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Modeling the Reliability of a Fuel Cell and the Influence of Mechanical Aspects on the Production of Electrical Energy

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Abstract : A fuel cell is a multi-physical system. Its electrical performance depends on chemical, electrochemical, fluid, and mechanical parameters. Many studies focus on physical and chemical aspects. Our study contributes to the evaluation of the influence of mechanical aspects on the performance of a fuel cell. This study is carried out as part of a reliability approach. Reliability modeling allows to consider the uncertainties of the incoming parameters and the probabilistic modeling of the outgoing parameters. The fuel cell studied is the one often used in land, sea, or air transport. This is the Low-Temperature Proton Exchange Membrane Fuel Cell (PEMFC). This battery can provide the required power level. One of the main scientific and technical challenges in mastering the design and production of a fuel cell is to know its behavior in its actual operating environment. The study proposes to highlight the influence on the production of electrical energy: Mechanical design and manufacturing parameters and their uncertainties (Young module, GDL porosity, permeability, etc.). The influence of the geometry of the bipolar plates is also considered. An experimental design is proposed with two types of materials as well as three geometric shapes for three joining pressures. Other experimental designs are also proposed for studying the influence of uncertainties of mechanical parameters on cell performance. - Mechanical (static, dynamic) and thermal (tightening - compression, vibrations (road rolling and tests on vibration-climatic bench, etc.) loads. This study is also carried out according to an experimental scheme on a fuel cell system for vibration loads recorded on a vehicle test track with three temperatures and three expected performance levels. The work will improve the coupling between mechanical, physical, and chemical phenomena.

Keywords : fuel cell, mechanic, reliability, uncertainties
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