STUDY OF DIFFERENT FILLERS ON ALUMINIUM ALLOYS 6061 AND 7075 BY MIG WELDING

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We hereby declare that we have checked this thesis and in our opinion, this thesis is adequate in terms of scope and quality for the award of the degree of Master of Engineering (Mechanical).

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STUDENT'S DECLARATION

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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NUR FAKHRIAH BINTI MOHD NOORDIN

Thesis submitted in fulfillment of the requirements
for the award of the degree of
Master of Engineering (Mechanical)

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This report is dedicated to:

My beloved husband and son;

WAN MOHD AZAHARI BIN WAN ABDULLAH HADI
WAN AFNAN AQIEF BIN WAN MOHD AZAHARI

My lovely father and mother;

MOHD NOORDIN BIN ZAKARIA
KAMSIAH BINTI MOHAMED NOOR

My dearest sisters and brother;

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NURUL SABIHAH BINTI MOHD NOORDIN
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ABSTRAK

Pengurangan berat dalam industri automotif dan kapal terbang adalah satu keutamaan dalam meningkatkan ekonomi bahan api dan mengurangkan pencemaran alam sekitar. Sejak kebelakangan ini, aloi aluminium yang berbeza semakin penting sebagai bahan struktur ringan untuk aplikasi automotif. AA6061 dan AA7075 digunakan secara meluas dalam industri kenderaan dan penerbangan kerana beratnya yang ringan, ketahanan kakisan dan kekuatan yang tinggi. Kaedah kimpalan logam gas lengai (MIG) digunakan kerana harganya yang rendah dan ini adalah kaedah umum yang digunakan oleh pengimpal. Walaubagaimanapun, logam kimpalan yang berbeza akan menghasilkan kecacatan seperti keliangan, retak dan banyak lagi yang dapat membatasi pengembangannya. Kecacatan ini boleh mengakibatkan kemerosotan sifat mekanikal sendi seperti kekuatan tegangan dan kekerasan yang terutama berlaku pada zon yang terkena haba (HAZ). Hal ini biasanya berlaku bila menggunakan kimpalan pelakuran parameter kimpalan yang tidak betul dan jenis logam pengisi yang berlainan. Masalah ini dapat diatasi dengan pemilihan parameter yang tepat seperti arus elektrik (WC), voltan (WV), kelajuan kimpalan (WS) dan logam pengisi. Penyelidikan ini memfokuskan pada kebolehkimpalan antara aloi yang berbeza AA6061 dan AA7075 dengan kaedah kimpalan MIG dan untuk mengkaji kesan pengisi yang berbeza pada sifat mekanikal dan mikro struktur. Kimpalan berbeza AA6061 dan AA7075 dengan ketebalan 2 mm dikimpal dengan menggunakan mesin kimpalan semi automatik MIG. UTS tertinggi dengan gabungan masing-masing WC, WV dan WS dengan menggunakan ER5554 adalah 95 A, 18 V dan 3 mm/s, gabungan dengan menggunakan ER5183 adalah 100 A, 17 V dan 3 mm/s dan gabungan dengan menggunakan ER5356 ialah 115 A, 18 V dan 4 mm/s. Kecacatan minimum didapati melalui pemerhatian visual. Spesimen dengan UTS tertinggi iaitu masing-masing 168.67 MPa, 234.93 MPa dan 261.23 MPa untuk setiap sambungan dengan menggunakan logam pengisi ER5554, ER5183 dan ER5356, dinilai untuk sifat mekanik. Nilai kekerasan di kawasan zon pelakuran (FZ) untuk sambungan yang menggunakan pengisi ER5356 menunjukkan nilai tertinggi iaitu 123 Hv berbanding dengan sambungan menggunakan pengisi ER5183 dan pengisi ER5554 masing-masing dengan nilai 109 Hv dan 93.7 Hv. Nilai purata kekerasan kawasan HAZ lebih rendah daripada BM dan FZ untuk kedua-dua belah pihak. Untuk sisi AA6061, purata nilai kekerasan HAZ adalah hampir sama iaitu 75.3 Hv, 78.4 Hv dan 79.3 Hv masing-masing untuk sambungan dengan pengisi ER5554, ER5183 dan ER5356. Sementara itu, kawasan HAZ untuk sisi AA7075 nilai kekerasan pada sendi menggunakan pengisi ER5183 dan ER5356 menunjukkan nilai yang sama iaitu 121 Hv dan menggunakan pengisi ER5554 adalah 71.6 Hv. Kawasan HAZ lebih rendah daripada kawasan lain disebabkan oleh perubahan ukuran butiran kerana kepanasan dari proses kimpalan yang mengubah struktur mikro logam asas (BM). Dari hasil ukuran butir yang diperoleh, pada sisi HAZ AA6061 dengan menggunakan pengisi ER5356 menunjukkan ukuran yang lebih halus iaitu 73.71 μm, untuk gabungan menggunakan ER5183 dan ER5554 dengan nilai masing-masing 75.38 μm dan 75.5 μm. HAZ sisi AA7075 juga menunjukkan corak yang sama dengan ukuran butiran yang lebih halus dengan menggunakan pengisi ER5356 dengan nilai 79.65 μm. HAZ sisi AA7075 dengan menggunakan pengisi ER5183 dan ER5554 menunjukkan ukuran yang lebih kasar masing-masing dengan nilai 83.3 μm dan 89.6 μm. Kesimpulannya, aloi aluminium AA6061 dan AA7075 berjaya dikimpal dengan menggunakan Metal Inert Gas. Logam pengisi yang berbeza memberi kesan kepada sifat mekanikal dan struktur mikro pada gabungan. Penggabungan dengan

menggunakan pengisi dengan kandungan Mg yang lebih tinggi menunjukkan kekuatan tegangan yang lebih tinggi dengan ukuran butiran halus dan sama rata yang menunjukkan kekerasan yang lebih tinggi.

ABSTRACT

Weight reduction in automotive and aircraft industries is a main concern in improving fuel economy and reducing environmental pollutions. Recently, dissimilar joint of aluminum alloys are constantly gaining importance as lightweight structural materials for automotive applications. AA6061 and AA7075 are widely used in automobile and aviation industry due to its light weight, high corrosion resistance, stronger and high hardness. Metal Inert Gas (MIG) welding method was used due to its low cost and it is general methods used by the welders Nevertheless, welding dissimilar metal can generate defects, such as porosity, crack and many others which could limit its development. These defects may result degradation of mechanical properties of the joint such as tensile strength and hardness which especially occurred at heat affected zone (HAZ). One of the major causes associated with the dissimilar welding of aluminum alloys is the difference in composition in the alloying element which attribute to different thermal conductivity of the materials. These problems can be encountered with proper selection of parameters such as welding current (WC), welding voltage (WV), welding speed (WS) and filler metal. This research is focuses on the weldability between dissimilar AA6061 and AA7075 by MIG welding method and to investigate the effect of different filler metal on the mechanical and microstructural properties of MIG welded dissimilar AA6061 and AA7075. AA6061 and AA7075 thickness of 2 mm were welded by using semi-automated MIG welding machine. The highest UTS with the combination of WC, WV and WS for joining by using ER5554 is 95 A, 18 V and 3 mm/s, for joining by using ER5183 is 100 A, 17 V and 3 mm/s and joining by using ER5356 is 115 A, 18 V and 4 mm/s was produced. Visual observation of minimal defect was observed. Specimen with highest UTS which is 168.67 MPa, 234.93 MPa and 261.23 MPa for each joining by using filler metal ER5554, ER5183 and ER 5356, respectively were evaluated for mechanical properties. The hardness value at fusion zone (FZ) region for joint using ER5356 filler exhibited the highest value which is 123 Hv compared than joint using filler ER5183 and filler ER5554 with 109 Hv and 93.7 Hv, respectively. The average hardness values of HAZ region are lower than the BM and FZ for both sides. For side AA6061, the average hardness values of HAZ were approximately similar which are 75.3 Hv, 78.4 Hv and 79.3 Hv for joint with filler ER5554, ER5183 and ER5356, respectively. Meanwhile, HAZ region for side AA7075 the hardness value at joint using filler ER5183 and ER5356 exhibited same value which is 121 Hv and using filler ER5554 is 71.6 Hv. HAZ region was lower than the other region is due to the changes of the grain size due to the heat from the welding process that changes the microstructure of base metal (BM). From the result of grain size obtained, at HAZ side AA6061 by using filler ER5356 shows the finer size which is 73.71 μm for joining using ER5183 and ER5554 coarser size with value of 75.38 μm and 75.5 μm, respectively. HAZ side AA7075 also shows the same pattern which is has finer grain size by using filler ER5356 with value of 79.65 μm. HAZ side AA7075 by using filler ER5183 and ER5554 shows a coarser size with value of 83.3 μm and 89.6 μm, respectively. In conclusion, the aluminum alloy AA6061 and AA7075 was successfully welded by using Metal Inert Gas. Different filler metal gives effect to the mechanical and microstructural properties of the joint. The joining by using filler with higher Mg content shows higher tensile strength with fine and equiaxed grain size that indicate higher hardness.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

Tm	Melting Temperature
σu	Ultimate Tensile Strength
F	Force
HV	Vickers Hardness
N	Load
D	Diagonal length
F	Force

LIST OF ABBREVIATIONS

AA	Aluminium Alloy
MIG	Metal Inert Gas
SEM	Scanning Electron Microscope
UTS	Ultimate Tensile Strength
DOE	Design of Experiment
EDX	Energy Dispersive X-spectroscopy
TIG	Tungsten Inert Gas
FSW	Friction Stir welding
HAZ	Heat Affected Zone
TWD	Tip to Work Distance
WC	Welding Current
WV	Welding Voltage
WS	Welding Speed
WI	Weld Interface
RSM	Response Surface Method
ASTM	American Society for Testing and Materials
ER	Electrode Rod

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