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Influence of Friction Stir Welding Parameters on Properties of AL-7075 Alloy

Anil Kumar Bodukuri, Rajendar Katla. Upender

Abstract—Welding of non-ferrous materials like aluminum, magnesium, copper etc, is difficult with conventional welding process as they are affected by oxidation. Friction stir welding (FSW) appears as a promisingly ecological weld method that enable to reduce material waste and to avoid radiation and harmful gas emissions usually associated with fusion welding processes. The welded joints are mainly affected by the rotational speed and transverse speed of the tool during welding this paper deals with the study of friction stir welding of Al 7075 Alloy with different speeds and feeds.

Index Terms— Friction stir welding, Al-7075, Square tool, Taghuchi, Orthogonal array, Hardness and Uts.

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1 Introduction

The most of the engineering applications today require materials having properties like low weight to strength ratio, low density, low cost and abundantly available. These requirements are nearer to many materials but mostly satisfied by aluminum metal which results the use of aluminum in air crafts, ship vessels, rockets, pressure vessels and many more applications. Generally aluminum alloys are divided as non-weldable because of the poor solidification microstructure and porosity in the fusion zone. Furthermore, the loss in mechanical properties as compared to the base material is very significant. The factors put together the joining of these alloys by conventional welding processes unattractive. Some aluminum alloys can be resistance welded, however the surface preparation is expensive, with surface oxide being a major problem. To compensate the huge equipment cost of above process we go for an alternate process of joining technique for metals called friction stir welding which is a simple ,compact and effective method of welding high thermal conductive materials like aluminium, copper ,bronze and others .Friction stir welding process can be done on non-ferrous and also ferrous materials. FSW has proven to be an excellent joining technique for a variety of different materials, including polymers and metals.. Metals among low melting temperatures such as copper and aluminium were among the first to be joined this technique using a steel tool.FSW retain much of the base material strength and have many other advantages over joints produced by traditional welding techniques. It is generally thought that such advantages stem from the lower heat input required by FSW. FSW can create welds that are high in superiority, strong, and economical to make with absence of oxidation and porosity.

- Upender Yelutla. Student Department of Mechanical Engineering, KUCE&T, Kakatiya University,Warangal Telangana
- *Anil Kumar Bodukuri Scholar in Department of Mechanical Engineering Kakatiya University. Telangana-506009 Mob no:9700381439. E-mail: anil.kucet@gmail.com.*
- *Rajendar Katla Scholar in Department of Mechanical Engineering Kakatiya University. Telangana-506009 Mob no:9700381439*

2 Literature Review

The Response Surface Methodology based on a central composite rotatable design with three parameters which was used to develop a mathematical model predicting the tensile properties of friction stir welded AA6061 aluminium alloys.[1] The mechanical properties and failure mechanisms of friction stir welded 6061 aluminum alloy is investigated based on experimental observations. A preferable appearance of the joint can be obtained at higher rotational speed and longer duration time. The insufficient pressure vertical to the tool, and the amount of material extruded upward and the effective weld width increase with the increasing of rotational speed and duration time. The tensile/shear strength increases with the increasing rotational speed at a given duration time. However, under a given rotational speed, differences in tensile/shear strength among three duration times are rather small. The tool rotational speed plays a determinant role in determining the tensile/shear strength. The dependence of tensile/shear strength on tool holding time is less remarkable at lower rotational speed There was a direct correlation between the effective weld width and the strength, the presence of larger effective weld width results in stronger weld [2]. The relationship between tool profiles, spindle speed, travel speed, and other process parameters for friction stir welding (FSW) at high spindle speeds, and correlate the results predicting the properties, tensile strength and hardness.[3],[12]

3 Design of Experiment.

Design of experiments (DOE) or Experimental design is the design of any information-gathering exercises where variation is present, whether under the full control of the experimenter or not. A methodology for designing experiments was proposed by Ronald A. Fisher.

Design of experiments is a sequence of tests in which changes are made to the input variables of a system. and the effects on response variables are measured [4]. Design of experiments is applicable to both physical processes and computer simulation models. However in statistics these terms are usually used for controlled experiments. Experimental design is an effective tool for maximizing the amount of information gained from a study while minimizing the amount of data to be collected. Factorial experimental designs investigate the effects of many different factors by varying them simultaneously instead of changing only one factor at a time. Factorial designs allow estimation of the sensitivity to each factor and also to the combined effect of two or more factors.

The fundamental principles in design of experiments are solutions to the problems in experimentation posed by the two types of nuisance factors and serve to improve the efficiency of experiments. Those fundamental [4].principles are

1. Randomization
2. Replication
3. Blocking
4. Orthogonality
5. Factorial experimentation

Uses.

The main uses of design of experiments are

1. Discovering interactions among factors
2. Screening many factors
3. Establishing and maintaining quality control
4. Optimizing a process, including evolutionary operations (EVOP)
5. Designing robust products emphasis; do not underline.

3.1 Taguchi method.

Taguchi methods are statistical methods developed by Genichi Taguchi it is one of the most powerful DOE methods for analyzing of experiments. It can be used to improve the quality of manufactured goods, and more recently also applied to [5]engineering biotechnology, marketing and advertising. Taguchi first applied his methods was Toyota. Since the late 1970s.

Product robustness, pioneered by Taguchi, uses experimental design to study the response surfaces associated with both the product means and variances to choose appropriate factor settings so that variance and bias are both small simultaneously. Designing a robust product means learning how to make the response variable insensitive to uncontrollable manufacturing process variability or to the use conditions of the product by the customer.

Taguchi defines three quality characteristics in terms of signal to noise (S/N) ratio which can be formulated for different categories which are as follows [6]:

3.2 Nominal and small are best characteristics.

Data sequence for stresses developed on FSW tool, which are lower-the-better performance characteristics, are pre processed as per equations.

$S/N = -10 \log (\hat{y}/s^2y)$…………………1

$S/N = -10 \log ((l/n)\ (\Sigma y^2))$…………..……2

3.2 Larger is best characteristics.

Data sequence for material removal rate, which is higher-the-better performance characteristics, is pre processed as per equation 3.

$S/N = -10 \log ((1/n)\ (\Sigma\ (1/y^2))$……..…3

where, y is value of response variables and n is the number of observations in the experiments

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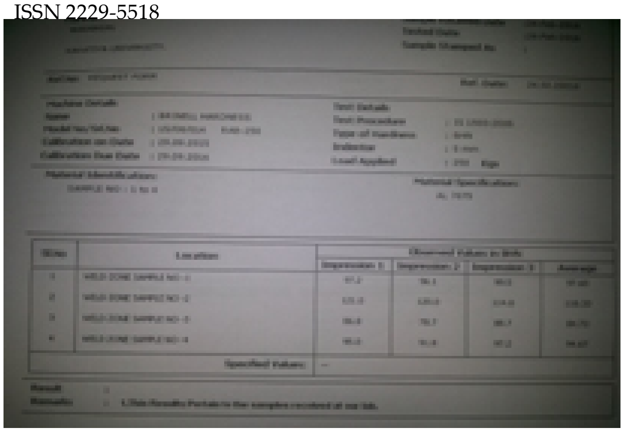

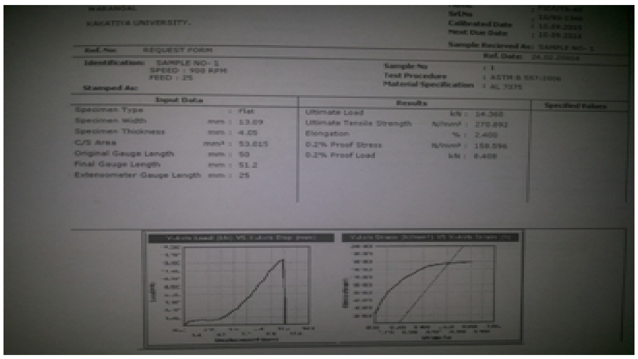

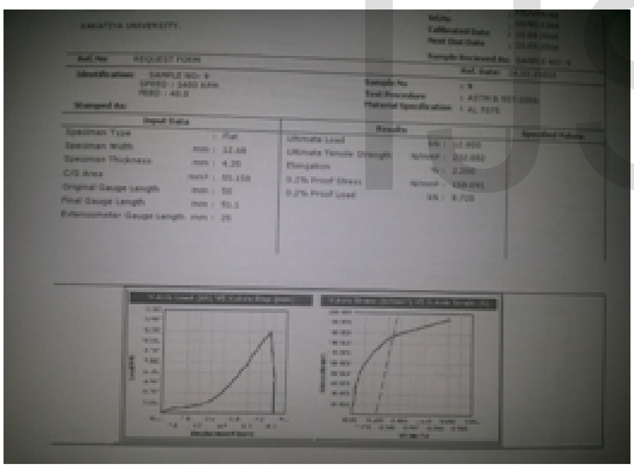

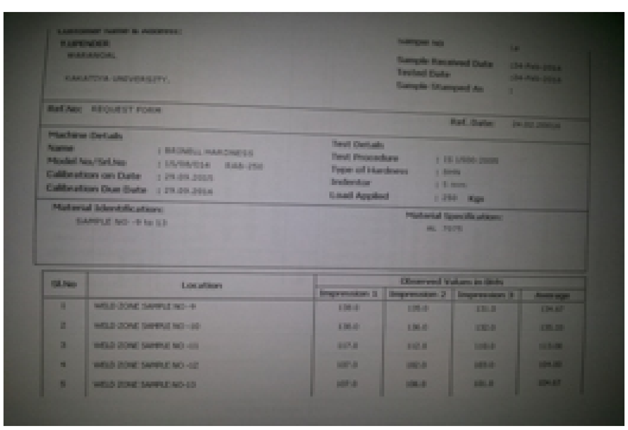

Table 3: The basic Taguchi L 9(4^3) orthogonal array

Run Order	Speed	Feed	Hardness	Uts
1	900	25	97.6	270.8925
2	900	31.5	118.33	117.535
3	900	40	84.73	109.056
4	1120	25	94.67	151.717
5	1120	31.5	105.33	188.383
6	1120	40	118.76	111.563
7	1400	25	118.67	162,254
8	1400	31.5	104.67	165.783
9	1400	40	134.67	232.052

4 RESULTS

It was concluded that the differences in tool geometry and welding parameters induced significant changes in the material flow path during welding in weld nugget. The different mechanical properties of the weld obtained like hardness and tensile strength is observed to be greatly influenced by two parameters one the rotation of the tool and second the weld speed. It is observed that observed now that by varying these two parameters the strength of the joint can be varied and optimized .It is also seen that the friction stir welding may also depend upon many other factors like the material used for tool and base metal, indentation force, tool geometry, rigidity of the machine and other miscellaneous parameters. After FSW operations carried on and then considering the all above terms, the better values obtained for hardens test, tensile test constituting specific speed and feed are like

4.1 Hardness

The hardness at the weld zone even depends on the weld speeds and feeds.

1. For square shouldered tool at rotational speed 1400rev/min and transverse speed 40mm/min the maximum hardness value obtained is 134.67 BHN.
2. At rotational speed 900 rev/min and transverse speed 40mm/min the minimum hardness value obtained is 84 BHN.

4.1 UTS

The UTS at the weld zone even depends on the weld speeds and feeds

1. For square shouldered tool at rotational speed 900rev/min and transverse speed 25mm/min the maximum UTS value obtained is 270.892 N/mm^2
2. At rotational speed of 900rev/min and transverse speed 40mm/min the minimum UTS value obtained is 109.056 N/mm^2

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