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Dissimilar metal welding of J4-16Cr. austenitic stainless steel with Grade 201LN austenitic stainless steel experimental analysis through optimization Taguchi method

Harpreet Singh
harpreet996@gmail.com
Delhi Institute of Technology Management and Research, Faridabad, Haryana

Barkat Ali
noorbarkat@gmail.com
Delhi Institute of Technology Management and Research, Faridabad, Haryana

ABSTRACT

A literature review of studies and research has been made in the field of dissimilar metal welding. It has various industrial applications such as in the field of automobile chemical mechanical thermal power generation, nuclear plant. The main purpose of this paper is to review

(a) Dissimilar metal welds and aspect of mechanical and metallurgical point of view.

(b) Enhancing GMAW Technique. And second the main objective of present study is to apply the Taguchi method.In this technique, an orthogonal array, signal to noise ratio (S/N) and analysis to variance (ANOVA) are made to study the welding characteristics of the material and optimize the welding parameters

Keywords: *Automated MIG welding system, Grinding machine, Orthogonal array, Signal noise (s/n) ratio, Anova.*

1. INTRODUCTION

There are many different factors in which weld ability depend like metallurgical changes that occur welding process. Oxidation occurs during welding contamination with environment and effect of hardness due to instant solidification Stainless steel of 201LN is welded to 300 series basically called Jindal step(J4-16Cr.) using a metal inert gas welding which also known as gas metal arc welding with the help of filler wire. Argon gas is used as an inert shielding gas in this process. There is larger numerous application of a combination of higher quality grade and inferior quality grade austenitic steel in the industry such as the nuclear plant in heat exchanger assembly. In this combination, we adhere the cumulative application of J4-Cr stainless steel as its low cost and corrosion resistance property of higher quality stainless steel. All these applications are major essential in welding of two which can perform the desired durable service requirement in industry.

Originality/ value

with the help of optimal parameter computed result are prepared and these factors are identified such as tensile strength, stress concentration, percentage elongation.in this paper new result of dissimilar metal weldment are emphasized with optimization technique using Taguchi method.

Process Parameters

There is various parameter encountered in which the welding quality is the major element. Actually the welding quality mainly depends on bead geometry, mechanical and metallurgical characteristics of weld as well as aspects of weld chemistry and these features are influenced by various input parameters like voltage, current, gas flow rate, position of welding, electrode stick out, edge preparation, moreover the summative effect of the above mentioned quality indices determine the joint strength that must be meet the functional aspects of weld in practical application field of area. So it is challenging job to prepare a satisfactory good quality of weldment.

Composition

Here we are choosing two dissimilar metal that is further described with composition. These are following composition of the J4-16Cr steel.

Chemical Composition of J4 Austenitic stainless steel								
%C	%Mn	%P	%S	%Si	%Cr	%Ni	%Cu	%N
0.10 Max	8.5 to 10.0	0.08 Max	0.015 Max	0.75 Max	15 to 17	1.0 to 1.5	1.5 to 2.0	0.1 to 0.2

And balance iron

These are following mechanical Properties of J4-16Cr steel

Mechanical Properties of J4				
Yield Strength MPa (Minimum)	Ultimate Tensile Strength MPa (Minimum)	% Elongation (Minimum)	BHN	HRB
325	650	40	245	98

Grade 201 LN Stainless Steel Composition

Chemical Composition of Austenitic stainless steel 201 LN								
%C	%Mn	%P	%S	%Si	%Cr	%Ni	%Cu	%N
0.10 Max	5.5 to 7.50 max	0.06 Max	0.03 Max	1 Max	16 to 18	3.5 to 5..5	1.5 to 2.0	0.25 Max

Mechanical Properties

The mechanical properties of grade 201LN stainless steel are displayed in the following table.

Mechanical Properties of Austenitic stainless steel 201 LN				
Yield Strength MPa (Minimum)	**Ultimate Tensile Strength MPa (Minium)**	**% Elongation (Minimum)**	**BHN**	**HRB**
350-550	650-880	8-25	255	100

2. REVIEW OF WELDMENT

J4-16Cr. Austenitic Stainless-steel

J4 belongs to the Cr-Mn-N series of stainless steels (commonly referred to as the 200 series. There is numerous application of this steel in industry. During the Second World War, a serious shortage of Ni forced scientists to look for ways of making stainless steels with good formability & weldability but with a lesser amount on Ni. Several grades were developed (200 series) but were not commercially produced on a large scale since the availability of Ni improved. This kind of difficulty obstructs its application. This kind of steel faced such like the situation in the eighties due to high Ni prices and import restrictions in India. The major identified was to focus on 200 series to offer more efficient and durable stainless steel to customers. Major research and development were made to create alloys which were superior to the initial 200 series alloys steel. These grades were introduced in the market in the eighties and were constantly improved upon resulting in J4, we find the largest selling 200 series grade in the world today. These grades were introduced in the Indian market with enhance better quality in the eighties and were constantly improved upon resulting in J4, the largest selling Cr-Mn-N grade in the concurrent world. History has reflected the capability of J4 to act as a catalyst in the development of stainless steel consumption. Actually, on that time, the Indian stainless steel market was a mere 55,000 tons in 1980 decade. This grew to 1,450,000 tons in 2004. 75% of this is Cr-Mn-N series grade steel. This growth was facilitated by making J4 available as The Affordable Stainless Steel in the market. Stainless steels are corrosion resistant but not corrosion proof exactly. Several factors such as grade, finish design, fabrication and environment influence the corrosion behavior of stainless steel in various applications. Selecting the appropriate grade, having a good design and adopting correct practices for fabrication will ensure the long durable life of stainless steel. Stainless steel corrodes in different ways and a brief idea of the common types of corrosion of stainless steel is essential for the correct usage of stainless steel in industry. Corrosion resistance of stainless steel is primarily from chromium. Other elements like molybdenum & nitrogen also increase corrosion resistance. Stainless steel designers often refer to a term called Pitting Resistance Equivalent or PRE as a good indicator of corrosion resistance. J4 falls into the 200 series of stainless steels, which are stainless steel alloys containing nitrogen. Nitrogen is added in a very small percentage of 0.15% in J4. But, since nitrogen is 16 times as effective as chromium in corrosion resistance, it makes a bigger impact on the corrosion resistance of J4 steel.

Grade 201LN Stainless steel

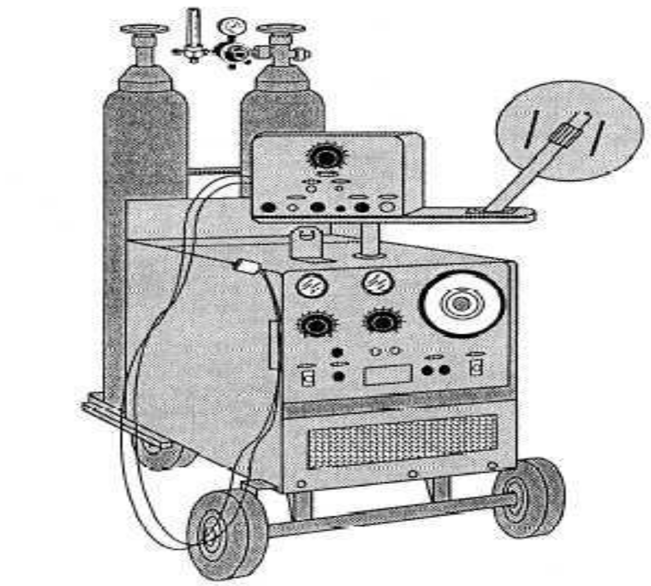
Grade 201 is very cheaper comparative to the traditional Cr-Ni austenitic stainless steels such as grade 304. Grade 201LN stainless steel has good resistance to oxidation, easy fabrication, and excellent toughness even in low temperatures. Its high elongation allows bending and forming. It is not expensive as lower cost nitrogen and manganese is added as a partial alternative for a nickel. The yield and tensile strengths of grade 201LN increase when the temperature is decreased. It is available in sheet and plate forms. Grade 201LN stainless steel is quite similar to grade 304; however, there are advantages unique to grade 201LN. It has good resistance to corrosion, excellent mechanical strength, and increased hardness than grade 304. The following data sheet provides an overview of grade 201LN stainless steel.

Grade 201LN is used widely in the transportation industry.201LN stainless steel is an alloy that contains half the nickel and increased manganese and nitrogen of more popular steels. Because of its low nickel content, it is not so much costlier). Greade 201LN is an austenitic metal as it is a non-magnetic stainless steel that possesses high levels of chromium and nickel element and low levels of carbon. Actually, grade 201LN stainless steel is a mid-range product with a variety of useful qualities. While it is ideal for certain uses, perhaps, it is not a good choice for structures that may be prone to corrosive forces such as salt water. This is part of the 200 series of austenitic stainless steels. In many application, we can use 200LN steel as a substitute of 300-grade steel such as J4-16Cr steel, but is less corrosion resistant than its counterpart, particularly in chemical environments. It is noticed that higher nitrogen content in SS201 provides higher yield strength and toughness than Grade 301 steel, especially at low temperatures. It is noticed that that the steel having grade 201LN is not hardened by heat treatment process and it is to be done annealed at temperature 1015-1068°C), followed by water quenching or rapid air cooling method. Grade 201 is used to produce a range of household appliances, such as sinks, cooking utensils, washing machines, windows, and doors. It is also used in the manufacturing of automotive trim, In a wheel, architecture slides, railway cars, trailers, and clamps, hanging objects. Actually, It is not preferred for structural outdoor applications due to it susceptibility of pitting and crevice corrosion that ultimately degrade it life.

3. METHODS AND EQUIPMENT INVOLVED

GMAW EQUIPMENT AND SUPPLIES

The basic GMAW equipment for a system consists of a power source, wire feed unit, a welding gun, shielding gas supply system and water cooling system. Increasing demand for mass production rate leads to the development of gas metal arc welding (GMAW) in which nonconsumable tungsten electrode is replaced by consumable filler wire and composition compactible with inherent work material. In a practical point of view, it is possible to weld all metal for which electrode wire is available, As initially this process was used mainly for welding aluminum and stainless steels with inert gas shielding it is more popularly known as metal inert gas (MIG) welding. GMAW offers many of the advantages of GTAW.



When using a conventional type of welding machine for GMA welding, the voltage varies depending on the length of the arc. Whenever the nozzle-to-work distance changes, the arc length and the voltage changes. If we want to produce a uniform weld quality, the power source should have to maintain constant the voltage and arc length. Besides producing no uniform welds, this inconsistent voltage can cause the wire to burn back to the nozzle. It is to be overcome inconsistent voltage characteristics of a welding machine, it can be either a dc rectifier or motor generator that supplies current with normal limits of 200 to 250 amperes. Actually, the flat voltage characteristic is found in the CV type power source. This means that the machine maintains the same voltage regardless of the amount of current used. This type of power sources specially design to modify or change the wire feed speed in higher range without causing the wire to burn back to the nozzle considerably. When the wire-feed speed is set at a specific rate, a proportionate amount of current is automatically drawn. In other words, the current selection is based on the wire-feed speed. When the wire is fed to be at faster rate, the current increases; In other words when it is to fed slower or at interrupting rate, the current likely to be decreases. In this type of power supply, variations in the nozzle-to-work distance will not change the arc length as well as burn back is completely eliminated. In gas metal-arc welding, direct-current reverse polarity (DCRP) is recommended.

You should recall from the previous section that It is to be noticed that the Direct current reverse polarity DCRP produces excellent cleaning action and provide deeper penetration as compare to other.

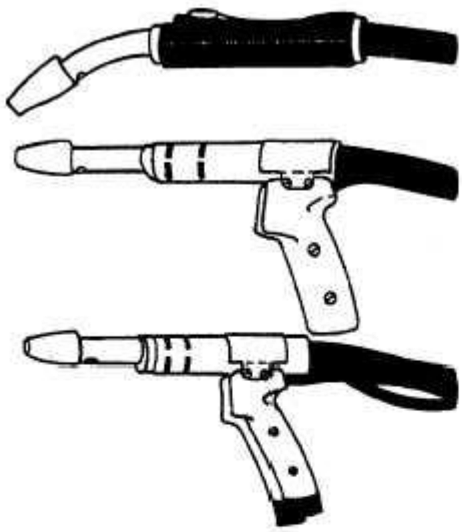
Wire Feed Drive Motor

The function of wire feed drive motor is to drive the electrode from the wire spool

Through the gun up to the arc point. You can vary the speed of the wire feed by adjusting the controls on the wire-feed control panel. The wire feeder can be mounted or attached to the power unit it can be separate from the welding machine.

Welding Gun

The main function of the welding gun is to carry out the electrode wire, the welding current, and the shielding gas to the arc area effectively.It may be pulled or push type. The gun has a trigger switch that controls the wire feed and arc as well as the shielding gas



In GMA welding guns as Shown in the figure when using these guns, the wire is fed to the torch by an automatic wire feeding machine which pushes the wire through a flexible tube to the arc point.

Shielding Gas and cooling system

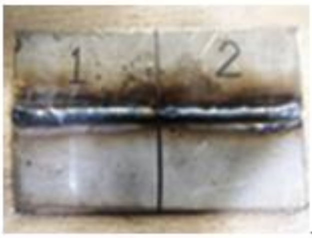
The gas pressure regulator is provided on the standard gas cylinders to provide constant pressure and flow of shielding gas. Flowmeter in the front of a calibrated plastic tube is provided to control the gas flow rate. However, a gas mixing units are also available which can be connected to two cylinders of different gases to obtain a mixture in desired proportions. Such units are mostly used for mixing CO2 and argon.

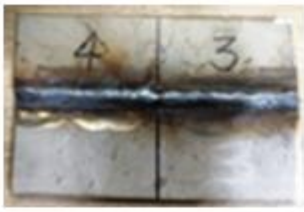
Taguchi method

In Electronic Control Laboratory in Japan, Dr. Genechi Taguchi has made a significant research with DOE techniques in the late 1940's. He put a considerable effort to make the experimental technique more user-friendly (easy to apply) and applied it to improve the quality of manufactured products effectively. Dr. Taguchi's standardized version today known as the Taguchi method or Taguchi approach was implicit in the USA in the early 1980's. Now it is one of the most effective quality building tools used by engineers in all types of manufacturing activities. The Taguchi approach can efficiently as well as technically satisfy the needs of problem-solving. By learning and applying this technique in modern techniques, engineers, scientists, and researchers can significantly reduce the time required for experimental investigations.

Design of Experiment

The Design of experiment is such like a powerful statistical techniques to study the effect of multiple variables simultaneously that involves a series of steps which must follow a certain sequence for the experiment to yield, reform and improved understanding of process performance. In the designed experiments we have required a certain number of combinations of factors and levels be tested in order to observe and examine the results of those test conditions. In the Taguchi approach relies on the assignment of factors in specific orthogonal arrays to find out the test combinations. The DOE process is made up of three main phases: the conducting phase, the planning phase, and the analysis phase respectively. The DOE process is the determination of the combination of factors and levels which will provide the desired information instantly. Analysis of the experimental results uses a signal to noise ratio to aid in the determination of the best process designs combination. In the kind of present work, a planned order for performing the experiments was originated by Taguchi method using orthogonal array and analysis of parameters was done using ANOVA techniques. This method yields the rank of various parameters with the levels of significance or influence of a factor on a particular output response in very fast manner. In Taguchi designs, a measure of robustness used to identify control factors that reduce variability in a product or process by minimizing the effects of uncontrollable factors such as (noise factors). Control factors are those design and process parameters that can be controlled. Noise factors cannot be controlled during production or product use but can be controlled during performing experiment of that product. In a Taguchi designed experiment, we manipulate noise factors to force variability to occur and from the results, identify optimal control factor settings that make the process or product robust, more compact or resistant to variation from the noise factors. Higher values of the signal-to-noise ratio (S/N) determine the control factor settings that minimize the effects of the noise factors . Taguchi experiments generally use a 2-step optimization process. In the first step use the signal-to-noise ratio to identify those control factors that reduce variability. In the second step identify control factors that move the mean to target and have a small or no effect on the signal-to-noise ratio. The signal-to-noise ratio determines and measures how the response varies relative to the nominal or target value under different noise conditions. We can choose from different signal-to-noise ratios, depending on the motto of our experiment. For static designs, Minitab actually offers four signal-to-noise ratios:





Signal-to-noise ratio

The signal-to-noise ratio actually measures the response varies relative to the nominal under the different noise conditions. You can choose from different signal-to-noise ratios, depending on the goal or motto of your experiment. For example in static designs, now Minitab offers four signal-to-noise ratios.

ANOVA Analysis

This is a statistical tool generally used in the determination of the result of an experiment to determine the percentage contribution of each element. It is specially applied to know that factor which is controllable or not.

Results and analysis of various parameters

Taguchi Design
Taguchi Orthogonal Array Design
L9 (3^3)
Factors : 3
Runs : 9
A column of L9 (3^4) Array
Type of workpiece: joint of stainless steel
201LN &J4-Cr Stainless steel
The thickness of workpiece: 5 mm

S.No.	Current	Voltage	Wire feed rate	Hardness	SNRA	MEAN1
1.	160	20	400	86	-38.6900	86
2.	160	22	410	84	-38.4856	84
3.	160	24	420	85	-385884	85
4.	170	20	410	82	-38.2763	82
5.	170	22	420	84	-38.4856	84
6.	170	24	400	87	-38.7904	87
7.	180	20	420	84	-38.4856	84
8.	180	22	400	83	38.3816	83
9.	180	24	410	82	-38.2763	82

Taguchi Analysis: Hardness versus current, voltage, wire feed rate

Response table for Means

Level 1	C	V	w
1.	85.00	84.00	85.33
2.	84.33	83.67	82.67
3.	83.00	84.67	84.33
Delta	2.00	1.00	2.67
Rank	2	3	1

Response Table for the signal to Noise Ratios Smaller is better

Level 1	C	V	w
1.	-38.99	-38.48	.38.62
2.	-38.52	-38.45	-38.35
3.	-38.38	-38.55	-38.52
Delta	0.21	0.10	0.27
Rank	2	3	1

4. FUTURE SCOPE

There is a major difference between J4-16Cr. And Grade 201LN steel is quality and their comparative cost. In Future forecasting point of view before manufacturing, we should have to consider cost-effectiveness. Any kind of manufacturing done with prior planning and think it future demand and supply. Actually 300-grade series material such as J4 is more costly and 200-grade steel is less costly with the same quality and durability of its life. So by fabrication both of them, we generate a newer better robust high durable product with comparative lesser cost and similar utilization of it.

5. CONCLUSION

With the help of various welding equipment and precise instrument successfully complete the experiment and I analyze that the current, voltage and wire feed rate as an input parameter creates a significant effect. as well I reach on the main conclusion that wire feed rate is the first parameter that effects the hardness first then current and voltage that initiates in variation in another parameter.

6. ACKNOWLEDGEMENT

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