

Automobile Waste Heat Utilization using TEG

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Abstract: *The aim of utilizing waste heat from automobiles using Thermoelectric Generators (TEGs) is to convert the otherwise wasted thermal energy from the vehicle's exhaust system into useful electrical energy. The objective of utilizing waste heat in automobiles using Thermoelectric Generators (TEGs) is to enhance energy efficiency by converting otherwise lost heat energy from the vehicle's exhaust system into useful electrical power. To harness and convert the waste heat generated by automobile engines into useful electrical energy using thermoelectric generators (TEGs), thereby improving overall energy efficiency and reducing fuel consumption.*

Keywords: Automobile, Waste Heat, Utilization, TEG.

I. INTRODUCTION

Thermoelectric Generators (TEGs) have gained significant attention as a promising technology for harnessing waste heat, particularly in the automotive industry. In the context of automobiles, a substantial amount of energy generated by internal combustion engines (ICEs) is lost as waste heat through exhaust gases, cooling systems, and other components. This unutilized heat represents a significant inefficiency in conventional vehicles, which rely primarily on fossil fuels. The efficiency of internal combustion engines (ICEs) in vehicles is typically low, with about 60-70% of the fuel energy being wasted as heat. This waste heat is mainly expelled through exhaust gases and engine coolant. Recovering even a fraction of this heat could significantly improve the overall efficiency of vehicles, reduce fuel consumption, and lower emissions.

Automobile waste heat utilization using Thermoelectric Generators (TEGs) recovers energy from exhaust gases to generate electricity, improving fuel efficiency and reducing emissions by converting heat directly into electrical power via the Seebeck effect. By creating a temperature difference across solid-state TEG modules placed between hot and cold surfaces, the system leverages the temperature gradient to produce electricity, which can then power vehicle electrical systems. Efficient designs incorporate optimized heat collectors, advanced thermoelectric materials like BiTe or half-Heusler alloys, and improved cooling methods for both heat transfer and power output.

Components:

- Hot Side: Exhaust gases are passed over a hot side, often with aluminum fins to maximize heat transfer.
- Thermoelectric Modules (TEMs): TEG modules are placed between the hot and cold sides, converting the thermal energy into electricity.
- Cold Side: A cooling mechanism, such as water-cooled heat sinks or innovative wicking systems, is used to create the necessary temperature difference across the TEG modules.

II. LITERATURE REVIEW

literature survey on the topic of "Automobile Waste Heat Utilization using Thermoelectric Generators (TEGs)" involves an exploration of various studies, technologies, and methodologies that have been proposed or developed to convert waste heat from automobiles into useful electrical energy. Importance of renewable energy sources. Overview of washing machines and their energy consumption. Need for sustainable and energy efficient appliances. Utilizing waste heat from automobiles is a promising way to improve fuel efficiency and reduce emissions. Thermoelectric Generators (TEGs) are devices that convert heat directly into electrical energy using the Seebeck effect.

III. PROBLEM-STATEMENT

1. High Waste Heat Loss
2. Challenges with Conventional Energy Recovery
3. TEG Limitations
4. Weight and Space Constraints

Automobile waste heat utilization using Thermoelectric Generators (TEGs) seeks to recover a portion of the large amount of heat energy lost in internal combustion engines by converting it into usable electrical energy. TEGs harness the temperature differences in exhaust and coolant systems to generate electricity through the Seebeck effect.

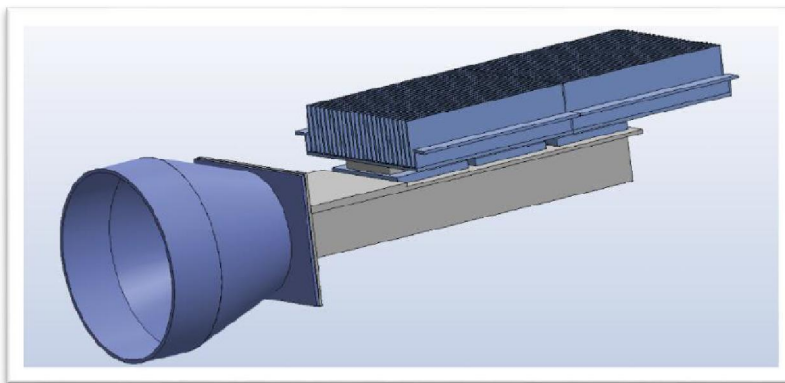


Fig. 1 :3-D Model

IV. RESULTS AND DISCUSSION

This research shows that this design is able to produce power up to 2.67 watt using only 3 number of TEGs in this design. Graphshows that with the increase in velocity of the exhaust gases, power produced also increases.

Power vs exhaust gas velocity

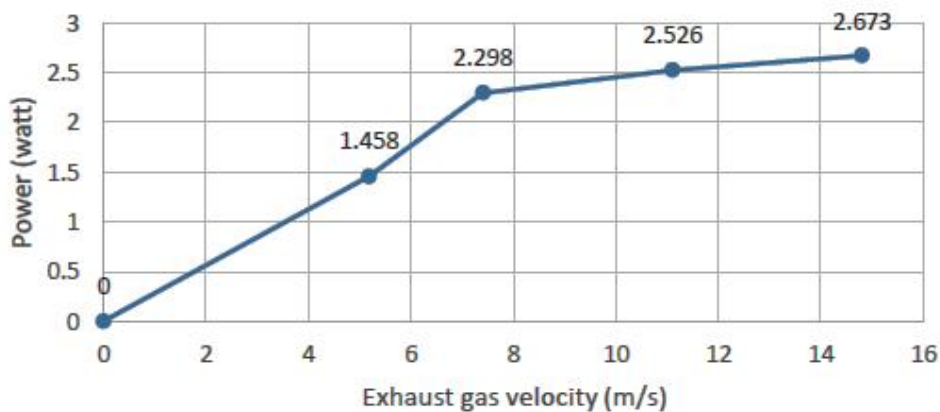


Fig 2: Power vs exhaust gas velocity

V. CONCLUSION

Based on the above experiment and research, it is concluded that velocity of hot gases passing through the system significantly affect the performance of the system. Other than that temperature falls at the end of the automobile exhaust system which can be improved by putting this design on the muffler where temperature will be maintained at higher degree.

Advantages:-

1. *Energy Recovery*: TEGs convert waste heat from the exhaust and other heat-generating components into electricity, improving the overall energy efficiency of the vehicle.
2. *Fuel Efficiency*: By capturing waste heat and converting it into usable energy, TEGs can reduce fuel consumption, leading to cost savings and less reliance on fossil fuels.
3. *Reduction in Emissions*: Increased energy efficiency from TEGs results in lower CO₂ emissions and other harmful pollutants, helping to meet stringent emission standards. *Power Limitation*: The system's power output is limited to the capacity of the solar panels and batteries, which may not meet high power demands.

Disadvantages :-

1. *Low Efficiency*: TEGs typically have a low energy conversion efficiency (around 5–10%), meaning a large amount of waste heat is still lost and not converted into useful energy.
2. *High Cost*: Thermoelectric materials, especially efficient ones, are often expensive to produce and integrate into automotive systems, making it less cost-effective compared to other energy recovery methods.
3. *Material Limitations*: The materials used in TEGs, such as bismuth telluride or lead telluride, can be toxic or have limited availability, making widespread application difficult. Some materials also degrade at high temperatures, limiting the operational lifespan of TEG systems

Application

Thermoelectric generators (TEGs) are devices that convert heat directly into electrical energy based on the *Seebeck effect*, where a temperature difference across the thermoelectric material generates an electrical voltage. Automobile waste heat, primarily from internal combustion engines, represents a significant opportunity for energy recovery using TEGs

Future Scope

- Utilizing automobile waste heat with Thermoelectric Generators (TEGs) has significant future potential.
- Efficiency Improvements
- Integration
- Cost Reduction
- Durability and Reliability
- Energy Management Systems
- Hybrid Systems

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