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

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***Abstract*— Reduction of greenhouse gases attained significant concern since last few decades. Limited quantity and polluting nature of fossil fuel-based resources made the researchers investigate on eco-friendly energy extraction techniques. In this aspect, fuel cell plays a vital role as it converts chemical energy to electricity without any combustion at a higher efficiency. With the advancement in polymer technology, several types of fuel cells have been fabricated and among all of these proton exchange membrane fuel cell (PEMFC) has gained much importance in several 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

Growing concerns on the detrimental effects of the fossil fuels on the environment led the researchers to focus on environment-friendly energy extraction techniques. Among different renewable resources, fuel cell plays a vital role [1] due to its comparatively higher efficiency [2-4]. Fuel cell-based systems are found as cost-effective in comparison to other renewable counterparts [5-6]. Like other renewable resources fuel cells are almost pollution-free as the end product in most of the cases is water [7]. Fuel cell generates electricity by electro-chemical reaction through oxidation of the fuel without any intermediate stage. The advantage of such a system is that electricity is generated only during its need. The cell continues delivering power until supplied with fuel and oxidant. Unlike IC engines, fuel cell converts the internal chemical energy of the fuel into electricity rather than converting it. Hence, it is quieter in operation and eco-friendly by nature which makes it a promising approach for stationary, portable and transportation applications [8-10]. The similarity between a battery and a fuel cell is that both converts chemical energy into electricity. However, they are not the same. The major difference between these two is that battery works as an energy storage element whereas fuel cell is an energy conversion device. A fuel cell can have a battery as an integrated part from storage point of view. As a method of comparison, it can be stated that a propane tank of approximately 10 kg can be utilized to give nearly 3400 Ah whereas a lead-acid battery weighing approximately 15 kg can merely give 80 Ah [11].

In a fuel cell, hydrogen is used without combustion hence there is no emission. Hydrogen has a good ability to store energy and has potential role in many applications such as in minimizing peak load, powering vehicles, homes etc. There are several other advantages gained in fuel cell technology such as lower operating temperature, higher power density and flexibility in operation etc. Fuel cell can be found useful particularly in automobile sectors and hence few automobile companies are engaged in research and development of fuel cell-based automobiles [12-14].

Even a few test flights have been tested based on fuel cell. In such a case, performance analysis of unpressurized fuel cell at higher altitude is carried out considering derating factor [15]. However, several operating and working constraints of fuel cell has made the job of the researchers tough particularly in transportation sector [16-18]. However, rigorous researches in this field have enhanced its suitability for various applications and presently these can be effectively utilized in co-generation, particularly in combined cooling, heating and power applications (CCHP) [19].

Presently, the most common electrolytes used for fuel cells are alkali, molten carbonate, proton exchange membrane (PEM), solid oxide and phosphoric acid [20-23]. Out of the above-mentioned types of fuel cells, PEM and solid oxide-based fuel cells possesses solid electrolytes.

Output of a fuel cell is very low. So, for proper operation, several cells needed to be connected suitably in series-parallel combination. For boosting of lower output voltage of fuel cell to a significant value, suitable arrangement is required. Usually, this is done with the help of power electronic interfaces [24]. This type of system may find suitability in transportation, power system or in domestic applications.

In practice several types of fuel cells are in use depending on the type and nature of application. In present study, a

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