INVESTIGATION OF SURFACE METAL MATRIX COMPOSITES OF REINFORCED ALUMINIUM ALLOY PRODUCED USING FRICTION STIR PROCESSING

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I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Science

Faculty of Manufacturing & Mechatronic Engineering Technology

UNIVERSITI MALAYSIA PAHANG

AUGUST 2020

ACKNOWLEDGEMENTS

In the name of Allah, the Most Merciful, the Most Compassionate.

Praise to Allah the Almighty God for His blessing, finally this research is successfully completed.

I also take this opportunity to say highly thanks especially to my supervisor, Dr. Nanang Fatchurrohman for support, contribution and supervision throughout this research.

Special thank to all my colleagues and staff members of Faculty of Manufacturing and Mechatronic Engineering Technology of University Malaysia Pahang and Central Laboratory of University Malaysia Pahang, SIRIM Malaysia Berhad, BERNAS Malaysia as well as for those who had involved directly or indirectly for cooperation and support from the beginning until the end of this research.

I would like to record my gratitude to my parent and family members who are always praying and support for my successful life.

I had achieved a lot of valuable knowledge and experiences during this journey.

Thank you, Allah. Thank you to all. May Allah bless us.

ABSTRAK

Aloi aluminium mempamerkan ciri-ciri yang diperlukan dalam pelbagai aplikasi. Bagaimanapun, aloi aluminium akan mempamerkan ciri-ciri tribologi yang lemah untuk jangka masa yang tertentu. Pelbagai kajian telah dijalankan bagi menambahbaik sifat di permukaan aloi aluminium disamping mengekalkan sifat teras aloi aluminium. Proses lakuran dan penuangan telah diperkenalkan untuk menambahbaik sifat permukaan aloi aluminium. Akan tetapi, proses ini melibatkan takat suhu yang tinggi di mana mengakibatkan kebolehbasahan zarah seramik tidak dapat berlaku. Kajian tesis ini betujuan mengkaji pengubahsuaian ke atas lapisan permukaan aloi aluminium AA6061 menggunakan proses geseran teraduk (FSP). Pengubahsuaian ke atas AA6061 telah dilakukan tanpa dan bersama bahan tetulang yang mana masing-masing dinamakan FSPed AA6061 bagi tiada bahan tetulang dan AA6061/RHA bagi berserta bahan tetulang. Abu sekam padi (RHA) telah digunakan sebagai bahan bertulang dengan komposisi 6 vol.%. RHA merupakan zarah seramik yang mengandungi tinggi kandungan silika (SiO_2). Dalam kajian ini, proses FSP dijalankan pada pada kelajuan perjalanan tetap 25 mm/min dengan beberapa kelajuan putaran berbeza pada 1000, 1200, 1400, 1500 dan 1600 rpm menggunakan alat FSP dari perkakas silinder kuar. FSP telah digunakan bertujuan untuk memperhalusi struktur butir seterusnya menambahbaik sifat mekanikal serta perlakuan tribologi AA6061. Pemeriksaan mikroskop menggunakan mikroskop optik (OM) menemukankan FSP memperhalusi saiz butir serta bahan tetulang yang berjaya ditemukan di dalam aloi. Sifat mekanikal aloi terutama kekerasan mikro diuji dan dibandingkan. Nilai purata kekerasan mikro menyusut berdasarkan tokokan kelajuan putaran FSP direkodkan bagi kedua-dua FSPed AA6061 dan FSPed AA6061/RHA. Walau bagaimanapun, dengan menggunakan FSP, sifat mekanikal pada FSPed AA6061 dan AA6061/RHA telah ditambahbaik berbanding AA6061 adalah disebabkan oleh saiz butir AA6061 diperhalusi dan kehadiran RHA di dalam AA6061 meningkatkan lagi kekerasan mikro. Adalah didapati bahawa perlakuan haus ditambahbaik untuk FSPed AA6061/RHA berbanding FSPed AA6061 diikuti oleh AA6061. Sementara itu, pemerhatian di bawah pengimbasan mikroskop elektron (SEM) telah mendapati bahawa mekanisma haus telah berubah dari haus perekat ke haus lelas. Selain itu, dari sinar-dispersif tenaga (EDX) menunjukankan kehadiran RHA di dalam AA6061 membuktikan bahawa RHA membantu dalam memperbaiki mekanikal dan perlakuan haus FSPed AA6061 dan AA6061 itu sendiri.

ABSTRACT

Aluminium alloy demonstrates promising excellent properties in many applications. However, aluminium alloy exhibits poor tribological behaviour in some extends. Studies have developed for surface modifications of aluminium alloy in order to alter the surface properties while maintaining the properties of the core. Fusion route and casting methods have been developed to improve the surface properties of aluminium alloy. However, these methods deal with high temperatures that lead to poor wettability of ceramic particle during the process. This research is aimed to investigate the surface modification of aluminium alloy, AA6061 using friction stir processing (FSP). The surface modification of was done on non-reinforced aluminium alloy and reinforced aluminium alloy, namely FSPed AA6061 and FSPed AA6061/RHA, respectively. Rice husk ash (RHA) was used as reinforced material with composition of 6 vol.% . RHA is a ceramic particle which contains high level of silica (SiO_2). In this research, FSP was performed at a constant travel speed of 25 mm/min and different rotation speeds were varied at 1000, 1200, 1400, 1500 and 1600 rpm using a probe cylindrical tool. FSP was used as an approach to refine and enhance the mechanical properties and the tribological behaviour of AA6061. A microscopic examination was done using an optical microscope (OM) and revealed that FSP refined the grain size and the reinforced material is successfully held within the alloy. The mechanical properties of the alloys particularly the microhardness, were tested and compared. The average microhardness value decreased as the FSP rotational speed recorded for both FSPed AA6061 and FSPed AA6061/RHA were increased. However, by using FSP, the mechanical properties of FSPed AA6061 and FSPed AA6061/RHA have improved compared to AA6061. This significance was due to grain refinement of AA6061 and the presence of RHA within the AA6061. It was found that wear behaviour has improved for FSPed AA6061/RHA compared to FSPed AA6061 followed by AA6061. Meanwhile, observation under a scanning electron microscope (SEM) has found that the wear mechanism changed from adhesive wear to abrasive wear. Furthermore, based on the energy-dispersive X-ray spectroscopy (EDX) remark, the presence of RHA within the AA6061 proved that RHA helps to improve the mechanical and wear behaviour of FSPed AA6061 followed by AA6061 itself.

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LIST OF SYMBOLS

ρ	Density

LIST OF ABBREVIATIONS

MMC	Metal matrix composite
AMC	Aluminium matrix composite
AA	Aluminium alloy
RH	Rice husk
RHA	Rice husk ash
FSP	Friction stir processing
FSW	Friction stir welding
XRF	X-ray fluorescent
OM	Optical microscope
SEM	Scanning electron microscope
EDX	Energy-dispersive X-ray spectroscopy
ASTM	American Society for Testing Materials
MML	Mechanically mixed layer

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