RESEARCH TOPICS

Recovery, storage and energy management for stationary and mobile power systems.

Background
Many processes, especially in industrial applications, produce large amounts of excess heat, beyond what can be efficiently used in the process. Typical methods of recovering heat in industrial applications include direct heat recovery to the process itself, such as regenerators, waste heat boilers, etc. Innovative recovery methods attempt to extract some of the energy as work that otherwise would be wasted. Affordable criteria applicable to low-temperature streams or low temperature surfaces could expand the number of viable applications of waste heat recovery, as well as improve the performance of existing applications. In this way, the thermo-electrical effect devices could represent the efficient apparatuses applicable to low grade waste heat from which cannot be recovered easily with conventional methods.

Typically, thermoelectric modules are joint to storage issues, because in many cases for both stationary or mobile power systems, the more efficient way is to accumulate in batteries the produced electricity from thermoelectric devices, instead of convert to alternating current to feed the electric grid. About mobile applications such as electric propulsion, the energy storing is a crucial topic, because the required gravimetric and volumetric energy density should be the high as possible. For these cases, the proper management of the available energy should be addressed to cover the load requirements, so, recovering and storing energy in electric batteries only, could be insufficient because a greater energy capacity could be required. For increase the gravimetric and volumetric energy density, solutions based on fuel cells coupled to electric batteries may be investigated. If the fuel cell is conceived as a battery charger only, i.e. never follows the load requirements, its sizing could be adequately reduced, so it can enable to work with the nominal optimal efficiency. DEFC (Direct Ethanol Fuel Cell) that operate at low temperature could be suitable for this purpose.

Topics for the Doctoral Thesis
Starting from a wide literature review performed on the involved devices and apparatuses, highlighting the basic physics on the involved phenomena, the main topics to be develop are:

- Development of a numerical model for thermoelectric devices, with particular care to heat exchange at the cold side by using heat pipe and fins with free and forced convection, useful to predict the behaviour in steady and transient working conditions;
- Investigation on maximum work carried out from an electric battery for matching the imposed load, considering both internal resistance and its lose of charge over time because of its internal discharge related to its inner leakage resistance;
- Setting up of a fuel cell straightforward model based on polarization curves at given temperatures, and relationship between the fuel cell efficiency and output power rate;
- Assembling of the entire model including, fuel cells and electric batteries with DC/DC converter between them, and thermoelectric devices, when applicable. Parametric simulations to comprehend the best applying strategy between load requirements and the energy storage management;
- Design and built up of a laboratory facility in order to perform a measurement campaign useful to validate each developed model and the whole one;
- Economic evaluations and environmental effects for application into stationary and mobile power systems.

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