Optimization Of Mechanical Behavior Of Hybrid Joints Of Stainless Steel 304

Manoj Kumar [1] Vivek Khokhar [2]

Ganga Institute of Technology and Management, Kablana, jhajjar

Department of Mechanical Engineering

Abstract :

Hybrid joint parameters which are formed by weld bond were optimized with the use of Taguchi Method. Range of parameters were selected by conducting a series of pilot experiment and Taguchi method was used to optimize selected Hybrid joint and Resistance Spot Welding process parameters like (welding current, welding time, squeeze time and roughness).Taguchi method was used to design the experimental layout, which consists of four factors having three levels. Tensile shear strength was determined by the Universal Testing Machine (UTM). Fracture study of the joint was also done. The weld joints were observed through Optical Microscopy and Scanning Electron Microscopy. The results were analyzed by Analysis of Variance (ANOVA) and the signal to noise (S/N) ratio for the optimal process parameters. And the response was predicted by Taguchi method, experimental results point that the spot welded joints were improved successfully by optimizing the input parameters used in the Taguchi method. Optimum value of the response variables were obtained through the conformation test with 95% confidence level. The percentage contributions of the welding current on the tensile shear strength was found to be the major factor which affected the tensile strength which had contribution of about 80%.Optimal results were found by Taguchi method using current 9.18 kA, squeeze time of 40 cycle, welding time of 80 cycle and roughness 100 µm. Increasing welding current will increase the nugget size in spot weld.

Introduction

In order to fulfill the world competition and therefore the survival of merchandise within the market a brand new manner of thinking is critical to vary and improve the present technology and to develop products at economical value. It means not solely to invest in procuring new equipments however additionally effectively management method variables concerned in any producing process. These process variables should be measured, controlled and optimized to get the specified and valuable outputs. The typical method parameters for a attachment method that have an effect on the specified output for a attachment process are fastening time, holding time, welding current etc. The weld process parameters vary for the completely different variety of the attachment process chosen. Advancement of the connection strategy parameters depends on the ability

to gauge and administration method variables stressed inside the welding technique. Resistance spot welding (RSW) has changed auto business wanders resulting to mid Seventies for its mechanical assemblages. To date one mechanical social affair out of 5 is welded using spot welding development as a piece of different business endeavors and stainless-

Steel ended up being to an incredible degree conspicuous among essential materials. Spot welding system is a joining procedure in the midst of which 2 or a huge amount of metal sheets are joined together through blend at an unmistakable reason. The spot welder uses 2 copper electrodes to press the work sheets along and force high current to pass through it. The weld nugget growth is thus determined by its dominant parameters like this, weld time, electrode tips and electrode force. The development of recent structural adhesives improved the utilization of adhesive bonding within the manufacturing sector to hitch assemblies, specialty aerospace and automotive industries. To increase the applying of adhesive bonding, many researchers have developed special hybrid attachment technologies to improve bonding properties. The advantage of the application of 2 different techniques simultaneously to create hybrid joints includes a significant increase of static strength, fatigue strength, corrosion resistance & energy absorption. In addition, with the modern adhesives is possible to obtain high bonding properties for metal joints.

Resistance Spot Welding

Resistance spot welding (RSW) has a key spot in assembling and it's the main and most by and large utilized sort of the electrical resistance welding technique inside which faying surfaces territory unit joined in one or extra spots. It is alluring to have the most temperature at the interface of the components to be joined. In this manner, the resistance of the example and the contact resistance between the terminals and work should be unbroken as low as potential with reference to the resistance between the faying surfaces. This could be accomplished by overwhelming the contact space, terminal materials, measurements, connected weight, and surface nature of the work pieces. The resistance spot weld generally encounters high push obsession that subsequently reduces static and shortcoming load passing on limit of the spot weld joints. To vanquish these issues a hybrid affiliation procedure suggested as weld-holding including spot welding and concrete joining has been created.

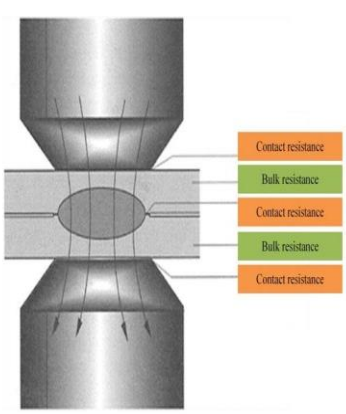


Fig: Resistance spot welding

Resistance Spot Welding Parameter

1. Electrode force
2. Diameter of the electrode contact surface
3. Squeeze time
4. Weld time
5. Hold time
6. Weld current

Adhesive Bond

Adhesive bonding is a joining procedure in which materials are held together by the surface connection of adhesives. It is like welding just in the capacity it performs, and in that capacity it might give a worthwhile other option to great joining methodology in all around characterized applications.

Stress Reduction

Because they are unfold on the length of a bond, adhesives spread stresses over a wider space than a weld or mechanical fastener, which tends to localize a stress wherever the rivet or screw is placed.

Hybrid joint

In hybrid joining, two or more joining operations are carried out either simultaneously or sequentially, leading to enhanced properties of the joint due to a synergistic load bearing interaction under service conditions. Weld-bolding innovation is a propelled half breed welding strategy, in which resistance spot-welding is joined with glue holding. If you want to joint 2 plates by bolting then hole is formed within the plate that lead to stress concentration or if you joint by weld then there's localized heating of the part occur that alter its mechanical properties. The most common hybrid joint includes an adhesive in conjunction with a point joint such as for example a mechanical fastener or a spot weld. It is generally used for joining sheet materials, but there are also applications involving extrusions and thin castings.

Literature Review

Resistance spot welding is commonly included in many research papers in which they where applying different parameters like weld current, weld time, electrode force, hold time. Also comparison of RSW with different other welding like fusion welding. These comparisons are done in order to choose the right welding during the joining process. Nowadays, welding is mixed with other joining process like adhesive joint in order to increase the efficiency of particular welding. Resistance spot welding has a place with a gathering of resistance welding process including projection welding and crease welding. The warmth to shape a weld by means of this procedure is created by imperviousness to the stream of electrical current through the parts being joined. For this situation of Resistance spot welding, a couple of cathodes held by the welding machine lead the electrical current to the work piece under a power more often than not supplied by an air incited barrel. Since the anodes are made of a copper composite and are for the most part water cooled, warmth is immediately separated far from the surfaces in direct contact with the cathodes, in this manner keeping away from the likelihood of the terminals being welded in the sheet surface. After studying various research papers and works we found some kind of gaps as follows:

As evident from the literature review, studies has been done on many process parameter of welding such as welding current, electrode force, welding time but they used these parameters only on simple spot welding for analysis There is no Taguchi analysis of Hybrid joints was done where spot welding is combined with adhesive joint. This study aimed on process parameter such as welding time, roughness, welding current and squeeze time. The weld joints were observed through tensile and hardness test, nugget diameter, Optical Microscope, Scanning Electron Microscopy and Energy Dispersive X-ray.

Objectives of Research Work

The objective of this thesis is the study of Hybrid joint and RSW of SS304 by controlling the process parameters under certain conditions and then optimizing under those limits.

a. Identifying the important parameters.
b. Finding the upper and lower limits of the factors.
c. Developing the design matrix.
d. Conducting the experiment as per the design matrix.
e. Recording the responses.
f. Evaluation of the adequacy of the models by ANOVA method.
g. Developed model by conducting confirmation tests.
h. Analysis of the applied factors process parameter of weld e.g. weld current, weld time, squeeze time and roughness on tensile shear strength.

Research Methodology

In this materials and experimental set up used to develop resistance spot weld joints are described along with investigation methods employed to characterize the base metals and resistance spot weld joints for microstructure and mechanical properties.

Base Material

Stainless steel is utilized where both the properties of steel and erosion resistance are required.304 evaluations is the most widely recognized type of stainless steel utilized the world over. It contains somewhere around 16 and 24 percent chromium and up to 35 percent nickel—and in addition little measures of carbon and manganese.304

stainless steel has a high imperviousness to rust. It withstands erosion from most oxidizing acids and is regularly utilized for kitchen and nourishment applications.

Grade	C	Mn	Si	P	S	Cr	Mo	Ni	N
Wt. %	0.08	2.0	0.75	0.045	0.030	18.0-20.0	0.0	8-10.5	0.10

Fig: Composition of base material

Experimental Procedure:

This experimental study was carried out in two steps (a) pilot experiments (b) final experimentation. The pilot experimental study was done mainly to identify the significant and controllable process parameters of weld bonding (surface roughness, curing time, welding current, and weld time) and their ranges.

Preparation of Work-piece

For resistance spot welding, material had been cut in specific dimension for single spot welding. The CNC Press Brake Machine is used to cut the sample in required dimension.

The dimension of the specimen for Resistance spot welding is width 20 mm, length 100mm and thickness 1mm (20×100×1 mm).The overlap of the lap joint is of 25mm in cross-section which makes the overlapping dimension (25×20×2),where 2 is the thickness at lap joint. This overlap was chosen as per AWS recommendation.

Fig : CNC Press Brake Machine

Adhesive Bonding

The stainless sheet SS304 of thickness 1mm was bonded using epoxy adhesive (consisting of equal amount of resin and hardener by weight). The different grade emery papers (100,120,180 µm) were used to clean the surface of the specimen sand for roughening followed by wiping with acetone for degreasing and removing other foreign materials surface before applying adhesive. The adhesive was applied between two pieces of SS 304 and allowed to get strengthen by hardening of adhesive. The thickness of the adhesive layer was 0.235 mm. Thereafter, curing of adhesive joints was done in an oven at 1200C for 60 minute.

Resistance Spot Welding

The stainless sheet SS304 of thickness 1mm thickness was resistance spot welded by using the microprocessor controlled CEA spot welding machine of 150 kVA rating. The faying surfaces of the specimen were cleaned mechanically by rubbing against emery paper of 100,120,180 grade followed by wiping with acetone before welding. Resistance spot welding was carried out using 10 kA welding current, eight cycles weld time, and 5 kg/cm2electrode pressure.

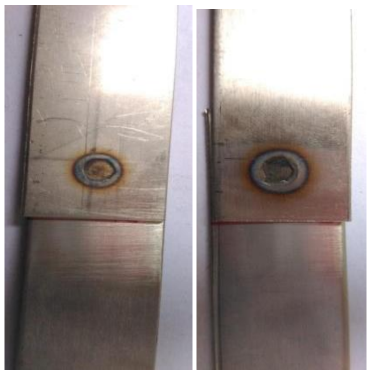


Fig: Resistance spot welding

Weld-Bonding

The stainless sheet SS304 of thickness 1mm was weld-bonded by applying adhesive (consisting of equal amount of resin and hardener by weight) on the faying surfaces followed by resistance spot welding. The surface of the specimen was cleaned mechanically with emery paper of 100,120,180 grade followed by wiping with acetone before adhesive joining. Then resistance spot welding was carried out by using 16 kA welding current, six cycles weld time, and 4kg=cm2 electrode pressure followed by curing of joint at 120C for 60 minutes. These conditions were corresponding to maximum tensile shear load carrying capacity of joints.

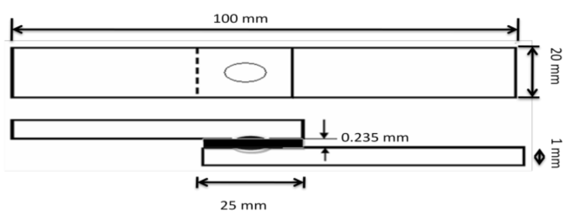


Fig: Specimen Geometry

Taguchi Method

Taguchi Technique is applied to plan the experiments. The Taguchi method has become powerful tool for improving productivity during research and development, so that high quality products can be produced quickly and at low cost. Dr. Taguchi of Nippon Telephones and Telegraph Company, Japan has developed a method based on "Orthogonal Array" experiments which gives much reduced "variance" for the experiment with "optimum settings" of control parameters. Thus the marriage of Design of Experiments with optimization of control parameters to obtain best results is achieved in the Taguchi Method Orthogonal Arrays" (OA) provide a set of well balanced (minimum) experiments and Dr. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results.

Steps of Taguchi method are as follows:

1. Identification of the main function, to be optimized and its side effects and failure mode.
2. Identification of noise factors, testing conditions and quality characteristics.
3. Identification of the main function to be optimized.
4. Identification the control factors and their levels.
5. Selection of orthogonal array and matrix experiment.
6. Conducting the matrix experiment.
7. Analyzing the data and prediction of the optimum level.
8. Determining the contribution of the parameters on the performance.
9. Performing the verification experiment and planning the future action.

Testing of Hybrid joint & RSW

Testing of Resistance spot welding and Hybrid joint is to be with a specific end goal to get yield parameters of the joining procedure. In the yield parameters ductile shear quality is considered as the most imperative result which is utilized the Taguchi improvement process. Further to comprehend the qualities of the weld joint different smaller scale basic tests are additionally led. Testing is done by following ways:

1. Tensile Test by UTM
2. Vickers Micro Hardness
3. Micro Structural Study
4. Optical microscopy
5. Scanning Electron Microscopy
6. Energy-dispersive X-beam spectroscopy

Results & Discussions

In this chapter, results of Resistance spot welding and Weld bond were analyzed. Firstly macrostructure of the spot by measuring its nugget size and heat affected zone size then microstructure analysis study the change in the micro structure after welding is applied then optimizing the input and output parameters using Taguchi method.

Macrostructure:

Macrostructure study of the spot weld (nugget size and heat affected zone size) is done. Study is conducted by measuring nugget size and heat affected zone size (HAZ).

Nugget diameter:

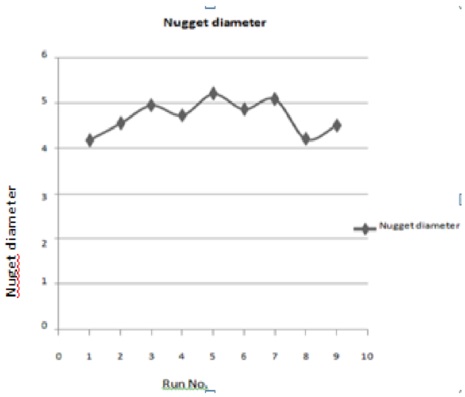
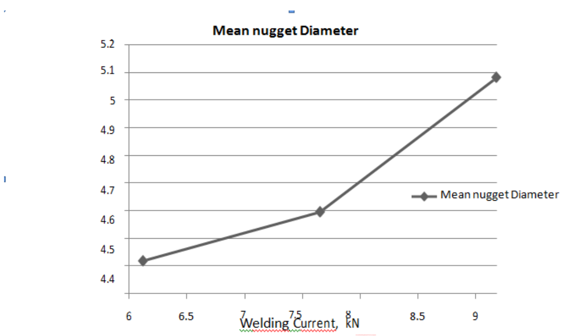


Fig: Nugget size in each run

Nugget diameter is maximum at Run No. 5 where welding current level is high and Run No. 1 has the minimum diameter where weld current is minimum.



Nugget diameter increases with increase in welding current and when welding current is 9.18kN nugget diameter is 5.09 kN.

Heat Affected Zone thickness:

Heat affected zone is also measured which increases with increase in nugget diameter. Heat affected zone is calculated by taking the whole diameter of the spot weld including heat affected zone and nugget. Then thickness is calculated by subtracting the diameter of the nugget size from the value and dividing the result by two, which gives the thickness of the heat affected zone.

Microscopy Test:

Microstructure of weld cross-segment is appeared in Fig.

Three diverse zones are seen in fig Seen in the microstructure are: combination zone (FZ), which is dissolved and re-hardened amid the welding procedure and demonstrating a cast structure with columnar grains, heat influenced zone (HAZ), which is not liquefied but rather experiences smaller scale basic changes, and base metal (BM) which does not encounter any miniaturized scale basic changes.

Scanning Electron Microscopy:

Miniaturized scale basic examination of resistance spot weld joints and base metals was performed utilizing an optical magnifying lens and field outflow filtering electron magnifying lens (SEM). SEM was worked in backscattered electron picture (BSEI) and optional electron picture (SEI) mode for picture obtaining. A quickening voltage of 15 kV, a working separation of 9-10 mm and a picture size of 2000 pixels was utilized for getting quality pictures for miniaturized scale auxiliary examination 1of resistance spot weld joints. These examinations comprehend the advancement of microstructure in resistance spot weld joints in various conditions. Further, SEM was used to explore the crack surfaces and method of break of the fizzled elastic examples. Picture examination of weld micrographs was done utilizing Image J 1.37v, picture dissecting programming to decide normal size of α aluminum grains present in various zones of RSW joints and base metal utilizing direct block strategy Fig

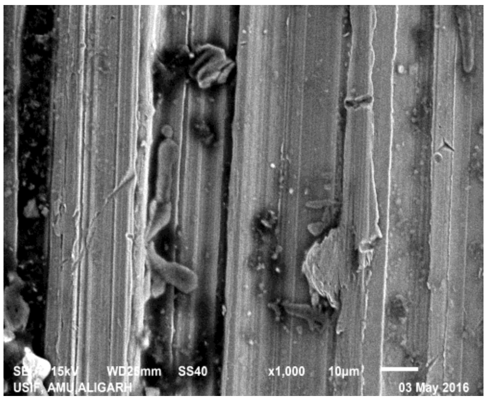


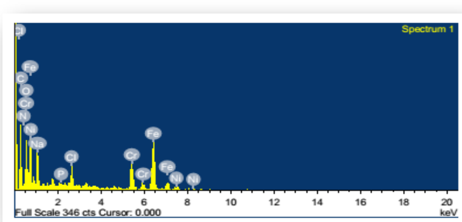
Fig: SEM

EDX

EDX is a systematic method utilized for the essential investigation or compound portrayal of an example. It depends on partner degree communication of some light emissions beam excitation and an example. Its portrayal abilities are expected in vast half to the essential rule that each part contains an unmistakable nuclear structure allowing particular arrangement of crests on its X-beam range. To empower the discharge of trademark X-beams from an example, a high-vitality light emission particles, for example, electrons or protons, or a light emission beams, is engaged into the specimen being examined**.**

Tensile Testing of Weld Joints

Load versus dislodging bends for RSW and Weld bonds are appeared in Fig. From the bend plainly weld bonds



have higher pliable shear quality than RSW joints. The pliable shear quality and uprooting of weld bonds were discovered 8%-10% and 4%-6% higher than RSW joints respectively. In spot welded joints, in the wake of achieving the top drive, the power diminishes bit by bit with the tearing procedure of the base metal around the weld piece. At the point when the single lap-joints are joined by spot weld, the joint can withstand a most extreme heap of 7.9 kN at a removal of 12.88 mm, while for the adhesive reinforced joints it was equivalent to 8.64 kN with a dislodging of 13.45 mm.

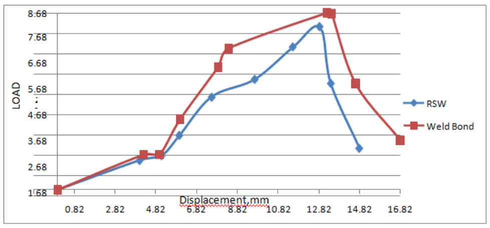


Fig: Load vs. Displacement

Fracture Mode

Among the three types of the joints, only the adhesive joint did not have any deformation in SS 304 steel. The fracture occurred along the adhesive surfaces. Fig. 4.14 illustrates the types of disjunction that occurs in RSW and the AWB joints after the tensile and shear test.

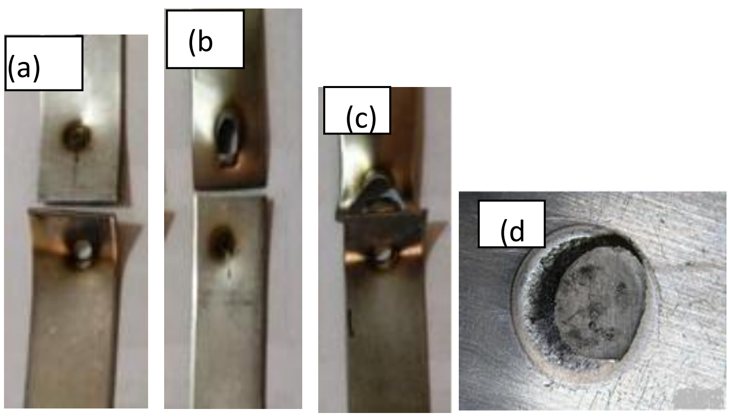


Fig: Fracture occurred after tensile test (a), (b), (c), (d)

As seen in Fig., knob and tear shaped fractures occurred in all of the welded specimens, during all of the weld times. The physical analysis, carried out on the fracture regions of the welded joints, indicated that the deformation that occurred during the fracture displayed different characteristics in the AWB and RSW joints. The RSW specimens deformed considerably during the tensile shear test and they curved back at approximately 70o to 80o. This indicates that stainless steel 304, which is widely used in the automotive industry, may endanger the safety of people in an automobile during an accident that occurs towards the tensile direction.

On the other hand, the deformation during the tensile shear test was more limited (approximately 5o to l0o), and the corners of the specimens curved back less in the AWB joints. This means that the behavior of the welded regions, especially for SS 304 specimens, will appear during a, crash (accident). The combined joints will be able to carry more loads and stress in the tensile direction and absorb shocks during any accident. In the spot welding joint, both the tensile and shear strength are lower, causing an extreme physical deformation, which endangers those in the vehicle. This result proves that the steel in question provides better results in the AWB joint during an accident.

Vickers micro hardness Analysis

Hardness can be divided into three zones as show in Fig.. Vickers the micro hardness of the FZ is higher than the micro hardness of BM. In stainless steel 304, the increase in hardness in FZ was from a value of 171 HV, measured in the base metal, and to hardness of 220 HV measured in the weld joint. The hardness measured in AISI 304 steel increased from a value of 209 HV to a value of 220 HV fusion zone.

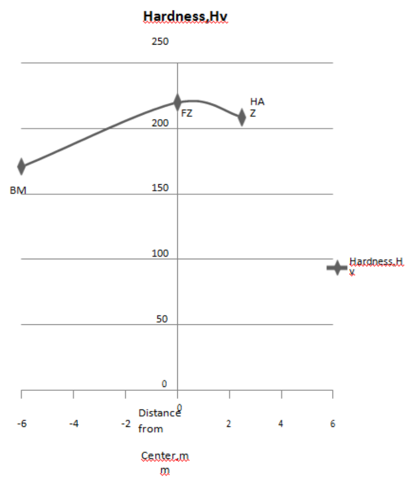


Fig: Vickers Micro Hardness of different zones

$$L_j = (\frac{1}{n}\sum_{k=1}^{n}\frac{1}{y_i^2})$$

Taguchi Method

In complex assembling frameworks and nonlinear procedures, the collaboration impacts of the procedure parameters get to be noteworthy. In any case, in the present study, subsequent to orthogonal clusters don't test every variable blend, the cooperation impact of the welding parameters couldn't be taken into advancement process. Subsequently, the principle impact of every welding parameter on the elasticity reaction was only taken. There are in this way eight degrees of opportunity inferable from the four arrangements of three-level welding process parameters. The degrees of opportunity for the orthogonal exhibit ought to be more prominent than or if nothing else equivalent to those for the procedure parameters. In this study, a L_9 orthogonal exhibit which has 8 degrees of flexibility was utilized. Nine investigations are required to concentrate on the whole welding parameter space when the L_9 orthogonal exhibit is utilized.

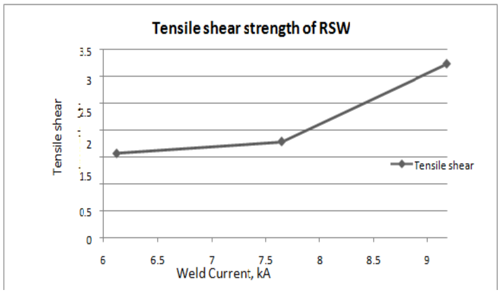


Fig: Tensile Shear strength of Resistance Spot Welding

Overall Loss Function and its S/N ratio

Run No.	Squeeze time	Weld time	Current	Roughness	TS	S/N ratio
1	40	50	6.12	100	2.040	6.192
2	40	65	7.65	120	1.551	3.812
3	40	80	9.18	180	3.568	11.048
4	55	50	7.65	180	1.595	4.055
5	55	65	9.18	100	3.129	9.908
6	55	80	6.12	120	1.407	2.965
7	70	50	9.18	120	3.006	9.559
8	70	65	6.12	180	1.281	2.150
9	70	80	7.65	100	2.201	6.852

Table: S/N Ratios for the Tensile Shear Strength Measurements

Tensile shear strength of the welded structures is largely dependent on the quality and microstructure. Better the quality higher the tensile strength. The loss function of the larger-the-better quality characteristics can be expressed as

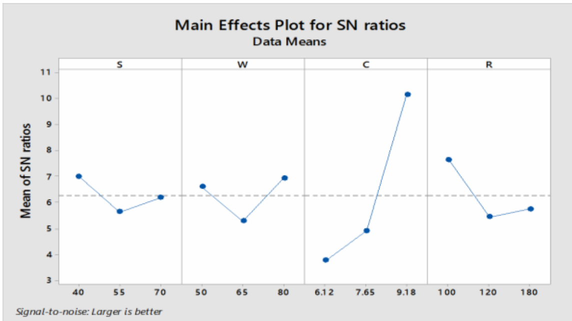
$$\eta_j = -10 \log L_j$$

where n is the number of tests, and y_i the experimental value of the i_{th} quality characteristic, L_j overall loss function, and η_j is the S/N ratio. By applying above Equations, the η corresponding to the overall loss function for each experiment of $L_9$was calculated and given in Table

The effect of each welding process parameter on the S/N ratio at different levels can be separated out because the experimental design is orthogonal. The S/N ratio for each level of the welding process parameters is summarized in Table. In addition, the total mean of the S/N ratio for the 9 experiments is also calculated and listed in Table

RSW parameter	Level 1	Level 2	Level 3	Max-Min	Rank
Squeeze Time	7.018	5.643	6.188	1.375	4
Weld Time	6.603	5.290	6.956	1.665	3
Weld Current	3.770	4.907	10.172	6.402	1
Roughness	7.651	5.446	5.752	2.205	2

In Fig. below the S/N ratio graph shows the welding current as the most significant factor in the welding process. As center line is the value of the total mean of S/N ratio. Basically the larger the S/N ratio the better is the quality characteristic for the tensile shear strength and the response of S/N ratio with respect to tensile strength indicates the welding current to be the most effective.



Analysis of variance:

Analysis of variance (ANOVA) was introduced by Sir Ronald Fisher. This analysis was carried out for a level of significance of 5%, i.e., for 95% level of confidence. The purpose of ANOVA is to investigate which turning parameter significantly affects the performance characteristics. Table shows the results of ANOVA for TS. It is found that welding current is the significant parameters affecting RSW. Therefore, based on S/N ratio and ANOVA analyses, the optimal cutting parameters for RSW are the squeeze time at level 1, welding time at level 3, welding current at level 3 and roughness at level 1.

Parameter	Process Parameter	Degree of freedom	Sum of square	Mean of square	Contribution percentage %
Squeeze Time	Squeeze time	2	2.875	1.438	3.34
Weld Time	Welding Time	2	4.619	2.309	4.843
Weld Current	Welding Current	2	70.007	35.004	81.39
Roughness	Roughness	2	8.564	4.282	9.95
	Error	0			
	Total	8	86.066		

Table: Sum of square of RSW

Confirmation Experimental Test Results:

Table : Confirmation test

	Initial process parameters	Optimal Process Parameter		Improvement in S/N ratio
		Predicted	Experiment	
Level	$S_2W_2C_2R_2$	$S_1W_3C_3R_1$	$S_1W_3C_3R_1$	9.886
TSS (kN)	1.208	3.998	4.132	
S/N (dB)	2.437	12.948	12.323	

Hence, the S/N ratio has been improved from initial process parameter to optimal process parameter by 9.886 dB. This confirms that the optimization by Taguchi Method will increase the tensile shear strength of the Resistance Spot Welding.

Verification tests:

T9he verification experiment is that the final step within the first iteration of the design of the experiment method. The determination of the verification experiment is to valid the conclusions. The verification experiment is performed by conducted a test with a particular combination of the factors and levels previously examine. When determined the optimum conditions and predicted the response below these conditions, a new experiment was designed and conducted with the optimum levels of the welding process parameters. The final step is to predict and ensure the improvement of the performance characteristic. The predicted S/N ratio µusing the optimum levels of the welding method parameters will be calculated as

$$\mu = Tavg + (A2avg - Tavg) + (B1avg - Tavg) + (C1avg - Tavg) + (D2avg - Tavg)$$

Where Tavg= is total mean of S/N ratio

A2avg, B1avg, C1avg, D2avg=Average value of response at different level of parameter A, B, C and D respectively. The results of predicted tensile shear strength using the optimum welding parameter are mentioned in table. The improvement in S/N ratio from the starting welding parameter to the level of optimal parameter is 2 dB for 1mm stainless steel, respectively. The tensile shear strength is increased by 1.8 for 1mm.therefore; the tensile shear strength is greatly improved by using Taguchi method.

	Initial Process Parameter	Optimal Process Parameter		Improvement in S/N ratio
		Predicted	Experiment	
Level	$S_2W_2C_2R_2$	$S_1W_3C_3R_1$	$S_1W_3C_3R_1$	10.131
TSS (kN)	1.228	4.421	4.529	
S/N (dB)	2.988	14.139	13.12	

Table: Confirmation Experimental Test Results

Hence, the S/N ratio has been improved from initial process parameter to optimal process parameter by 10.13 dB. This confirms that the optimization by Taguchi Method will increase the tensile shear strength of the Resistance Spot Welding.

Conclusions

In this proposal examination was done on the streamlining and the impact of welding parameters on the tensile shear quality of spot welded SS 304 sheets. The level of significance of the welding parameters on the tensile shear quality is controlled by using ANOVA. In light of the ANOVA technique, the profoundly viable parameters on tensile shear quality was found as welding current, roughness whereas holding time and welding time were less successful components. The outcomes demonstrated that welding current was around eight times more imperative than the second positioning component (roughness) for controlling the tensile shear quality. An ideal parameter blend for the greatest tensile shear quality was acquired by utilizing the investigation of sign to noise (S/N) ratio. The affirmation tests showed that it is conceivable to increment tensile shear quality fundamentally by utilizing the proposed factual strategy. The trial results affirmed the legitimacy of the utilized Taguchi technique for upgrading the welding execution and improving the welding parameters in resistance spot welding operations.

The impact of procedure parameters of weld-bonding and spot welding on tensile shear quality was considered utilizing Taguchi technique. In view of this study taking after conclusions can be drawn:

(1) Taguchi philosophy is an amazing method, which can be effectively used to discover which the most contributed parameters are in a specific welding process.

(2) The created model for tensile shear quality gives a decent forecast of tensile shear quality inside the connected scope of parameters.

(3) The tensile shear strength of weld-bond joint is approximately 53% higher than that of spot welded joint under the same parameters.

The limitation of the Taguchi method is that it cannot judge and determine the effect of individual parameters on entire process while percentage contribution of individual parameters can be determined using (ANOVA) technique. ANOVA can be useful for determining influence of any given input parameter from a series of experimental results using design of experiment.

Future Scope

In Resistance Spot Welding, in place of similar metals dissimilar metals can be used. Dissimilar metals like aluminum with stainless steel or copper with stainless steel.

In weld bond, in place of epoxy various other types of adhesives like Cyanoacrylates, methacrylates, Polyurethanes and thermosetting adhesive can also be experimented in weld bonds. There is also a possibility of varying the adhesive types to check whether which product is more strongly bonded that the rest of them.

Using of different material for the RSW process would be certainly is a point to be considered. Use of dissimilar material as the base metal rather than what we have use as same material weld, use of dual phase and steels with other alloying materials can be very important as new materials are being introduced in these times and have different properties which could help us giving best of both worlds.

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