UNIVERSITI PUTRA MALAYSIA

PROPERTIES OF TITANIUM CARBIDE REINFORCED ALUMINIUM SILICON ALLOY MATRIX

M. SAYUTI

PROPERTIES OF TITANIUM CARBIDE REINFORCED ALUMINIUM SILICON ALLOY MATRIX

By

M. SAYUTI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

May, 2012

In the Memory of

My Father, Allahyarham Fadhil Aziz

And

Special Dedication to

My Mother
Hj. Cut Nurlaila

My Wife
Cindenia Puspasari

And

My Children :
Nyak Intan Fadhilati
Nyak Qurratu Aini
and Ibnu Sina

M. Sayuti
2012

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfillment of the requirement for the degree of Doctor of Philosophy

PROPERTIES OF TITANIUM CARBIDE REINFORCED ALUMINIUM SILICON ALLOY MATRIX

By

M. SAYUTI

May 2012

Chairman : Professor Shamsuddin Sulaiman, PhD

Faculty : Engineering

Metal matrix composites are engineered materials which are a combination of two or more materials, one of which is a metal, whose tailored properties can be attained by systematic combination of different constituents. From a variety of methods available for producing these advanced materials, the conventional casting process is considered as the easiest processing technique. Preparation of these composite materials by foundry technology has the unique benefit of near-net shape fabrication in a simple and cost effective manner. Besides this, casting processes lend themselves to manufacture large number of complex shaped components of composites at a faster rate required by the automotive, aerospace, sports and other consumer oriented industries. Several methods have been developed to control the microstructure of composites during solidification including mechanical vibration, electromagnetic vibration, electromagnetic stirring and semi-solid processing. It is established that

mechanical mould vibration can significantly enhance the structure and properties of composites. In this study, titanium carbide particulate reinforced aluminiums 11,8 wt% silicon alloy matrix composites were fabricated by carbon dioxide sand moulding process by varying the particulate addition by weight fraction on percentage basis using mechanical vibration mould. The influence of a wide range of vibration amplitudes and frequencies on the solidification kinetics, microstructure formation and mechanical properties of Titanium carbide reinforced aluminiums 11,8 wt% silicon alloy were examined. Results show strong influence of mould vibration during solidification on the fabricated composites. The mechanical properties such as tensile strength, impact strength, surface hardness and physical properties such as density, thermal conductivity were significantly increased as a result of mould vibration. The maximum tensile strength is 141.125 MPa with vibration and 135.832 MPa without vibration. The maximum impact energy is 15.073 kJ with vibration and 14.514 kJ without vibration and hardness value based Rockwell superficial 15N-S scale is 85.88 for 2% without vibration and 86.08 with vibration. In addition, the change in microstructure and mechanical properties were successfully represented by the changes in solidification characteristics. Various vibration frequencies have reduced the lamellar spacing that changes the microstructure of the composites which as a result became more fibrous. The corresponding changes in mechanical properties indicate that ductility is more influenced by vibration than without vibration. The increase in ductility was believed to be due to the structural refinement.

Abstrak tesis dikemukakan kepada senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

CIRI TITANIUM KARBIDA DIPERKUKUH ALOI ALUMINIUM SILIKON MATRIK

Oleh

M. SAYUTI

Mei 2012

Pengurusi : Profesor Shamsuddin Sulaiman, PhD

Fakulti : Kejuruteraan

Komposit metal logam kejuruteraan bahan-bahan ini merupakan gabungan dua atau lebih bahan-bahan, satu daripadanya adalah logam yang ciri terbentuk boleh dicapai oleh gabungan sistematik dengan unsur-unsur yang berbeza. Dari pelbagai kaedah yang ada untuk menghasilkan bahan-bahan termaju ini, proses penuangan konvensional dianggap sebagai teknik pemprosesan yang paling mudah. Penyediaan bahan-bahan komposit oleh technologi faundri mempunyai manfaat unik fabrikasi bentuk berhampiran dengan cara yang mudah dan kos yang berkesan. Di samping itu proses penuangan menjadikan ianya boleh mengeluarkan sejumlah besar komposit komponen kompleks pada kadar yang lebih cepat yang diperlukan oleh industri automotif, kapal terbang, sukan dan yang berorientasikan pengguna. Beberapa kaedah telah dibangunkan untuk mengawal mikrostruktur komposit semasa pemejalan termasuk getaran mekanikal, getaran elektromagnet, kacau elektromagnetik dan pemprosesan

separa pepejal. Ia dibentuk dimana getaran acuan mekanikal dengan ketara boleh meningkatkan struktur dan sifat-sifat komposit. Dalam kajian ini, titanium karbida zarah diperkukuh dalam silikon aluminium 11.8wt% komposit matriks aloi yang dibentuk oleh acuan karbon dioksida pasir dengan mengubah penambahan zarahan oleh pecahan berat berdasarkan peratusan menggunakan acuan getaran mekanikal. Pengaruh pelbagai amplitud getaran dan frekuensi kinetik pemejalan, pembentukan mikrostruktur dan sifat-sifat mekanik zarah titanium karbida diperkukuh silikon aluminium 11.8wt% komposit matriks aloi telah diuji. Keputusan menunjukkan pengaruh yang kuat getaran acuan semasa pemejalan komposit yang direka. Sifat-sifat mekanikal seperti kekuatan tegangan, kekuatan hantaman, kekerasan permukaan dan sifat-sifat fizikal seperti kepadatan, kekonduksian terma dengan ketara meningkat akibat getaran acuan. Kekuatan tegangan maksimum iyalah 141.125 MPa dengan acuan getaran dan 135.832 MPa tanpa getaran. Kekuatan hantaman adalah 15.073 kJ dengan acuan getaran dan 14.514kJ tanpa getaran dan kekerasan Rockwell skala 15N-S adalah 85.88 untuk 2% tanpa getaran dan 86.08 dengan acuan getaran. Di samping itu, perubahan mikrostruktur dan sifat mekanik telah dihasilakan dengan jaya diwakili oleh perubahan dalam ciri-ciri pemejalan. Getaran pelbagai telah mengurangkan jarak lamela bahawa perubahan mikrostruktur komposit menjadi lebih bergentian. Perubahan yang sama dalam sifat-sifat mekanik menunjukkan bahawa kemuluran adalah lebih dipengaruhi oleh kekerapan getaran daripada tanpa getaran. Peningkatan dalam kemuluran dipercayai disebabkan oleh penghalusan struktur.

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APPROVAL

I certify that a Thesis Examination Committee has met on May 24, 2012 to conduct the final examination of M. Sayuti on his thesis entitled "Properties of Titanium Carbide Reinforced Aluminium Silicon Alloy Matrix" in accordance with the Universities and University College Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Doctor of Philosophy. The Members of the Supervisory Committee were as follows:

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Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universisiti Putra Malaysia or other institution.

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M. SAYUTI
Date: 24 May 2012

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