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CRITICAL ANALYSIS OF PARAMETERS AND CASE STUDIES OF FRICTION WELDING PROCESS WITH IT'S APPLICATION IN AUTO INDUSTRIES

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ABSTRACT

Friction welding (FW) is a fairly recent technique that utilizes a non-consumable welding tool to generate frictional heat and plastic deformation at the welding location, there by affecting the formation of a joint while the material is in solid state. The principal advantage of frictional welding, being a solid-state process, low distortion, absence of melt-related defects and high joint strength, even in those alloys that are that are considered non-weldable by conventional welding techniques. Furthermore, friction welded joints are characterized by the absence of filler-induced problems or defects, since the technique requires no filler, and by the low hydrogen contents in the joints, an important consideration in welding steel and other alloys susceptible to hydrogen damage. FW can be used to produce butt, corner, lap, T, spot, fillet and hem joints, as well as to weld hollow objects, such as tanks and tubes or pipes, stock with different thickness, tapered section and parts with 3-dimensional contours. The technique can produce joints utilizing equipment based on traditional machine tool technologies, and it has been used to weld a variety of similar and dissimilar alloys as well as for welding metal matrix composites and for repairing the existing joints. Replacement of fastened joints with FW welded joints can lead to significant weight and cost savings, attractive propositions for many industries. This document reviews some of the FW work performed to date, presents a brief account of mechanical testing of welded joints, tackles the issue of generating joint allowables, and offers some remarks and observation. FW is a leap forward in manufacturing technology, a leap that will benefit a wide range of industries, including transportation industry in general and the airframe industry in particulars.

Keyword: - frictional welding, being a solid-state process, low distortion.

INTRODUCTION

A method of operating on a workpiece comprises offering a probe of material harder than the workpiece material to a continuous surface of the workpiece causing relative cyclic movement between the probe and the workpiece while urging the probe and workpiece together whereby frictional heat is generated as the probe enters the workpiece so as to create a plasticized region in the workpiece material around the probe, stopping the relative cyclic movement, and allowing the plasticized material to solidify around the probe. This technique, which we refer to as "friction welding" provides a very simple method of joining a probe to a workpiece. The method can be used for repairing cracks and the like within a workpiece or for joining members, such as studs or bushes, to a workpiece. Another aspect of the invention comprises causing a probe of material harder than the workpiece material to enter the joint region and opposed portions of the workpieces on either side of the joint.

Friction welding is a type of forge welding, i.e. welding is done by the application of pressure. Friction generates heat, if two surfaces are rubbed together, enough heat can be generated and the temperature can be raised to the level where the parts subjected to the friction may be fused together. In conventional friction welding, relative rotation between a pair of workpieces is caused while the work pieces are urged together. Typically thereafter once sufficient heat is built at the interface between the workpieces, relative rotation is stopped and the workpieces are urged together under forging force which may be same as or greater than the original urging force.

It has a very short cycle, which is associated with heightened efficiency and mass production. It is known as a solid-state welding process that produces quality welds with no cast structure common in other welding processes. Nevertheless, there are several drawbacks associated with frictional welding. This also includes consideration of ease of configuration and it may not make economic sense in running short prints. Aspects such as the requirement of power tools, tooling, and other associated costs should be considered under the total feasibility assessment of friction welding. Friction welding possesses a great level of flexibility, and as such, it can be applied in different industries. Friction Welding is used for a wide range of parts in the commercial sector such as extension tools, fasteners, and medical equipment. Turbine wheels, shaft straps, landing gear struts, and gear assemblies are made of full-strength welded inertia products which benefit the aerospace market. Inertia welding is one of an ideal choice in the hydraulic industry particularly in applications involving the usage of hydraulic cylinders as well as valves owing to its cost cutting and a little stock requirement. Friction welding is widely applied in the automotive sector where many parts are exposed to different stresses and need the fusion of materials of diverse properties. They can be used as drive shafts, axles, wheels, rims, engine heads or blocks among others. Since 1966 it was possible to use bi-metal welding for critical products, e.g., electrical connectors, satellite heat pipes, and cryogenic fittings.

Friction welding is used in agriculture and trucking for the forge quality welds that have high resistance to stress and torque. An example of this is friction welding which is used to manufacture Drill Tubes and Rotary Drilling for Drill Rods having API connection. This study critically analyses friction welding processes in auto industry using case studies. Specific objectives will involve looking into various aspects that relate to the machine and component used in friction welding. The study also takes into account setup settings, safety considerations, and load capacity in special focus onto a KUKA frictional welder of 45 tonnes. Subsequent chapter will discuss in details the aspects of friction welding like machines and components setting up arrangements and four types of components in the automotive sectors. This paper is designed to provide useful information regarding the use of friction welding process to improve efficiency, safety and production in automobile Industry. This study will also address many issues that relate to friction welding. The sections below will give an insight into different facets that determine how it works, why it is used and what the influence of this practice on the auto industry entails. Case studies will be used as a tool for critical analysis that is meant to contribute to the contemporary developments within welding technology applied to automotive manufacturing processes.

Friction welding is a cutting-edge, solid-state joining process that has proven crucial in sectors like car manufacture. Unlike traditional welding, friction welding employs mechanical friction to create heat, removing the need for fillers, flux, or external heat. This results in an efficient, cost-effective, and eco-friendly procedure. In the automobile sector, friction welding is crucial for fulfilling the increased demand for lightweight, high-performance cars. By permitting the connecting of different materials like aluminum and steel, it promotes the development of lightweight components without compromising strength. Common uses include drive shafts, engine components, and structural elements for electric and conventional vehicles.

The process is determined by important parameters such as rotating speed, friction pressure, forge pressure, time, material qualities, and workpiece shape. These elements determine the quality, strength, and longevity of the welded junction. For example, incorrect regulation of friction or forge pressure might produce to flaws or suboptimal joints. This study focuses on studying the essential characteristics impacting friction welding, supplemented by case studies illustrating its usefulness in automotive applications. Additionally, it discusses problems and improvements, stressing the process's transformational potential in current car manufacture.

OBJECTIVES

1. To Analyze the Impact of Rotational Dynamics.
2. To Examine Heat Generation and Contact in Friction Welding.

MATERIAL SELECTION

From the above literature study there was various methodology used to optimize the process parameters by different authors like Taguchi, Response Surface methodology etc. so the Taguchi (L9) orthogonal array is used to optimize the process parameters, such as tool rotational speed, welding speed and tool tilt angle. Analysis of variance was also utilised to figure out the relevant parameter that impacts the mechanical characteristics. The following are the steps to be taken for process parameter optimization using this technique.

Step 1: Determine the quality characteristic to be optimized.

Step 2: Identify the noise factors and test conditions.

Step 3: Identify the control factors and their alternative levels.

Step 4: Design the matrix experiment and define the data analysis procedure.

Step 5: Conduct the matrix experiment.

Step 6: Analyze the data and determine optimum levels for control factors.

Step 7: Predict the performance at these levels

A. Selection of Orthogonal Array

As three levels and three elements are taken into consideration, L9 OA is employed in this inquiry as indicated in Table 1. Only the primary factor impacts are taken into consideration and not the interactions. The degrees of freedom (d.f.) for each element is 2 (number of levels- 1, i.e. 3 - 1 = 2) and consequently, the total d.f. will be 3× 2 = 6. Generally, the d.f. of the OA should be more than the total d.f. of the components. As the d.f. of L9 is 8 it is acceptable for the study

Table-1:-Experimentation control log using OA L9.

Exp. No	RPM	Feed	TiltAngle
I	I	I	0
2	I	2	I
3	I	3	2
4	2	I	I
5	2	2	2
6	2	3	0
7	3	I	2
8	3	2	0
9	3	3	I

RESULTS AND DISCUSSION

From the aforementioned literature analysis it is obvious that there is a possibility for Friction Stir Welding of aluminum alloys in many domains. FSW continues to be the focus of studies and ongoing development and advancements in the joining of aluminum alloys. Even numerous studies have been completed; there is still a great need to further analyse current and novel combinations of process factors such as tool rotational speed, traverse speed and tool tilt angle. Existing investigations are confined to the microstructure of weld joint. Hence an attempt has been made to examine the optimization of parameters of FSW. Experimental procedures that integrate statistical design of experiment, such as Taguchi method is examined to get an optimal solution. Study on different process parameter of FSW on 6061-T6 aluminum alloy was carried out on vertical milling machine.

Material Selection

The basis material utilised in this investigation is aluminum alloy AA6061-T6. The composition and mechanical characteristics of is provided in Tables 2 and 3, respectively.

Table 2 Chemical Compositions of Aluminum Alloy.

	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti

Al								
6061-	0.4-	0.7	0.15-	0.15	0.8-	0.15-	0.25	0.15
T6	0.8		0.40		1.2	0.35		

Table 3 Mechanical properties of base metal.

Tensile strength (MPa)	Yield strength (MPa)	% Elongation	Hardness
295	240	8.0	105

Specially developed tool as illustrated in Fig.1 is utilised in the Friction stir welding. The material of the tool is HSS M2 Steel Rod of Dia. 22 mm. A non-consumable high-speed steel tool is used for welding 6061 Al alloy with the shoulder diameter of 22 mm and the tool has cylindrical shaped probe (tool pin) with threads. Probe diameter and length is 6 mm and 5.7mm correspondingly. The diameter of the head is 18mm. The hardness of tool is roughly 54HRC.

Selection Of Process Parameters and Levels

The main parameters that affect the mechanical properties of FS welded joints and the practical limits are summarized in Table 4.

Table 4—Process parameters values and their three levels

Level	**Rotational speed(rpm)**	**Transverse speed (mm/min.)**	**Tool tilt angle(deg)**
1	500	16	0
2	710	20	1
3	1000	25	2

CONCLUSION

This review is defined by two purposes, i.e., emphasising the major process parameters in a friction stir welding process between two different aluminum alloys and exhibiting the primary tools to design and forecast the mechanical behavior of dissimilar aluminum joints. Although this joining method is relatively new, a large array of literature available on the optimization of the process for both comparable and different materials and also for both similar and dissimilar aluminum alloys. However, the thermal, mechanical, and metallurgical factors of the process are so complicated that substantial experimental testing is necessary with an ambiguous outcome concerning the most critical parameters impacting strength, microhardness, or other mechanical qualities. This is only more challenging if the materials to be connected are different. In this environment, the literature on this issue is always in continual change.

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