Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/he

Integration of finite element analysis and design of experiment for the investigation of critical factors in rubber pad forming of metallic bipolar plates for PEM fuel cells

Roza Kolahdooz [a], *Saeed Asghari* [b,*], *Sahar Rashid-Nadimi* [a], *Amir Amirfazli* [c]

[a] *Department of Renewable Energies Engineering, Faculty of Advanced Sciences and Technologies, University of Isfahan, 81746-73441 Isfahan, Iran*

[b] *Institute of Materials and Energy, Iranian Space Research Center, 7th Kilometer of Imam Ave., Isfahan, PO Box: 81395-619, Iran*

[c] *Mechanical Engineering Department, University of Akron, 302 East Buchtel Avenue, Akron, OH 44325, USA*

ARTICLE INFO

Article history:
Received 16 June 2016
Received in revised form
24 October 2016
Accepted 2 November 2016
Available online xxx

Keywords:
Polymer electrolyte membrane fuel cell (PEMFC)
Rubber pad forming (RPF)
Metallic bipolar plate
Finite element method (FEM)
Design of experiment (DE)

ABSTRACT

In the present study, rubber pad forming process of metallic bipolar plates of PEM fuel cells is investigated. A 3D finite element model of the process with damage initiation criterion is developed. Design of Experiment (factorial design method) is used to find the key parameters of the forming process and their optimal levels. The required input data of the factorial design method is provided by the output results of the finite element model. The finite element results show that the thickness distribution in the formed bipolar plate is not uniform. Also, the corners of the micro-channels are the regions in which the damage initiation criteria (the von Mises stress and the plastic strain) reach maximum values. The design of experiments shows that the outer corner radius, draft angle, and the friction coefficient are the most critical parameters in the forming process. The optimal values for the draft angle, the outer corner radius, and the friction coefficient are found as 40°, 0.4 mm, and 0.05, respectively. Finally, some experimental tests are performed to validate the results of the finite element simulations and the design of experiments.

Introduction

The proton-exchange membrane fuel cell (PEMFC) is a promising candidate among different fuel cell types for use as an alternative power supply due to its high efficiency, fast startup, and high power density. However, the high cost has prevented it from widespread commercialization. Among different components of the fuel cell, bipolar plate is one of the barriers for the commercialization, which comprise about 30–35% of the stack cost and 60–80% of the stack weight [1]. The bipolar plates perform several tasks in a fuel cell stack i.e.: uniform distribution of reactant gases on the effective surface of fuel cell, separating of reactant gas passages through the

* *Corresponding author*. Fax: +98 31 33222446.
E-mail address: s.asghari@isrc.ac.ir (S. Asghari).

http://dx.doi.org/10.1016/j.ijhydene.2016.11.020