EFFECT OF CUTTING PARAMETER ON MICRO DRILLING CHARACTERISTICS OF D2 -STEEL: A REVIEW

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Abstract: **This paper investigates the effect of the tool pin profile and friction stir welding parameters on the microstructure and mechanical properties of the D2-Steel alloy welded joints prepared by friction stir welding. It has been found that a fine grain microstructure obtained by hexagonal pin profile. But using a square pin profile produced a higher strength welded joints. FSW process offers a potential advantage in manufacturing industries to eliminate mechanical fastening such as riveted or bolted joints. Incorporation of light aluminum alloy**
coupled with steel by the FSW process as sub-frame component in auto industries also yields a milestone in the weight reduction capability of this process. There is no melting involved in FSW process, hence this solid state joining technique offers some specific advantages over fusion weld by preserving material properties in the joint closest to that of base materials.

Keywords*: *Friction Stir welding, Aluminum Alloy, Pin profile, Tensile

I. INTRODUCTION

Friction stir welding is a solid state welding process developed by Wayne Thomas at The Welding Institute (TWI) in 1991. The research was funded in part by the National Aeronautics and Space Administration (NASA) in an effort to find a welding method that would not add weight to orbital spacecraft. A major advantage of friction stir welding is that it is a solid state weld where the base material does not reach the melting point. Therefore, it does not exhibit the same deficiencies as fusion welding, which is associated with cooling from the liquid phase.

Other benefits of friction stir welding include the ability to make welds in “hard-to-weld” materials and in dissimilar metals. It also eliminates toxic fumes which makes it much more environmentally friendly than fusion welds [1]. Friction stir welding is extensively used by NASA to join large portions of aluminum for their space shuttle external fuel tank at the Michoud research facility. It is the preferred NASA welding technique for their moon rocket. As friction stir welding advances and is used in more applications, tool materials will need to be selected for optimal weld efficiency. This thesis will determine the significance a tool material has on the mechanical properties of a friction stir weld in 5083-H131 aluminum[2].

The difference in the friction stir welds will be compared directly to both MIG welds and the parent material. A fixture was developed which allowed welds to be performed in a vertical CNC machine. Test samples were cut from the work piece for visual evaluation, tensile, bend, and hardness testing. Welds produced by three different tool materials were compared: H13 tool steel, 420 stainless steel, and A2 tool steel. The system developed at Auburn University, with support from Anniston Army Depot and NASA’s Marshal Space Flight Center, uses a threaded pin and scrolled shouldered tool to perform welds as detailed in Figure 1.1 [2].

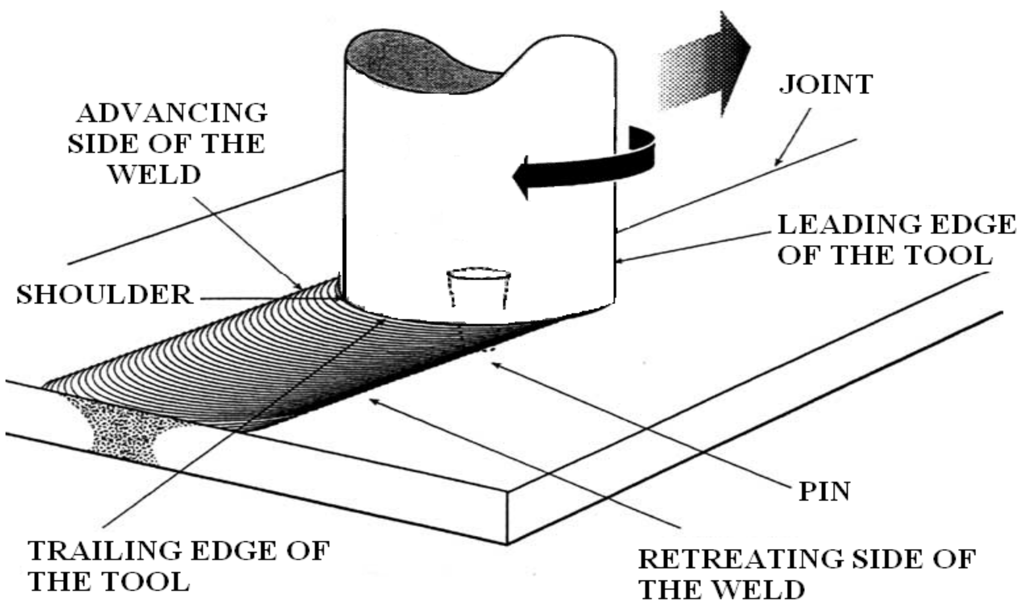

Figure 1.1 Friction Stir Welding Process [2]

The following research paper is designed as follows. Section II describes the overall previous research work whereas Section III gives idea of problem formulation. Performance parameter define in section IV and last but not the least Section V concludes paper.

II. LITERATURE SURVEY

In this section, we will discuss basic introduction and high points of influence, explanations and issues in the research work by researchers in different field. Researchers have tried a lot in recent times to attain the max tensile strength.

Gurmukh Singh et al (2017) studied the effects of tool speed, feed rate, and shoulder dia. On various mechanical properties of Aluminium alloy 6063 produced through friction stir welding have been analysed. AA6063 is an aluminium alloy with magnesium and silicon as the alloying detail. It has usually moral mechanical properties and is heat mendable and weld in a position. It is similar like to aluminium alloy HE9.

Experiments are exposed by using varying rotational velocity, transverse velocity and altered shoulder diameter. The Taguchi approach is used to treasure the mixture of the 3 welding parameters. In this work 3 parameters are taken and L9 orthogonal array are decided on to improvement parameters for power of the welded joint. A most desirable result has been received using main results plot the usage of S/N ratio values. The elongation is particularly posh by temperature distribution and near it shoulder diameter & feed rate also have an effect on to some extent.

Anitesh Mukherjee et al (2017) studied on comprehensive essay of understanding that has been documented with recognize to the friction stir welding (FSW) of various alloys because the technique was invented in 1991 is reviewed on this paper. The friction stir welding is an unexpectedly growing welding technique within the manufacturing industries. The design of device pin profile and device shoulder diameter creates vast variations on welded microstructure. Special system parameters are considered for the variations inside the final results of the weld materials to optimize the welding techniques [1].

(Gharaibeh, Al-jarrah and Sawalha, 2016) the effect tool pin profile and welding process on friction stir welding of AA 6061 Al alloy was studied and based on the results the following conclusions can be drawn. The weld prepared by hexagonal pin profile possessed better micro hardness and microstructure compared to the one prepared by square or triangle pin profiles. The strength of the joints prepared by square pin profile have higher ultimate tensile

strength compared by one produced by hexagonal and triangle pin profiles. The highest ultimate tensile strength observed at 1120 rpm and 1.5 mm/sec for stir zone produced by square pin profile.

Sushant Sukumar Bhate et al (2016) reviewed of research papers related to friction welding is performed. Friction welding is a best till date recognized approach to weld similar as well as dissimilar metals. It is an ordinarily used welding process in industries like vehicle industries, submarine engineering industries aeronautical industries, and heavy responsibility industries.

Vanita S. Thete and Vijay L. Kadlag (2015) studied the effect of process parameters of friction stir welded joint for comparable aluminium alloys H30 was studied. Taper cylindrical with 3 flutes all made of high speed metallic was used for the friction stir welding (FSW) aluminium alloy H30 and the tensile test of the welded joint were tested via universal testing method. The optimization completed using distinctive mathematical model is simulated by means of Minitab17. In this investigation a powerful method primarily based on Taguchi technique, has been developed to

decide the top-quality conditions main to higher tensile strength. Experiments had been performed on various rotational speed, transverse speed, and axial force using L9 orthogonal array of Taguchi technique.

Sirajuddin Elyas Khany et al (2015) studied the impact of friction welding parameters which includes rotational speed, friction time, forging pressure and friction stress on tensile strength of a joint among SS316 and EN8 is experimentally investigated. A partial factorial design of experiment based totally on Taguchi analysis is conducted to obtain the response measurements. Analysis of variance ANOVA and fundamental results plot is used to determine the significant parameters and set the optimal level for each parameter.

(Dawood et al., 2015) discussed geometry and dimension of the welding tool used in the FSW process influence the mechanical properties of the joints. The best mechanical properties are obtained for the FSW joint produced by a triangular tool pin profile when compared with their counterparts. Moreover, the less pulsating action experienced in the NZ of triangular tool pin profile produces fine grains

(Ilangovan, Boopathy and Balasubramanian, 2015). The effects of tool pin profile on microstructure and tensile properties of friction stir welded dissimilar AA 6061- AA 5086 aluminum alloy joints were investigated and the following conclusions are derived. The three tool pin profile used, the straight cylindrical pin profile tool yielded cross-sectional macro level defects in the stir zone and hence is not available for AA 6061 and AA 5086 dissimilar joints. Prakash

Kumar Sahu and Sukhomay Pal (2015) have been accomplished experiments by using the usage of Taguchi's L18 factorial design of experiment. Grey rational analysis became used for optimizing process parameters. Percentage

impact of individual process parameter on the weld quality was measured. They used AM20 Magnesium alloy to form square but joint. Process parameters had been used such as tool rotation speed, welding speed, shoulder diameter and plunge depth

Ali Akbar Nadim and Hakeemuddin Ahmed (2014) have executed an experiment on CNC Milling device to weld the elements together.

The components being welded are made from multiple materials like Aluminium and Copper. The rotational velocity is various from 900 rpm to 1500 rpm whilst the welding velocity is kept regular at 25 mm/min. the opposite parameter worried is the axial load, which reaches two hundred bars.(Singla and Burman, 2014)

Welding is a fabrication process used to join materials, usually metals or thermoplastics, together. During welding, the work pieces to be joined are melted at the joining interface and usually a filler material is added to form a weld

pool of molten material that solidifies to become a strong joint. In contrast, Soldering and Brazing do not involve melting the work piece but rather a lower melting point material is melted between the work pieces to bond them together. Friction Stir Welding is a solid-state process, which means that the objects are joined without reaching melting point.

(Zhang et al., 2014) presented study demonstrate that the plastic flow could provide a driving force for the formation of banded textures and flashes and could also be critical for the keyhole welding. The flash of the FSW joint was mainly distributed on the retreating side, and the microstructures could be divided into two layers. The forming and healing process of the transient state keyhole was studied visually in one rotation period, including flowing out of the weld materials from the keyhole region until 1/3 period and back flowing into the keyhole region after the FSW tool was rotating to the 2/3 period. The large deformation region Mainly distributes near the top surface of the FSW joint and was close to the advancing side, which is consistent with the previous work in other literatures.

(Narsimhachary et al., 2014) the following conclusions can be drawn that AA 6061-T6 Al alloy samples were laser-welded with different welding parameters and the welds were defect free. The hardness value was very low at the weld zone compared to the base metal even after post-weld aging treatment, but hardness of the FZ and HAZ of the specimen were increased after PWHT.

(Tikader, Biswas and Puri, 2014) research study, 6 mm thick commercial grade aluminum plates have been welded by using 4 different types of tool (two straight cylindrical and two tapered cylindrical). For various FSW tool geometry and different process parameters, eight no. of very good quality welds have been obtained The following conclusions may be drawn from the above study that tensile strength was higher in case of tapered cylindrical tools with same process parameter. The hardness value is more in case of straight cylindrical tool pin than tapered cylindrical tool pin for the same process parameter. The hardness values of the weld zone and HAZ are lower than the base material which indicates the improved ductility of the weld.

(Jannet, Mathews and Raja, 2014) The mechanical and metallurgical properties of TIG, MIG and Friction Stir Welded joints dissimilar AA 5083-O and 6061- T6 were evaluated in detail, a comparison was made and the following conclusions were derived from the investigation.

The tensile properties of welded joints AA 5083-O and 6061-T6 aluminium alloy joints were influenced by welding process and post weld aging treatment with a reasonable increase in tensile properties been noted for post weld aged joints as com- pared to welded joints.

(Gadakh and Adepu, 2013) an analytical model for heat generation for FSW of Al alloy using taper cylindrical pin profile was developed. A combined of both analytical as well as numerical approach was considered. There is good agreement between the generated heat energy and the associated maximum temperature by the proposed model and results available in the literature. With the proposed analytical approach one can directly see the peak temperature for respective taper probe angle under given process conditions which will be helpful for predicting the mechanical properties for that Al alloy and hence elimination of post weld testing cost and time.

(State and Street, 2012) During FSW of AA7075, fatigue is unlikely to be the mechanism of tool failure except for welding of 8mm or thicker plates. Although the toughness of the tools varies, uncertainty in the toughness values does not change this finding. Bending stress, which affects the fatigue life of the tools, increases significantly with plate thickness, and somewhat less significantly with the reduction in tool shoulder radius and decrease in tool rotational speed. Computed values of peak temperature and the maximum shear stress, obtained from ANN models trained with results from a well-tested three-dimensional heat and materials flow model, were used to generate a series of maps aimed at enhancing tool durability against mechanical erosion ignoring chemical erosion. These maps examine the effects of welding velocity, tool rotational speed, tool shoulder radius, tool pin radius, pin length (or plate thickness) and axial pressure from a series of maps of an index of tool durability that is defined as the ratio of the tool shear strength to the maximum shear stress on the tool pin.

(Rajakumar, Muralidharan and Balasubramanian, 2011) Using the friction stir welding machine, within the limits of the process parameters and tool parameters considered in this study, the following points can be concluded that multi objective optimization using RSM is an useful technique to optimize the friction stir welding parameters to obtain the maximum tensile strength without deteriorating the corrosion resistance of FSW joints. A tool rotational speed between 1155 and 1157 rpm is an optimum input to obtain an excellent welded component produced from AA6061-T6 aluminum alloy. The welding speed is the most predominant welding parameter and its interaction with the rotational speed should be monitored. Welding speed between 84.51and
84.67 mm/min is compatible with axial force 7.17 kN, while shoulder diameter 15.71 mm, pin diameter of 5.21 mm and tool hardness 44.85 HRC is compatible.

III. PROBLEM FORMULATION

From the literature review following research issues are identified and are summarized as below: -

1. In order to get good weld strength and weld geometry it is necessary to optimize the friction welding process such as friction time, friction pressure, upset pressure, upset time, rotational speed.
2. Optimization of above parameters is highly material specific.
3. The optimum welding parameters that obtained from equal diameters parts could not be used in welding of different diameters parts.

IV. MACHINE USED & PERFORMANCE PARAMETER

To set off the FSW experiment a vertical milling machine is used. The tool is fix inside the vertical arbour using the perfect collates. The plates to be connected are clamped to the horizontal bed with nil root gaps. The clamping of the check pieces are executed such that the strength of the plates is definitely constrained beneath each plunging and translational forces of the FSW tool.

1. S/N Ratios For Tensile Test

For the calculation of S/N ratios 'Bigger the Better' is selected and is given by formula:

$$\frac{S}{\mathrm{N(bigger)}} = -\log\frac{(\sum(1/y))}{n}$$

2. Confirmation Test

Largest the best characterization

$$\frac{S}{\mathrm{N(bigger)}} = -\log\frac{(\sum(1/y))}{n}$$

Where yi are the responses and n is the number of tests in a trial. The level of a factor with the highest S/N ratio was the optimum level for responses measured. In order to test the predicted result, confirmation experiment has been conducted by running three trials at the optimal setting of the process parameters determine from the analysis i.e. A2, B3, C3 for tensile strength.

V. CONCLUSION

In the present study, the effect tool pin profile and welding process on friction stir welding of AA 6061 Al alloy was studied and based on the results the following conclusions can be drawn that the weld prepared by hexagonal pin profile

possessed better micro hardness and microstructure compared to the one prepared by square or triangle pin profiles. The strength of the joints prepared by square pin profile has higher ultimate tensile strength compared by one produced by hexagonal and triangle pin profiles. The micro-hardness of the welded joints decreased as the rotational speed increased, irrespective of the pin profile used to prepare the joints.

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