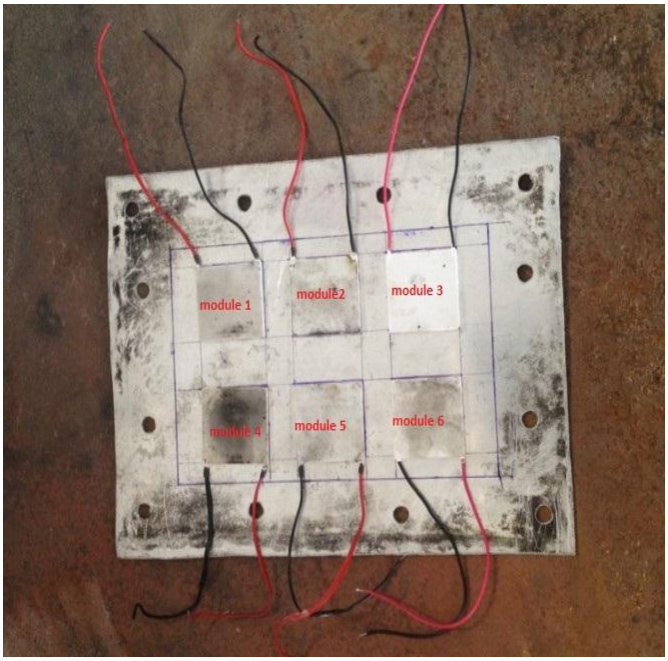

Figure 3: Selected location of modules on a aluminium plate

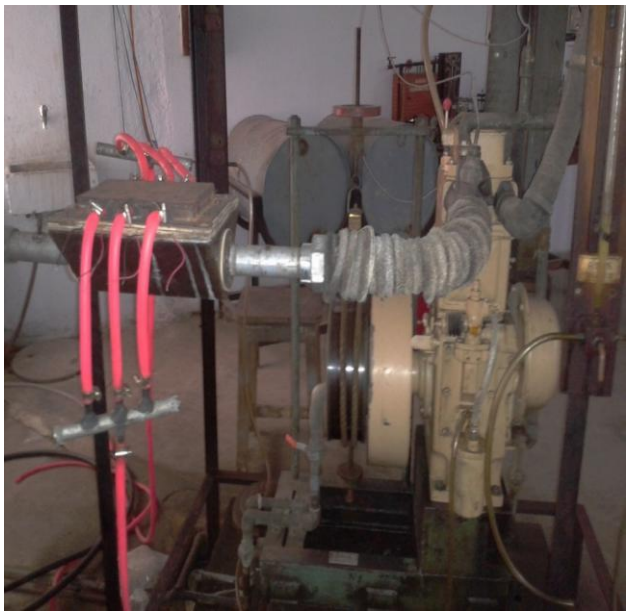

Figure 4: Assembly of TEG to a Compression Ignition engine.

The electricity required for continuous charging of battery used in automobiles is found to be around 12 volts, which is to be generated by these thermoelectric modules. Dynamometer torque, engine speed, TEG output, TEG coolant inlet and exit and surface temperatures were measured. The engine was operated at various loads using eddy current dynamometer. Engine load was varied by changing the engine speed keeping the torque constant. Horiba exhaust gas analyzer was used to measure the exhaust gas toxicity. To achieve higher exhaust gas temperature the thermoelectric generator was located just down- stream of the exhaust headers next to catalytic converter. The only concern is that the generator, if located upstream of the catalytic converter, would decrease the efficiency and increase the warming time of the catalytic converters.

A test was carried out on a four stroke single cylinder diesel engine with brake drum dynamometer without any modifications performed on it. The exhaust pipe was insulated on the upstream side of the exhaust chamber up to the catalytic converter to minimize heat loss. 0-1200°CK-type thermocouples with digital measuring unit was used to measure exhaust gas temperature on hot and cold side of TEM. Back pressure of the Exhaust gas was measured using a U- tube mercury manometer. D. C. voltmeter was used to measure the voltage produced by the TEG. A rotameter, was used to find the water flow rate through engine and cooling chamber. An additional coolant circuit (by-pass) was provided for TEG using solenoid valve in order to overcome the burn out of the TEM during the engine warm up period.

3. Results and Discussion

A study has been performed to test the performance of modules used in TEG. Some of the results have been presented for the purpose.

Table 1: Specifications of a Compression Ignition Engine

Item	*Details*
Type	Single cylinder Four stroke vertical water cooled diesel engine.
Bore (D):	80 mm
Stroke length (L)	110 mm
Compression ratio	16.1
Rated power (BP)	3.68 KW at 1500 rpm
Rated speed (N)	1500 rpm
Mechanical dynamometer (Rope brake)	Drum diameter (d_d): 3000 mm Rope diameter (d_r): 15 mm Effective radius (R_e) = d_d + d_r/2 = 157.5 mm =0.1557 m (i) Dead weights for loading the engine in kg. (ii) Hand Tachometer for measuring speed in rpm (iii) Orifice meter in Conjunction with. U-Tube manometer for measuring volume flow rate of air (m^3/Sec).

Exhaustive studies were performed to check the effect of assembly of TEG on engine. As an example, a study is performed on the effect of mechanical efficiency of a four stroke single cylinder diesel engine with brake drum dynamometer with applied load for two different cases is presented in Fig. 5. Curve 1 shows the case of variation of mechanical efficiency before assembling of TEG voltage with the application load on an engine while the curve 2 shows the variation of mechanical efficiency after assembling TEG. We can observe that there is almost no effect on the engine due to assembly of TEG.

Figure 6 shows the variation of voltage with the application load on an engine for three different modules 1, 2, 3. The location of modules on the aluminium plate was shown in Fig. 2. It is observed that for a given module as the load or brake power increases the voltage increases and reaches maximum. Also, for a given load the voltage is in module 1 is more than that of for module 2 and 3 because it is placed nearer to the heat exchanger than that of module 2 and 3.

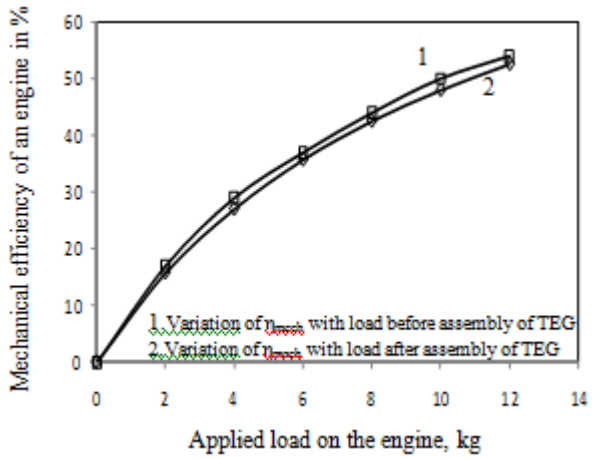

Figure 5: Variation of mechanical efficiency with applied load

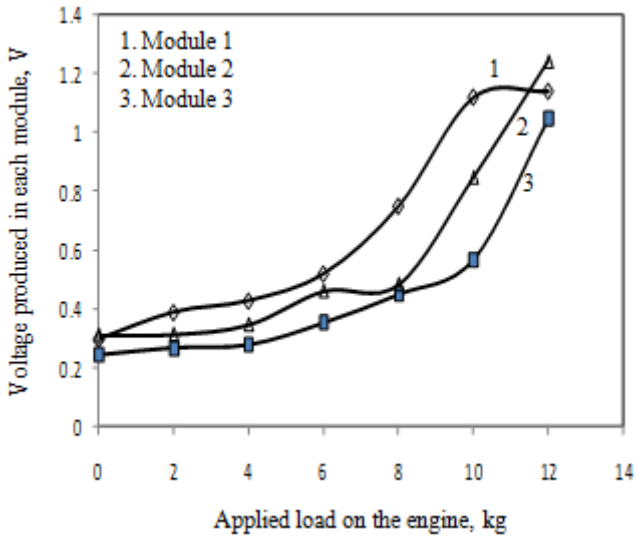

Figure 6: Variation of voltage with applied load for modules 1, 2, 3

The variation of voltage with applied load in modules 4, 5 and 6 is shown in Fig. 6. Here too we can observe that for a given module as the load or brake power increases the voltage increases and reaches maximum. Also, for a given load the voltage is maximum for module 4 than that of for module 5 and 6. Also we can observe that the voltage is more in module six at maximum load than that of module 5. This is obvious because as we move at the end location the temperature difference between the water and exhaust gases increases.

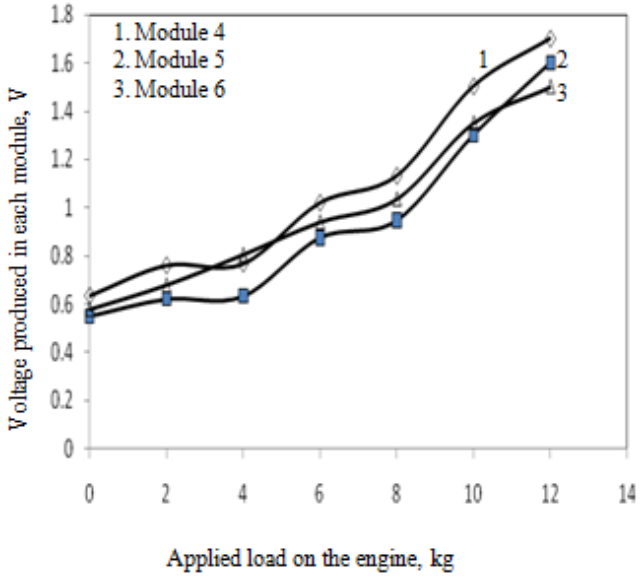

Figure 7: Variation of voltage with applied load for modules 4, 5, 6

4. Conclusion

A detailed study was performed to discuss performance of thermo-electric generator modules used in Compression Ignition engines for production of an electrical energy. Exhaustive studies were presented to show that the assembly of TEG module have no effect on the performance of an engine.

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