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To find effects of GMAW parameters on Mechanical Properties of Aluminum Alloys

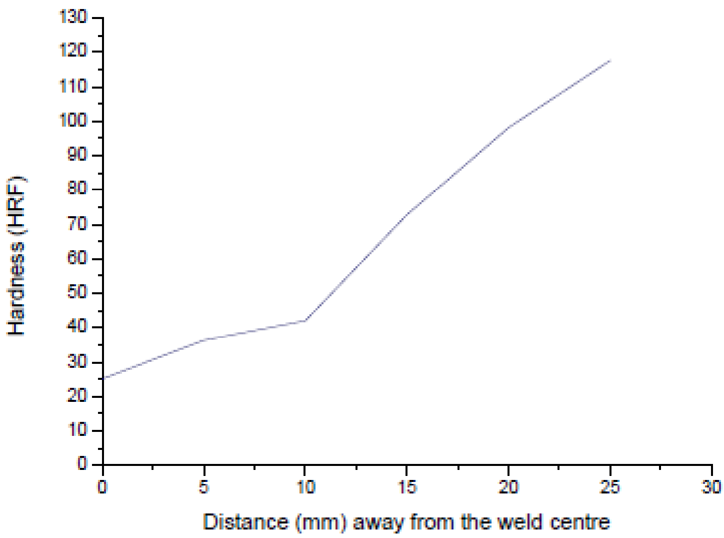
Chandan Kaushal*, Lochan Sharma**
*(Department of Mechanical Engineering, Lovely Professional University, Jalandhar, Punjab India)
** (Department of Mechanical Engineering, Lovely Professional University, Jalandhar, Punjab, India)

Abstract
The present research aims to investigate the effects of Gas Metal Arc Welding (GMAW) on the mechanical properties of different grades of aluminum alloys. GMAW is the most common method of joining aluminum alloys used in various industrial processes. It replaces the Tungsten Inert Gas (TIG) method of providing equally high quality of joints with a much higher performance. Aluminum alloys under consideration for this experiment will be from 6XXX series, consisting of Silicon and Magnesium as main alloying elements. Weld joints Will be produced with the help of a Gas Metal Arc Welding (GMAW) process. The Hardness, Tensile strength, yield stresses and elongation will be the mechanical properties to be obtained. As aluminum alloys show large micro structural changes after welding it is necessary to know about the effect of welding parameters on the mechanical properties of weldements as too high welding current and too high welding speed will result in high heat input and weakening of weld profile so a balance is need to be struck between welding parameters and mechanical properties. Scattering Electron Microscopy (SEM) technique will be used to analyze micro structural changes.

Keywords : GMA welding, Aluminum alloys, Mechanical properties

I. Literature Survey

Elsadig O. Eltai and E. Mahdi performed an experiment to find out the effects of MIG welding on the corrosion and mechanical properties of AA 6061 T6.Filler wire used for experiment is A404. Specimen were prepared using cutting machine after that a corrosion environment consisting of 3.5% (wt) NaCl in distilled water was prepared and weldments were inserted in solution. To conduct the welding process, commercial welding machine with a capability of changing its electric current was used. Specimens were welded under Ar (99% purity) as a shielding gas. Specimens were welded under Ar (99% purity) as a shielding gas. A current of 110 Ampere using Telwin Master MIG machine was applied. Rockwell hardness test was carried out on circular welded samples with a load of 60 kg, a ball indenter of 1/16 inch diameter, and duration of 15s using Indentec hardness tester Model 8187.LKV,UK. Torsion Test was carried on welded and un-welded specimens as.



The conclusions drawn from this research are as follows.

1. The corrosion potential of the HAZ was largely fluctuated over the immersion time showing more negative potential peaks .
2. The hardness of the welded specimens was increased as we moved away from the weld centre even at HAZ
3. Welded specimens were shown to have lower torsion properties comparing to the non-welded specimens .[1]

II. Nanda Munasinghe and Wajira Mirihanage

revealed about the welding characteristics of al-alloy 5083.In the experimental work AA 5083 GMAW samples were subjected to controlled heating procedures and their mechanical properties were measured. Filler metal used for this experiment was AA5356.Weldements were subjected to heat treatment processes in the temperature ranges of 473 K to 673 K. Tensile testing and Vickers hardness testing were done to know about the nature of mechanical properties of the weldments. Tensile tests were carried out for differently treated samples to obtain the stress – strain curves of thee weld metal zone as well as the HAZ. Micro-hardness values along the cross sections(transverse to weld direction) of samples was measured by using Vickers micro hardness testing machine and polished cross sections were etched by using Hydrofluoric and Hydrochloric and mixture for optical microscopy.

It was concluded that certain mechanical properties were dependent on the heat treatment parameters. In addition to that the pattern of variation was not uniform along the entire cross section of the weldment.

Further In the case of HAZ potential of fractional restore of the AA 5083 - H321 mechanical properties can be acquire through the heat treating at around the 473 K for approximately five minutes and heat treating at the higher temperatures does not make the improvements of hardness or ultimate tensile strengths.[2]

S. Missori and A. Sili performed an experiment to know about the microstructure and mechanical characteristics of joints welded with GMA technique made of plates AA 6082-T6. Tensile tests on both welded and unwelded specimens, with 20x10 mm2 rectangular section and 80 mm gage length Vickers microhardness tests (500g, 10 s) along traverses on the cross welded section, in order to distinguish the effects of the various passes. Moreover Vickers microhardness measurements were performed along the specimens previously fractured by fatigue rotating bending test. Fatigue rotating bending tests on unnotched specimens of cylindrical shape, diameter 9 mm, smoothly finished. A number of 17 specimens taken from parent metal and 15 from welded sample were submitted to a standard rotating bending test (ratio of the minimum stress amplitude to the maximum stress amplitude R = -1). The load was imposed by four symmetrically located bearings, in order to obtain a pure bending along the central portion of the specimen. There was SEM observation and fractography of both unwelded and welded fatigue specimens.

The main conclusions drawn from this experiment can be described.

1. Tensile strength of welded joints of 6082-T6 Al alloy, under the experienced welding conditions, undergoes a remarkable reduction of the initial value.
2. In the HAZ both tensile strength and hardness reduce to a minimum at a distance from the weld fusion line of about 6 mm, presumably due to over-aging consequent to the transformation of the strengthening metastable precipitate.
3. Fracture toughness KIC, evaluated from Charpy V test impact energy data through an empirical relation, exhibits the minimum value in WM and the same values in HAZ and parent metal.[3]

W Xu and M F Gittos performed an experiment to investigate quasi-static and dynamic material behaviour for the parent material, weld metal and HAZ of MIG welds. The parent material used was 6005A aluminium alloy in the solution treated and artificially aged condition. The filler wires selected were 4043(aluminium-5%silicon) and 5356(aluminium-5%magnesium). The testing programme included hardness surveys, tensile, Charpy impact and fracture resistance tests. These tests were carried out in dynamic servo-hydraulic testing machines and in a 10m drop-weight tower. The quasi-static crush tests were carried out using a servo-hydraulic testing machine with a maximum load capacity of 1,800kN. The specimen was subjected to an axial compressive load applied under a slow displacement rate of 6mm/min. The drop-weight impact tests were performed using a drop-weight testing machine. A total mass of 102kg can be dropped from a maximum height of 9.8m.

The conclusions drawn from the experimental work was that The aluminium-silicon weld metal in the extruded plates was poorer than the weld metal made using aluminium-magnesium filler metal in terms of strength, ductility and fracture resistance. Moreover under quasi-static loading, the aluminium-magnesium weld metal in the extruded plate outperformed the parent material in terms of the ultimate strength, ductility and fracture toughness, but its 0.2% proof strength was lower than the parent material. In terms of the ability to sustain uniform plastic deformation, the HAZ was the worst zone, as indicated by the smallest amount of elongation at the maximum load. This, coupled with the lower strength than the parent material, will cause strain localization in the HAZ.[4]

R. Ahmad, M.A. Bakar revealed about the effect of a post-weld heat treatment (PWHT) on the mechanical and microstructure properties of an AA6061 sample welded using the gas metal arc welding (GMAW) cold metal transfer (CMT) method. The CMT method was used because the method provides spatter-free welding, outstanding gap bridging properties, low heat input and a high degree of process flexibility. The welded samples were divided into as-welded and PWHT samples. The PWHTs used on the samples were solution heat treatment, water quenching and artificial aging. Both welded samples were cut according to the ASTM E8M-04 standard to obtain the tensile strength and the elongation of the joints. The failure pattern of the tensile tested specimens was analysed using scanning electron microscopy (SEM). A Vickers microhardness testing machine was used to measure the hardness across the joints.
The main conclusion drawn from the experimental work is that by implementing PWHT, a 3.8% increase was recorded for tensile strength, hardness strength was increased by 25.6% and a 21.5% higher elongation was achieved. The results proved that PWHT was able to enhance the hardness strength and tensile properties of AA6061 welded joints using the GMAW CMT method. From SEM fractographs, a smaller grain size, a smaller gap between the grains and relatively small voids were observed for the PWHT joints. The higher values of hardness, tensile strength and elongation are due to the fact that PWHT produces a fine and uniform distribution of precipitates at the weld joints.[5]

Krzysztof Dudzik performed an experiment on 5083,5059 and 7020 Al alloy pieces joined by MIG welding to know about their mechanical properties. The study was aluminum alloy EN AW-7020 T6. For a comparative study was carried out using aluminum alloy EN AW-5083 (AlMg4, 5Mn0, 7) and AW-5059 ALUSTAR (AlMg5Mn0, 7). For the 7020 alloy welding wire used alloy AlMg5 (5356) - Nertalic AG5 SAF. For the 5083 alloy welding wire used 5383 alloy and 5059 alloy welding wire alloy 5183. Wire electrodes immediately prior to welding was etched. Argon shielding gas was used with a purity of 99.99%.In order to determine the mechanical properties were carried out static tensile test. The study was performed at ambient temperature, i.e. + 20 ° C ± 2 Tensile testing was carried out on samples with flat-type testing machine EU-40 on the strength of 200 kN ± 1 During the study determined parameters such as ultimate tensile strength UTS, yield stress YS, and elongation EL.
The conclusions drawn from the study included that using a static tensile test on flat specimens of alloys 7020, 5083 and 5059 showed that the alloy 7020 is characterized by the highest strength properties. Both the alloy 7020 and 5059 had higher strength properties but low ductility of welded joints can be a big problem.[6]

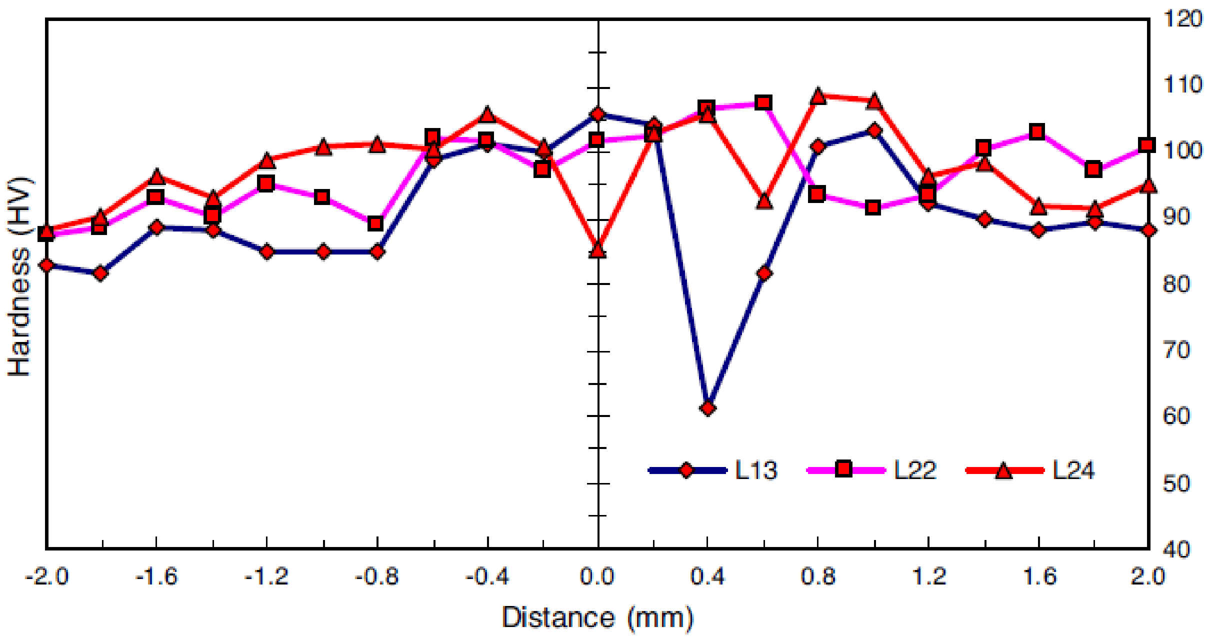
H. Guo, J. Hu, H.L.Tsai performed an experiment to know about formation of the crater formed in a GMAW of aluminum alloy 6005-T4. Transient weld pool shape and the distributions of temperature and velocity were calculated by a three-dimensional numerical model. The final weld bead shape and dimensions were obtained. Corresponding experiments were conducted and in good agreement with modeling predictions. Metallurgical characterizations were also performed on the experimental samples. Weld pool and weld bead shapes, temperature field, and velocity distribution were obtained for the terminating stage of the welding process. Experiments were conducted on the formation of the stopping end of the weld.
The conclusions drawn from the experiments were as :

1. It was found that the crater is formed because of the depression at the weld pool center as a result of droplet impingement effect and arc pressure.
2. The weld pool solidifies very quickly once the weld process stops. Due to the rapid heat dissipation, there is no time for the molten metal to flow back towards the weld pool center and close up the crater. Thus, a crater is formed at the end of the weld bead.[7]

P.M.G.P. Moreira ,M.A.V. de Figueiredo, P.M.S.T. de Castro experimented on two age hardenable Al alloys weldments to know about their fatigue beaviour using MIG and FSW techniques. In the MIG welding process, the arc and the weld are protected from atmospheric contamination by a gas shield, and an electric potential is established between the electrode and the work piece causing a current flow, which generates thermal energy in the partially ionized inert gas. A study of the fatigue behaviour of Metal Arc(MIG) butt welds of two 3 mm thickness age hard enable aluminium, 6082-T6 and 6061-T6 alloys, was carried out. Tensile tests and micro hardness measurements of weld joints and base materials were performed in order to determine the influence of each welding process in the mechanical properties.

Main conclusion drawn from the experiment was Yield and rupture stress of MIG welded specimens are lower than for base material.The MIG welded 6061-T6 specimens presented higher fatigue lives than the MIG 6082-T6 specimens.[8]

Rakesh Kumar, Ulrich Dilthey, D. K. Dwivedi, S. P. Sharma & P. K. Ghosh performed an experiment to know about the micro-structure, weld bead geometry, dilution rate and mechanical properties of the butt and overlap weld joints of 1-mm-thick 6082 aluminum alloy sheet. Weld joints were produced with the help of a variant of gas metal arc welding (GMAW) process, i.e. direct current-pulsed GMAW (DC P-GMAW), using a Vario wire. The filler wire of the 4047 alloy, a Vario wire of size 1.2×0.4 mm2 (which was originally a round wire of 1 mm diameter), was used for welding.
Vickers hardness profile across weld cross section of lap joint can be shown as below.



Welding results with this process showed good process stability in the welding of thin sheets of aluminium. This process variant permits a higher deposition rate, a lower energy input and fair gap-bridging capacity than the conventional GMAW process with round filler wire. Weld mismatch was found to increase with the increase in heat input primarily due to greater differential thermal expansion in HAZ and the basemetal. Weld bead geometry parameters such as weld size, throat and weld convexity increases with an increase in heat input. Lap joints required more heat input than butt weld joints for the same thickness. The dilution in case of lap joints (10–25%) was less than that of butt joints (60–80%). [9]

III. Concluding Remarks

In this literature survey of Gas Metal Arc Welding (GMAW) processes the effect of various welding parameters is investigated. Following conclusions are found from the investigation.

1. As aluminum alloys are susceptible to large microstructual changes after welding it is important to know behavior of weldments at different parameters and effect on mechanical properties.
2. Increasing of the arc voltage and welding current increases the welding heat input: accordingly the chance of defects formation such burn through in weld metal also increases.
3. MIG welding technique can be used for comparing different aluminium alloys, Using new transfer method like CMT which enhanced mechanical properties also.

IV. Future Scope

During experimental work welds will be prepared using Gas Metal Arc Welding (GMAW) technique of AA 6061 and AA 6063 alloys. In the experiment welding parameters Arc Voltage, Welding current, will be altered suitably and their effect on mechanical properties which include Hardness, Ultimate Tensile Strength, Yield Stress and Elongation will be investigated. For observation of micro structural changes in weldments, Scattering Electron

Microscopy (SEM) technique will be used. This research work will allow us to know values of optimum welding parameters for above mentioned grades of aluminum alloys.

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