THERMOELECTRIC GENERATORS IN INCOMESS PROJECT

The Seebeck phenomenon, named after its discoverer, is the thermoelectric phenomenon involving the generation of an electromotive force in a circuit containing two metals or semiconductors when their junctions are at different temperatures. This phenomenon is used in thermoelectric generators (TEG). They enable heat to be converted into electricity due to the temperature difference between the two sides of the generator (cold and hot side) which causes the diffusion of charge carriers (electrons or holes) along the material. TEGs are thus suitable for converting both solar energy and waste heat (from furnaces, photovoltaic panels or vehicle exhaust) into electrical energy. These generators have many advantages: they have no moving elements, are compact and noise-free.

Due to low efficiency, there are still works in progress to increase the operating efficiency of generators, including modifications to the structural properties of the materials used or changes to the geometry of the generator.

Materials used for the construction of the TEG shall be characterised by high electrical conductivity, good Seebeck coefficient for maximum conversion of heat to electrical power and low thermal conductivity. Thermoelectric materials can be divided into three groups: organic, inorganic and mixed (inorganic- as an additive / organic - as a matrix). The most commonly used inorganic thermoelectric materials are: Bismuth Telluride (Bi2Te3) and its alloys, Silicon-Germanium (SiGe) alloys, Lead Telluride (PbTe) and its alloys, tin Selenide (SnSe), Antimony Telluride (Sb2Te3) or CoSb3. The main feature of the materials used for BeTe-based TEG is their high thermal conductivity, which is difficult to reduce. Moreover, they are rigid, contain toxic elements that are rare in the environment and are therefore expensive to microfabricate. Therefore, the advantages offered by Polymers, such as, increasingly high electrical conductivity and Seebeck coefficient values with low thermal conductivity or non-toxicity make them a very interesting alternative.

The InComEss project focuses on the optimal configuration of a Polymer-based Thermoelectric generator for automotive and aeronautical applications. Temperature distribution, voltage potential and thermal stress analyses are carried out in COMSOL Multiphysics. This software enables to combine the thermoelectric effect, electromagnetic power dissipation and temperature dependent electromagnetic material characteristics.

Figure 1 presents a typical geometry of a TEG generator consisting of 128 pairs. Thermoelectric elements are thermally connected in parallel and electrically connected in series, therefore, and as it can be seen, the voltage potential varies from one side of the models to the other end. Figure 2 shows the temperature distribution and stress analysis for two pairs in the TEG module.

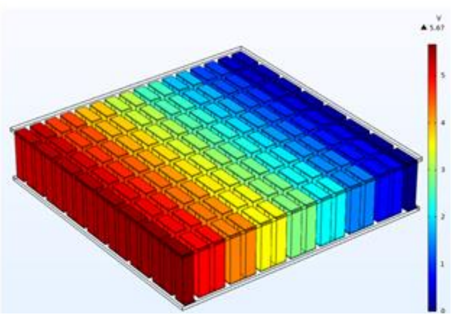

Figure 1: Electrical potential in TEG with typical geometry.

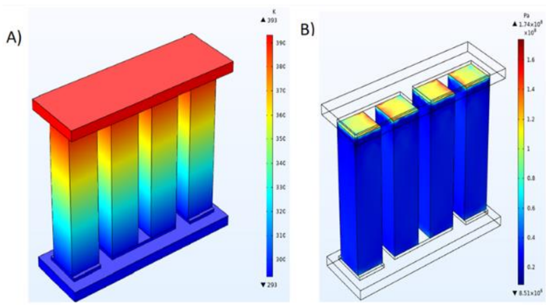

Figure 2: TEG temperature distribution (A) and the stress analysis (B).

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