Fabricate flow channel on conducting polymer composite bipolar plate by machining process

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Keywords: PEMFC bipolar plate; serpentine; interdigitated

ABSTRACT – Bipolar plates are the most important parts in Proton Exchange Membrane Fuel Cell (PEMFC). It plays a huge effect on the performance of PEMFC. Therefore, this research objective is determining the dimensional accuracy of the fabricating flow channel on the surface of bipolar plate types and shapes through the machining process. Therefore, the materials used are Gr/CB/Fe/PP composites. Meanwhile, serpentine and interdigitated types with flow channel shapes of V and U shapes with a width of flow channel of 1 and 2mm have been selected. The accuracy of the fabricated flow channel through machining compared to actual drawing was investigated. Smartscope CNC500 was used to measure specimen dimensions (width, channel length, depth, width and channel length of 2 channels). Based on the result, serpentine and interdigitated specimen with 2mm width delivers better dimension accuracy with 0.1mm margin of error.

1. INTRODUCTION

Polymer Electrolyte Membrane Fuel Cell or Proton Exchange Membrane Fuel Cell (PEMFC) has been identified as a power source for many applications and the development of this sector rapidly expanding from year to year. It is because of PEMFC promising many advantages compared to other fuel cells, such as low temperature operation, quick start up time and dynamic operation capabilities [1]. PEMFC has huge potential to be commercialized because of high energy conversion efficiency and low pollutant emission [2].

In commercialize of PEMFC as energy resources, in involved high cost and durability of PEMFC become main barriers to widespread the commercialization [3]. Bipolar plates were categorized by its flow channel design. The most popular flow channel designs are serpentine and interdigitated flow channel as shown in Figure 1.1. The serpentine flow channel was popular as their pressure drop requirements and water removal rate correlates each other [4-5]. Interdigitated flow channel consists of multiple dead-ended flow channels and it forced gas flow through the adjacent diffusion layer.

Graphite has become major bipolar plate materials due to adequate electrical conductivity, light weight and good corrosion resistance but producing precise flow field channels is difficult and expensive due to brittleness issue [6-7]. Conducting Polymer Composite (CPC) offers better mechanical properties to wind stand stress the force during the machining process. This research aims to investigate the fabrication of flow channel through the machining process while types, width, depth and taper angle of flow channel will be measured and compare with actual drawing.

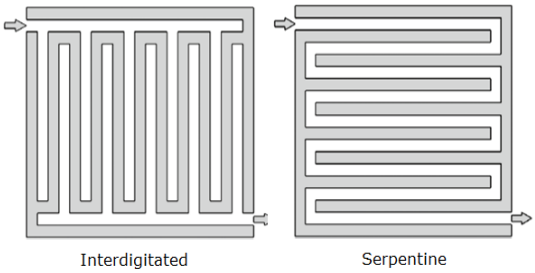

Figure 1.1 Interdigitated and Serpentine flow channel

2. RESEARCH METHODOLOGY

Fabrication of polymer composites: All fillers were mixed by using ball mill machine for $1\frac{1}{2}$ hours. After that, Gr/CB/Fe/PP were further mixed using Haake Poly lab Rheodrive Internal Mixer machine at the temperature of 200° C, rotor speed of 50 RPM and duration time of 15 minutes. After that the mixture was collected and has been pulverized to further refine using Retsch ZM200 Pulveriser. Compression molding method has been chosen to shape the sample and Gotech (GT 7014 – A) hot press machine was used. The temperature has been set at 185°C, pre-heating times is about 10 minutes and pressure has been set at 50 tons and the duration of pressing time is about 10 minutes. After that the mold has been cooled down about 15 minutes before specimen relished from mold.

Flow channel drawing process: Flow channel was drawn by a CAD program. Main parameters have been selected as show in Table 2.1.

Table 2.1 Parameters of flow field design

Parameters of flow channel	Plate
Dimension	50mm x 50mm
Type of flow channel	U Interdigitated & V Serpentine
Width of flow channel	1 mm & 2 mm
Depth of flow channel	0.5mm
Taper angle of flow channel	45°

They are three different designs were drawn, serpentine V with 1mm and 2mm depth and interdigitated

U shape with 2 mm depth. Figure 2.1 shows a CAD drawing for both flow channel design.

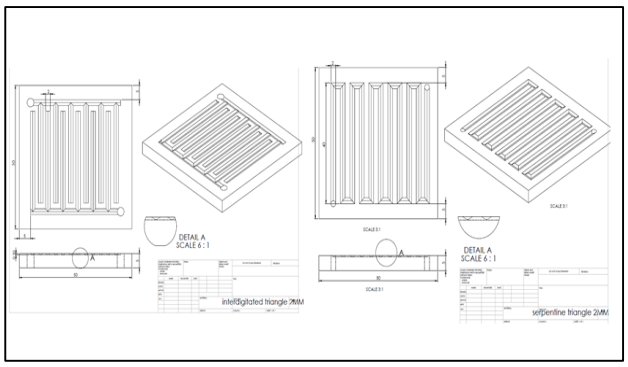

Figure 2.1 CAD drawing for serpentine and interdigitated

Fabrication of flow channel by machining: The machining process of flow channel for U and V shapes on the surface of plate was used Bridgeport Model GX 710 with spindle speed of 4000 RPM and feed rate of 400.

Measurement Test: The specimens were measured to determine the dimension parameters. Smartscope CNC500 was used to measure specimen dimensions (length, depth, width, etc.) and shown on Figure 2.2.

Figure 2.2 Smartscope CNC500

3. RESULTS AND DISCUSSIONS

Serpentine V shape: Figure 3.1 shown serpentine flow channel type specimens. Both specimens are serpentine V shape with 45^0 draft angles with 2 mm and 1mm channel width.

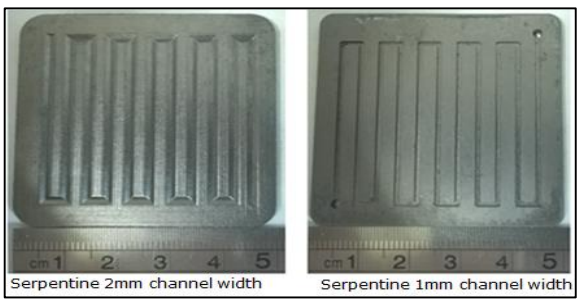

Figure 3.1 Serpentine V shape flow channel specimens

Interdigitated U shape: Figure 3.1 shows the interdigitated flow channel with 2 mm channel width.

Figure 3.1 Interdigitated U shape flow channel

Measurement Test Result: There are 4 dimensional points which are 1 up to 4 were measured and recorded using Smartscope. While Table 2 shows measured value of dimension versus drawing.

This Table 3.1 shows that V shape serpentine and U shape interdigitated specimens with 2mm channel produced by machining process have a better dimension accuracy than serpentine with 1mm channel width.

Table 3.1 Specimen Measurement vs Drawing

No	Point of Dimensions	Drawings (mm)	Serpentine				Interdigitated	
			1 mm channel		2 mm channel			
			Specimen	Different	Specimen	Different	Specimen	Different
1	Width	50	49.97	0.03	50.096	-0.096	49.919	0.081
2	Channel Width 1	1 or 2	1.267	-0.267	1.946	0.054	2.034	-0.034
3	Channel Width 2	1 or 2	1.374	-0.374	1.919	0.081	2.022	-0.022
4	Channel Depth	0.5	0.556	-0.056	0.41	0.09	0.651	-0.151

4. CONCLUSIONS

As a conclusion, Conducting Polymer Composite (CPC) consist of Gr/CB/Fe/PP composites is suitable to go thru the machining process due to its good mechanical properties to wind stand the stress force during the machining process. Serpentine and interdigitated specimen with 2mm width delivers better dimension accuracy with 0.1mm margin of error.

ACKNOWLEDGEMENTS

The authors would like to thank the Malaysia Ministry of Higher Education, Malaysia and Ministry of Science, Technology and Innovation for sponsoring this work under Grant FRGS(RACE)/2013/FKM/TK2/2 F00203 and Universiti Teknikal Malaysia Melaka (UTeM) for financial sponsoring during this research.

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