Process Parameters Optimization of MIG Welding using Taguchi Technique

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ABSTRACT:
Metal Inert Gas welding is one of the most broadly used welding processes in mass production as well as in small scale industries. The main reason after it is that MIG welding can weld both ferrous and nonferrous metals. The aim of present study is to investigate experimentallytheultimate tensile strength during MIG welding of AISI 304. The input parameters included were wire speed, gas flow rate and welding timeis used for experimental work. Mean effect plot and S/N ratio graphs have been used tooptimize the welding parameters of MIG on AISI 304 stainless steel using the Taguchi method and ANOVA. It has been observed that wire speed- has the largest effect on the tensile strength of AISI 304 steel MIG weldments. The optimum welding conditions for large strength werewire speed(m/min), gas flow rate (ltr/min) and welding time (sec).

Keywords:* *AISI 304, MIG, Ultimatetensile strength, Taguchi Method&ANOVA.

1. INTRODUCTION

Welding is a fabrication technology that is used to join materials, usually metals or thermoplastics by causing fusion which usually results by melting the base metal.

Welding is considered as the most conservative and proficient approach to join metals forever. It is the primary strategy for joining no less than two bits of metal to make them go about as a singular piece. Welding is one of those procedures which positions high among mechanical procedures and includes a bigger number of sciences and factors than those included in some other modern process. There are numerous approaches to make a weld and a wide range of sorts of welding. Some procedure requires flashes and others don't require additional warmth. Welding should be possible anyplace in a wide range of condition outside or inside, submerged and even in space. Welding at exhibit is required in every one of the fields. Fields incorporate agribusiness, development, and vehicle fabricating and even in oil boring apparatuses.

Welding can be divided into various categories.Figure 1 Show different types of weldingTechniques

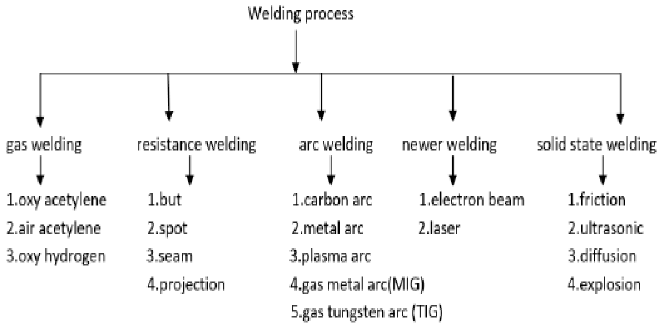

Figure1. Different types of weldingtechniques.

1.1 MIG WELDING

Metal inert gas welding (MIG) is a process in which a consumable wire electrode is fed into an arc and welds pool at a steady but adjustable rate, while a continuous envelope of inert gas flows out around the wire and shields the weld from contamination by the atmosphere.

The MIG welding process has several advantages which account for its popularity and increased use in the welding industries. The most widely recognized utilization of MIG welding is car repair and it can be performed on any assortment of vehicle.MIG welding can be effectively fused into apply autonomy as well.MIG welding can even be utilized to fortify the surface of a ragged out railroad track. MIG welding will help add to the production of vehicles, the working of extensions, and considerably more essentially, a more effective approach to weld.

1.1.2 WORKING PRINCIPLE

As appeared in figure2 the cathode in this procedure is as loop and consistently bolstered towards the work amid the procedure. In the meantime inactive gas (e.g. argon, helium) is passed around anode from a similar light. Idle gas normally argon, helium, or an appropriate blend of these is utilized to keep the climate from reaching the liquid metal and HAZ. At the point when gas is provided, it gets ionized and a curve is started in the middle of terminal and work piece. Warmth is subsequently created. Cathode softens because of the warmth and liquid filler metal falls on the warmed joint. The circular segment might be created between a consistently sustained wire and the work. Steady welding with wound wire empowers high metal declarations to rate and high welding speed. The filler wire is generally connected with the positive furthest point of DC source molding one of the anodes. The work piece is related with the negative limit. The power source could be relentless voltage DC control source, with cathode positive and it yields an unfaltering bend and smooth metal trade with least sprinkle for the entire current range.

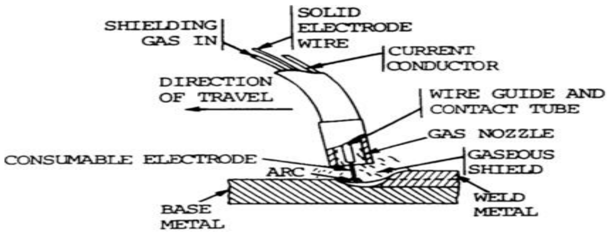

Figure2. MIG welding process[11]

The AISI 304 stainless steel has been selected as work material to be welded by MIG welding. Some of the desirable mechanical properties of AISI 304 are high strength, and high ductility. The chemical composition and properties of AISI 304 are shown in table 1 and 2.

Table 1: Chemical composition of AISI 304

S.No.	Element	Percentage by weight
1.	C	0.08 Max
2.	Mn	2.0
3.	Si	0.75
4.	P	0.045
5.	S	0.03
6.	Cr	18-20
7.	Ni	10.5
8.	N	0.1

Table 2: Properties of AISI 304

Property	Value
Tensile Strength, Ultimate	505 MPa
Yield Tensile Strength	215 MPa
Brinell Hardness	123
Modulus ofElasticity	193-200 GPa
Poisson's Ratio	0.29
Shear Modulus	86 GPa
Density	8.00g/cm^3
Thermal Conductivity	16.2 W/m.K at 100°C

2. LITERATURE SURVEY

HoodaAjit et al.[1] found out the maximum yielding stress of two pieces of AISI 1040 medium carbon steel welded together with the help of metal inert gas welding. KanwalVineeta, Jadoun R. S.[2]performedexperiments on aluminum alloys of grades6061 and 5083, welded with metal inert gas welding tofind the hardness of MIG welding joint usingTaguchi method. Parameters involved in thisstudy were Welding Speed, Welding Currentand Welding Voltage.Chauhan Vikas, Jadoun R. S.[3] determinedparametric optimization when two dissimilarmetal Stainless steel (SS 304) and Low carbonsteel were weld together using MIG welding.The parameter on which analysis is done wascurrent, voltage and travel speed. ANOVA and Taguchi technique were applied for the optimizationusing MINITAB 13 computer software. SaxenaVivek et al.[4]carried out a researchstudy to determine the optimized value MIG welding Parameters for attaining maximumtensile strength of Aluminium alloy AM-40(EN AW 5083). Welding current andWelding Voltage were taken as parameters tojudge this studyPatil S.R, Waghmare C. A.[5]observed theeffect of MIG welding on AISI 1030's ultimate tensile strength. The major parameters used inthis study were welding speed and weldingcurrent. ANOVA and Taguchi technique werepracticed to generate orthogonal array so as tooptimize characteristics, such as signal to noiseratio.

VermaSudesh et al.[6]presented a researchstudy on cold reduced low carbon steel IS 513GR 'D' welded together metal inert gas.Welding current, wire elongation and weldingvoltage was used as the welding parameters forthe observation. The signal to noise ratio,ANOVA and orthogonal array of L9 was usedto optimize the input parameters and Taguchimethods were employed on weld width andweld height.Utkarsh.S. et al.[7]demonstrated the effect onUTS(ultimate tensile strength) of st-37 lowalloy steel material. The parameters beingworked upon were current (A), voltage (V),gasflow rate and speed. Experiment was done byusing L9 orthogonal array to find out UTS.Confirmatory experiments were also performedto find out the optimal range sets of current,Voltage speed and gas flow rate.KalitaDiganta,Barua. Parimal B.[8]researched the effect of three processparameters on MIG Welding. Current, voltageand gas flow rate were the chosen parametersand their effect was studied on tensile strengthof welded joints on C20 carbon steel grade.Taguchi's L9 Orthogonal array method wasused for optimization of these parameters.From the results we could conclude thatvoltage affected both mean and variation oftensile strength whereas the current had asignificant effect on mean variation only.

3. EXPERIMENT DETAILS

Work metal, AISI 304 stainless steel was welded together using AISI 308L filler material in MIG welding apparatus due to its comparable properties with AISI 304. AISI 308L Spool is shown in figure 3.

Figure3. Welding spool

Experiments were carried out based on Taguchi's L9and ANOVA method. The three factor i.e. wire speed,gas flow rate and welding time wereselected for conducting experiment with three levelseach. Selected parameters and their levels areshown in table 3.

Table 3: Electrical Parameters and Their Levels to be used in MIG Welding

S.No.	Input Parameters	Levels		
		1	2	3
1.	Wire Speed (m/min)	6	8	10
2.	Gas Flow Rate(ltr/min)	8	12	16
3.	Welding Time (sec)	5	7	9

In the present work tensile strength was measured after conducting total 09 numbers of experiments. Total eighteen numbers of pieces of AISI 304 were cut down from raw material. These pieces were then welded in pair as per L9 orthogonal array suggested bytaguchi's design of experiment. Welded joints are shown in figure 4.

Figure4. Welded specimens for testing

Tensile strength of weld-joints was carried out on a universal testing machine. Tensile specimen used in this investigation is a standardized sample cross-section as shown in figure5.

Figure5. Specimens for Testing in UTM

Table 4: Results forUltimate tensile strength

Wire Speed	Gas Flow Rate	Welding Time	Tensile Strength	SNRA
6	8	5	429.60	53.1709
6	12	7	375.00	52.6613
6	16	9	456.48	51.4806
8	8	7	463.88	53.1884
8	12	9	430.55	53.3281
8	16	5	510.18	52.6805
10	8	9	495.37	54.1545
10	12	5	503.70	53.8986
10	16	7	429.60	54.0434

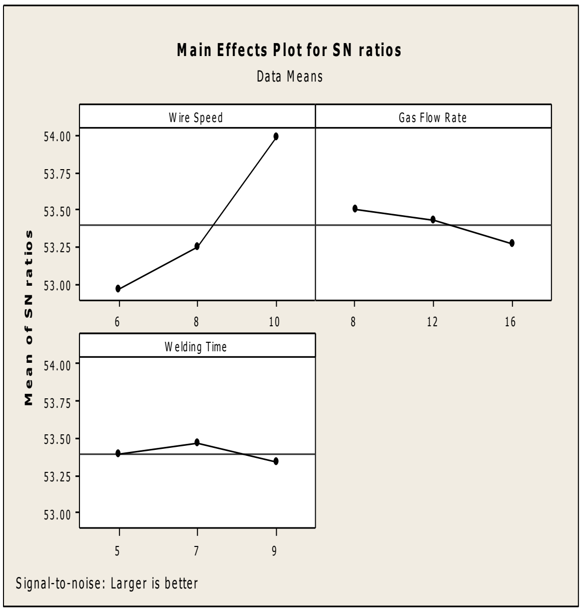

Figure6. Main Effect Plot Graph of S/N ratios of Hardness

Table 5: ANOVA for S/N ratio of Hardness

Source	SS	DOF	Adj MS	%Contribution
Wire Speed	5018.13	2	2509.07	91.04
Gas Flow Rate	217.5	2	108.76	3.95
Welding Time	64.80	2	32.40	1.18
Residual Error	211.17	2	105.58	3.83
Total	5511.62	8		100

Table 7: Ranking of parameters for Hardness

Level	Wire Speed	Gas Flow Rate	Welding Time
1	52.95	53.50	53.39
2	53.24	53.42	53.46
3	53.98	53.27	53.33
Delta	1.03	0.23	0.13
Rank	1	2	3

It could be noted that wire speed has the largesteffect on the strength of AISI 304 steel at weld beadin MIG welding. The welding speed has the smallest outcome onthe tensile strength. From above main effect plot, it may beobserved that optimum condition for hardness ofweldparts are, A3, B1 and C2i.e. wire speed (10 m/min), gas flow rate (8ltr/min) and welding time (7 sec).

The interaction plot, figure7 which is the combination of all three parameters interacting with each other at different levels gives the idea that wire speed, gas flow rate and welding time had their considerable effects on Weld bead hardness of AISI 304 stainless steel.

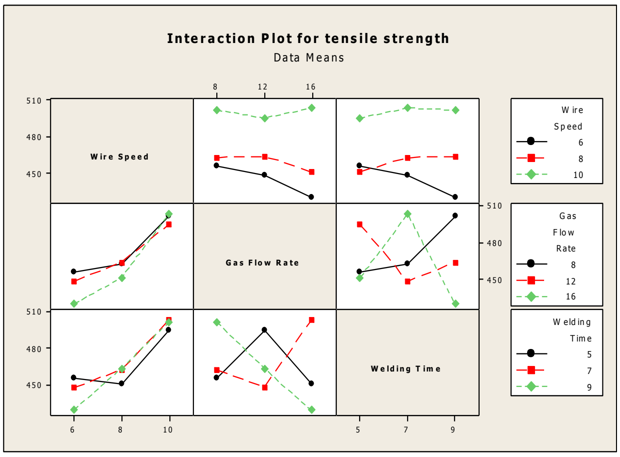

Figure7. Interaction plot between all the three input parameters and tensile strength

4. CONCLUSIONS

It can be concluded from experimental investigation that for optimum ultimate tensile strength at weld zone during metal inert gas welding of AISI 304 stainless steel wire speed and gas flow rate could have significant role to contribute.For AISI 304 steel optimum welding conditions for higher tensile strength were, welding speed (10m/min),gas flow rate (8ltr/min) andwelding time (7 sec).

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