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Analysis of the System to Produce 150watt Thermo Electric Power from Waste Heat of Any Furnace

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ABSTRACT:

There is a lot of heat energy being wasted in several forms so we can trap this heat energy to produce electricity for running the electrical accessories. The accessories consume waste heat thus any furnaces recovery waste heat as effective energy will contribute to reducing the energy consumption of the social system as a whole, and thus can contribute not only to solving future energy problems, but also to solving environmental problems such as global warming. Most of the current power-generation technologies must first convert thermal energy to mechanical work before producing electricity. Thermoelectric generation technology, as one entirely solid state energy conversion method, can directly transform thermal energy into electricity by using thermoelectric transformation material. A thermoelectric power convert has no moving parts, and is compact, quiet, highly reliable and environmentally friendly. Therefore, the whole system can be simplified and operated over an extended period of time with minimal maintenance. In addition, it has a wider choice of thermal sources. It can utilize both the high and low quality heart to generate electricity. The main objective of this system is to produce 150watt of power by using 15 TEG modules which individually produce 10 watt power by using waste of any furnaces. For this model design and assembly is done by pro-E and analysis part is done in ansys software.

Key Word: furnace, TEG module.

INTRODUCTION:

TEM's can be used to produce electricity without relying on alternators for electricity. Improvements can be done by developing new materials with better seebeck's co-eff. By utilizing the total heat from the exhaust systems without losses of radiation there is a scope to produce more electricity by connecting the modules in series. Heat transfer Analysis can be done for better heat removal from the heat sink. One of the advantages of employing this system is effective utilization of waste heat and reduces the formation of harmful pollutants such as NOx, CO2 etc. Moreover the fuel economy is improved and it can be used in Hybrid vehicles also.The less efficiency of the modules and relatively high cost does not promote the use of these modules. Initially they have to attain certain temperature to start producing the electricity.

HISTORY OF TEG:

Although the See beck effect, on which TEG works, was discovered in 1821, the use of TEGs was restricted mainly to military and space applications until the second half of the twentieth century. This restriction was caused by the low conversion efficiency of thermoelectric materials at that time. In 1963, the first TEG was built and reported by Neild. Birkholz at a published the results of their work in collaboration with Porsche. These results described an exhaust-based ATEG which integrated iron-based thermoelectric materials between a carbon steel hot-side heat exchanger and an aluminum cold-side heat exchanger. This ATEG could produce tens of watts out of a Porsche 944 exhaust system as was carried out by Haidar and Ghojel.

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In the early 1990s, Hi-Z Inc designed an ATEG which could produce 1 kW electricity from a diesel truck exhaust system. The company in the following years introduced other designs for diesel trucks as well as military vehicles. In the late 1990s, Nissan Motors published the results of its ATEG which utilized silicon germanium (SiGe) thermoelectric materials. Nissan ATEG produced 35.6 W in testing conditions similar to running conditions of a 3.0 liters gasoline engine in hill-climb mode at 60.0 km/h. Clarkson University in collaboration with General Electric Motor has designed an ATEG for a Sierra pick-up truck and the published literature of this ATEG explained its ability to produce 255 W at a vehicle speed of 112 km/h. In 2006, scientists in BMW of North America announced their intention to launch the first commercial ATEG in 2013 .The ATEG, providing power to drive thermoelectric air-conditioner (TEA) in vehicle is more efficient and serviceable.

The TEA obtained with ATEG with no belts, valves, hoses (refrigerant lines), compressor and refrigerant is more reliable. The number of papers and conferences being held in recent times to discuss the applications of ATEG shows that the technology has come of age . This paper discusses the design formulae to assess the performance of the TE applications in automotive engine and then presents the different configurations put in place to use TEGs in internal combustion engines (ICEs). A typical total waste heat energy recovery technology with a Cusson laboratory gasoline engine test rig with TEGs coupled to it, under idle and running conditions of the engine, is investigated. The concluding sections deal with the presentation of the experimental tests results

CONSTRUCTION OF THERMOELECTRIC MODULE:

A thermoelectric module consists of a number of alternate p- and n- type semiconductor thermo elements, which are connected electrically in series by metal interconnects, sandwiched between two electrically insulating and thermally conducting ceramic substrates. Alloys of the Bismuth Telluride or the Bismuth Selenide and the Antimony use for making of semiconductor elements. Lead wires joint to the ceramic substrate that is called "hot side", other ceramic substrate is called "cold side".

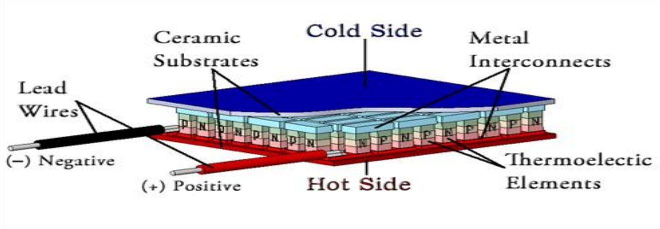

Fig 1 Construction of thermoelectric module

Thermo Electric Effect:

The thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa. A thermoelectric device creates voltage when there is a different temperature on each side. Conversely, when a voltage is applied to it, it creates a temperature difference. At the atomic scale, an applied temperature gradient causes charge carriers in the material to diffuse from the hot side to the cold side. This effect can be used to generate electricity, measure temperature or change the temperature of objects. Because the direction of heating and cooling is determined by the polarity of the applied voltage, thermoelectric devices can be used as temperature controllers.

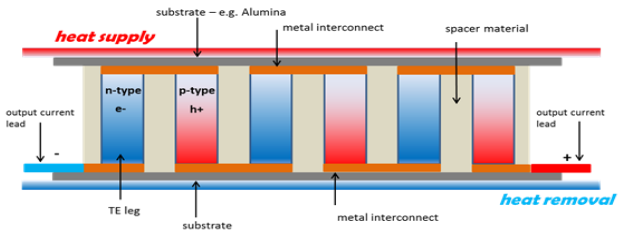

Fig 2 Flow of electrons in a Thermoelectric module

METHODOLOGY:

Design of 150watt Thermoelectric System:

The system is to be produce 150watt of power by using 15 thermoelectric modules which individually produce 10 watt of power.

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Operating parameters:

- Operating Temperatures
- Type of convection
- capacity of modules

10 watt TEG module properties:

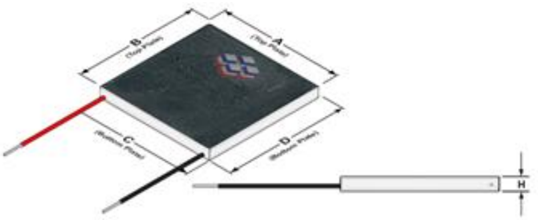
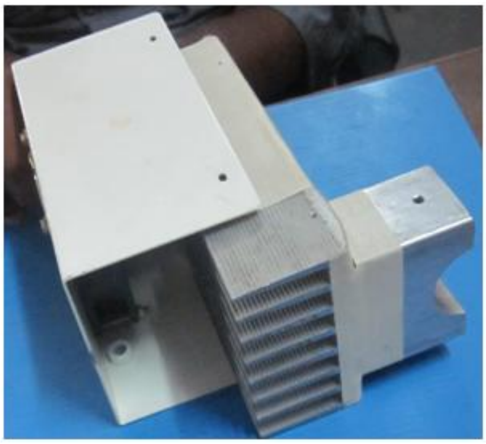


Fig 3 Configuration 10 watt TEG module

Top & Bottom Plates				Height w/ Foil		Lapped Height	
A,B		C,D		H		H	
Mm	inch	Mm	inch	Mm	Inch	mm	Inch
40	1.57	40	1.57	4	0.157	3.75	0.148



TESTING OF MODULE WITH CHULAS (WOODSTOVES)

Specification of the module	
Hot Side Temperature (˚C)	300
Cold Side Temperature (˚C)	30
Open Circuit Voltage (V)	8
Matched Load Resistance (ohms)	1.59
Matched load output voltage (V)	4
Matched load output current (A)	2.4
Matched load output power (W)	9.8
Heat flow across the module(W)	≈166
Heat flow density (W cm-2)	≈10.4
AC Resistance (ohms) Measured under 27 ˚C at 1000 Hz	0.8~1.0

Elements Specifications:

- wattage : 10W
- Voltage : 10 V
- Current : 1A

Modules are connected in series:

- V = V1+ V2
- I = I1+ I2

S.N0	Time	Voltage (v)	Hot side temp(°C)	Cold side temp(°C)	Δ (°C)
1.	10.00				
2.	10.30	15	80	30	50
3.	11.00	17	135	45	90
4.	11.30	18	170	52	118
5.	12.00	18	126	55	151
6.	12.30	16	200	60	140
7.	01.00	16	197	63	134

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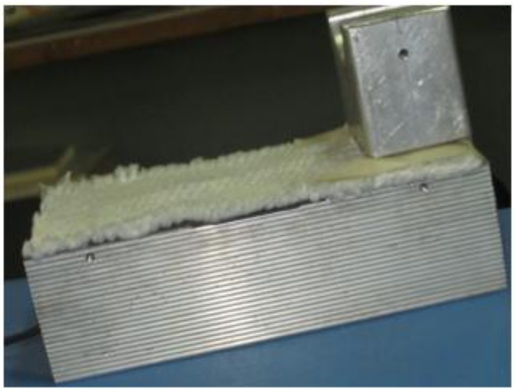

OBSERVATION TABLE:

MODELING OF THE SYSTEM:

Components involved:

1. Heat plate(heat source)
2. Aluminum blocks
3. TEG modules
4.water circulating system

PART MODELS :

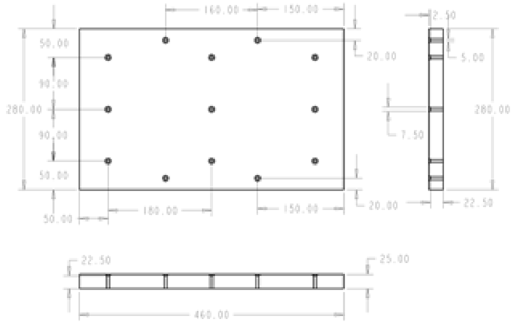

Fig 4 Heat Plate

Fig Aluminum plates

HEAT SINK (water circulating system):

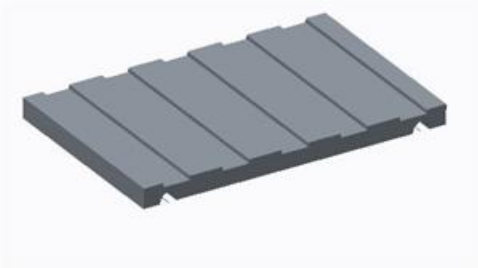

Fig 5 lower part of the water circulating system

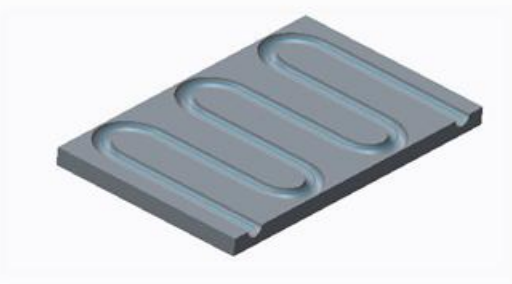

Fig 6 upper part of the water circulating system

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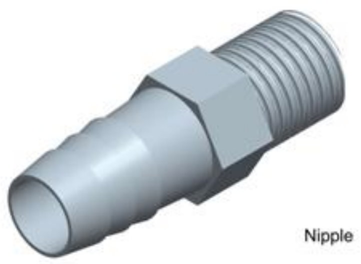
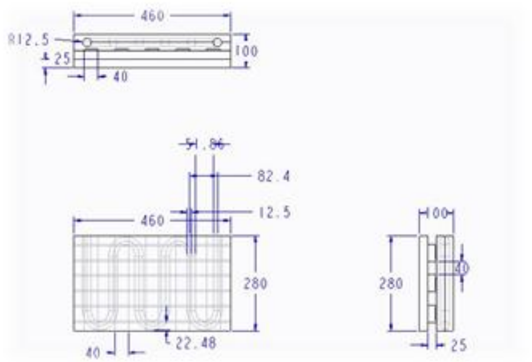
Nipple :

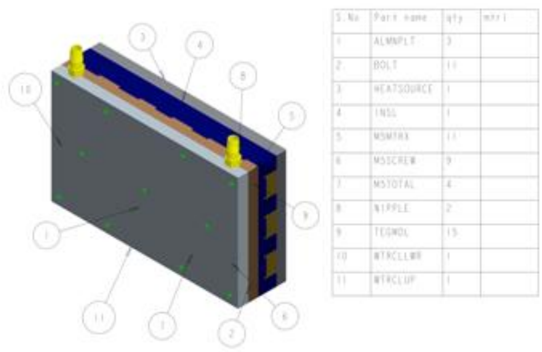


Assembly Models :

2D model :

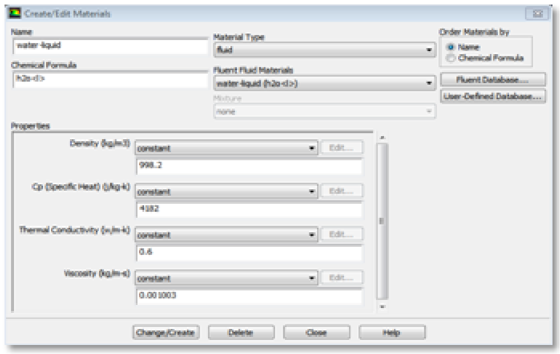


Final Assembly :

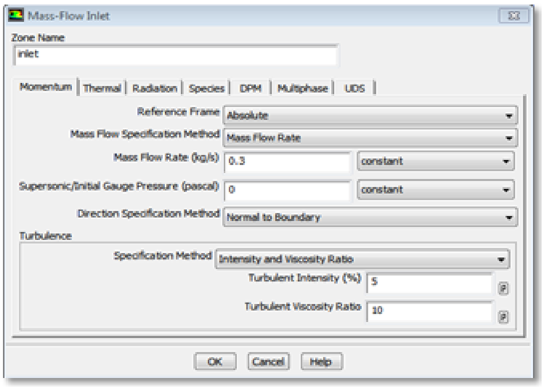


THERMO ELECTRIC ANALYSIS OF THE SYSTEM

Coolant properties

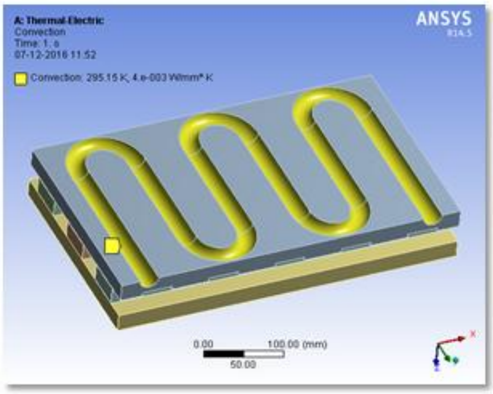


Boundary conditions



Working fluid	**Water**
Density	998.2kg/m^3
Mass flow rate	0.3kg/s
Hot side temperature	230°C
Cold side temperature	78°C

Convection:



Temperature:

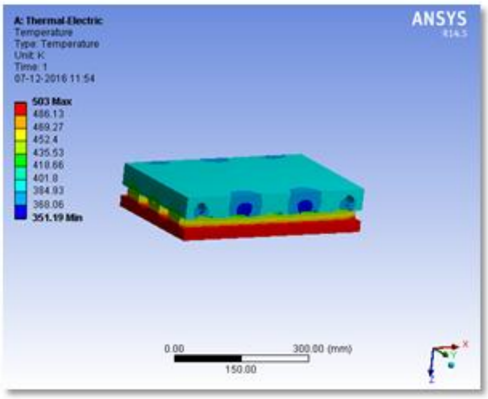
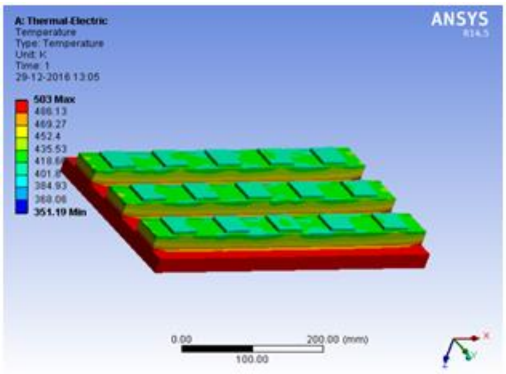


Fig the thermal profile of the system

Temperature Profile through The Modules:

The temperature which we directly given to the system hot side which pass through the hot and aluminum plates around 150 °C will pass to the teg module which can use the 5% of the temperature from our given temperatures.



CONCLUSION:

The broad objective of this study was operating of teg module under certain conditions for transfer of heat energy at 150watt thermoelectric power . The study comprised of Designing , Modeling in order to analyse the Performance of the total system and thermal characteristics of TEG module which produce 10 watt individually operating under the required range of operating temperatures. The following conclusions are drawn :

- By the operating 2 modules of 10 watts with Chula we shown that with that given temperature system will produce power as shown.
- In this analysis we mainly observed 230°C of temperature to the hot plate in this 150watt is only gone through a module can only used 5%of temperature the remaining is reduce to 78°C.

FUTURE SCOPE:

With the rapid development of technology in the field of material science there is a lot of scope for the TEM's in the future to gain attention .the research of new materials in thermo electrics is expected to produce TEM's with an efficiency of 20% with time the cost of the modules also comes down. The current modules are working with an efficiency of 5 % but the Thermo Electric pipes (tubes) are going to arrive in the markets shortly with above 10 % efficiency. They can produce 10 watts of power with a temperature difference of 80 degree Celsius. By making the product tubular the surface area is increased to take in more heat for the same area. As a result the output power is 3 to 4 times high. By reducing the heat losses through radiation from exhaust system the total waste heat can be converted into electricity. By 2020 it is expected to produce the power of about 1kw. With the increasing prices of the electricity it is a viable option to go for TEM where there is some heat being wasted. The rising pollution levels at a large scale have become a serious threat. TEM's provide a step towards the control of these pollutants.

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