Feasibility study of Friction Stir Welding Process for Metal to Plastic material for Lap-joint Configuration

Mr. Nitesh Radadiya[1], Mr. Uchit Patel [2]

[1]Student, Dept. of Mechanical Engineering, U.V. patel college of engineering,Gujarat, India
[2]Professor, Dept. of Mechanical Engineering, U.V. patel college of engineering,Gujarat, India

---***---

Abstract - *Friction stir welded Polypropylene & Al6061 plates with a thickness of 3 mm using welding settings (weld speed and rotational speed). The trials were planned using the Taguchi design of experiment approach. An increasingly common technique, friction welding (FW) is a set of solid state joining methods based on friction that may produce high-quality welds of different components comprised of similar or different materials. The input parameter choosen rotational speed & welding speed And Output Parameter is Tensile strength. The Taguchi technique recommended allocating the factors selected for the experiment using an orthogonal array design. Using the Taguchi method's L9 orthogonal array, nine experiments have been constructed. The signal-to-noise (S/N) ratio and analysis of variance (ANOVA) have been used to examine and optimise the welding settings. Following examination, the most important control factor for tensile strength is identified.*

Keywords: **FSW, ANOVA, Taguchi method, Minitab.**

1. INTRODUCTION

The process of joining metals by means of heat and pressure is known as welding. Welding is a construction or artistic technique that, unlike brazing and soldering, which do not melt the base metal, creates fusion between materials, most commonly metals or thermoplastics. It is common practice to augment the base metal with a filler material before welding the two together. This creates a pool of molten material, called the weld pool, which, when cooled, forms a junction that is just as strong as the base metal itself. A weld can be formed using either heat or pressure alone or both. Several different types of energy can be used to conduct welding processes. These include gas flames, electric arcs, lasers, electron beams, friction, and ultrasound. The outdoors, underwater, and even space are all viable locations for welding. The hazards of welding include the possibility of burns, electric shock, eye injury, exposure to harmful gases and fumes, and intense UV radiation. One kind of friction welding, FRICTION STIR WELDING, will be the primary topic of discussion as we go over the study's classification of welding processes and their uses.

2. OBJECTIVE

- I have selected Polypropylene and Al 6061 sheet material With Thickness 3 mm for carried out the experiment.
- Selected Taguchi Method With L9 Orthogonal Array
- Minitab software is used for analyze the experimental data
- Prepare Friction Stir Welding Job And Find out Microstructure, Tensile strength of Welding Job
- Examine how the welding process parameter affects the weld shape and use this work to optimise the process parameter.

3. DESIGN OF EXPERIMENT

3.1 Different Techniques of DOE

1. Factorial design
2. Response Surface Method
3. Mixture Experiments
4. Taguchi Design

3.2 Objective of Taguchi Method

To improve process and product design, Taguchi is looking for easily controllable factors and their settings that reduce product response variability while maintaining a desired mean response. By adjusting those parameters to their sweet spots, we may make the product more resistant to variations in both operating and environmental circumstances. Removing the bed effect rather than the cause of the bed effect allows for more stable and high-quality goods to be obtained during the Taguchi parameter design stage. In addition, the method can save money and eliminate wasted goods by systematically applying it at the pre-production stage (off line), which means fewer tests are needed to determine cost-effective process conditions.

Input parameters

- Factor A : Rotational Speed (rev./min)
- Factor B : Welding Speed (mm/min)

Output Parameter

Tensile Strength (MPa)

Table-1: Process Parameter Level

Parameters	Level1	Level2	Level3
Rotational Speed	900	1300	1900
Welding Speed	15	19	24

Table-2: Taguchi Design Factor

Ex. No.	Rotational Speed (rev/min)	Welding Speed (mm/min)	Tickness (mm)
1.	900	15	3
2.	900	19	3
3.	900	24	3
4.	1300	15	3
5.	1300	19	3
6.	1300	24	3
7.	1900	15	3
8.	1900	19	3
9.	1900	24	3

4. EXPERIMENTAL WORK AND RESULTS

Fig-1: FSW Machine Set-up

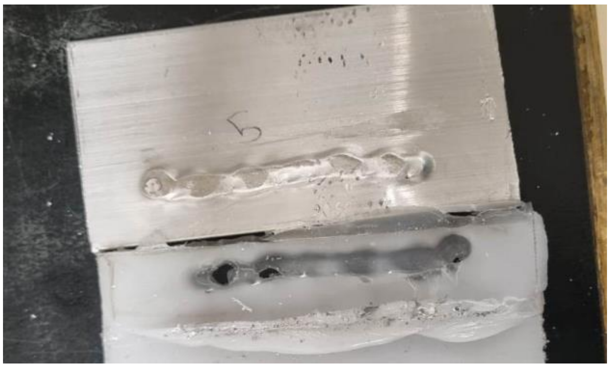

Fig-2: Workpiece after welded

Table-3: Results Table

Ex. No.	Rotational Speed (rev/min)	Welding Speed (mm/min)	Tensile Strength (MPa)
1	900	15	58.75
2	900	19	63.97
3	900	24	59.66
4	1300	15	60.66
5	1300	19	59.21
6	1300	24	55.47
7	1900	15	50.40
8	1900	19	52.62
9	1900	24	48.66

Table-4: SN ratio for tensile strength

Ex.No.	Tensile Strength (MPa)	S/N Ratio
1	58.75	35.3802
2	63.97	36.1195
3	59.66	35.5137
4	60.66	35.6580
5	59.21	35.4479
6	55.47	34.8812
7	50.40	34.0486
8	52.62	34.4230
9	48.66	33.7434

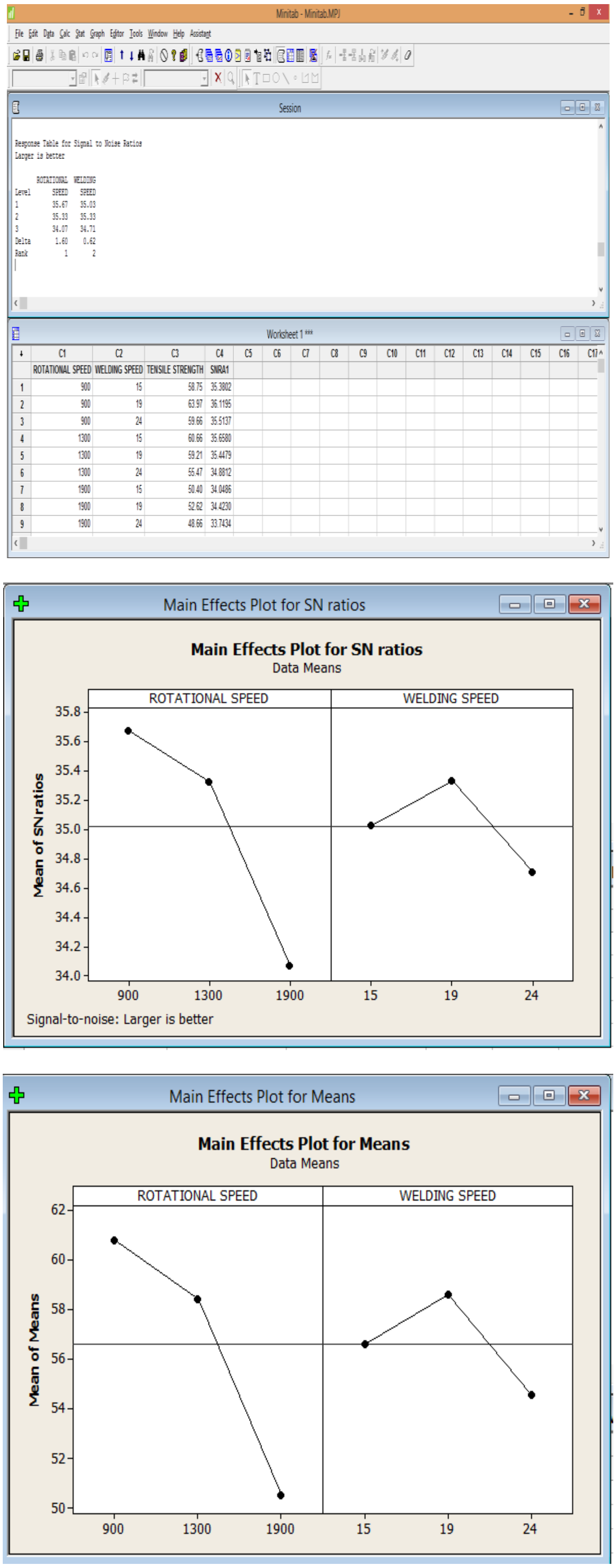

Fig-3: Minitab-16 Analysis Tensile Strength

Figure 3 illustrates the main plot's impact on tensile strength for a 3 mm thickness at various rotational and welding speeds.

The minimal tensile strength attained is at a rotational speed of 1900 rev/min and a welding speed of 24 mm/min, as shown in Fig. 3. Additionally, at welding speeds of 19 mm/min and rotating speeds of 900 rev/min, the maximum tensile strength was reached.

5. CONCLUSION

- The current work used parametric analysis to determine the tensile strength of Al6061 and polypropylene materials. In order to conduct experiments, the Taguchi Method is used to change the rotational and welding speeds for 3 mm thick polypropylene and Al6061 material. The software Minitab 16 was utilised to examine the experimental data.
- After much research, I've determined that the lowest tensile strength can be achieved at 1900 rev/min rotational speed and 24 mm/min welding speed. Additionally, at welding speeds of 19 mm/min and rotating speeds of 900 rev/min, the maximum tensile strength was reached.
- Rotational speed increase with decrease of tensile strength.
- Rotational speed is most significant control factor tensile strength.

REFERANCES

[1] John VICTOR CHRISTY, Abdel-Hamid ISMAIL MOURAD, Muhammad M. SHERIF, B. SHIVAMURTHY "Review of recent trends in friction stir welding process of aluminum alloys and aluminum metal matrix composites"(2021)

[2] M. Shunmugasundaram , A. Praveen Kumar , L. Ponraj Sankar , S. Sivasankar "Optimization of process parameters of friction stir welded dissimilar AA6063 and AA5052 aluminum alloys by Taguchi technique" (2020)

[3] M. Shunmugasundaram , A. Praveen Kumar , N.K. Amudhavalli , S. Sivasankar "Parametric optimization on tensile strength of friction stir butt joints of dissimilar AA6061 and AA5052 aluminium alloys by Taguchi technique"(2020)

[4] Austine D. D'Souza , Shrikantha S. Rao , Mervin A. Herbert "Taguchi method of optimization of process variables for ultimate tensile strength of friction stir welded joint of Al-Ce-Si-Mg aluminium alloy plates" (2021)

[5] M.R. Adibeig , Gh Marami , M.A. Saeimi-Sadigh , L.F.M. da Silva " Experimental and numerical study of polyethylene hybrid joints: Friction stir spot welded joints reinforced with adhesive", (2020)

[6] C.Elanchezhian, B.Vijaya Ramnath, P.Venkatesan, S.Sathish,T.Vignesh, R.V.Siddharth, B.Vinay, K. Gopinath "Parameter Optimization of Friction Stir Welding Of AA8011-6062 Using Mathematical Method", (2014)

[7] Shayan Eslami, Tiago Ramosa, Paulo J. Tavaresa, P. M. G. P. Moreira "Effect of friction stir welding parameters with newly developed tool for lap joint of dissimilar polymers" , (2015)

[8] Gomathisankar M, Gangatharan M, Pitchipoo P "A Novel Optimization of Friction Stir Welding Process Parameters on Aluminum Alloy 6061-T6"(2018)

[9] C. Labesh Kumar , V. Jayakumar , G. Bharathiraja "Optimization of welding parameters for friction stir spot welding of AA6062 with similar and dissimilar thicknesses" (2019)

[10] Timothy Odiaka , Stephen A. Akinlabi , Nkosinathi Madushele , Olawale S. Fatoba , Surnir Hassanb, Esther T. Akinlabi "Statistical analysis of the effect of welding parameters on the tensile strength of titanium reinforced mild steel joints using taguchi's DoE"(2021)

[11] A. Paoletti, F. Lambiase, A. Di Ilio "Optimization of friction stir welding of thermoplastics" (2015)

[12] P. Raj kumar , S. Nandhakumar , S. Seenivasan , R. Chandraprakash "Parametric optimizationof friction stir spot welded aluminium AA6063 alloy joints", (2020)

[13] Manish T. Shete, Ravindra B. Yarasu "Experimental investigation and finite element simulation of friction stir spot welding (FSSW) of high-density polyethylene joints", (2021)

[14] Shrinivas Balraj Uyyala , Sreedhar Pathri "Investigation of tensile strength on friction stir welded joints of dissimilar aluminum alloys" , (2019)

[15] Mumin Tutar , Hakan Aydin, Celalettin Yuce, Nurettin Yavuz, Ali Bayram "The optimisation of process parameters for friction stir spot-welded AA3003-H12 aluminium alloy using a Taguchi orthogonal array" , (2014)