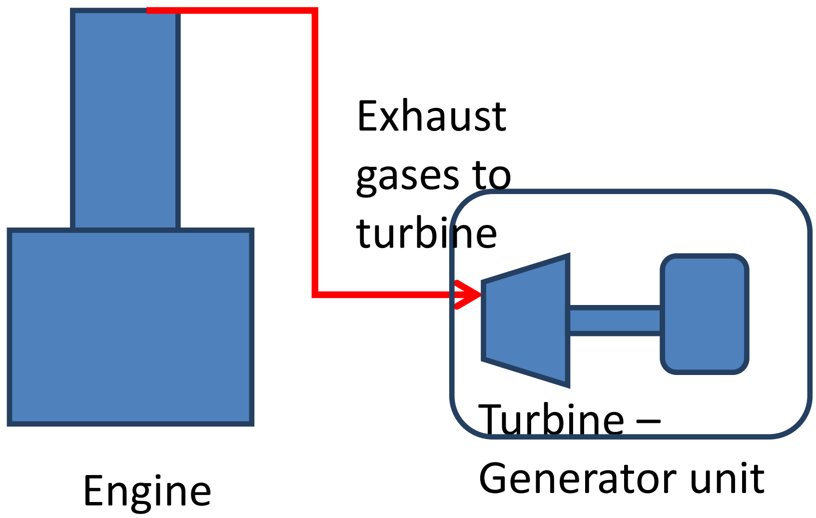

Fig.2. Proposed model for waste heat recovery

The experimental model used consists of a turbo charger (TATA Indica) attached to the exhaust manifold of the Maruti ALTO 800 petrol engine. The turbo charger shaft is coupled to a DC Generator of voltage rating of 24.

VI. RESULTS AND DISCUSSION

In order to find out the feasibility of running a DC dynamo by the turbo charger, the engine was allowed to run at different speeds .the output of the generator was also noted.

Table: 1 Voltage output measured from generator

Engine Speed in RPM	2000 RPM	2500 RPM	3000 RPM
Output voltage of the Alternator	------	18	24

Power produced by the electrical machine
Power (P) = V x I = 24 V x 0.9 A =21Watts
Before mounting electro turbo generator:

Table: 2 Energy split data as applied to the test engine

Total power given by fuel	Useful power at crank shaft	Frictional losses	Cooling losses	Unaccounted	Exhaust gases
100%	23%	5%	25%	7%	40%
35000Watts	8050Watts	1750 Watts	8750 Watts	2450 Watts	1400watts

From the experiment, the power obtained by connecting the alternator to the turbo charger is 21 Watts which is 0.06% of the total power supplied by the fuel. Thus it is obvious that, out of the 40% exhaust losses 0.06% can be recovered by electro turbo charging in this engine.The output from the generator was measured by a voltmeter and ammeter and thus the output in energy was calculated by the product of voltage and current.

Table: 3 Energy split data after mounting electro turbo generator

Total power given by fuel	Useful at crank shaft	Frictional losses	Cooling gases	Exhaust gases	Recovered power from electro turbo generation
100 %	23%	7%	25%	40%	0.06%
35000 Watts	8050 Watts	1750Watts	8750Watts	14000Watts	21 Watts

VII. CONCLUSION

In an attempt to explore the possibilities of waste heat recovery in an IC engine, the concept of Electro Turbo generator has been proved by running an alternator coupled to a turbocharger. By the introduction of electro turbo generation the useful work obtained from the engine has been increased from 23% to 23.06%.The above quantity is a very small quantity. As the electro turbo generation system used here is not a specially designed one for this engine. By designing an alternator for this engine conditions, the quantity of useful work recovered can be improved. In a small engine this quantity may be of less advantageous. Scope for Future work : At higher speeds the high temperature of the exhaust gases can be utilized by supplying a small quantity of fuel in an auxiliary combustion chamber and that cam run the turbine to produce more power.Direct energy conversion techniques can also be used to tap more energy from the combustion chamber.

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