# Process Optimization of Robotic Arc Welding By Using Taguchi Method on Stainless Steel Er316l

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***Abstract-*** *Manufacturing metal components via robotic welding are a crucial procedure, particularly in heavy sectors like shipbuilding, oil & gas, automotive, and aerospace. Robotic welding is a production process that uses a wide range of diverse approaches, and these operations are always evolving since each advancement might help to prevent welding faults. The primary goal of this publication is to define and review works that show the advances in the main inspection, modelling, monitoring, and automated operations during the welding process in order to avoid, or predictably identify, any possible defect in order to obtain an optimal degree of welding quality. Although a great deal of research work has been carried out in recent years, as a result of which results and reviews have been presented on this subject.*

## I. INTRODUCTION

Welding is, at its core, simply a way of bonding two pieces of metal. While there are other ways to join metal (riveting, brazing and soldering, for instance), welding has become the method of choice for its strength, efficiency and versatility. There are tons of different welding methods, and more are being invented all the time. Some methods use heat to essentially melt two pieces of metal together, often adding a "filler metal" into the joint to act as a binding agent. Other methods rely on pressure to bind metal together, and still others use a combination of both heat and pressure. Unlike soldering and brazing, where the metal pieces being joined remain unaltered, the process of welding always changes the work piece

## II. LITRATURE REVIEW

Hakenates et al. [1] has conducted an experiment in which low carbon steel plates (15 x 150 x 450 mm) were welded under 180 A and 28 V to determine the mechanical parameters of the welded low alloy steel using the GMA method. CO2, Ar, and O2 mixes of three gases were employed as the shielding media in a MIG/MAG welding equipment. The experiment was run with the contact tip 15 mm away from the work piece and the shielding gas flowing at a rate of 151/min. The electrode wire is 1.2 mm in diameter. a test that was done to evaluate these experiments' mechanical qualities. For the prediction of the welding parameters for a gas metal arc, artificial neural networks (ANNs) are used. Gas mixes make up the model's input parameters. While the mechanical properties of tensile strength, impact strength, elongation, and weld metal hardness, respectively, are outputs of the ANN model. The research has demonstrated the viability of using neural networks .

Achebo et al. [2] demonstrated through his work that the Taguchi Method was used to optimize the selection of input parameters, such as welding current, voltage, speed, and time, against the response of the steel's ultimate tensile strength. The Taguchi Method study revealed that a welding current of 240A, a welding time of 2.0 minutes, a welding speed of 0.0062 m/s, and a welding voltage of 33V were the ideal process parameters. These ideal settings were shown to enhance the S/N ratio by 2.32 dB and the UTS by 1.11 times over the baseline process parameters. This study explains how to use the Taguchi Method step by step.

D.S. Nagesh et al. [3] By choosing input parameters like electrode feed rate, arc power, arc voltage, arc current, and arc length, as well as by using the ANN method for optimization of output parameters like bead height, bead width, depth of penetration, area of penetration, and are travel rate, weld bead geometry and penetration can be predicted. According to the experimental findings, using preheated plates, a low arc-travel rate, or a high arc-power produced superior fusion. With a rise in arc-travel rate, the bead's height and width both decrease, but the height decrease is more pronounced, resulting in a flatter bead with a greater 27 arc-travel rate. With an increase in electrode feed rate while keeping are-length fixed, the penetration and HAZ rise.

D. S. Correia et al. [4] proposed was a genetic algorithm (GAS)-based method of MIG welding parameter optimization. Step-by-step, the search for the nearly optimal was conducted, with the GA anticipating the upcoming experiment based on the results of the preceding experiments without knowledge of the modelling equations between the inputs and outputs of the MIG welding process. With only a few number of experiments, the GA was able to produce circumstances that were very close to ideal. But a good setting of its own parameters, such as the number of generations, population size, etc., is necessary for the optimization by GA approach. Otherwise, there is a chance that the search area will not be sufficiently large.

Wahab H. Khuder et al. [5] Utilizing MIG spot welding, researchers have examined the impact of welding process parameters in welding joints between dissimilar metals. In this study, carbon steel and austenitic stainless steel of type AISI 316L were used as the welding base materials. E80S-G is utilized as a filler metal and CO2 is used as a shielding gas when welding this dissimilar metal. Wire feed, wire feed time, and weld current were used as input parameters in the experiment. By carrying out the experiment, it was possible to estimate how these characteristics would affect the spot's diameter and shear force. They draw the conclusion that whereas shear force decreases with increased welding time, it increases with increasing welding current and spot weld size.

Amit Kumar et al. [6] have worked on improving the MIG welding settings using genetic algorithms (GA) and artificial neural networks (ANN). In this study, a mathematical model is created using the artificial neural network (ANN) method to predict how welding parameters like welding voltage, welding speed, and welding current will affect the final tensile stress during the joining of dissimilar materials such stainless steel grades 304 and 316. The experiment was conducted using argon as a shielding gas and a full factorial design. The output parameter's value is optimized using the Genetic Algorithm (GA). According to the analysis, the greatest ultimate tensile strength is achieved at 110 A welding current, 18 V welding voltage, and a travel speed of 43.362 cm/min. They've also demonstrated that the Artificial.

AjitHooda et al. [7] have created a response surface model to forecast the tensile strength of an AISI 1040 medium carbon steel joint produced by inert gas metal arc welding. The welding voltage, current, wire speed, and gas flow rate are taken into consideration as input parameters in this study. Face-centered composite design matrix was used to create the experiment. 28 According to the results of the experiment, the welding voltage of 22.5 V, the wire speed of 2.4 m/min, and the gas flow rate of 12 l/min are the best values for process parameters

## III. METHODOLOGY

Control of the operating variables in submerged arc welding is essential if high production rates and the welds of good quality are to be obtained.

The following important variables are
1. Welding amperage
2. Gas flow rate
3. Welding time

**Welding amperage :**

The most significant characteristic is welding current since it impacts deposition rate, regulates the rate of electrode melting, and consequently regulates deposition rate, heat affected zone, depth of penetration, and amount of base metal melted. As welding current increases, penetration and reinforcement also do.

**Gas flow rate :**

Argon, carbon dioxide, oxygen, nitrogen, hydrogen, and other mixes are among the available welding or shielding gases. The choice of gas is particular to the working metals and impacts production costs, electrode life, weldtemperature, stability, difficulty of welder control, and fluidity, speed, and spatter of the molten weld. Most significantly, it also has an impact on the 30 depth and subsurface profile of the completed weld, as well as its composition, porosity, corrosion resistance, strength, ductility, hardness, and brittleness**.**

**Welding Speed :**

The rate at which the welding procedure is carried out, which is commonly measured in units of length per unit of time, is referred to as welding speed. It shows how quickly the joint or workpiece being welded advances through the welding process. Depending on the welding technique, the kind of material being welded, and the particular application, the welding speed can change. The ideal speeds for various welding procedures vary, and they are frequently influenced by elements including heat input, material thickness, joint design, and desired weld quality. In general, a higher welding speed denotes a more expedited welding procedure, which leads to a quicker welding task completion. Finding a balance between speed and quality is crucial, though. Rapid welding may result in insufficient penetration, insufficient fusion, or more flaws. On the other side, excessive heat input, distortion, or burn-through can occur when welding too slowly.

## IV. FABRICATION

**Raw material**

Stainless steel 316, also known as SS316 or AISI 316, is a popular grade of stainless steel that belongs to the austenitic stainless steel family. It is widely used in various industries due to its excellent corrosion resistance and high temperature properties.

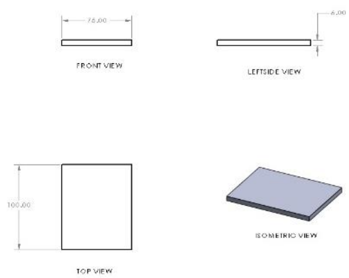



Figure dimensions for raw material plate

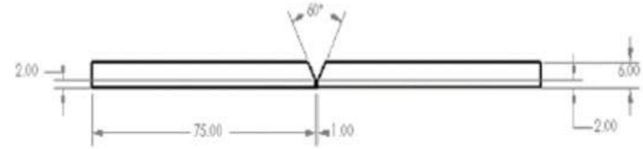
**Groove making**

Groove is a long and narrow indentation built into a material, generally for the purpose of allowing another material or part to move within the groove and be guided by it.(figure)


Figure Portable grinding machine

**V Groove making**

V-grooves are cut into the matboard by directing bevel cuts to face each other, creating a "V" shape. This cutting exposes the core of the board providing an accent line around the mat opening. (Figure)




Welding process

Welding is a fabrication process whereby two or more parts are fused together by means of heat, pressure or both forming a join as the parts cool. Welding is usually used on metals and thermoplastics but can also be used on wood. The completed welded joint may be referred to as a weldment.(figure)

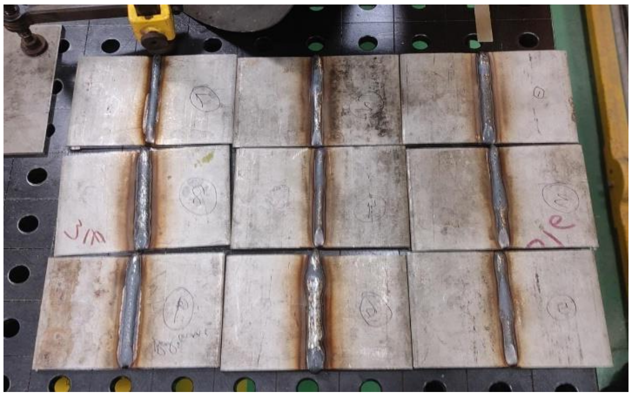
**Welding parameters**

| S.No | Gas flow rate | Current | Welding speed |
|---|---|---|---|
| 1 | 5 | 130 | 2 |
| 2 | 5 | 160 | 3 |
| 3 | 5 | 200 | 4 |
| 4 | 10 | 130 | 3 |
| 5 | 10 | 160 | 4 |
| 6 | 10 | 200 | 2 |
| 7 | 15 | 130 | 4 |
| 8 | 15 | 160 | 2 |
| 9 | 15 | 200 | 3 |

**Taguchi design output:**

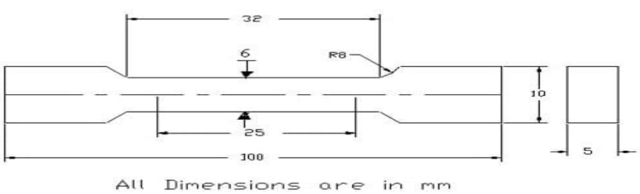
| Process parameter | Unit | Levels | | |
|---|---|---|---|---|
| | | Lower level (1) | Medium level (2) | Upper level (3) |
| Gas flow rate | (l/m) | 5 | 10 | 15 |
| Current | (Amp) | 130 | 160 | 200 |
| Welding speed | (mm/sec) | 2 | 3 | 4 |

**After welding process**



**Making of dog bone shape**

Dog-bone shaped specimens are recommended for uniaxial tension tests (ASTM D638 2003) in order to reduce the influence of stress concentrations induced by loading grips. The details of recommended specimen dimensions are provided in ASTM D638. (Figure)




## V. RESULTS AND DISCUSSION

**Nondestructive test**

Penetration testing

Penetrant testing (PT), is a widely applied and low-cost inspection method used to check surface-breaking defects in all non-porous materials (metals, plastics, or ceramics). The penetrant may be applied to all non-ferrous materials and ferrous materials, although for ferrous components magnetic-particle inspection is often used instead for its subsurface detection capability. LPI is used to detect casting, forging and welding surface defects such as hairline cracks, surface porosity, leaks in new products, and fatigue cracks on in-service components.

**Penetrant test results**

| Sample No | Non Destructive Test Results |
|---|---|
| Sample 1 | No defect |
| Sample 2 | No defect |
| Sample 3 | No defect |
| Sample 4 | Lack of fusion |
| Sample 5 | No defect |
| Sample 6 | No defect |
| Sample 7 | No defect |
| Sample 8 | Pin hole |
| Sample 9 | No defect |

**Destructive testing**

Tensile testing

Tensile testing is a destructive test process that provides information about the tensile strength, yield strength, and ductility of the metallic material. It measures the force required to break a composite or plastic specimen and the extent to which the specimen stretches or elongates to that breaking point.

**Tensile Test Results**

| PLATE NO | TEST PARAMETRES | OBSERVED VALUES |
|---|---|---|
| 1 | Ultimate Tensile Strength (MPa) | 464 |
| 2 | Ultimate Tensile Strength (MPa) | 609 |
| 3 | Ultimate Tensile Strength (MPa) | 444 |
| 4 | Ultimate Tensile Strength (MPa) | 351 |
| 5 | Ultimate Tensile Strength (MPa) | 432 |
| 6 | Ultimate Tensile Strength (MPa) | 612 |
| 7 | Ultimate Tensile Strength (MPa) | 484 |
| 8 | Ultimate Tensile Strength (MPa) | 441 |
| 9 | Ultimate Tensile Strength (MPa) | 548 |

**Bending test**

A bending test (bending tensile test) is a method of testing materials for their bending strength and other important properties. Destructive materials testing is used for plastics, fiber-reinforced plastics (FRP), metals and ceramic materials. In bending tests, standardized, mostly cylindrical specimens are placed in the center of the checking fixture. The rounded support rollers (bearings) are arranged parallel to each other at a certain distance (support width). The diameter of the cylindrical specimen is proportional to the support width of the bearings. The test punch, which moves down slowly and at a constant speed, loads the sample with increasing force until it breaks or reaches the previously determined deformation. The maximum load exerted during the bending test is called breaking force

**Bending test results**

| **Plate no** | **Length(mm)** | **Width (mm)** | **Thickness (mm)** | **Mandrel dia (mm)** | **Angle of bend (deg)** | **observation** |
|---|---|---|---|---|---|---|
| 6 | 150 | 19.02 | 6.42 | 24 | 180 | No crack found |

## VI. ACKNOWLEDEMENT

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