Operating strategy of solid oxide fuel cell system for lifespan extension and performance optimization

General information

Type: Master project
Period: Spring 2024
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Project description

In the context of global climate change, numerous countries have launched their targets and routes toward "Carbon neutrality", which leads to the booming of low-carbon-emission and efficient renewable energy technologies. Solid oxide fuel cell (SOFC) technology is favored as one promising clean energy application due to (1) the high efficiency (>60%), (2) the capability of heat integration under high operating temperature (>650 ºC), (3) compact system design, and (4) flexible fuel choice, including hydrogen, natural gas, diesel, etc. By connecting to the city gas grid, this technology can efficiently convert natural gas into electricity and domestic heating. There have been several commercialized SOFC power systems in the market, however the high cost hinders its further application. To tackle this problem, prolonging product lifespan by reducing the degradation rate is an effective and direct option.

Conventionally, researchers tend to refine the cell microstructure and material composition to decrease the degradation rate and hence prolong the lifespan. The degradation characterization of the new-material based technology will take numerous time. However, the basic degradation mechanism won't change, meaning that the new material only reduces the degradation rate from temperature, fuel humidity and other parameters, rather than eliminates or reverses their impacts. In this case, the operating strategy should be investigated to help prolong the technology lifetime regardless of the material difference.

Operating condition with minimized degradation generally leads to a reduced cell performance, which contrarily increases the operation cost. On the other hand, optimization strategy generally considers how to optimize the cell performance, which push the cell to higher degradation rate. Hence, it is necessary to propose a control strategy which balances the system performance, i.e., efficiencies (electrical efficiency and combined heat and power efficiency), and degradation rate, to achieve minimized operating cost with expected product lifespan.

This project aims to study the control strategy of solid oxide fuel cell systems to gain expected the system lifespan whilst optimizing the system performance and operating cost. Solid oxide fuel cell system modelling and optimization algorithm will be combined to exploit the suitable control strategy.

Objectives

1. By literature review, develop a good understanding of SOFC technology, degradation characterization and its control strategy.
2. Perform sensitive analysis concerning degradation rates in a SOFC system model and optimize the SOFC system with multiple objectives.
3. Analyze the system lifespan and the operating expenditure under different power load profile.
4. Propose a control strategy that minimizes the operating expenditure and optimizes the system performance with expected system lifespan.

Required skills

- Good knowledge of energy systems and renewable technologies.
- Good knowledge of SOFC, system modeling, and optimization algorithm is preferred.
- Coding skill with MATLAB is a plus.
- High-level motivation and ability to work in an autonomous environment.