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Investigation of Parameters on the Efficiency of the Fuel cell Based on the Principles of Sealing

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ABSTRACT: One of the major parameters which affects fuel cell performance is the ohmic loss due to electrical resistance among fuel cell components. Assembly and design parameters affect the pressure distribution on gas diffusion layer. In this study, the influence of effective parameters such as the amount of clamping force, sealant groove depth and the thickness of end plate on the uniform pressure distribution over gas diffusion layer were investigated. By decreasing clamping force, the amount of end plate deformation decreases and uniform pressure distribution on gas diffusion layer increases. By reducing pressure on the gas diffusion layer, the possibility of leakage increases. By using an experimental sealing test, the minimum compression stress over washer for no leakage condition was achieved to be 2 MPa. According to the gas diffusion layer manufacturer, the most efficiency was achieved in 1 MPa compressive stress. Furthermore, the influence of effective parameters on the uniform pressure distribution over gas diffusion layer was examined and discussed. Finally, optimum parameters were obtained using radial basis function neural network and Bee algorithm.

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1- Introduction

The increasing demand for renewable and alternative energy sources has attracted a great interest in the study of fuel cells technology. To be useful for general applications, fuel cells should exhibit a promising performance while being cost-effective. Among the various types of fuel cells, Proton Exchange Membrane (PEM) fuel cells have triggered an enormous attention in recent years due to their high efficiency, high energy density, low-temperature operation, and low or zero emission. One of the major parameters which is less well-discussed is ohmic losses. Electrical resistance depends on the intrinsic electrical resistance of components and contact resistance between them. Chang et al. [1] studied the effect of clamping pressure on the electrochemical performance of a PEM fuel cell. Lee et al. [2] investigated the effect of three different types of Gas Diffusion Layers (GDLs) and various bolt torque (clamping pressure) on the performance of a PEM fuel cell. They indicated that a higher efficiency can be reached with less bolt torque and higher bolt torques can damage the gas diffusion layer. They found an optimum torque in terms of changes in the GDL porosity and the electrical contact resistance. Xing et al. [3] used a global optimization method, namely, Simultaneous Perturbation Stochastic Algorithm (SPSA), to find optimum clamping pressure under different operating voltages. Asghari et al. [4] proposed a new procedure to design end plates. They used finite element analysis to find an optimum thickness of 35 mm for the end plate.

The objective of this study is to reach a sufficient pressure distribution over the gas diffusion layer and identify the effect on electrical resistance. For this reason, an optimum value of clamping force should be selected to obtain good sealing and proper pressure on GDL, simultaneously.

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2- Methodology

First, an experimental test is used to find the minimum compression stress over washer in which no leakage happens. Results showed that for clamping pressures higher than 2 MPa over the washer, a complete sealing is guaranteed. To investigate the desired parameters, a single cell is designed and fabricated. Because of the symmetry of the stack and to reduce computational time, only half of the single fuel cell is used to build the model. Fig. 1 illustrates the employed single fuel cell stack model.

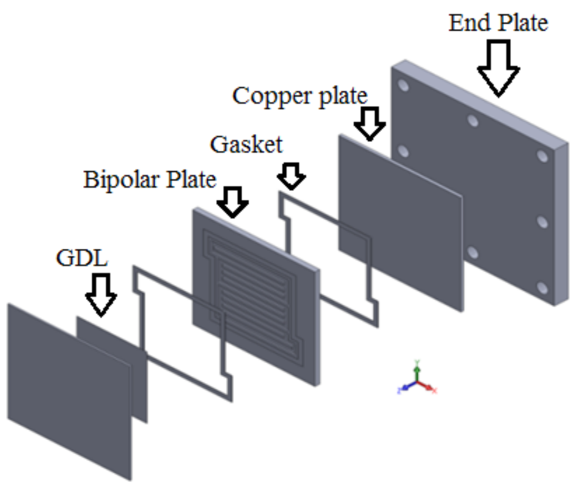


Figure 1. The employed single fuel cell stack model

A commercial code of ABAQUS has been used for simulation. To simplify the model, bolts and nuts are ignored and equivalent compressive pressure is applied directly to the contacting areas of the end plate.

3- Results and Discussion

3- 1- Sealant groove depth between GDL and Bipolar Plate (BP)

In the current study, the effect of various groove depth (0.1 mm and 0.15 mm) and different clamping pressures on the pressure distribution over GDL was investigated. The pressure distribution of the first channel of GDL on different sealant groove depth was shown in Fig. 2.

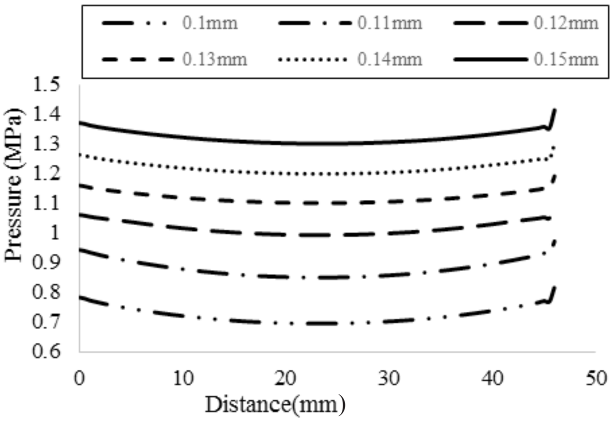


Figure 2. Effect of depth of channel on pressure distribution of GDL

3- 2- The thickness of end plate

The effect of the thickness of end plate on pressure distribution of GDL was also investigated in the current investigation. The thickness of end plate was selected to be 8, 10 and 12 mm. Pressure distribution over GDL for different thicknesses of the end plate, with clamping pressure of 11 MPa and sealant groove depth of 0.11 mm is shown in Fig. 3.

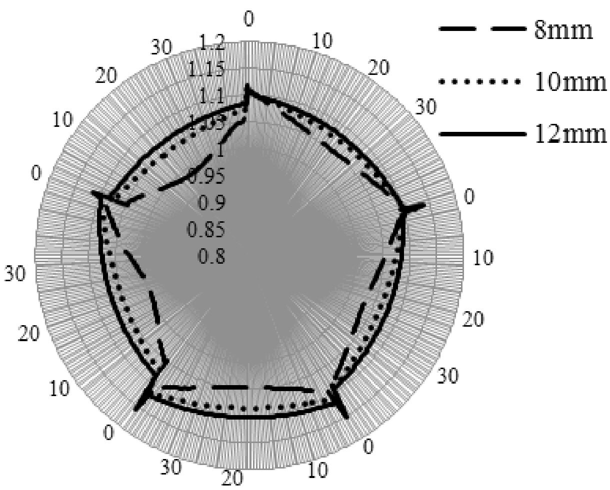


Figure 3. Pressure distribution over GDL for different thicknesses of the end plate.

3- 3- Finding best parameters

Radial Basis Function Neural Network (RBFNN) as an estimator implemented in this article and different numbers of radial functions and dispersions were tested. In the constructed RBFNN, the minimum error reached by the use of 17 radial function with a dispersion of 2.691. The error was 0.0015. Fig. 4 shows the accuracy of the network.

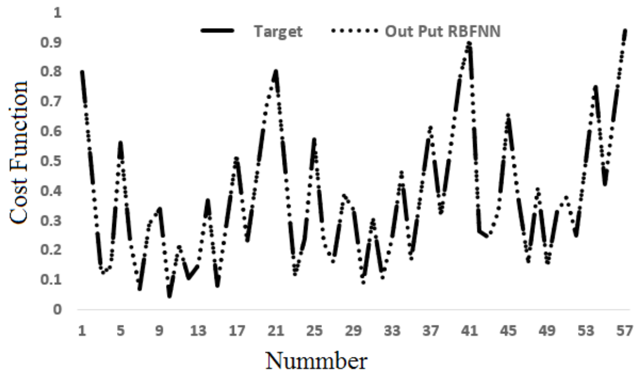


Figure 4. Comparison between deviation in pressure distribution and output of RBFNN.

Finally, the optimum value of parameters was found by the use of both radial basis Function neural network and Bee algorithm. These values are listed in Table 1.

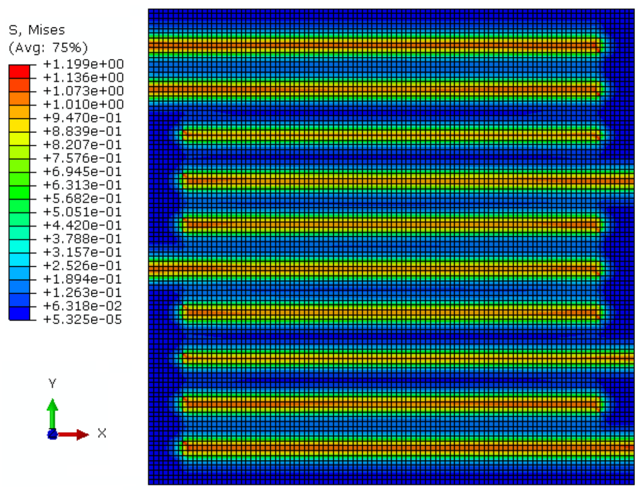
Table 1. The optimum value of parameters

Parameter	Clamping Pressure (MPa)	The depth of the channel (mm)	The thickness of end plate (mm)
Appropriate value	9.8	0.125	8.7

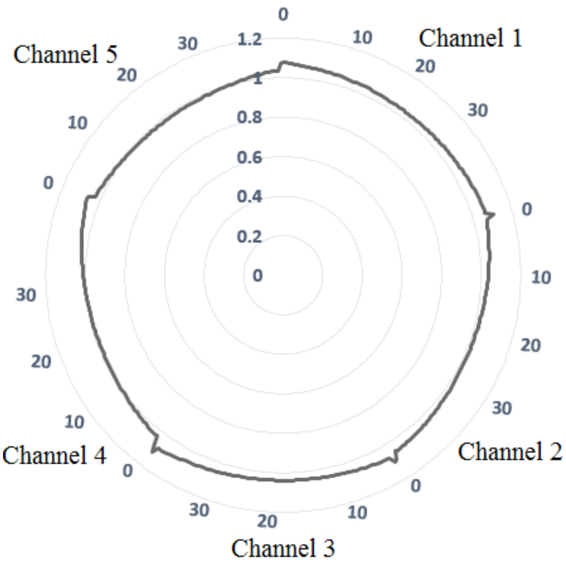
The applied pressure distribution over GDL reached the proper value of 1 MPa. Simultaneously, the pressure over washer attained the suitable value for sealing (minimum value of 2.09 MPa). The stress distribution contour along the first five channels of GDL is shown in Fig. 5. By applying the obtained parameters, a uniform pressure distribution over GDL was achieved.

4- Conclusions

In this research, a minimum stress on the washer to maintain complete sealing was measured. Then the clamping force



(a)



(b)

Figure 5. The stress distribution contour along the GDL base at optimization parameters

was determined in a way that stress reaches a suitable value and proper sealing is achieved simultaneously. Parameters which affect stress distribution over GDL, like thickness of end plate, and sealant groove depth, were investigated. Furthermore, using neural network modeling and optimizing with Bee algorithm, best parameters were acquired to reach a good stress distribution and a minimum weight of the end plate.

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