FUEL CELL RESEARCH & DEVELOPMENT GROUP
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ADVANCES IN FUEL CELL RESEARCH AND DEVELOPMENT IN MALAYSIA 2004

EDITORS

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Preface

Advances in Fuel Cell Research and Development in Malaysia are series of proceedings of a seminar annually conducted by Fuel cell Research Groups in Universiti Kebangsaan Malaysia (UKM) and Universiti Teknologi Malaysia (UTM) to present and evaluate the progress taking place in fuel cell program launched in 2002. The first seminar was held on 27-30 June 2003 at Port Dickson was organized by UKM fuel cell research group and the papers presented were compiled in the 1st proceedings volume entitled "Advances in Malaysian Fuel Cell Research and Development 2003" Published by UKM 2003.

The current proceedings volume consists of papers presented at the 2nd seminar on Advances in Fuel Cell Research and Development in Malaysia 2004, which was held at Renaissance Hotel, Melaka, on 3-5 December 2004. The seminar is organized by Fuel Cell Research Group at UTM.

The proceedings contain 40 papers divided into three sections: polymer electrolyte membrane (PEM) fuel cell, hydrogen production and storage system, and PEM fuel cell applications. The first section covers the development of PEM fuel cell components including proton conducting membranes, membrane electrode assemblies and bipolar plates in addition to simulation of fuel cell stack. The hydrogen production section covers production of hydrogen from methanol and natural gas and by using solar energy. It also covers papers on the development of hydrogen storage system based on carbon nanotubes. The last section deals with PEM fuel cell applications including bus air-conditioning system and vehicle (scooter).

The papers were submitted in camera-ready form, which limited the amount of possible editing. The policy of editing was that the content of the material and its rapid dissemination was more important than its form. Even though misspellings and grammatical errors were corrected, there was no attempt to revise the material to correct solecisms.

The editors would like to thank to the authors for their contributions, patience in following the manuscript preparation guidelines and the care they took in preparing their work. Special thanks are also due to the organizing committee members for their commitment, patience and hard work to make this seminar a successful event.

The editors also would like to take this opportunity to thank Malaysian Ministry of Science, Technology and Innovation (MOSTI) for financing the Research and Development program of PEM fuel cell through the IRPA mechanism.

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CONTENTS

... Fuel Cell Research and Development in Malaysia, pp. 8-15.

Editors: Hamdani Saidi, Mohamed Mahmoud Nasef, and Inayati

THE MANUFACTURING STUDY OF MEMBRANE ELECTRODE ASSEMBLY APPLYING SPRAYING TECHNOLOGY

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ABSTRACT

The MEA layer manufacturing of PEM fuel cell requires an instrument that can design an appropriate layer. The sprayer in this experiment can yield various sizes of thickness, pore diameter, porosity and activated specific suface area of electrode layers. The configuration coating on substrate is a periodic function and layer sizes can be performed with characteristic number robotic sprayer. From experimental results, the characteristic number of robotic sprayer is to be unity which improves the electrode performance. This characteristic number can be utilised as the method for MEA design manufacturing.

1. INTRODUCTION

One of the important processes in MEA engineering is to manufacture various designs. Among those designs the best one will be determined and will be manufactured. In manufacturing PEMFC there are eleven layers involved in the design and manufacture. The sequence of those layers are the bipolar plate (BP), gas flow field (FF), gasket (G), gas diffusion layer (GDL), electrode (E), and membrane (M). This layer configuration is the BP-FF-G-GDL-E-M-E-GDL-G-FF-PP [1-19]. The membrane electrode assembly (MEA) part consists of 5 layers i.e. *GDL-E-M-E-GDL* and recently it has been developed to 6 layers, named as MEGA or G-GDL-E-M-E-GDL-G. The designing and manufacturing of gas flow field PEMFC have been fast developed and manufactured applying CNC instrument. The MEA design will develop continuously to improve the performance of PEMFC. The basic principle for designing MEA is the nanotechnology therefore it requires a very sensitive instrument such as the vacuum plasma spray coating, vacum atomizing and sputtering. This project introduces a spray robotic instrument with x-y axis configuration to manufacture the MEA design. The form of MEA layer which can be produced by this sprayer will follow the periodical function while the layer size included thickness, porosity, pore diameter, activated specific surface area are described by their spraying characteristic values.

2. THE SPRAYING CHARACTERISTICS

The type design of a sprayer is a robotic sprayer which a nozzle type with its feed pressure, fluid nozzle orifice of 0.5 mm, maximum spray distance of 200 mm, and automizing air of maximum pressure of 6 kgf/cm2. The robot used in this system employs a specific pattern expression of the x-y configuration. The spray variable is expressed by its frequency (ω), nozzle height (W_1), distribution distance (W_2), division number of spray coating line on substrate (N) and nozzle velocity (S) [22]. The spray direction coating process is designed to be orthogonal to substrate. If the nozzle height *W1* is linearly proportional to Δx, *W1* is designed to be linearly proportional with *W2* and supposed the N_{ukm} is known as the characteristic number of robotic sprayer , therefore the N_{ukm} calc is described in equation (1).

$$N_{ukm} = \frac{S - 2\omega Sy}{2\omega W_1} \qquad (1)$$

Based on equation (1), the CAD is designed to possess the dimensions of x, y, N, S and W_1 level. The nozzle position on x-y axis is generated on the CAD system according to N_{ukm} parameter. The spray coating consists of the nozzle position and a control code. The control code has a value corresponding to the desired substrate condition [21, 22, and 23].

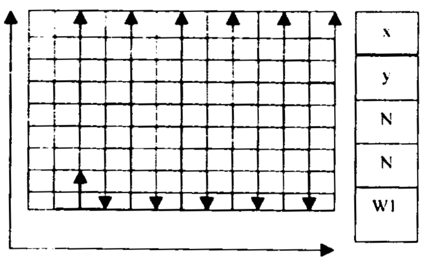

Figure 1. CAD of workpiece

The research in MEA layer designing includes two steps, the first step is the spraying characterization and, the second step is the MEA designing and manufacturing. The effect of N_{ukm} on electrode layer size is demonstrated in fig 2. From fig 2 the electrode thickness on the surface of GDL can be determined. When we observe the distribution of data point (N_{ukm},t_e) there are many choices in determining the electrode thickness which in agreement with the results as described in journals [1-19].

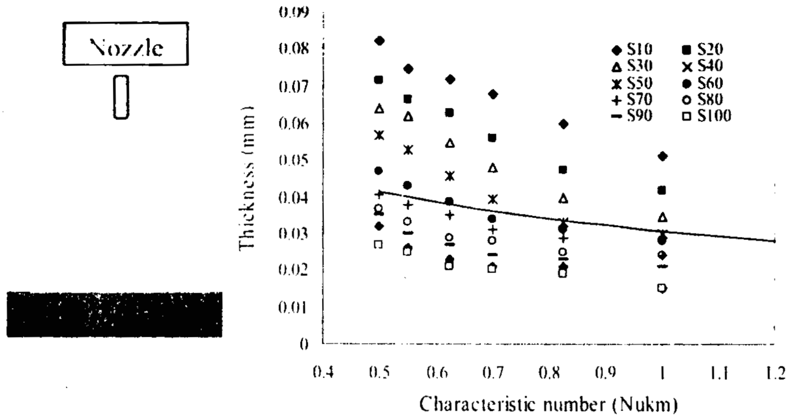

Figure 2. The effect of characteristic number on electrode thickness

On the other side we obtain the interdependent of sizes, i.e. t_c, d_p, ε, a_s which each other will be correlated with the value of N_{ukm}. The larger the value of N_{ukm}, the smaller the value of t_c while d_p, ε and a_s will be larger. This condition indicates that when one of the sizes is measured so the other sizes have to be fixed. So far the charactéristic sprayer can only be adjusted for determining the layer thickness. Those interdependents are described in equation (2) to (5).

$$t_c = 2.572.10^{-5}\,N_{ukm}^{0.59}\text{, m} \quad \text{.............................(2)}$$

$$d_p = 3.87.10^{-7}\,N_{ukm}^{0.23}\text{, m} \quad \text{.................................(3)}$$

$$\varepsilon = 0.7236\,N_{ukm}^{0.43} \quad \text{...(4)}$$

$$a_s = 3.84.10^{5}\,N_{ukm}^{0.0944}\text{, m2/m3} \quad \text{...........................(5)}$$

3. THE MEA MANUFACTURING

Fig.3 illustrates the commercial MEA design. Increasing N_{ukm} value will yield higher current density of PEM fuel cell. The current density value is increased from 450A/m2 to 620 A/m2. Using the design as described in this investigation the results are shown in figure 4.

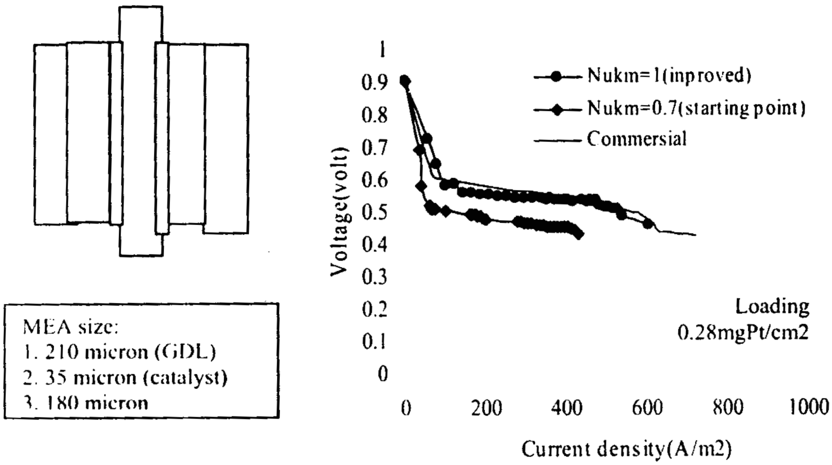

Figure 3. The performance of PEM fuel cell design

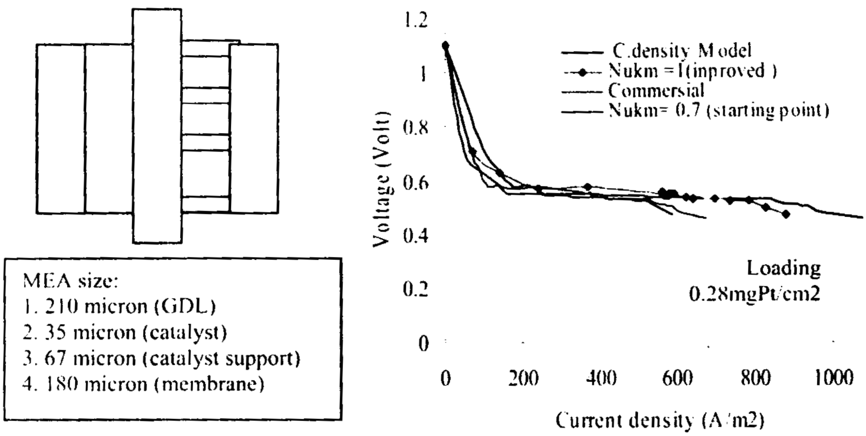

Figure 4. The performance of PEM fuel cell design

At the starting point of MEA experiment, the N_{ukms} is to be 0.7 and yields current density of PEM fuel Cell around 600 A/cm2. When N_{ukm} is to be unity, the PEM fuel cell yields current density of 850 A/cm2. This means that if the electrode on the GDL surface is made thiner, the higher current density will be obtained. This examination yields an increase in current density as large as 41.6%. This increement is high enough, thus the N_{ukm} will be unity which can be used for electrode layer manufacturing on the GDL surface.

4. CONCLUSION

The increment in spraying characteristic values will yield an improvement in the PEM fuel cell performance. From experimental results, the value of N_{ukm} is to be unity which improves the electrode performance as large as 41.6%. This facts finding can be utilised as the method for MEA design manufacturing.

NOTATION:

a_s	= activated specific surface area, m2/m3	v	= ink velocity, m/h
d_p	= pore diameter, m	$W1$	= nozzle height, m
N	= devision number	$W2$	= ink distribution width, m
N_{ukm}	= robotic sprayer number	X, Y	= coordinat of substrate, m
p	= pressure, bar	μ	= viscosity, cp
R_e	= Reynold number	ε	= porosity
S	= nozzle speed, m/h	ω	= frequency, 1/s
t_c	= thickness, m		

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