ANALYSIS OF TIG AND MIG WELDING PROCESSES USING ALUMINIUM ALLOY AND STRUCTURAL STEEL: A REVIEW

Rahul Kumar[1], Prof.R.K.Satankar[2]
[1](M.Tech Machine Design, Jabalpur Engineering College. Jabalpur, India)
[2](Professor Mechanical Engineering, Jabalpur Engineering College. Jabalpur,, India)

Abstract* – The dissimilar metal joints of have been emerged as a structural material for various industrial applications which provides good combination of mechanical properties like strength, corrosion resistance with lower cost. Selections of joining process for such a material are difficult because of their different physical and chemical properties. The stainless steel and aluminum alloy dissimilar material joints are very common structural applications joining of stainless steel and aluminum alloy is very critical because of carbon precipitation and loss of chromium leads to increase in porosity affects.

KEYWORDS: TIG, MIG, Tensile strength, dissimilar metal welding, stainless steel, Aluminum alloy.

I. INTRODUCTION

The stainless steel is one of the most popular materials for structural applications, due to their excellent physical properties but increase the structural cost. The additional benefits and the design codes of stainless steels have focused their industrial use for conventional structural engineering applications such as civil construction, nuclear reactors, thermal power plants, vessels and heat exchangers for several industrial applications. The better joint efficiency, simple process, low fabrication cost, welding reliability and efficient metal joining process are essential for production of many engineering and structural components .The metallurgical changes such as micro-segregation, precipitation of secondary phases, presence of porosities, solidification cracking, grain growth in the heat affected zone and loss of materials by vaporization are the major problems which produces poor mechanical properties in stainless steel welds. Therefore, for structural applications, the stainless steels are utilized efficiently by dissimilar steel welds between stainless and carbon steels with effective and economical utilization of the special properties of each steel dependent in the same structure .

II. LITERATURE REVIEW

Danijela Zivojinovicb [1] In this paper the fatigue crack propagation in thin-walled aluminum alloy structure with two friction stir welded (FSW) joints has been numerically modelled. Crack propagation in unstiffened part of the structure between two FSW joints is analyzed. The analyzed models made from aluminium alloy 2024-T351. During its (stable) growth, the crack remains within the base material. As it gets closer to the FSW joint (HAZ), considerable crack growth leading to structure failure starts to occur, before the crack can reach the HAZ.

Andrijana Durđevic [2] In this work, fatigue crack propagation in thin-walled aluminum alloy structure with two friction stir welded T joints has been simulated numerically. Crack propagation in stiffened part of the structure between two friction stir welded T joints is analyzed by using the extended Finite element method. He analyzed the stress intensity factors that obtained for each step of crack propagation along the crack. During its propagation, the crack remained within the base metal in the analyzed case, leaving more detailed analysis for future work, including crack propagation through different welded joint zones and the effect of stiffeners.

D. Fersini [3] in this paper the fatigue strength of 2024-T3 aluminum alloy friction stir welded single-lap joints is determined by the presence of two crack-like unwelded zones at the overlap ends. In this work, a finite element analysis is performed to predict the crack path and the stress intensity factor at the crack tip, then the lifetime is estimated by examining the crack propagation behavior of the base material.

S. Lomolino [4] This paper collects available fatigue data on FSW of Al alloys and statistically analyses these deriving a first set of reference fatigue curves. It is envisaged that a comparison of the reference curves obtained with the design curves given by design standards. The aim of the present work was to give, for the Al alloys, as first draft, an overview of the fatigue properties of butt joints friction stir welded, trying to use the same criteria employed in the standards for providing design data.

Wei Dong [5] In this paper the analysis of crack propagation of normal strength concrete at a crack tip the initial fracture toughness and nil-stress intensity factor (nil-SIF) are two distinguished and widely adopted types of crack propagation criteria. The beams under three-point bending with different concrete strength grades were obtained from experiment, The corresponding results obtained from numerical analysis using the nil SIF and the initial fracture toughness criteria are also presented.

HE Zhen-bo [6] In order to study the welding process, microstructure and properties of Al-Mg-Mn-Sc-Zr alloy, comparative methods of friction stir welding (FSW) and tungsten inert gas (TIG) were applied to the two conditions of this alloy, namely hot rolled plate and cold rolled-annealed plate. For each condition of Al-Mg-Mn-Sc-Zr alloy, namely thick hot rolled plate and cold rolled-annealed plate, the tensile strength, elongation and welding coefficient of FSW welded joints are higher than those of TIG welded joints.

Hideo Koguchi [7] Stress singularities usually occur at vertexes in three-dimensional joints. Cracks frequently initiate at the vertex, and the joint fails under an external force or a thermal load. In the present study, the stress distribution near a small crack occurring at a vertex in a three-dimensional joint under a tensile load is examined, and the stress intensity factors at the crack tip are investigated along the crack tip front.

Hassan Mirahmadi [8] In this study, obtaining stress intensity factors (SIFs) for functionally graded cylinders with two internal radial cracks using the weight function method has been discussed. For this purpose, reference SIFs are calculated from the results of finite element analysis, using a modified domain of the J integral.

Yufeng Zhang [9] In this analysis an excellent butt joint of 5A06 and Ti6Al4V was achieved via MIG/TIG double-side arc welding-brazing process with Al-5Si wire. The conventional MIG welding-brazing process was carried out at the same welding heat input for comparison. Then formation and microstructure of joints were investigated, and the quality of joints was examined by tensile test. The results showed that weld formation, especially the formation of back weld, was improved .

Zhenhuan Zhou [10] An analytical method is presented for finding the complex stress intensity factors (SIFs) and T-stress at an edge bi-material interface crack. A Hamiltonian system is first established by introducing dual (conjugate) variables of displacements and stresses whose solutions are expanded in terms of the simplistic series.

III. THE MATERIAL PROPERTIES USED IN PRESENT STUDY:

Material Properties			
Physical Properties	**Structural Steel**	**2219-T8 Aluminum Alloy**	**2024-T351 Aluminum Alloy**
Youngs Modulus (GPA)	211	73.8	68
Poisson's ratio	0.3	0.33	0.33
Density (Kg/m^3)	7850	2480	2785

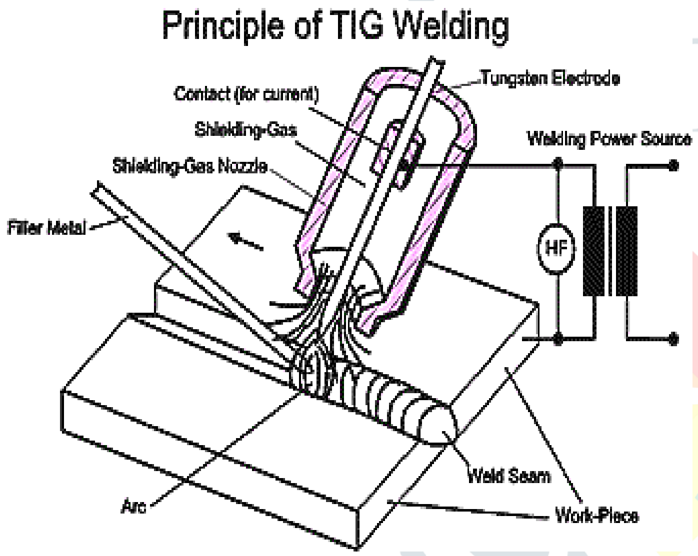

Fig.1 The principle of Friction TIG Welding

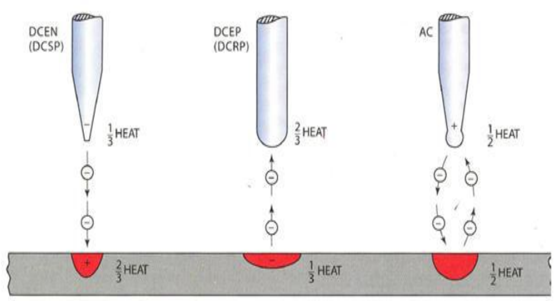

Figure 2 - Heat distributions between the tungsten electrode and the work with each type of welding current.

IV. CHARACTERISTICS OF CURRENT TYPES FOR GAS TUNGSTEN ARC WELDING

All three types of welding current can be used for GTA welding. Each current has individual features that make it more desirable for specific conditions or with certain types of metals. The current used affects the heat distribution between the tungsten electrode and the weld and the degree of surface oxide cleaning that occurs. A look at each type and its uses will help the operator select the best current type for the job. The type of current used will have a great effect on the penetration pattern as well as the bead configuration. In Figure 2 above shows the heat distribution for each of the three types of currents.

DCEN, which used to be called direct-current straight polarity (DCSP), concentrates about two-thirds of its welding heat on the work and the remaining one- third on the tungsten. The higher heat input to the weld results.

V DIRECT-CURRENT ELECTRODE POLARITY:

DCEP, which used to be called direct-current reverse polarity (DCRP), concentrates only one-third,-of the' heat on the plate and two-thirds of the heat on the electrode. This type of current produces wide welds with shallow penetration, but it has a strong cleaning action upon the base metal. The high heat input to the tungsten indicates that large-size tungsten is required, and the end shape with a ball must be used. The low heat input to the metal and the strong cleaning action on the metal make this a good current for thin, heavily oxidized metals.

VI APPLICATION ADVANTAGES:

The TIG welding process has a very large area of application due to its many advantages, e.g.:

- It provides a concentrated heating of the work piece.
- It provides an effective protection of the weld pool by an inert shielding gas.
- It can be independent of filler material.
- The filler materials do not need to be finely prepared if only the alloying is all right.
- There is no need for after treatment of the weld as no slag or spatter are produced.
- Places of difficult access can be welded.

Areas of application:

TIG welding is often used for jobs that demand high quality welding such as for instance:

- The offshore industry
- Combined heat and power plants
- The petrochemical industry
- The food industry
- The chemical industry
- The nuclear industry

VII Objective of the Work

The main objective of the current work is:

- Validation of the ANSYS models by comparing the present simulated results with the simulation result of base paper Danijela Zivojinovicb [1].
- To predict stress intensity factor.
- To simulate the welded joints of the different material having different nugget shapes for variable loads.

REFERENCES

[1] Danijela Zivojinovic, Andrijana Durđevic, Aleksandar Grbovic, Aleksandar Sedmak, Marko Rakin, Numerical modelling of crack propagation in friction stir welded joint made of aluminium alloy, Procedia Materials Science 3 (2014) 1330 – 1335.

[2] D. Fersini, A. Pirondi, Analysis and modelling of fatigue failure of friction stir welded aluminum alloy single-lap joints. Engineering Fracture Mechanics 75 (2008) 790–803

[3] Andrijana Durdevic, Danijela Zivojinovic, Numerical simulation of fatigue crack propagation in friction stir welded joint made of Al 2024-T351 alloy. Engineering Failure Analysis 58 (2015) 477–484

[4] Dong-yang YAN, Hui- qiang WU, Fracture behavior of double-pass TIG welded 2219-T8 aluminum alloy joints under transverse tensile test. Trans. Nonferrous Met. Soc. China 25(2015) 1794−1803

[5] Wei Donga, Zhimin Wu, Xiangming Zhou,Cuijin Wang , A comparative study on two stress intensity factor-based criteria for prediction of mode-I crack propagation in concrete, Engineering Fracture Mechanics 158 (2016) 39–58

[6] HE Zhen-bo, PENG Yong-yi, YIN Zhi-min, LEI Xue-feng, Comparison of FSW and TIG welded joints in Al-Mg-Mn-Sc-Zr alloy plates,trans. Nonferrous Met.soc.china 21(2011) 1685-1691

[7] Hideo Koguchi, Koki Yokoyama, Chonlada Luangarpa, Variation of stress intensity factor along a small interface crack front in singular stress fields, International Journal of Solids and Structures 71 (2015) 156–168.

[8] Hassan Mirahmadi, Majid Azimi, Seyed Sajad Mirjavadi Calculation of stress intensity factor for functionally graded cylinders with two radial cracks using the weight function method, Theoretical and Applied Fracture Mechanics (2016) .

[9] Yufeng Zhang, Jihua Huang, Zheng Ye, Zhi Cheng An investigation on butt joints of Ti6Al4V and 5A06 using MIG/TIG double-side arc welding-brazing. Journal of Manufacturing Processes 27 (2017) 221–225.

[10] Zhenhuan Zhou, Xinsheng Xu, Andrew Y.T. Leung, Yi Huang, Stress intensity factors and T-stress for an edge interface crack by symplectic expansion. Engineering Fracture Mechanics 102 (2013) 334–347.

[11] *en.wikipedia.org/wiki/GTAW*

[12] www.weldwell.co.nz/site/weldwell