EFFECT OF DEPOSITION OF NANOPARTICLES DURING JOINING OF DISSIMILAR METALS BY FRICTION STIR WELDING

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LIST OF ABBREVIATIONS

AA	Aluminium Alloy
Al_2O_3	Aluminium oxide
ASTM	American society of testing materials
Cu	Copper
EDM	Electrical Discharge Machining
EBW	Electron Beam Welding
EDX	Electron dispersive X-ray analysis
FESEM	Field emission scanning electron microscope
FSW	Friction Stir Welding
FSP	Friction Stir Processing
GTAW	Gas tungsten arc welding
HAZ	Heat affected zone
HSS	High Speed Steel
Hv	Hardness Vickers
MPa	Megapascal
MWCNT	Multi-walled carbon nanotubes
NC5T	Numerical Control 5Tons
NZ	Nugget zone
Rpm	Revolutions per minute
SEM	Scanning electron microscope
SZ	Stir Zone
TiO_2	Titanium dioxide
TMAZ	Thermo-mechanically affected zone

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ABSTRAK

Kimpalan Geseran Berputar atau lebih tepat lagi '*Friction Stir Welding*' (FSW) adalah proses pencantuman bahan pepejal, ricih-panas di mana alat yang berputar dengan pin bergerak di sepanjang permukaan dua kepingan plat yang dilekatkan pada plat penyokong. FSW telah berkembang sebagai teknik alternatif untuk aluminium dan mendapat perhatian penyelidikan pada aloi yang boleh dikimpal secara bukan konvensional, yang boleh meningkatkan kekuatan kimpalan apabila dibandingkan dengan proses kimpalan biasa. Kajian terdahulu mengenai pencantuman logam yang sama dan berbeza sifatnya dengan kimpalan secara membezakan parameter proses untuk mengenal pasti perubahan pada sifat-sifat mekanikal kimpalan boleh dilihat dalam literatur. Dalam kajian terdahulu seseorang dapat mencari nilai optimum parameter proses sama ada untuk pencantuman aloi yang sama atau berbeza sifatnya. Komposit yang dihasilkan oleh proses FSW didapati dapat meningkatkan sifat mekanikal bahan. Kekuatan pencantuman melalui kimpalan dapat dipertingkatkan lagi dengan memasukkan bahan tambahan ke dalam matriks logam semasa kimpalan secara FSW dilakukan. Oleh itu, terdapat keperluan untuk mengkaji pencantuman aloi aluminium yang berbeza sifatnya dengan memasukkan bahan tambahan iaitu nanopartikel semasa FSW dilakukan. Justeru, penyelidikan ini dijalankan bertujuan untuk mengkaji kesan pencantuman aloi aluminium yang berbeza sifatnya dengan memasukkan bahan tambahan iaitu nanopartikel. Eksperimen telah dijalankan pada aloi aluminium yang mempunyai kekuatan sederhana iaitu jenis AA5052 dan AA6063. Kesan tambahan nanopartikel tembaga terhadap kekuatan pencantuman menggunakan FSW telah dikaji. Selain itu, untuk memahami kesan tambahan nanopartikel ini, kajian juga dilakukan terhadap aloi aluminium kekuatan tinggi iaitu AA2024 dan AA7075 dengan memasukkan bahan tambahan seperti nanotube karbon pelbagai-dinding, titanium dioksida dan aluminium oksida dengan pelbagai parameter proses. Sifat-sifat mekanikal pencantuman yang dikimpal sama ada menggunakan atau tanpa menggunakan nanopartikel dinilai yang mana ia berkaitan dengan kajian mikrostruktur oleh mikroskop optik. Dapatan menunjukkan ada peningkatan dalam sifat mekanikal disebabkan oleh penambahan nanopartikel pada pencantuman yang dibuat, berbanding dengan pencantuman yang dilakukan tanpa penambahan nanopartikel. Kekuatan tegangan dan kekuatan mikro pencantuman yang dikimpal meningkat sebanyak 8.01% dan 23.7% pada 90 mm / min, berbanding dengan pencantuman melalui kimpalan tanpa nanopartikel CNT untuk aloi aluminium kekuatan tinggi yang berbeza sifatnya. Situasi perubahan terhadap proses pencantuman ini seterusnya disokong oleh kajian analisis X-ray Dispersive Electron (EDX), yang memberikan maklumat pengenalan unsur dan maklumat komposisi kuantitatif. Adalah didapati bahawa pengedaran nanopartikel dipengaruhi oleh saiz alur dan sifat mekanikal ditingkatkan dengan alur lebar 1 mm. Dapatan juga menunjukkan bahawa peningkatan peratusan maksimum kekuatan dan kekuatan mikro untuk sampel dengan nanopartikel CNT adalah sekitar 6.59% dan 20%. Peningkatan kekuatan dan kekerasan lebih banyak apabila menggunakan nanopartikel TiO_2. Oleh itu, dengan mengawal parameter proses dan saiz alur, pengedaran nanopartikel dan sifat mekanikal pencantuman yang dikimpal dapat ditingkatkan dengan berkesan, tetapi berubah-ubah bergantung kepada jenis bahan tambahan yang digunakan semasa proses FSW dilakukan.

ABSTRACT

Friction stir welding (FSW) is a solid–state, hot–shear joining process in which a rotating tool with a pin moves along the butting surfaces of two rigidly clamped plates placed on a backing plate. FSW has evolved as an alternative joining technique for aluminium and is gaining research importance on non-conventional weldable alloys, which improves the strength of the welded joint when compared to the fusion welding process. The earlier research studies on joining of similar and dissimilar metals by varying process parameters to identify change in mechanical properties of weldments can be seen in the literature. In all the studies reported earlier, one can find optimized values of process parameters either for similar or dissimilar alloy joints. Also the composites produced by friction stir processing enhance the mechanical properties of the material. The strength of the welded joint can be further enhanced by the addition of reinforcements into the metal matrix during friction stir welding. Hence, there is a necessity to study the joining of dissimilar aluminium alloys by depositing the nano particles during the friction stir welding. With this motive, the present research aims out to study the effect of dissimilar aluminium alloy joints by depositing nano particles. Experimentation has been carried out on medium strength aluminium alloys AA5052 and AA6063.The effect of copper nanoparticles addition on the strength of welded joint has been studied during friction stir welding. Further, in order to understand the influence of nanoparticles deposition on high strength aluminium alloys AA2024 and AA7075 the reinforcements like multi-walled carbon nanotubes, titanium dioxide and aluminium oxide were studied at various process parameters. The mechanical properties of the welded joint with and without nanoparticles are evaluated which are correlated with the microstructure study by optical microscope. The results show an improvement in mechanical properties due to the addition of nanoparticles in the joints fabricated, compared to that of that of bare joints. The tensile strength and microhardness of the welded joint was improved by 8.01% and 23.7% at 90 mm/min, when compared to the welded joint without CNT nanoparticles for high strength dissimilar aluminium alloys.This behavior was further supported by Electron dispersive X-ray analysis (EDX) study, which provides elemental identification and quantitative compositional information. It has been found that the distribution of nanoparticles was influenced by the groove size and the mechanical properties were found to be enhanced with groove of 1 mm width. It has been observed that the maximum % increase in strength and microhardness for the samples with CNT nanoparticles is about 6.59% and 20%. The improvement of strength and hardness was more with TiO_2 nanoparticles.Thus, by controlling the process parameters and groove size the distribution of nanoparticles and mechanical properties of the welded joint were enhanced effectively, but varied depending on the type of reinforcement added during friction stir welding process.

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