International Journal of Research Publication and Reviews, Vol 4, no 8, pp 2251-2253 August 2023

WWW.IJRPR.COM

International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Optimization of Process Parameters for Friction Stir Welding Using Taguchi Method

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ABSTRACT

In this study, the process parameters for friction stir welding 60/40 brass plates are optimized using a multi-objective optimization strategy based on response surface methodology (RSM). For creating a weld joint with superior maximum hardness (HRB), the best combination of method parameters setting is found: tool rotation speed of one thousand rates, tool travel speed of twenty mm/min, and two numbers of passes. The hardness of the weld joint is predicted using response surface methods. The ANOVA technique is used to assess the correctness of the developed model and find relevant terms. The desirability function is used to evaluate the replies and calculate the optimal process parameters. The ideal configuration for the process parameters is discovered to be: 20 mm/min tool travel speed, two passes, and a tool rotation speed of 1000 rpm to ensure that the outcomes are accurate, confirmation runs are used.

Keywords- Friction stir weld, Taguchi, Optimization, Hardness

1. INTRODUCTION

Friction A cylindrical-shouldered tool is rotated on the surface of the workpiece to be linked during the solid state welding process known as stir welding. The FSW machine's fixture securely fastens the workpiece, and when the tool rotates, an axial force is applied to the welding surface. When a non-consumable tool is used to join workpiece without melting them during the welding process, the plasticization of the workpiece results from the production of heat and friction. A non-consumable rotating tool with a specially crafted pin and shoulder is inserted into the abutting edges of the two elements to be linked and moved along the joint line. This is the basic idea of FSW. In the friction stir welding process, a cylindrical necked tool with a profiled probe is rotated and slowly lowered between two pieces of sheet or plate material to form a connection. The components must be attached to a back bar in a way that prevents the abutting joint faces from being yanked apart or otherwise pushed out of position. The wear-resistant welding tool and the substance of the workpiece produce frictional heat. After reaching the required temperature, the heat softens the workpiece, enabling the machine to cross the weld line. When the tool's shoulder and pin head come into close contact, the plasticized material is then transferred from the tool's top to its trailing edge, where it is cemented together to form a solid-phase connection between the two pieces.

2. PROBLEM IDENTIFICATION

A popular solid-state welding process called friction stir welding (FSW) is used to combine materials that are challenging to weld using traditional techniques. It entails the production of heat through the frictional interaction of a rotating tool with the workpiece, which causes plastic deformation and the subsequent development of a weld connection. Different process variables, such as rotational speed, traverse speed, axial force, tool geometry, and tool tilt angle, have an impact on the effectiveness and quality of the FSW process. The complicated interplay between these parameters and their effects on weld quality, mechanical characteristics, and defect formation make it difficult to achieve the best process settings for FSW. The Taguchi Method is used in this situation.

3. OBJECTIVES

Depending on the precise objectives of the project and the anticipated results, the Taguchi Method can be used to optimize process parameters for friction stir welding (FSW). Here are some typical goals that researchers or practitioners may try to accomplish:

- Maximize tensile strength of welded joints.
- Minimize defects for improved weld quality.
- Optimize microstructure to enhance mechanical properties.

- Reduce energy consumption while maintaining performance.
- Minimize distortion for precise dimensional control.

4. DESIGN OF EXPERIMENT

In this experiment, three input factors—tool travel speed of 20 mm/min, tool rotation speed of 1000 rpm, and the number of passes—are taken into account. answers are chosen based on hardness. According to Taguchi's method, choosing the right orthogonal array depends on the following three things: (1) The quantity of input and response components as well as the crucial interactions. (2) The quantity of data levels for the input variables. (3) The desired outcome of the experiment and the constraints set on its performance and cost [27]. Table 1 lists the three input variables with three levels that were chosen based on the literature [28]. In MINITAB 17 software, a design matrix for experimentation is produced using the Taguchi technique and presented.

Table 1: Significant parameters of FSW technique and their levels for Brass

Level	A	B	C
	Tool Rotation Speed (rpm)	Tool Travel Speed (mm/min)	No. of passes
1	710	20	1
2	1000	28	2
3	1400	40	3

5. RESULT AND DISCUSSION

The average hardness values taken at the weld nugget zone for each parameter are presented in Table 2. 1000 rpm and 20 mm/min rotational and Tool Travel Speed, No. of passes2 respectively, gave the highest Vickers hardness at the nugget zone.

Table 2 Taguchi employees also include the estimated SN ratios for hardness

Tool Rotation Speed (rpm)	Tool Travel Speed (mm/min)	No. of passes	Hardness	SNRA1	MEAN1
710	20	1	79.8333	38.0437	79.8333
710	28	2	77.3333	37.7673	77.3333
710	40	3	72.5	37.2068	72.5
1000	20	2	85.3333	38.6224	85.3333
1000	28	3	72.6667	37.2267	72.6667
1000	40	1	75.6667	37.5781	75.6667
1400	20	3	73.3333	37.306	73.3333
1400	28	1	70.8333	37.0047	70.8333
1400	40	2	74.6667	37.4625	74.6667

6. CONCLUSION

The following observations were made from the studies:

- Taguchi’s orthogonal array has been successfully used to find the optimum level setting of process parameters.
- The optimum process parameters levels which are found to achieve greater hardness are such, The average of measured values for Tool Rotation Speed (rpm) A2 1000 rpm (b) Tool Travel Speed (mm/min), B1 20 mm/min (c) No. of passes result a maximum hardness values.
- ANOVA result for hardness. It is observed that the **Tool Travel Speed (mm/min)**, (P=**0.015**) (**66.94**%) is most influences the hardness followed by **No. of passes** (P= **0.015**) (**64.02**%) and least significant of **Tool Rotation Speed (rpm)** (A) (P=**0.023** (**42. 13%).In** the present study parameters are significantly factor for the hardness.

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