A picture containing logo

Description automatically generated**Master of Science in Embedded Systems Design**

**Submitted in accomplishment of**

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# INTRODUCTION

## Introduction of Fuel Cell Stack:

The stack generates the electrical energy used to power the fuel cell electric vehicle. As its name suggests, the component is a stack of fuel cells. In each one of these cells arranged in series, a “cold combustion” process takes place that converts the energy from the chemical reaction between the continuously fed hydrogen and airborne oxygen into electricity. The only products of the reaction are water, electricity, and heat. No pollutants such as particulate matter or nitrogen oxides are emitted.

## Working of FC Stack:

Diagram

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The fuel cell stack consists of a stack containing up to several hundred fuel cells; it forms the core of the fuel cell system. In each one of these cells arranged in series, a “cold combustion” process takes place that converts the energy from the chemical reaction between the continuously fed hydrogen and airborne oxygen into electricity. This takes place when the hydrogen is catalytically split down into electrons and protons.

While the protons diffuse through a polymer membrane in the direction of the cathode, the electrons flow from the anode to the cathode via an electrical circuit. In the process, they supply a consumer with electric current. At the cathode, the protons, electrons, and oxygen from the air ultimately react to form the end product: water. No pollutants such as particulate matter or nitrogen oxides are created as by-products of this process.

## Fuel Cell Stack Properties:

|  |  |
| --- | --- |
| Model Name | H-300 PEM FUEL CELL FCS-C300 (Horizon) |
| No. of Cells | 60 |
| Rated Power | 300W |
| Rated Performance | 36V @ 8.3A |
| H2 Supply Valve Voltage | 12V |
| Purging valve Voltage | 12V |
| Blower Voltage | 12V |
| Maximum Stack Temperature | 65 Celsius |
| H2 Pressure | 0.45 – 0.55 Bar |
| Flow rate at max Output | 3.9L/min |
| Startup time | ~ 30 sec |
| External Power supply | 13V, 5A |
|  |  |

## Fuel Cell stack Block Diagram:

Diagram

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## Fuel Cell Control Unit (FCCU):

The fuel cell control unit (FCCU) is the central control unit for operation of the fuel-cell system – or “electrical power plant” – of an electric vehicle equipped with a fuel cell. The FCCU controls operation of the fuel cell system with its individual sub-systems, such as the hydrogen supply, air system, thermal and water-management systems, and the storage system. A monitoring concept is integrated into the FCCU to safeguard the system’s operation.

## Subsystems found in Fuel Cell controller:

Typically, software running on fuel cell controllers divides the system into subsystems and defines various states of operation. This enables easier management of the states defined by the control system layout. The choice of subsystems is highly dependent on the kind of fuel cell system in operation. The following are four common examples.

* The reaction control subsystem

The reaction control subsystem focusses on controlling the variables around the reactants which are aimed to be introduced to each other at certain stoichiometric ratios, temperature levels and pressure levels. This is a critical balance to be held in order not to destroy the membrane, catalyst or any other element of the fuel cells themselves. In addition, inadequate supply of reactants to the cells (fuel starvation) leads to inefficient use of the cells and invariably reduces overall system performance and efficiency.

* The thermal control subsystem

The thermal subsystem focusses on maintaining optimal thermal conditions for the reaction area and in other areas of the fuel cell system. A significant amount of heat is generated during the chemical reactions that occur at the cells and deviations from optimal values can lead to damage of the cell membrane, the catalyst, other elements of the cells or even other elements of the entire system. Generally the reaction occurs more rapidly at higher temperatures and as a result more heat is generated which in turn leads to an even faster reaction. Cooling measures therefore need to be dosed accordingly, anticipating this additional heat generation at higher temperatures.

* The electrical control subsystem

The electrical subsystem aims at converting the varying current and voltage output of the fuel cells to levels required by the electric consumer for which the system is designed. In line with the polarization curve and as a result of ohmic losses, the voltage output of the fuel cell stack varies with the current drawn from the system. For this reason, electric converters, for instance buck converters (to lower the voltage), boost converters (to increase the voltage), filters, and stabilizers are introduced into the power electronics module of a fuel cell system. These are all controlled as part of the electrical subsystem.

* The fuel cell storage subsystem

The fuel storage subsystem handles the tank and its peripheral elements. Depending on the storage method and concept the elements included in this subsystem vary. When hydrogen as a fuel is stored in gaseous form no conversion aside from a pressure regulation is required. However, when other forms such as a dissolution in a storage substance or reformation from methanol is required the fuel cell storage subsystem increases in complexity. As a significant amount of energy is stored in the storage system primary focus is on safe and stable supply of fuel to the fuel cell system.

# Fuel Cell System Market Analysis

# Literature Survey

# Project Management

## Date and Timeline

## Gantt Chart

# High Level Requirements

# Low Level Requirements

# Architectural Design

## Hardware Design

## Software Flowchart

## Software Architecture

# System/Model Implementation

## Component Table

## Circuit Diagram and Schematics

# Unit Testing Results

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