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OPTIMISATION OF PROCESSING PARAMETERS OF TITANIUM ALLOY FOAMS USING TAGUCHI METHOD FOR IMPROVED ELECTRICAL CONDUCTIVITY

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1.0 INTRODUCTION

Metal foam has many beneficial physical and mechanical properties. These properties are from high impact energy absorption, high stiffness and strength to weight ratios, high gas permeability, and finally to high thermal conductivity. There are several applications of open-celled metal foam which are widely used as lightweight constructional materials, architectural materials, impact absorbers, silencers, filters, heat exchangers and implants. Metal and metal alloy foams containing up to 95% porosity are being explored for many applications. They offer many potential benefits for components that operate in extreme environments and at temperatures where conventional polymeric foams cannot be used (Degischer & Kriszt 2002). They also promise cost advantages over conventional lightweight honeycomb structures and rib-stiffened panels used in many aerospace and ship structures (Toru 2007).

2.0 METHOD

Initially, PEG and CMC are stirred in deionised water for one hour. Titanium alloy powder is subsequently added to the solution and stirred for two hours. The titanium alloy slurry is used to impregnate the PU foam. The PU foam is dipped into the slurry and the dipping and drying processes are repeated until the struts of the foam are completely coated with the titanium slurry. The excess slurry is then removed by pressing the foam under a roller.

The samples are dried in the oven for 24 hours at 30°C. After the sample is completely dried, the PU is removed from the matrix by heating it at 600°C for 60 minutes. Subsequently, the samples are sintered at 1250°C with a holding time of two hours. The rate for heating is 1°C/min.

3.0 RESULTS

Table 1 Experiment layout and electrical conductivity of titanium alloy foams

no. run	A	B	C	D	R1	R2	R3	sum	average
1	0	0	0	0	324.12	232.75	345.42	902.29	300.7633
2	0	1	1	1	205.94	414.54	630.93	1251.41	417.1367
3	0	2	2	2	301.51	530.63	685.2	1517.34	505.78
4	1	0	1	2	545.79	590.96	409.78	1546.53	515.51
5	1	1	2	0	329.13	358.02	319.66	1006.81	335.6033
6	1	2	0	1	407.68	455.6	366.63	1229.91	409.97
7	2	0	2	1	1006.22	750.83	644.6	2401.65	800.55
8	2	1	0	2	692.91	945.38	921.7	2559.99	853.33
9	2	2	1	0	1095.47	835.47	699.83	2630.77	876.9233

Table 2 ANOVA for electrical conductivity of titanium alloy foams

	DOF	ss	varience	F test	pure ss	percent
A	2	1107386	553693	25.996	1064787	66.03663
B	2	21953.22	10976.61	0.515	-20645.7	0
C	2	31479.77	15739.89	0.739	-11119.1	0
D	2	68210	34105	1.601	25611.12	1.588366
e	18	383389.9	21299.44			32.375
total	26	1612419				100

*significant at 99% significance level (6.0129)

From the Analysis of Variance (ANOVA), the composition of titanium powder has the highest percentage of contribution (25.996) to the electrical conductivity followed by the soaking time (1.601). The optimum electrical conductivity was found to be 997.367 ± 126.54 S/cm^{-1} for this titanium foam. It was achieved with a 70% composition of titanium, sintering temperature of 1250°C, a heating rate of 0.5°C/min and 2 hours soaking time. Confirmatory experiments have produced results that lay within the 90% confidence interval.

4.0 CONCLUSION

Titanium alloy foam has been successfully produced by the slurry method without inducing oxidation on the samples. The titanium alloy foam shows a good electrical conductivity and it suitable to make a bipolar plate for Polymer Electron Membrane Fuel Cell (PEMFC). The sintering process is found to play a critical part in forming the titanium alloy foam. For further research, the focus is to produce the stack for the PEMFC application.

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REFERENCE

H. P. Degischer and B. Kriszt, Handbook of Cellular Metals: Production, Processing, Applications, Wiley-VCH, pp 22-23, 2002.

S. Toru, "Production of High Porosity Metal Foams using Foamed Polysyrene Sphere"Accessed April 18, 2007.