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Modeling and Performance Analysis of a closed loop PEMFC in small scale stand alone DC System

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***Abstract*— Minimizing the emission of greenhouse gases attained significant concern during last century. Eco-friendly energy extraction has been a matter of great concern due to the finite and polluting nature of fossil fuel-based resources. In view of this, fuel cell possesses an important part. A fuel cell generally converts chemical energy embedded within fuel into electricity without any combustion as well as through more efficient way. With the advancement in polymer technology, different fuel cells have been fabricated and proton exchange membrane fuel cell (PEMFC) has found efficient in most of the applications now-a-days. In this study, the objective was to analyze the performance of a PEM fuel cell in small scale DC system using a boost converter. The converter is actuated by a Fuzzy logic controller (FLC). The simulation was done in MATLAB/Simulink environment. Such a system can be used to implement small DC charging stations in view of charging electric vehicles.**

Keywords*— Renewable energy, Proton exchange membrane fuel cell, Boost converter, Fuzzy logic controller, Duty ratio

I. INTRODUCTION

Fossil fuel-based resources emits greenhouse gases during their consumption which is responsible for the alarming situation of more pronounced global warming. This made the researchers engaged in research activities related to renewable resources. Fuel cell is one of the most promising field in this aspect [1]. It is one of the most cost-effectiveness option [2-3] as this possess high efficiency [4-6] as compared to other renewable counter-parts with the end product in almost all thee cases being water [7]. Fuel cell works on the principle of electro-chemical reaction by oxidation without any stage in between. Main feature of such a system is that electricity can be generated only during its requirement. Unlike IC engine, fuel cell is quieter in operation and can be effectively applied in transport or stationary applications [8-10]. There is a basic difference between a fuel cell and a battery as the former is an energy conversion device whereas the later one is energy storage device. However, a battery can be an integrated part of a fuel cell-based system. A physical comparison can make the scenario clearer. A 10 kg propane tank can give 3400 A whereas a lead-acid battery of 15 kg can provide maximum 80 Ah [11]. In most of the cases hydrogen is used inside a fuel cell which converts energy without emission. As a result, emission free energy conversion takes place. This process has very good potential as hydrogen possess good energy storage and can be found useful in several cases. Fuel cell technology adds flexibility in system operation as it works on higher power density at a lower operating temperature. This has made fuel cell a promising option in automobile sector [12-14]. In most recent developments, a few flights have been tested with fuel cell considering its derating factor at a relatively high altitude [15]. However, commercialization of the same has not been possible due to various operating as well as working constraints [16-18]. Presently, co-generation and cooling, heating and power applications (CCHP) are being tested rigorously for more efficient result with fuel cell technology [19]. Fuel cells differ from each other depending on the electrolyte in use such as molten carbonate, proton exchange membrane (PEM) etc. [20-23]. Among all other counter-parts SOFC and PEM has been found more useful as they are provided with solid electrolyte which is relatively easier to handle.

Generally, fuel cell provides a low output and hence for proper utilization and to get a reasonable output they are interconnected in a combination of series-parallel connection. In order to boost up the lower voltage output of a fuel cell for application in power and domestic applications, a power electronic interface is introduced in between [24].

In present study, a proton exchange membrane fuel cell (PEMFC) based DC system has been analyzed through MATLAB/Simulink environment. Main objective of this study was to analyze the performance of the fuel cell with a boost converter. A Fuzzy logic controller is used to control the duty ratio of the converter. Output of the cascaded assembly of fuel cell and power converter are analyzed and compared. It was observed that power electronic interface increased the system reliability as well as improved the steadiness.

II. OPERATION OF FUEL CELL

Fuel cell is a static device which generates electricity by oxidation of the fuel and hence no combustion takes place in its operation. Natural gas, hydrogen and other organic compounds may be used as a fuel within a fuel cell. A fuel cell becomes

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