Optimization of Process Parameters For Friction Stir Welding

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Abstract - Friction Stir Welding (FSW) is a solid state welding process in which the relative motion between the tool and the work piece produces heat which makes the material of two edges being joined by plastic atomic diffusion. In this project an attempt is made to determine and evaluate the influence of the process parameters of FSW on the weldments.The tensile strength are considered for investigation by varying tool speed, welding speed and clamping position. Experiments were conducted on Aluminium alloy in a CNC Vertical Machining Centre. The output factors are measured in UTM. Results show strong relation and robust comparison between the weldmesh strength and process parameters. Hence FSW process variable data base is to be developed for wide variety of metals and alloys for selection of optimum process parameters weld. For efficient.

Key words - Friction Stir Welding, CNC, Parameter, Tensile Strength, Atomic Diffusion

1. INTRODUCTION

FSW works by mechanically intermixing the two piece of the metal at the place of the join, which get send to the softened states that allows the metal at the place to of the join, pressure like joining clay, dough or plastic. Friction-stir welding (FSW) is a solid-state joining process (meaning the metal is not melted) and is used for applications where the original metal characteristics must remain unchanged as much as possible. Once the time these process is firstly used on the aluminum and on the big size which cannot be simply heated post welded to modify to recover temper characteristics.

The FSW process is one of the latest creativity in ares of the welding .its has many types of the advantages compared to traditional to fusion welding technique and is mainly used for lightweight alloys such as aluminum & manganese. Friction Stir Welding was invented at The Welding Institute in Cambridge, UK, in 1991and the first patent for FSW in butt joint configuration was filed in 1991 by Wayne Thomas (Thomas et al., 1991).

1. FSW is energy efficient.
2. FSW requires minimal, if any, consumables.
3. FSW produces desirable microstructures in the weld and heat-affected zones
4. FSW is environmentally "friendly" (no fumes, noise, or sparks)
5. FSW can successfully join materials that are
"Unsellable" by fusion welding methods.
6. FSW produces less distortion than fusion welding techniques.

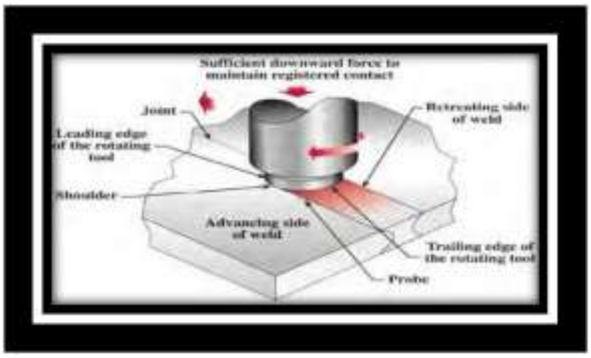

Figure.1 Friction stir welding

The process, uses a rotating, non-consumabletool, consisting of a bigger circular area, theshoulder, with a smaller diameter pin sticking out, the probe.The process is typically described in four steps:The plunge operation: the rotating probe is slowly pressed down until the shoulder makeContactwith the material. The dwelling period: the tool maintains its position, generating frictional heat until the desired temperature is reached. The actualwelding operation: the rotating tool is moved along a joint line with a certain contact pressurebetween the tool and the material and predefined traverse speed. This creates a solid-state joint, i.e. without melting the material.Theheat generation is mainly due to the frictional heat, generated between tool and material, and also by material deformation, similar to a hotworking1 process. The probe on the tool stirs the plasticized material, creating a very fine microstructure. To create more pressure and preventing void formation behind the probe, the tool is often tilted towards the trailing edge of the tool. This "tilt-angle" is typically between 1 and 3.Finallywhen the joint is created, the tool is pulled up leaving a small "key-hole" in the end.

Friction stir welding (FSW) is a solid-state welding

Process developed by The Welding Institute (UK) in1991, and now being used increasingly for joining Aluminum alloys, for which fusion welding is often difficult. FSW uses a rotating tool with a probe travelling along the weld path, and plastically deforms the surrounding material to form the weld. Since the material subjected to FSW does not melt and recast, the resultant weld offers advantages over conventional fusion welds, such as less distortion lower residual stresses and fewer weld defects.

When developing such a technology, one of the most important factors is the possibility to join different aluminum alloys. The development of sound joints between dissimilar materials is a very important consideration for many emerging applications, including ship building, aerospace, transportation, power generation, as well as the chemical, nuclear, and electronics industries

MIG welding is a flexible and productive methodand is therefore widely used for welding of aluminum alloys in shipbuilding. However, two disadvantages with MIG welding are deformation of the base material and a decrease in strength within the heat affected zone. Other fusion welding techniques like TIG and plasma welding are also widely used. However, these methods have the same weakness as MIG welding. FSW presented an alternative welding/joining technique to existing fusion welding methods. The solid-state nature of FSW leads to several advantages over fusion welding methods as problems associated with cooling from the liquid phase are avoided. Issues such as porosity, soluteredistribution, solidification cracking and liquationcracking do not arise during FSW. In general, FSW has been found to produce a low concentration of defects and is very tolerant of variations in parameters and materials.

A.Operating principle:

The nib is slightly shorter than the weld depth required, with the tool shoulder riding a top the work surface. A constantly rotated cylindrical-shouldered tool with a profiled nib is reversely fed at a constant rate into a butt joint between two clamped pieces of butted material. the mechanical mixing process and the adiabatic heat within the material is generate the heat, produce the stirred materials to soften without melting. when the pin is move in down word direction and come in to contact with work piece Frictional heat is generated between the wear-resistant welding components and the work pieces.

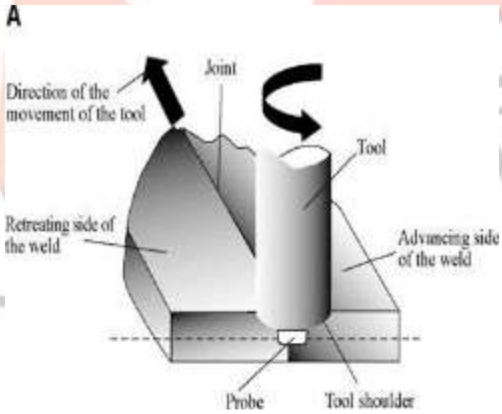

Figure.2 operating principle of Friction stir Welding

B.Microstructure feature:

The solid-state nature of the FSW process, combined with its unusual tool an asymmetric nature, results in a highly characteristic microstructure. The microstructure can be broken up into the following zones: The stir zone (also nugget, dynamically recrystallized zone) is a region of heavily deformed material that roughly corresponds to the location of the pin during welding. The grains within the stir zone are roughly equated and oftenan order of magnitude smaller than the grains in

3.3.1 Results for surface waviness

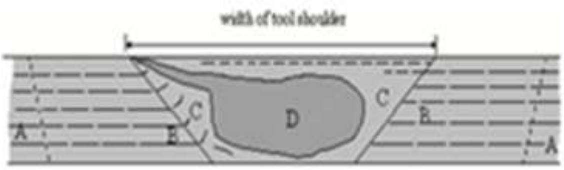

Fig.3.1 Effect of control factors on Main effect plot for means in surface waviness
Source: Graph from MINITAB17 Software

In this the observed value of surface waviness is transform in S/N ratio values to find out the optimum combination of parameters for response variable. In surface waviness response "smaller is better" is objective characteristics.

The parent material. A unique feature of the stir Zone is the common occurrence of several concentric rings which has been referred to as an "onion-ring" structure. The precise origin of these rings has not been firmly established, although variations in particle number density, grain size and texture have all been suggested. The flow arm zone is on the upper surface of the weld and consists of material that is dragged by the shoulder from the retreating side of the weld, around the rear of the tool, and deposited on the advancing side.

The thermo-mechanically affected zone (TMAZ)occurs on either side of the stir zone. In this region the strain and temperature are lower and the effect of welding on the microstructure is correspondingly smaller. Unlike the stir zone the microstructure is recognizably that of the parent material, albeit significantly deformed and rotated. Although the term TMAZ technically refers to the entire deformed region it is often used to describe any region not already covered by the terms stir zone and flow arm.

The heat-affected zone (HAZ) is common to all welding processes. As indicated by the name, this region is subjected to a thermal cycle but is not deformed during welding. The temperatures are lower than those in the TMAZ but may still have a significant effect if the microstructure is thermally unstable. In fact, in age-hardened aluminium alloys this region commonly exhibits the poorest mechanical properties.

A Unaffected material,
B Heat-affected zone (HAZ),
C Thermo-mechanically affected zone (TMAZ),
D Weld nugget (Part of TMAZ)
Figure3.Various zone in few process

c. Important welding parameter

• Tool rotation and traverse speeds
• Tool tilt and plunge depth
• Tool design
• Welding forces
• Flow of material
• Generation and flow of heat
• Clamping type & clamping position

II. REVIEW

3.3.2AM Jayaraman et al [1].Optimization of process parameter for friction stir welding of cast aluminium alloy A-319 by touchy methods of FSW AL alloy A319 has been evaluated under different processing conditions using 33 full factorial experimental design. Tool rotation speed has been found dominant parameter for TS followed by welding speed. Axial force shows minimal effect on TS compared to other

Parameters. A maximum TS (147 Map) exhibited by FSW joints with optimal process parameters (tool rotation speed, 1200 rpm; welding speed, 40 mm/min; and axial force, 4 kN) shows a **reasonable agreement with experimental value. A**nonlinear regression model, developed to correlateTS, has been found to be useful in predicting TS. However, contribution of nonlinear terms in regression model is insignificant. Thus linear regression analysis model may employ successfully for designing process parameters of FSW A319 alloy**.**

G. D'urso et al [2] the effect of process parameters and tool geometry on Mechanical properties of friction stir welded aluminium Butt joints. This study presented the effects of FSW parameters for two different tool geometries. A range of values for feed rate and rotational speed was determined to obtain an acceptable weld quality. Both rotational speed and feed rate resulted to have a significant effects on UTS. The threaded tool design for this study proved to be effective in friction stir welding of AA6060

Plates even though no significant differences were found in terms of UTS (compared with the standard tool). The strain values resulted always lower for the joints obtained using the threaded tool. As a general remark and within the limits of the present investigation, it is possible to confirm that a good weld joint can be obtained across a wide range of welding conditions.

Mushin J. J et al [3]Effect of friction stir welding parameters (rotation and transverse)speed on the transient temperature distribution infraction stir welding of a 7020-t53 .Axial load that measured from experimental work decreases with increase in rotational speed because that decrease in strength due to temperature increases in penetration position; The experimental data show the maximum temperature measured during SW at mid position 629k and numerically value from the simulation is 642Ko, which is significantly less than the melting temperature of7020-T53 aluminium alloy at 916Ko; The temperature at advance side (629k) is higher than retreated side (605k);Numerical results (Tmax = 642K) agreement with measured data (Tmax = 629k) (error 2%);Numerical results show the temperature increases with increaserotating speed (Tmax=642k at1400rpmmm/ min and Tmax=615k at 900rpm-40mm/min); and Numerical results show the temperature decrease with increase travel speed (Tmax =642k at1400rpm mm/min and Tmax = 680k at 1400rpm-16mm/min).

A. K. Lakshminarayanan et al [4] Process parameters optimization for friction stir welding of RDE-40 aluminium alloy using Taguchi technique.
1) The percentage of contribution of FSW process parameters was evaluated. It is found that the tool rotational speed has 41% contribution, traverse speed has 33% contribution and axial force has 21% contribution to tensile strength of welded joints. 2) The optimum value of process parameters such as rotational speed, traverse speed and axial force are found to be 1 400 r/min, 45 mm/min and 6 KN respectively.

Indira Rani M.et al [5] A study of process parameters of friction stir welded a 6061 aluminium alloy in o and t6 conditions .The parameters like welding speed, tool rotational speed, axial force, tool profile has effect on the weld. From the results obtained it can be inferred that tool rotational speed and welding speed has got influence on the welded joint. So it can be concluded that in annealed condition tool rotation speed 800 rpm and welding speed 10 mm/min and 15 mm/min are the optimal parameters. The tool rotation speed 1000 rpm and welding speed 10 mm/min are the optimal parameters in „T6" condition. The effect of different parameters on the mechanical properties of the butt welded joint
AA6061 is analysed.

Ahmed Khalid Husseinet al [6] evaluation of parameters of Friction stir welding for Aluminium aa6351 alloy. Vickers hardness of the well-meant is 85 as of 93.5 of parent metal; therefore the well-meant is weaker than parent metal due to misalignment of welding line& tool.
Alignment of work piece welding line and tool is an important factor to be considered to obtain high tensile strength. In experimental work, it has been observed that due to misalignment of welding line and tool, the tensile strength is lower that is 160 MPs when compared to the same work with proper alignment (274Mpa) Pure aluminium alloy cannot be friction stir welded due to its high thermal conductivity and low melting point as it is observed while conducting the experiment. Tensile strength is found to increase with increase in rotational speed. Maximum Tensile strength of 172 Map was observed at 1350 rpm (for 115 mm/minfeed). This indicates that for IS 64430 AA6351Al alloys, higher range of rotational speed is best suited to achieve maximum tensile strength. High surface finish is obtained at tool speed of 1350 rpm and weld speed of 115mm/mint ensile strength is higher with lower weld speed. This indicates that lower range of weld speed is suitable for achieving maximum tensile strength. No filler metals and external source of heat (arc, gas) was used while performing the experiment, hence adoptable as no exhaustible resources are involved. Friction stir welding being and ecofriendly metal joining process which is the need of the hour should be implemented to avoid environmental related problems.

III.EXPERIMENTAL PROCEDURE

Tensile test perform on universal testing machine. Comparing the all parameter for the tensile strength of the welded work piece by Design of experiment (DOE) method. Experimentally work is carried out in simple vertical milling machine. Performing the tensile test for each work piece getting from experimentally study.

IV. CONCLUSION

From critical literature review it is conclude that all the input parameter are effect on to tensile strength of welded joint. So find which combination of input parameter is give higher tensile strength of the weld joints. From the values of Delta of tool rpm, welding speed and clamping location we can conclude that the tool rpm is most affected parameter as compare to of clamping location, and welding speed

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