Analysis on Resistance spot welding strength by Process Parameter optimization through Taguchi Method

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Abstract: Applying a ***L9 Taguchi orthogonal array***, an experimental investigation on resistance spot welding has been conducted.

- For experimental work, ***mild steel*** has been considered as a material.
- Input parameters for spot welding in this study are ***electrode force on the plate, welding duration, and welding current***; however, the output parameter chosen is the ***nugget's tensile strength***.
- Orthogonal array L-9 results indicate that welding current significantly affects the nugget's tensile strength.

Keywords: Spot Welding, Tensile Strength, Taguchi Method,

INTRODUCTION

- Resistance welding is a popular welding process due to its high speed and low cost combination.
- It also provides great reproducibility
- One of the most important metal joining methods for **high - volume manufacturing** in the automotive, biomedical, and electronics industries is resistance spot welding (RSW).
- **Large-Scale Resistance Spot Welding,** which typically involves 2 to 6000 spot welds, has taken over as the primary method of vehicle body construction.
- **Small-Scale Resistance Spot Welding** is grabbing the interest of more and more researchers as the use of extremely thin metal sheets in the production of electronic parts and gadgets increases.
- With the use of the **Taguchi technique**, this study proposes a method for assessing the impact of the process variables (electrode force, weld duration, and welding current) on the tensile strength of a resistance weld joint for mild steel.
- Multi-variables had an impact on the Taguchi approach, which is useful for handling replies. When compared to studies using a complete factorial design, this approach significantly lowers the number of experiments needed to represent the response function. Finding any potential interactions between the factors is this technique's main benefit.
- Compared to conventional nickel-chromium stainless steels like 302-304, it is more resistant to general corrosion and pitting. It features the following things: Excellent formability, higher tensile and rupture strength at high temperatures, higher creep resistance, and resistance to corrosion.

Identifying the Important Process Control Variables:

The following significant process control factors affect the tensile strength and other parameters of spot welding: current, welding time, holding time, squeezing time, pressure, and electrode diameter. However, in this research, we simply take into account the electrode force, welding time, and welding current. According to the general spot welding heat equation.

$H= I^2Rt$

Where, H= heat generated, I= Current, R=resistance, t=time

Cycle duration, current, and electrode force were used in this study to see how they affected the tensile strength of mild steel.

Experimentation

In order to test the tensile strength, a sample measuring 100 x 25 mm was made. The two sections were then joined by spot welding, and the parameter range was determined before the tensile strength was calculated. To make mild steel, this method was utilized. Mild steel may be used using this manner most affordably. Electrode force, welding duration, and welding current are the three variables in this process.

Following analysis, Table 1's listing of these steels' chemical compositions.

Mill TC Material Properties & Chemical Properties for Hot Stamping material																			
				Chemical Properties													Mechanical Properties		
Part Name	Grade	Std.	Supplier	Properties	C	Si	Mn	P	S	Al	Cr	B	Ti	N	Mo	Ceq	Tensile Strength (Mpa)	Yield Strength (MPa)	Elongation %
				Min	0.19	0.15	1.10	-	-	0	-	0	0.020	-	-	-	500 to 700	35 to 550	Min 12%
				Max	0.25	0.35	1.80	0.03	0.01	0.070	0.50	0.01	0.050	0.02	0.35	0.41			
REINF-CTR PLR UPR, RH / LH	22MNBA5 AS	11-04-822	Arcelor Mittal (As per Mill TC)	Actual	0.22	0.24	1.14	0.01	0.01	0.040	0.18	0	0.04	0.01	0.010	0.33	555	394	24%

Steps in Performing a Taguchi Experiment

There are several separate phases that make up the Taguchi experiment procedure.
Step 1: to formulate the problem; any experiment's effectiveness depends on having a thorough knowledge of the issue at hand.
Step 2: Finding the output performance attributes that are most pertinent to the issue is step two.
Step 3: Determination of the control, noise, and signal variables (if any). Control factors are those that are able to be managed throughout routine manufacturing processes. Noise factors are those that are either too expensive or too difficult to regulate in a manufacturing setting. The process's mean performance is impacted by signal variables.
Step 4: Choosing the degrees of freedom connected to each element and the interactions' consequences, as well as any potential interactions.
Step 5: Create a suitable orthogonal array (OA).
Step 6: Get the experiment ready.
Step 7: Conducting the experiment and gathering the necessary data.
Step 8: Interpreting experimental data based on statistical analysis.

Table 2: L9 Table Formulation

Expt.	Electrode force	Welding current	Welding time
1	1	1	**1**
2	1	2	**2**
3	1	3	**3**
4	2	1	**2**
5	2	2	**3**
6	2	3	**1**
7	3	1	**3**
8	3	2	**1**
9	**3**	**3**	**2**

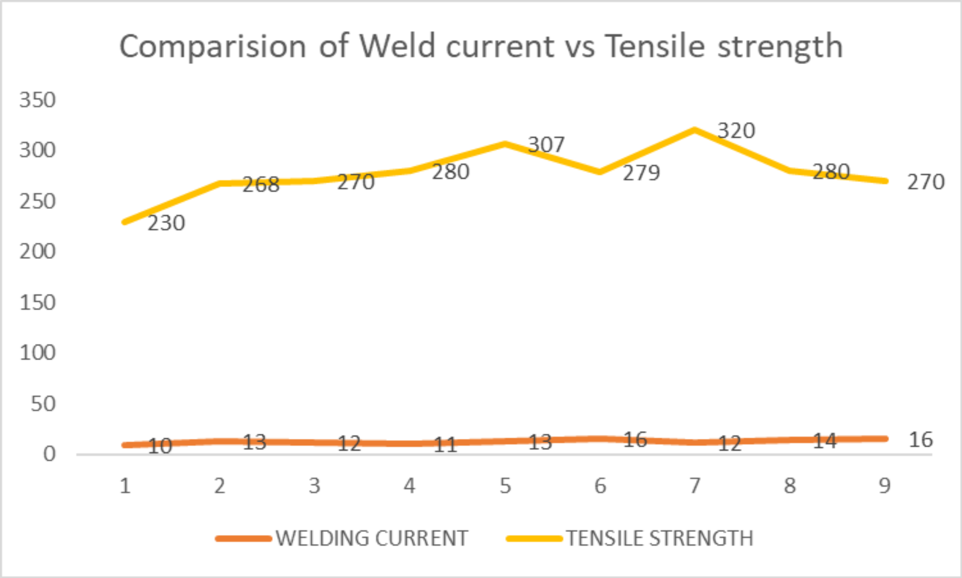
Table 3 Process Parameters With Their Values At Three Levels

LEVEL	1	2	3
ELECTRODE FORCE (KGF)	3000	3400	**3200**
WELDING CURRENT (KA)	12	11	**10.5**
WELDING TIME (Cycle)	**100**	**120**	**120**

Result and Discussion

The resilience of a product or process design is directly tied to the signal-to-noise notion. Robustness is founded on the premise that quality is a result of good design and has to do with a product's capacity to handle variance. Strong "signal" is delivered through a durable design or product. It carries out the anticipated function and can withstand internal and external fluctuations (noise). Robustness must be built into a product before manufacturing begins since a good manufacturing process will be true to a product design.

EXPT	ELECTRODE FORCE (KGF)	WELDING CURRENT (KA)	WELDING TIME (CYCLE in ms)	TENSILE STRENGTH (MPA)
1	3000	10	100	230
2	3100	13	120	268
3	3150	12	124	270
4	3200	11	121	280
5	3000	13	125	307
6	3300	16	118	279
7	2800	12	124	320
8	2900	14	118	280
9	3200	16	121	270



A product will have fewer manufacturing flaws if it is made to prevent failure in the field, according to Taguchi. There is a clear emphasis on minimizing the consequences of variation, with no attempt made to eliminate variance, which is regarded to be unavoidable. There will always be "noise" in processes, but by incorporating powerful signals into a product, their impact may be reduced. The controllable elements that can have such a detrimental impact on the performance of a design are measured using the dimensionless signal-to-noise ratio. It enables these elements to be conveniently adjusted. Adjustments may easily be performed using the signal-to-noise ratio to reach the desired objective, provided that a process is constant.

The sensitivity of the quality feature under study was measured in a controlled way using the signal to noise ratio (S/N ratio). In the Taguchi technique, the terms "signal" and "noise" refer to the desired effect (mean) and the undesired effect (signal disturbance, S.D.) for the output characteristic, respectively. The undesirable effect arises from noise components that have an impact on the outcome. One definition of the S/N ratio is:

Ratio of S/N, = -10 log (MSD)
Where, MSD is the output characteristic's mean-square deviation.

From a whole sheet of 1.2 mm thick mild steel, a sample measuring 100 x 25 mm was cut. The components were then spot-welded together.

Conclusion
L-9 Taguchi experiments has been tried for the phase1 and the nine common input parameter combinations have been tested to improve responsiveness. According to testing, the Avg output value was found to be 278, with the Avg of welding cycle is meant 119 despite the input variables being 3072 KGF for the electrode force, and we could see the tensile strength of the results is good. This allows the weld maker a chance to get input process parameters that are ideal or nearly optimal.

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