Thermoelectric generators

1 What is a Thermoelectric generator

Thermoelectric generators which we will abbreviate as TEG are defined as solid-state semiconductor devices, so what does that mean? solid-state means in essence semiconductor electronics, electronics based on the semiconductor (TechTarget [7]).

What is a semiconductor? Semiconductors are materials which have a conductivity between conductors (generally metals) and nonconductors or insulators (such as most ceramics (teacher [6]).

So TEGs are such solid-state devices that either convert heat directly into electricity or transform electrical energy into thermal power for heating or cooling.

here we have a heat source that provides the heat which then flows through a thermoelectric converter to a heat sink, which is maintained at a temperature below that of the source. The temperature differential across the converter produces direct current (DC) to a load (RL) having a terminal voltage (V) and a terminal current (I). This induced voltage due to junction heating became known as the Seebeck effect, though Alessandro Volto seemed to have discovered it 27 prior to Thomas Seebeck in actuallity (Harper [3]).

And one last bit of context I should add is that there is no intermediate energy conversion process. For this reason, thermoelectric power generation is classified as direct power conversion, this being one of it's big benefits as we will find out.

2 What are the advantages of TEGs?

So how could this pretty energy source help us? And how has it already done so, let's start by looking at NASA's Voyager I, having no parts that break or wear out as solid-state devices makes them very reliable, the Voyager I thermoelectric generator having have travelled 14.347 billion miles at the time I am writting this (Laboratory [4]) or roughly 23 billion kilometers, having been operational for 41 years without repairs.

You also have some minor benefits for when in use closer to home such as the fact that they can be designed to be quiet, using no greenhouse gases and having a wide range of fuel sources including body heat and waste heat as you can generate the heat anyhow.

We have a few more important benefits but the ones that matter include scalability, meaning we can be designed to output less than microwatts of power or kilowatts if you can get the heat required, ability to operate in both Zero G and high-G forces while some other energy conversion technologies cannot. They also have great design flexibility.

At last while we are on benefits let's mention what that being direct power conversion leads to intuitively: Each energy conversion step leads to loses meaning direct power conversion is less mechanically complex (Alfred [1]).

•the issues and a conclusion

though as can be seen (Mitofsky [5]) and as is known (Aswegen [2]) they are not that efficient with most thermoelectric devices having an efficiency of less than 10%.

So there are a few problems, and that also includes modeling expertise for TEGs not being common and simulations being unable to solve problems without human interpretation as projects are different. There is also the problem of higher up-front cost despite long-term savings.

However the implementation of higher usage of thermoelectric generators could still be a good idea despite what I mentioned due to the aforementioned benefits.

References

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[2] Mr Dean van Aswegen. *Advantages and disadvantages of the thermoelectric generator concept (in a cryptocurrency mining energy efficiency study)*. ResearchGate, 2019.

[3] Joseph Harper W. *Thermoelectric power generator*. Britannica encyclopedia, 2007.

[4] Jet Propulsion Laboratory. *NASA voyager I stats*. California Institute of Technology, 2021.

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[6] Material Science Engineering teacher. *Semiconductors*. University of Washington, 2003.

[7] writers TechTarget. *what is solid-state*. TechTarget, 2005.