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Investigation of Aluminium Alloy and Aluminium Alloy Using MIG Welding Process

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***Abstract*: Now-a-day's aluminum and aluminum alloys are widely used in automotive industries. These are light weight (density of about 2.7g/cc), having good malleability and formability, high corrosion resistance and high electrical and thermal conductivity. Welding is the manufacturing method, which is carried out by joining two similar and dissimilar metals MIG. Welding is one of the most widely used processes in industry. The MIG welding parameters are the most important factors affecting the quality, productivity and cost of welding. This review is based on optimization techniques and analysis tools used by researchers to optimize the parameters. And also we are going to investigate aluminium alloys using MIG welding processes.**

***Keywords*: Aluminium alloy, aluminium- silicon alloy, aluminium- silicon-titanium alloy, mig weldingprocess**

1. Introduction

Aluminium and aluminium alloy are gaining huge industrial significance because of their outstanding combination of mechanical, physical and tribological properties over the base alloys [1]. These properties include high specific strength, high wear and seizure resistance, high stiffness, better high temperature strength, controlled thermal expansion coefficient and improved damping capacity. These properties obtained through addition of alloy elements, cold working and heat treatment [2]. Alloying elements are selected based on their effects and suitability and they are used for the welding process such as MIG welding. MIG welding is a welding process in which an electric arc forms between a consumable wire electrode and the work piece metal causing them to melt and join. Along with the wire electrode, a shielding gas is supplied through the welding gun which shields the process from contaminants in the air. MIG welding is versalite and having less loss of alloying elements during the process and can be operated as semi-automatic and fully automatic welding. Most metals can be welded with this process and may be welded in all positions with the lower energy variations of the process [3].

2. Literature review

A number of research paper has been studied which deals with the tribological investigated lightweight materials like Aluminium- Silicon based alloy and the MIG welding process in it. The findings of those papers have been presented here.

Francis Uchenna et. al. studied the effect of parameters on wear characteristics of Al- Si alloys. Aluminium-silicon alloys containing 7%, 12% and 14% weight of silicon were synthesized using casting method. Wear characteristics of sample were studied against a hardened carbon steel (Fe-2.3%Cr-0.9%C) using a pin-on-disc. Observations were recorded keeping two parameters (sliding distance, sliding speed and load) constant against wear at room temperature. Micro structural characterization was done using optical microscope (OM) and scanning electron microscope (SEM). Hardness and wear characteristics of different samples have shown near uniform behavior. The wear rate decreased when the percentage of silicon increases. Wear was observed to increase at higher applied load, higher sliding speed and higher sliding distance. The wear characteristics of Al-14%Si was observed superior to those of Al-7%Si and Al-12%Si due to the degree of refinement of their eutectic silicon. The variation of silicon in Al-Si led to more degree of refinement of the eutectic silicon as the silicon content of the alloy increased beyond the eutectic composition. The amount of primary silicon increased with the increase in silicon amount in the cast. Hardness of the Al-Si alloy increased with the increase in amount of silicon present. The wear rate decreased when the percentage of silicon was increased. Wear was observed to increase at higher applied load and at higher sliding speed. Effect of load and sliding speed are more pronounced on the wear of the Al-Si alloys than sliding distance [5]. Riyadh A et al studied the effect of load and speed on sliding friction coefficient and performance tribology of aluminum–silicon casting alloy was evaluated using a pin-on-disc with three different loads (10, 20, and 30 N) at three speeds (200, 300, and 400 r/min) and relative humidity of 70%. Factors and conditions that had significant effect were identified. Experiments showed that the load and the speed affect the coefficient of friction and wear rate of the alloy. The results showed that the wear rate increased with increasing load and decreased with increasing sliding distance, whereas the friction coefficient decreased with increasing sliding speed before a stable state was reached. The friction coefficient also decreased with increasing load. The load and the sliding speed affect the amount of friction force. The wear rate significantly increases when the load increases. On the other hand, small coefficient of friction values, together with increase in sliding speed, loading, and sliding over long distances, reduce wear rate. Thus, maintaining appropriate sliding speed and normal load levels can reduce frictional force and wear and improve the mechanical processes [6]. Muna K. Abbass studied the effect of cadmium addition on microstructure and wear behavior of the alloy (Al-12%Si) under dry sliding conditions. Wear behavior was studied by using the Pin-On-Disc technique under different conditions at applied loads 5-20 N, at constant sliding speed and in constant time. The steel disc hardness was 35HRc. All alloys were prepared with different percentages of cadmium (1.0, 2.0, 3.0) wt%. Also the base alloy was prepared by melting and pouring the molten metal in a metallic mold. It was found that the cadmium addition to Al-Si matrix decreases the wear rate and improves the wear properties for alloys containing - Cd under loads above 10N. It was also found that the alloy Al-12%Si containing 3%Cd is the best alloy in wear resistance and friction coefficient. This is due to presence of the Cd-phase as cuboids or hard particles distributed in a eutectic matrix which reduces the friction coefficient at high loads (20N). Modification and grain refinement in the microstructure of Al-Si alloy have been achieved by the presence of cadmium particles in the alloy matrix.The wear behavior of base alloy A1-12%Si changes from mild wear (oxidative wear) at low loads 5-10 N to metallic wear at high loads 10-20 N. The cadmium added to alloy Al-12%Si changes the wear behavior at higher loads than 5-10 N. The alloy A1-12 % Si containing 3% Cd shows the highest wear resistance in comparison with other alloys at a high load 20 N. The cadmium added to alloy Al-12 % Si reduces the friction coefficient at high loads. The addition of cadmium at different ratios leads to an increase in the hardness of the aluminum silicon based alloy[7]. M. Zeren et al reported that the existence and morphology of intermetallic particles in Al–Si–xTi cast alloys. Near eutectic Al–Si alloys with 0, 0?1, 1, 2, and 5% Ti have been utilised for this purpose. Metallographic observations were made by the combination of an optical microscope and a scanning electron microscope. Wear tests were performed in a pin on disc tribometer under dry sliding conditions. The addition of Ti to the Al–Si alloys led to the precipitation of TiAlSi intermetallic phase. By increasing Ti content, hardness increases due to increasing volume fraction of relatively hard intermetallics. The conclusions based on the experimental results are as follows. Ti based intermetallics can have different morphologies (flakes and petals) depending on the Ti content, other alloying elements and the thermal history of alloy. Ti based intermetallic phases in Al alloys also have different chemical compositions depending on other alloying elements and cooling rate of the alloy. The petal-like particles were found in the cast Al–Si–1Ti microstructure. The flake-like particles were found in the cast Al–Si–2Ti and Al–Si–5Ti microstructures. The alloys have maximum 0?2% vanadium, but no effect of vanadium was reported in microstructural investigations. To understand influence of vanadium further investigations are required. The increase in the Ti content increases the hardness of the alloys by increasing the volume of hard TiAlSi intermetallic. The hardness increases from 841 HV to 1454 HV with addition of 5 wt-%Ti. The micro structural characteristics, namely, the morphology and size of the hard second phases greatly affect the sliding wear properties of the alloys. It was found that the weight loss of the as cast Al– Si–xTi alloys decreased with increasing Ti content up to 1% Ti. This may be due to the morphology and distribution of the hard TiAlSi intermetallic particles. It was found that the coefficient of friction of the as cast Al–Si–xTi alloys increased with increasing Ti content. The worn surface analyses show that the flake-like intermetallic particles causes the increase on wear rates. If the morphology of the intermetallics in high Ti including alloys can be modified to petal-like shapes, the wear resistance of the alloys will be enhanced. More research work is necessary to understand and control the morphologies and growth properties of TiAlSi intermetallics[8].

N. Saheb et al studied the influence of Ti addition (up to 4 wt.%) on wear behavior of as-cast and heat- treated Al–12 wt.% Si eutectic alloy prepared by rapid cooling has been investigated in dry sliding against a steel counterface using a pin-on-disk apparatus. Worn surfaces and wear debris were examined and analyzed by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), and X-ray diffraction (XRD). The addition of Ti to the binary Al–Si alloy led to the precipitation of Al3Ti phase. Among the Ti- containing alloys, the increase in Ti content improved wear resistance of both as-cast and heat- treated alloys. However, these alloys displayed higher wear rates, thus lower wear resistance, compared with the Al–Si binary alloy. The addition of Ti to Al–Si eutectic alloy resulted in the precipitation of the intermetallic compound Al3Ti phase, which induced an increase in the microhardness of the binary alloy. Among the Ti- containing alloys, the increase in Ti content improved their wear resistance as a result of increase in the microhardness due to the presence of relatively hard-phase Al3Ti. However, these alloys showed higher wear rates (thus lower wear resistance) compared with the binary alloy due to the tendency for embrittlement and microcracking brought about by Al3Ti particles. Heat treatment of the Ti- containing alloys at 200◦C for 6 h improved further their wear resistance[9]. A. S. Anasyida et al studied that the effect of cerium addition on wear behaviour of as-cast Al-4Si-4Mg alloys has been studied. Dry sliding wear tests were performed against a hardened carbon steel (Fe- 2.3%Cr-0.9%C) using a pin-on-disc configuration with fixed sliding speed of 1 m/s and a range of load10 N, 30 N and 50 N at room temperature (25 C). Morphologies of both worn surfaces and collected debris were characterised by a scanning electron microscope (SEM) equipped with an energy dispersive X-ray spectrometer (EDX). It was revealed that 1 - 5 wt% of cerium addition resulted in the formation of intermetallic phase Al-Ce and Al-Si- Ce. The increase of cerium content in the alloy led to higher wear resistance behaviour for as-cast alloys. Formation of craters and localised plastic deformation were observed on the worn surface of the alloys, resulting fine particulate and sheet-like wear debris. The change in morphology of the wear debris was also found consistent with the change in worn surface appearance. The addition of cerium to Al-4Si-4Mg leads to the precipitation of intermetallic compound needle-like shape Al-Ce and Al-Si-Ce phase. The increase of cerium up to 5wt% improved wear resistance and lowered the friction coefficient of the as-cast alloy. The severity of abrasive and delamination wear mechanisms observed on the worn surface was found to be consistent with the cerium content in the alloys. Formation of craters and severe localised plastic deformation were observed on the worn surface of alloys with higher cerium content, which produces fine particulate and flakes wear debris[10].

Dr. Adnan Ibrahim Mohammed et al conducted demonstration of the effect of Na addition to the microstructure and wear rate of hypereutectic Al-14 wt% Si alloy was carried out. It is found that the addition of Na has an important effect on shifting the eutectic composition of Al-Si alloys from approximately 12 wt% to 14 wt% Si; shifting the unmodified alloy from hypereutectic to eutectic alloys for the modified alloys. The modified alloys have a eutectic composition with fine needle at lower Na content (0.05%). Increasing the percentage of Na to 0.12 wt% resulted in producing a lamellar Si structure compared with acicular structure for unmodified alloy. The wear rate of modified alloys is lower than the hypereutectic alloy. Wear rates observed were in the range of 10-9 to 10-11 which is fully identified in the mild wear rate regime. Addition of sodium to Al-14 wt% Si changed considerably the morphology of Si from acicular to fine needle at low Na addition to lamellar at high Na addition. The percentage of porosity increased with increasing the Na addition. The unmodified alloy with hypereutectic composition has changed to eutectic structure for modified alloys. Addition of Na has a considerable improvement in wear resistance compared with unmodified Al-14 wt% Si alloy[11].Malek Ali et al in their study presented the mechanical properties of Al–12% Si matrix composite reinforced (which can used in light devices and energy storage) by various amounts of Titanium Nitride (TiN) particles. Macrostructural studies have shown near uniform distribution of TiN particles in the matrix. The mechanical properties such as hardness and wear resistance are observed to be increased considerably compared to the matrix composite. The wear behaviour was investigated using a pin-on-disc wear testing machine with varying parameters such as normal load, reinforcement's percentage and track velocity. The results suggested that the reinforced Al-12Si matrix composites showed significant improvement in their wear resistance accordingly with increasing the reinforcement's percentage at different conditions. The microstructural study of the composites before wear test showed uniform distribution through the cross-section of the specimens and finer surfaces than matrix composite after wear test. Fabricating Al-Si eutectic alloys reinforced by TiN ceramic particles using PM technique was done successfully. TiN reinforced samples have shown higher wear resistance than unreinforced samples. Similarly, when the speed increases with different applied loads, TiN reinforced samples have exhibited higher wear resistance than the rest. Where, after adding 15% of TiN particles it showed that the loss wear in average has been decreased about 49.5% compared to the base sample[12]. A. Apasi et al studied the wear behaviour of aluminium alloy (Al-Si-Fe) reinforced with coconut shell ash particles (CSAp) fabricated by stir casting process was investigated. The wear and frictional properties of the metal matrix composites was studied by performing dry sliding wear test using a pin-on-disc wear tester by varying the applied load from 10-50 N, speed 2.0 m/s and sliding distance 4000 m. The morphology of the worn out surface was determined by scanning electron microscope (SEM). The results show that the coefficient of friction increases with increasing load for the Al-Si- Fe alloy and the composites containing CSAp. It is observed that, as the applied load increases, the wear rate also increases but decreased with CSAp addition. This is because, whenever applied load increases, the friction at the contact surface of the material and rotating disc obviously increases. Hence, incorporation of the coconut shell particles in the Al-Si-Fe alloy matrix as reinforcement increases the wear resistance of the material. From they concluded that the presence of the coconut shell ash particles in the matrix alloy results in a much smaller grain size in the cast composites compared to the matrix alloy. The hardness values of the developed composites increased with an increasing percentage of coconut shell ash particle additions. The coefficient of friction increases with increasing load for the Al-Si-Fe alloy and the composites containing CSAp. The wear mechanism reported was oxidation at lower loads and adhesion and delamination at higher load. It is observed that, as the applied load increases, the wear rate also increases. This is because, whenever applied load increases, the friction at the contact surface of the material and rotating disc obviously increases. The incorporation of the coconut shell particles in the Al-Si-Fe alloy matrix as a reinforcement increases the wear resistance of the material[13]. Amro M. AI-Qutub et al studied the dry wear behavior of A1203/6061 Aluminum particulate composite under different sliding speeds and applied load using pin-on- disk tribometer at room temperature. Three grades of the submicron particle composites containing 10, 20, and 30 vol.% A1203 were tested. The results illustrate that higher load and higher concentration of A1203 particles lead to higher wear rates. For 10 and 20% A1203 concentrations, the wear rate decreases with increasing sliding speed, while it increases for 30% A1203. The surface morphologies of the worn composites indicate that at lower sliding speeds abrasion is dominant, while at higher sliding speeds delamination and adhesion increases. Results also indicate that the friction coefficient between the composite and the mating steel surface decreases with increasing sliding speed to a steady state. A pin-on-disk tribometer was used to perform dry wear tests for three grades of 6061 Aluminum composites containing 10, 20, and 30 vol.% AI20^ dispersions- Applied load (20 and 30 N) and sliding speeds (0.25, 0 .5, 1, and 1.5 m/s) were varied to investigate effects of particles concentration on the wear and friction mechanism. The results indicated that higher concentration of A1203 increases wear rate of the composites, primarily due to the increased abrasive wear on the steel counter face. In addition, wear rates increase with applied load for all the composites regardless of sliding speed. On the other hand, the composites containing 10 and 20 vol.% A1203 exhibit a decrease in wear rates with increasing sliding speeds. SEM results indicate increased delamination and adhesion wear with increasing sliding speed. It was also found that at low sliding speeds abrasive wear is the dominant wear mechanism EDAX analysis revealed that the transfer of iron from the counter disk to the composite is enhanced at lower speeds (abrasive wear). Friction coefficient between the composites and the mating steel surface marginally decreases to a constant level at higher speeds. Concentration of A1203 has negligible effect on friction coefficient of the composit[14]. Detao Cai, Shanguo Han, Shida Zheng, Ziyi Luo, Yupeng Zhang, Kai Wang investigated the Al5083 alloy was welded by plasma-MIG hybrid welding with optimized parameters of 58A MIG current and 130A plasma current with speed of 4.75 mm/s. Good appearance with defect-free of the joint was got. Microstructures and corrosion resistance of electrochemical impedance spectroscopy and potentiodynamic polarization of the welds and base metal in a 0.5 M NaCl solution at room temperature were investigated. Combined with simulated equivalent circuit by program, the relationship between microstructures and corrosion resistance was obtained. Plasma-MIG hybrid welded metal with as-cast structure presents a better corrosion resistance than the base metal with rolling structure. Unlike other welding method, the plasma-MIG welding method is helpful for improving the corrosion resistance of Al5083 welding joints [15]. Fuheng Nie, Honggang Dong, Su Chen, Peng Li, Leyou Wang, Zhouxing Zhao, Xintao Li, Hai Zhang investigated the microstructure and mechanical properties of pulse metal inert-gas (MIG) welded dissimilar joints between 4 mm thick wrought 6061-T6 and cast A356-T6 aluminum alloy plates were investigated. The tensile strength of the joints reached 235 MPa, which is 83% of that of 6061 aluminum alloy, and then decreased with the increase of travel speed while keeping other welding parameters constant. The microstructure, composition and fractography of joints were examined by the optical microscopy (OM), scanning electron microscopy (SEM) and electron probe microanalysis (EPMA). Grain boundary liquation and segregation occurred in the partially melted [16].

3. Conclusion

Alloying elements are selected based on their effect and Suitability. With the help of the MIG welding, the properties of the aluminium alloy using the same welding process is being studied here. Wide search had done on parametric optimization of MIG welding. Many researcher studied different response parameters like micro-hardness, microstructure, depth of penetration and heat affected zone (HAZ) of welded specimen.

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