Process Parameters of Lap Joint Using Taguchi Method: A Review

Neeraj Upadhyay
M.Tech Scholar, department of Mechanical Engineering, SIRTE, Bhopal (M.P.)

Dr. Yogesh Agrawal
Associate Professor, department of Mechanical Engineering, SIRTE, Bhopal (M.P.)

Dr. Vikas S. Pagey
Director, SIRTE, Bhopal (M.P.)

Abstract- Markets are affected by multiple consumer expectations that include good quality, faster delivery times, a higher level of customer service as well as lower prices. In order to compete effectively, several companies have recognized the need to enhance the quality of goods & services. These organizations need to develop new methodologies in order to compete in this challenging environment, enabling them to stay competitive and agile at the same time, so that they can adapt to new demands. One of the commonly used methods for experimental study of several production processes in engineering is the Design of Experiment (DOE). DOE is a statistical method in which, by experimental runs, a mathematical model is created. Therefore, on the basis of input parameters of the experimental setup, potential performance can be estimated.The use of Finite Element Method (FEM) in product creation has been well developed, but its use in production processes might not be very widespread and forms part of new developments in the areas of computational mechanics. To examine the welding characteristics, an apparatus plan based on Taguchi's technique has been used to achieve the research objective (ANOVA).

Keyword- welding, ANOVA, Taguchi, optimizationand Finite element models

I. INTRODUCTION

Welding is the most commonly used process for permanent joining of machine parts and structures. Welding is a fabrication process which joins materials (metals) or thermoplastics, by causing union. In the joining process of welding application uses heat and/or pressure, with or without the addition of filler material. In order to make the process practical or to make it faster, different auxiliary materials, such as shielding gases, fluxes or pastes, can be used. The energy needed for welding is supplied from external sources.

Here are five basic welding joint types commonly used in the industry, according to the AWS:

- Butt joint
- Tee joint
- Corner joint
- Lap joint
- Edge joint

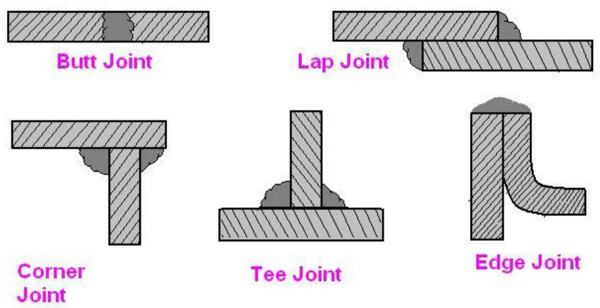

Fig. 1. Types of Weld Joint

II. OPTIMIZATION METHOD

Taguchi strategy was made by Dr. Genichi Taguchi. This strategy incorporates three stages: framework outline, parameter plan, and resistance outline. The Taguchi method is a measurable method used to enhance the item quality. The Taguchi procedure chooses or decides the ideal cutting conditions for turning procedure. Taguchi built up an extraordinary design of orthogonal arrays to examine the whole parameter space with few experiments as it were. The trial results are then changed into a solitary to commotion (S/N) proportion. It utilizes the S/N ratio as a proportion of value characteristics going amiss from or nearing to the coveted values. There are three classes of significant worth attributes in the examination of the S/N proportion, i.e. the lower the better, the higher the better, and the ostensible the better. The formula utilized for calculating S/N ratio is given below.

S/N Ratio Calculation

Smaller the better: It is used where the smaller value is desired

$$S/N Ratio = -10 log \frac{1}{n} \sum_{i=1}^{n} y i^2 \qquad (1)$$

Where y = observed response value and n = number of replications.

Nominal the best: It is used where the nominal or target value and variation about that value is minimum.

$$S/N Ratio = -10 log \frac{y^2}{\sigma^2} \qquad (2)$$

Where σ = mean and μ= variance.

Higher the better: It is used where the larger value is desired.

$$S/N Ratio = -10 log \frac{1}{n} \sum_{i=1}^{n} \frac{1}{yi^2} \qquad (3)$$

The values adopted for the elastic modulus E and the Poisson ratio ν were 210,000 N/mm^2 and 0.3, respectively for S275 steel.

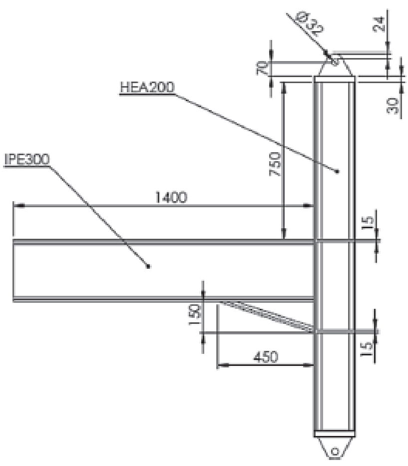

Fig. 2. Design of Weld joint

Published By:
International Journal of Engineering Research in Current Trends

III. LITERATURE REVIEW

[1] Casalino, Michele and Perulli, 2020 has evaluatedfor the simulation of hybrid laser TIG butt welding on 6 mm thick austenitic stainless steel, the finite element process (FEM) was used in this work for the simulation of hybrid laser TIG butt welding on 6 mm thick austenitic stainless steel (AISI 304) and martensitic stainless steel (AISI 304) (AISI 410). Many sectors such as aerospace, medical (AISI 304) and martensitic stainless steel (AISI 410) have attracted significant interest in these steels.

[2] Loureiro *et al.*, 2020has performed formation of the FEM of the joints have been performed and the results obtained in the tests have been properly calibrated. The compressed stiffness matrices of the joints were obtained and evaluated in the global analysis of 4 frames by adding such matrices as well as comparing the results achieved with those collected from the corresponding FEM.Better results are obtained from the use of condensed matrix and between different degrees of the freedom of joint, all the interactions are taken into account.

[3] Li, Hara and Duarte, 2019suggested that global-local enrichment Finite Element System for the assessment of stress intensity factors (SIFs) at spot welds under thermo mechanical loads. The methodology employs local boundary value problems to be solved as enhancement functions for the global/structural model and also provide precise solutions to structural-scale coarse meshes. Rather than mesh fitting the weld geometry, the faying surface as well as spot welds are expressed by special enrichment features.

[4] Vignesh, Perumal and Velmurugan, 2019analyzed the effects on tensile shear strength & dissimilar metal welding of sheets of 2205 duplex stainless steel (DSS) and AISI-316L stainless steel are reported in the current analysis of RSW process parameters such as heating time, welding current & electrode tip diameter. Tensile shear experiments were conducted to gain access to the tensile shear strength and related physical variations of the shaped nugget.Utilizing ABAQUS explicit FE software, finite element (FE) simulation of the tensile-shear test was carried out. By using graphical representation, the finite element results have been contrasted with experimental data by comparing the stress-strain values calculated for validation.

[5] Farajpour&Ranjbarnodeh, 2018in different industries, fusion welding is commonly used to connect various parts to each other. Nevertheless, welding-induced distortions often create issues during assembly, such as misalignment, and impose taxes for removal of them.In order to increase welding efficiency and therefore reduce production costs, it is therefore important to foresee and minimize these issues. A dissimilar welded framework was first modeled in ANSYS finite element software with 3D solid as well as shell elements in this analysis, and then welding-induced deformations were measured.

[6] Mishra &Sahu, 2018evaluated fromexperimental and even specified research software performed research job welding simulation to figure out the importance of stress as well as deflection under various loading conditions.The simulation results indicate that the stress concentration is maximally close to the joint and also at the corner where the cross section has shifted abruptly. The joint can bear is measured by using the experimental method in modern universal testing machines to figure out the most optimal load (UTM).

[7] Arunchai et al., 2015with aluminum alloy in the automotive industry, Resistance Spot Welding (RSW) is performed. The challenge of setting RSW parameters leads to inconsistent quality among welds. The welding current, electrode force and welding time are the significant RSW parameters.This is considered an essential parameter to provide an additional RSW parameter, that is, the electrical resistance of the aluminum alloy, which varies based on the thickness of the material. With aluminum alloy, the parameters added to the RSW process are sensitive to correct measurement.

[8] Reddy, 2015 have aimed in his study was to weld by continuous drive friction welding dissimilar metals of UNS C23000 brass as well as AISI 1021 steel. The study of finite elements was performed to design the continuous welding of drive friction. Through Taguchi techniques, the process parameters were determined.Under UNS C23000 brass as well as AISI 1021 steel, the optimum processing parameters were determined to be 60 MPa frictional pressure, 4 sec frictional time, 1500 rpm rotational speed as well as 62.5 MPa forging pressure.

[9] Mi et al., 2014a thermal -elastoplastic finite element method has been developed to model the mechanism of variable polarity plasma arc welding (VPPAW) for aluminum alloy plates. The welding temperatures as well as the stress field of the aluminum plates with various butt joint parameters were calculated using a 3D double-ellipsoidal heat source model.

[10] Matsushita, Taniguchi and Oi, 2013 new generation spot welding resistance technologies have been developed to minimize auto body weight. Intelligent Spot welding made it easier to perform simpler 3-sheet-lap-welding, more commonly done with enhanced application of high strength steels, by adjusting the force as well as the welding current during welding.

As the world has progressed a lot of work has been done in this area and today we have number of processes which are efficient enough to do this job some of the research work is mention in below.

AUTHOR	RESEARCH TITLE	METHODOLOGY USED	OUTCOMES
(Muthu, 2019)	Using Taguchi Method, Optimization of the Process Parameters of Resistance Spot Welding of AISI 316l Sheets	The analysis were carried under different process parameters, specifically diameter of the electrode, welding current, as well as heating time, by using Taguchi's L27 orthogonal array. In order to find the optimum processing parameters, the test data was	• The study of the optimization as well as effect of welding parameters on the tensile strength of AISI 301L stainless steel welded spot resistance is presented in this study. • The S/N ratio's response to tensile strength implies that the electrode diameter is the most important parameter that regulates the tensile shear stress, however in this

		analyzed by using signal-to-noise ratio (S/N ratio).	respect the welding current as well as heating time are considerably less important.
(Lepore *et al.*, 2017)	For thesimulation of multiple crack propagation in friction stir welds, FEM based methodology is used.	The energy release rate can be calculated by computing J-Integral, which is directly functional to determine the maximum energy release rate. Linear Elastic Fracture Mechanics (LEFM). Zen crack uses the technique of Virtual Crack Extension (VCE) to create multiple vectors for virtual crack extensions.	• Both the FEM and FEM-DBEM approaches are used in this study for the simulation of the fatigue propagation of multiple three-dimensional cracks in a welded part. • In the cracked model with elastic-plastic physical properties along with an initial residual stress scenario, the presented method introduces the capacity for SIFs calculation by adding an elastic-plastic tip; • In terms of the evolution of cracks with each propagation phase, a satisfactory agreement was obtained between the FEM as well as FEM-DBEM simulations.
(Islam *et al.*, 2015)	On the basis of FEM–RSM–GA integration technique, Process parameter optimization of lap joint fillet weld	A tool for welding process design focused on arc welding process parameters which are based on Finite Element Method (FEM), Genetic Algorithms (GA) and Response Surface Method (RSM)	• A second order answer surface model is built that is used in the Genetic Algorithm-based optimization loop to reduce the computational cost of computation. • It becomes possible to predict the quality of the final product and to detect potential faults at the time of early design phase through using CAE tools for numerical simulation of manufacturing techniques.
(Shu *et al.*, 2014)	FEM modeling of softened base metal in narrow-gap joint by using CMT+P MIX welding procedure	Depending on the interactions between arc, base metal and filler metal, a necessary finite element method (FEM) model suitable for narrow gap CMT+P MIX and CMT welding was developed.	• The thin gap CMT+P MIX welding process was recognized for the simulation of FEM model and applied in AA7A52 base plates forrecognizing the softened zone. • It was shown that the softened region was much broader within the base plates than near the flat surfaces by distinguishing the quenched and average zones.
(Vaghela, 2014)	By using Taguchi Method – A Review Analysis of Process Parameters for Resistance Spot Welding Process	The settings of the welding parameters were calculated by using Taguchi method of experimental design. The degree of significance of the welding parameters for the tensile shear strength is calculated by using variance analysis (ANOVA).	• The S/N ratio response for tensile shear strength implies that the most critical parameter that influences the welding strength is the welding current. However, electrode force and time for welding are less important. • In terms of peak load as well as energy absorption, weld nugget size and weld fusion penetration are the key regulating factors for spot weld efficiency.
(Urso, 2014)	By Experimental and FEM analysis, Thermo-mechanical characterization of friction stir spot welded AA6060 sheets.	Through the use of a CNC machine tool, an experimental campaign was carried out and FSSW lap joints were generated on AA6060-T6 aluminum alloy plates. For measuring the temperatures during the instrument plunge, five thermocouples were injected into the samples. By changing the process parameters, notably rotational velocity, axial feed rate, plunging depth and dwell time, a series of tests was performed.	• In this research, in FSSW a simulative framework was suggested for testing thermo-mechanical effects. A 2D method used for the simulation of a 3D problem is the particularity of the FEM model set up for this work.

Published By:
International Journal of Engineering
Research in Current Trends

(Manurung *et al.*, 2013)	Using 3D FEM and experiment, Welding distortion analysis of multi pass joint combination with different sequences	Based on the thermal-elastic-plastic method with low manganese carbon steel S3355J2G3 as specimen and Goldak's double ellipsoid as heat source model, the Multipass Welding Advisor (MWA) in SYSWELD 2010 is used.	• This can be outlined that the FE method is capable of modeling and simulating the multipass welding process via SYSWELD and could be used for the prediction of angular distortion with different sequences on combined butt and T-joints. By simulation, prior to the actual welding process, the details gathered could be used as a planning process.

IV. CONCLUSION

After analysis of these literary works, it is noted that much research has been carried out in the field of optimizing process parameters such as the speed of rotation of the instrument, the speed of travel of the instrument and the geometry of the instrument to increase joint. This approach is a very effective optimization technique for enhancing the nugget zone's microstructures as well as thermo-mechanical transformation zone. As a consequence, during numerical optimization routines, caution should be taken in identifying practical ranges of process variables; more research is needed to advance multi-scale finite element modelling techniques to include FSW process faults.

In order to figure out the best welding combinations for a certain welding process in which the process could be considered safe, good for the environment and economy, future work should concentrate on applying these modelling and optimization strategies.

REFERENCES

1. G. Casalino, D. Michele, and P. Perulli, "FEM model for TIG hybrid laser butt welding of 6 mm thick austenitic to martensitic stainless steels," Procedia CIRP, vol. 88, pp. 116–121, 2020, doi: 10.1016/j.procir.2020.05.021.
2. A. Loureiro, M. Lopez, R. Gutierrez, and J. M. Reinosa, "Experimental evaluation, FEM and condensed stiffness matrices of 2D external welded haunched joints," Eng. Struct., vol. 205, no. October 2019, p. 110110, 2020, doi: 10.1016/j.engstruct.2019.110110.
3. H. Li, P. O'Hara, and C. A. Duarte, "A two-scale generalized FEM for the evaluation of stress intensity factors at spot welds subjected to thermomechanical loads," Eng. Fract. Mech., vol. 213, no. March, pp. 21–52, 2019, doi: 10.1016/j.engfracmech.2019.03.027.
4. K. Vignesh, A. E. Perumal, and P. Velmurugan, "Resistance spot welding of AISI-316L SS and 2205 DSS for predicting parametric influences on weld strength – Experimental and FEM approach," Arch. Civ. Mech. Eng., vol. 19, no. 4, pp. 1029–1042, 2019, doi: 10.1016/j.acme.2019.05.002.
5. M. Farajpour and E. Ranjbarnodeh, "Finite element simulation of welding distortion in dissimilar joint by inherent deformation method," Soldag. e Insp., vol. 23, no. 1, pp. 60–72, 2018, doi: 10.1590/0104-9224/SI2301.07.
6. A. Mishra and P. Sahu, "Finite Element Method of Welding Joint in Shaft and Validation Using Different Method," Int. Res. J. Eng. Technol., pp. 191–195, 2018.
7. T. Arunchai, K. Sonthipermpoon, P. Apichayakul, and K. Tamee, "Ottimizzazione del processo di saldatura a resistenzamedianteretineuronaliartificiali," Riv. Ital. dellaSaldatura, vol. 67, no. 4, pp. 473–481, 2015, doi: 10.1155/2014/154784.
8. A. R. A. C. Reddy, "Finite Element Analysis of Friction Welding Process for UNS C23000 Brass and AISI 1021 Steel," Int. J. Sci. Res., vol. 4, no. 5, pp. 1691–1696, 2015.
9. G. Mi, C. Li, Z. Gao, D. Zhao, and J. Niu, "Finite element analysis of welding residual stress of aluminum plates under different butt joint parameters," Eng. Rev., vol. 34, no. 3, pp. 161–166, 2014.
10. M. Matsushita, K. Taniguchi, and K. Oi, "Development of next generation resistance spot welding technologies contributing to auto body weight reduction," JFE Tech. Rep., vol. 18, no. 18, pp. 111–117, 2013.
11. Islam, M. *et al.* (2015) 'Advances in Engineering Software Process parameter optimization of lap joint fillet weld based on FEM – RSM – GA integration technique', *ADVANCES IN ENGINEERING SOFTWARE*. Elsevier Ltd, 79, pp. 127–136. doi: 10.1016/j.advengsoft.2014.09.007.
12. Lepore, M. *et al.* (2017) 'A FEM based methodology to simulate multiple crack propagation in friction stir welds Reference : To appear in : Received Date : Revised Date : Accepted Date : A FEM based methodology to simulate multiple crack propagation in friction stir welds', *Engineering Fracture Mechanics*. doi: 10.1016/j.engfracmech.2017.08.024.
13. Manurung, Y. H. P. *et al.* (2013) 'Welding distortion analysis of multipass joint combination with different sequences using 3D FEM and experiment', *International Journal of Pressure Vessels and Piping*. Elsevier Ltd, 111–112, pp. 89–98. doi: 10.1016/j.ijpvp.2013.05.002.
14. Muthu, P. (2019) 'Optimization of the process parameters of resistance spot welding of AISI 316l sheets using Taguchi method', *Mechanics and Mechanical Engineering*, 23(1), pp. 64–69. doi: 10.2478/mme-2019-0009.
15. Shu, F. *et al.* (2014) 'FEM modeling of softened base metal in narrow-gap joint by CMT + P MIX welding procedure', *Transactions of Nonferrous Metals Society of China*. The Nonferrous Metals Society of China, 24(6), pp. 1830–1835. doi: 10.1016/S1003-6326(14)63260-X.
16. Urso, G. D. (2014) 'Thermo-mechanical characterization of friction stir spot welded AA6060 sheets: Experimental and FEM analysis', *Journal of Manufacturing Processes*. The Society of Manufacturing Engineers. doi: 10.1016/j.jmapro.2014.08.004.
17. Vaghela, C. B. (2014) 'Analysis of Process Parameters for Resistance Spot Welding Process Using Taguchi Method – A Review', 1(09), pp. 8–11.