Jomo Kenyatta University of Agriculture and Technology

College of Engineering and Technology

School of Mechanical, Materials, and Manufacturing Engineering

Department of Mechatronic Engineering

Designing a Hydrogen Fuel Cell Control System

Final year project (FYP 13-11)

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November 27, 2021

Declaration

We hereby declare that the work contained in this report is original; researched and documented by the undersigned students. It has not been used or presented elsewhere in any form for award of any academic qualification or otherwise. Any material obtained from other parties have been duly acknowledged. We have ensured that no violation of copyright or intellectual property rights have been committed.

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Abstract

Operation of a hydrogen fuel cell requires the control of factors that affect the safety performance, efficiency and lifespan of the proton exchange membrane. This proposal looks into different control strategies that will be employed for variable power delivery from the hydrogen fuel cell with consideration of safety, efficiency and longevity of operation. The project will go into modelling of the control system and simulation of different operating conditions to determine the best controllers along with the control parameters. The proposal also looks into control strategies such as neural networks, linear quadratic regulator and PID control to optimize on factors such as performance and efficiency. Each of the control strategies will be modeled and tested to select the best performing controller which will be developed for the hydrogen fuel cell.

1 Introduction

1.1 Background

(Insert your content)

gghjbbnmmm

1.2 Problem statement

As a measure to curb pollution due to the industrialization and transportation sectors, world governments are turning to alternative sources of energy. These alternative sources of energy should drastically reduce the pollution rates by cutting down emissions. Fuel cell technology is one such example of alternative sources of energy. A fuel cell uses the chemical energy of hydrogen or other fuels to cleanly and efficiently produce electricity. Moreover, fuel cells can operate at higher efficiencies than combustion engines and can convert the chemical energy in the fuel directly to electrical energy with efficiencies capable of exceeding 60%. Fuel cells have lower or zero emissions compared to combustion engines.

The various departments of energy, however, have to work closely with national laboratories, universities, and industry partners to overcome critical technical barriers to fuel cell development. These barriers are cost, performance, and durability which are still key challenges in the fuel cell industry.

This design proposal seeks to provide a solution to improving the fuel cell's performance by improving the robustness and efficiency of the Fuel Cell stack system for real world conditions through precise control of reactant flow and pressure, stack temperature, and membrane humidity.

1.3 Objectives

(Insert your content)

1.4 Justification of the study

Additive manufacturing offers the ability to produce intricate products and parts with lower development costs, shorter lead times, less energy consumed during manufacturing as well as less material waste. This method can be used to manufacture delicate components such as the bipolar plates with elimination of the risks involved such as breakage of brittle Graphene material during production.

Precise control of reactant flow and pressure, stack temperature, and membrane humidity will increase the fuel cell's robustness as well as efficiency.

The goal of this research is to develop physic-based dynamic models of fuel cell systems and fuel processor systems and then apply multivariable control techniques to study their behavior. The analysis will give insight into the control design limitations and provide guidelines for the necessary controller structure and system re-design.

2 Literature Review

Itemization

- Item 1.
- Item 2.
- ...

$$\dot{x} = Ax + Bu + B_d w \tag{2.1}$$

Refering a chapter in the main text. For instance Chapter 2

$$E = 210000\,\frac{\mathrm{N}}{\mathrm{mm}^2}$$

$$\rho = 7{,}85\,\frac{\mathrm{g}}{\mathrm{cm}^3} = 7850\,\frac{\mathrm{kg}}{\mathrm{m}^3}.$$

$$\Delta \boldsymbol{r}_k = \boldsymbol{r}_{\mathrm{GBE}_k} - \boldsymbol{r}_{\mathrm{C}_k} = (x_{\mathrm{GBE}_k} - x_{\mathrm{C}_k}, y_{\mathrm{GBE}_k} - y_{\mathrm{C}_k})^T = (\Delta x_k, \Delta y_k)^T \tag{2.2}$$

$k = 2 \dots n$

$$||\boldsymbol{r}_{\mathrm{GBE}_k} - \boldsymbol{r}_{\mathrm{C}_k}|| \leq r_{kj}, \tag{2.3}$$

k j

[To appear in the list of tables]Caption for the table should be at the top of the table

	First column	Second column	Third column
It can also overflow to next line	1	2	4
	4	6	23
	34	2	0

$$\operatorname{rank} \boldsymbol{Q}_{\mathrm{B}} = \operatorname{rank} \begin{bmatrix} \boldsymbol{C} \\ \boldsymbol{C}\boldsymbol{A} \\ \boldsymbol{C}\boldsymbol{A}^2 \\ \vdots \\ \boldsymbol{C}\boldsymbol{A}^{n-1} \end{bmatrix} = n. \tag{2.4}$$

$$K_\varphi = 3.64 \, \frac{\mathrm{V}}{\mathrm{rad}} \quad \text{and} \tag{2.5}$$

$$K_x = 28.32 \, \frac{\mathrm{V}}{\mathrm{m}}. \tag{2.6}$$

2.1 Name of a subsection

q_1, q_2 and q_3 (see Fig. **??**).

2.2 Another subsection

3 Methodology. . .

This is

4 Expected Outcomes