OPTIMIZATION OF MIG WELDING PARAMETERS FOR IMPROVING STRENGTH OF WELDED JOINTS

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Abstract: The problem that has faced the manufacturer is the control of the process input parameters to obtain a good welded joint with the required weld quality. Traditionally, it has been necessary to study the weld input parameters for welded product to obtain a welded joint with the required quality. To do so, requires a time-consuming trial and error development method. Then welds are examined whether they meet the requirement or not. Finally the weld parameters can be chosen to produce a welded joint that closely meets the joint qualities. Also, what is not achieved or often considered is an optimized welding parameters combination, since welds can often be formed with very different parameters. In other words, there is often a more ideal welding input parameters combination, which can be used.

In this thesis, the influence of welding parameters like welding current, welding voltage, welding speed on ultimate tensile strength (UTS) of AISI 1050 mild steel material during welding. A plan of experiments based on Taguchi technique has been used. An Orthogonal array, signal to noise (S/N) ratio and analysis of variance (ANOVA) are employed to study the welding characteristics of material & optimize the welding parameters. The result computed is in form of contribution from each parameter, through which optimal parameters are identified for maximum tensile strength. From this study, it is observed that welding current and welding speed are major parameters which influence on the tensile strength of welded joint.

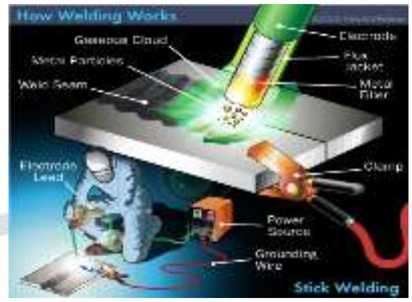
I. INTRODUCTION TO WELDING

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 pieces.

WELDING TOOLS OF THE TRADE

The most basic welding rigs, for occasional use in a home workshop, can be had for under $100. Typically, these rigs are set up for **shielded metal arc welding**(**SMAW**), or **stick welding**. Many units only have an on/off switch in the way of controls, making them simple to operate. **Torch welding rigs** are small and easy to work with, which is part of why they're commonly used.



Arc welding use-s an electrical arc to melt the work materials as well as filler material (sometimes called the welding rod) for welding joints. Arc welding involves attaching a grounding wire to the welding material or other metal surface. Another wire known as an electrode lead is placed on the material to be welded. Once that lead is pulled away from the material, an electric arc is generated. It's a little like the sparks you see when pulling jumper cables off a car battery. The arc then melts the work pieces along with the filler material that helps to join the pieces.

MIG WELDING

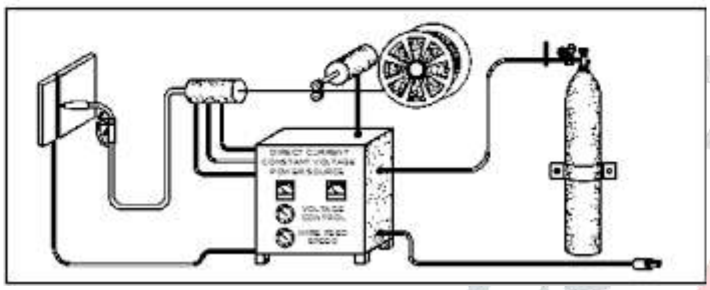
MIG (Metal Inert Gas) welding, also known as MAG (Metal Active Gas) and in the USA as GMAW (Gas Metal Arc Welding), is a welding process that is now widely used for welding a variety of materials, ferrous and non ferrous. The essential feature of the process is the small diameter electrode wire, which is fed continuously into the arc from a coil. As a result this process can produce quick and neat welds over a wide range of joints.

EQUIPMENT

- DC output power source
- Wire feed unit
- Torch
- Work return welding lead
- Shielding gas supply, (normally from cylinder)

POWER SOURCE

MIG welding is carried out on DC electrode (welding wire) positive polarity (DCEP). However DCEN is used (for higher burn off rate) with certain self shielding and gas shield cored wires. DC output power sources are of a transformer-rectifier design, with a flat characteristic (constant voltage power source). The most common type of power source used for this process is the switched primary transformer rectifier with constant voltage characteristics from both 3-phase 415V and 1- phase 240V input supplies. The output of direct current after full wave rectification from a 3-phase machine is very smooth. To obtain smooth output after full wave rectification with a 1- phase machine, a large capacitor bank across the output is required. Because of the expense of this, many low cost 1-phase machines omit this component and therefore provide a poorer weld characteristic. The switches to the main transformer primary winding provide the output voltage steps at the power source output terminals. Another method of producing different voltages at the power source output terminals is to use a Thruster or a Transistor rectifier instead of a simple diode rectifier. This system offers continuously variable output voltage, which can be particularly useful on robot installations and the cost of this type of rectifier can be partly offset with no need for primary voltage switch or switches and a single tapped main transformer primary winding. Most MIG power sources have a contactor or relay used to switch the output ON/OFF with operations of the trigger on the MIG torch. The switch off operation of this contactor is normally delayed to allow the welding wire to Burn back out of the molten weld pool. A thermostat is fitted on the hottest point in the power source, in series with the contactor coil to provide thermal protection to the machine. Power source performance is measured by it's ability to provide a certain current for a percentage of a 10 minute period before "Thermal Cutout". This is the "Duty Cycle".



M.I.G. ADVANTAGES

- Higher welding speeds
- Greater deposition rates
- Less post welding cleaning (e.g. no slag to chip off weld)
- Better weld pool visibility
- No stub end losses or wasted man hours caused by changing electrodes
- Low skill factor required to operate M.I.G / M.A.G.S welding torch
- Positional welding offers no problems when compared to other processes. (Use dip or pulsed mode of transfer)
- The process is easily automated
- No fluxes required in most cases
- Ultra low hydrogen process

M.I.G DISADVANTAGES

- Higher initial setup cost
- Atmosphere surrounding the welding process has to be stable (hence the shielding gasses), therefore this process is limited to draught free conditions
- Higher maintenance costs due to extra electronic components
- The setting of plant variables requires a high skill level
- Less efficient where high duty cycle requirements are necessary
- Radiation effects are more severe

II. LITERATURE REVIEW

Optimization of mig welding process parameters to predict maximum yield strength in aisi 1040

In this research work an attempt was made to develop a response surface model to predict tensile strength of inert gas metal arc welded AISI 1040 medium carbon steel joints. The process parameters such as welding voltage, current, wire speed and gas flow rate were studied. The experiments were conducted based on a four-factor, three-level, face centred composite design matrix. The empirical relationship can be used to predict the yield strength of inert gas metal arc welded AISI 1040 medium carbon steel. Response Surface Methodology (RSM) was applied to optimizing the MIG welding process parameters to attain the maximum yield strength of the joint.

II. METHODOLOGY

Objective of the work

In this thesis, materials AISI 1050 Mild Steel are welded by varying process parameters welding speed, welding current and welding voltage. Effect of process current on the tensile strength of weld joint will be analyzed.

III. EXPERIMENTAL PROCEDURE

In this thesis, experiments are made to understand the effect of MIG welding parameters welding speed, welding current and welding voltage on output parameters such as hardness of welding, tensile strength of welding.

MIG welding experimental images

MIG welding machine Work pieces (AISI 1050 STEEL)

Dumbbell shape work pieces for tensile test

Work pieces setup

Welding process

For the experiment, welding parameters selected are shown in table.

The welding current and electrodes considered are

PROCESS PARAMETERS	LEVEL 1	LEVEL 2	LEVEL 3
WELDING CURRENT (AMP)	180	230	280
WELDING SPEED (m. m/s)	200	300	400
WELDING VOLTAGE (V)	22	24	26

WELDING CURRENT (AMP)	WELDING SPEED (m. m/s)	WELDING VOLTAGE (V)
180	200	22
180	300	24
180	400	26
230	200	22
230	300	24
230	400	26
280	200	22
280	300	24
280	400	26

WELDING CURRENT (AMP)	WELDING SPEED (m. m/s)	WELDING VOLTAGE (V)	ULTIMATE TENSILE STRENGTH (MPa)
180	200	22	375
180	300	24	410
180	400	26	451.197
230	200	22	403
230	300	24	440.581
230	400	26	372
280	200	22	375.287
280	300	24	369
280	400	26	378

INTRODUCTION TO TAGUCHI TECHNIQUE

- Taguchi defines Quality Level of a product as the Total Loss incurred by society due to failure of a product to perform as desired when it deviates from the delivered target performance levels.
- This includes costs associated with poor performance, operating costs (which changes as a product ages) and any added expenses due to harmful side effects of the product in use.

PROCESS PARAMETERS	LEVEL1	LEVEL2	LEVEL3
WELDING CURRENT (AMP)	180	230	280
WELDING SPEED (m. m/s)	200	300	400
WELDING VOLTAGE (V)	22	24	26

Results

Using randomization technique, specimen was turned and cutting forces were measured with the three – dimensional dynamometer. The experimental data for the cutting forces have been reported in Tables. Feed and radial forces being 'lower the better' type of machining quality characteristics, the S/N ratio for this type of response was and is given below:

$$S/N\ ratio = -10\log\left[\frac{1}{n}(y_1^2 + y_2^2 + ... + y_n^2)\right] \quad ...(1)$$

Where $y_1, y_2, ..., y_n$ are the responses of the machining characteristics for each parameter at different levels.

TAGUCHI ORTHOGONAL ARRAY

WELDING CURRENT (AMP)	WELDING SPEED (m. m/s)	WELDING VOLTAGE (V)
180	200	22
180	300	24
180	400	26
230	200	22
230	300	24
230	400	26
280	200	22
280	300	24
280	400	26

OBSERVATION

The following are the observations made by running the experiments. The ultimate tensile strength observed.

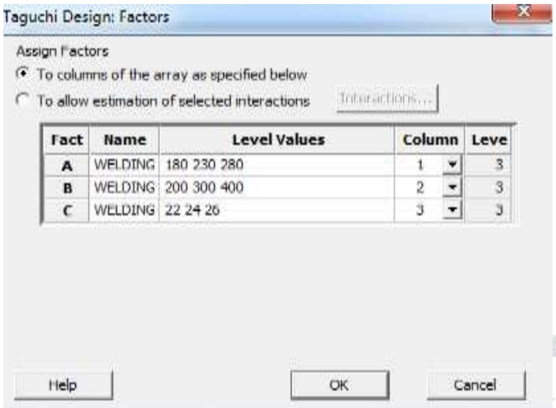
UTS (MPa)
375
410
451.917
403
440.581
372
375.287
369
378

OPTIMIZATION OF ULTIMATE TENSILE STRENGTH USING MINITAB SOFTWARE

Design of Orthogonal Array

First Taguchi Orthogonal Array is designed in Minitab17 to calculate S/N ratio and Means which steps is given below:

FACTORS



OPTIMIZATION OF PARAMETERS

Worksheet 1 ***

↓	C1	C2	C3
	WELDING CURRENT	WELDING SPEED	WELDING VOLTAGE
1	180	200	22
2	180	300	24
3	180	400	26
4	230	200	24
5	230	300	26
6	230	400	22
7	280	200	26
8	280	300	22
9	280	400	24

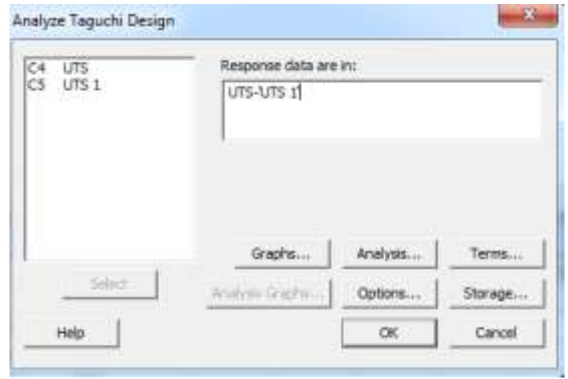
Worksheet 1 ***

↓	C1	C2	C3	C4
	WELDING CURRENT	WELDING SPEED	WELDING VOLTAGE	UTS
1	180	200	22	375.000
2	180	300	24	410.000
3	180	400	26	451.197
4	230	200	24	403.000
5	230	300	26	440.581
6	230	400	22	372.000
7	280	200	26	375.000
8	280	300	22	369.000
9	280	400	24	378.000

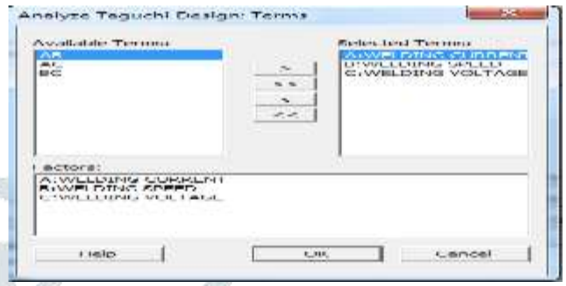
Worksheet 1 ***

↓	C1	C2	C3	C4	C5
	WELDING CURRENT	WELDING SPEED	WELDING VOLTAGE	UTS	UTS 1
1	180	200	22	375.000	376
2	180	300	24	410.000	409
3	180	400	26	451.197	450
4	230	200	24	403.000	404
5	230	300	26	440.581	441
6	230	400	22	372.000	371
7	280	200	26	375.000	374
8	280	300	22	369.000	368
9	280	400	24	378.000	379

Analyze Taguchi Design – Select Responses

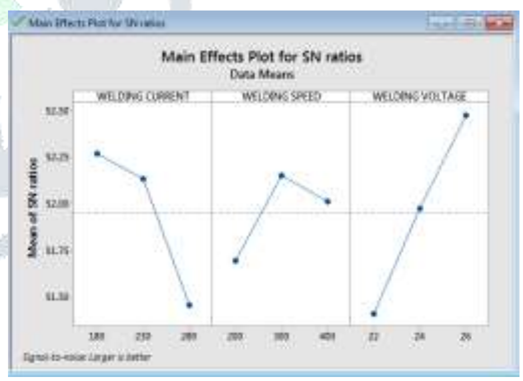


Terms

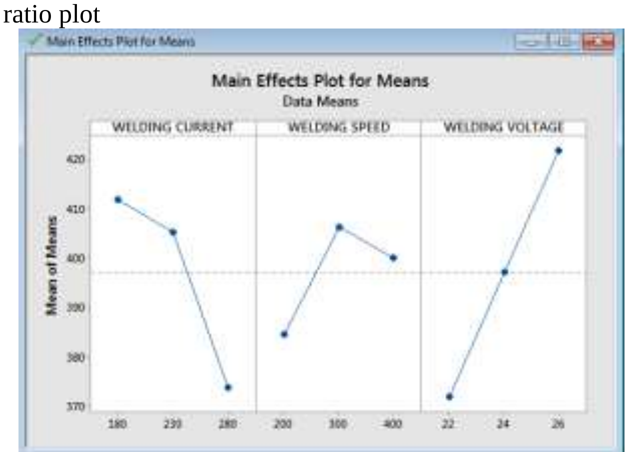


Worksheet 1 ***

↓	C1	C2	C3	C4	C5	C6	C7
	WELDING CURRENT	WELDING SPEED	WELDING VOLTAGE	UTS	UTS 1	SNRA1	MEAN1
1	180	200	22	375.000	376	51.4922	375.500
2	180	300	24	410.000	409	52.2451	409.500
3	180	400	26	451.197	450	53.0758	450.599
4	230	200	24	403.000	404	52.1169	403.500
5	230	300	26	440.581	441	52.8846	440.791
6	230	400	22	372.000	371	51.3992	371.500
7	280	200	26	375.000	374	51.4690	374.500
8	280	300	22	369.000	368	51.3287	368.500
9	280	400	24	378.000	379	51.5613	378.500



S/N ratio plot



Means plot

RESULTS

Taguchi method stresses the importance of studying the response variation using the signal–to–noise (S/N) ratio, resulting in minimization of quality characteristic variation due to uncontrollable parameter. The cutting force is considered as the quality characteristic with the concept of "the larger-the-better". The S/N ratio for the larger-the-better is:

$S/N = -10 * \log(\Sigma(Y^2)/n))$

Where n is the number of measurements in a trial/row, in this case, n=1 and y is the measured value in a run/row. The S/N ratio values are calculated by taking into consideration above Eqn. with the help of software Minitab 17.

The force values measured from the experiments and their corresponding S/N ratio values are listed in Table

Worksheet 1 ***

↓	C1	C2	C3	C4	C5	C6	C7
	WELDING CURRENT	WELDING SPEED	WELDING VOLTAGE	UTS	UTS 1	SNRA1	MEAN1
1	180	200	22	375.000	376	51.4922	375.500
2	180	300	24	410.000	409	52.2451	409.500
3	180	400	26	451.197	450	53.0758	450.599
4	230	200	24	403.000	404	52.1169	403.500
5	230	300	26	440.581	441	52.8846	440.791
6	230	400	22	372.000	371	51.3992	371.500
7	280	200	26	375.000	374	51.4690	374.500
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9	280	400	24	378.000	379	51.5613	378.500

CONCLUSION

The experiment designed by Taguchi method fulfills the desired objective. Fuzzy interference system has been used to find out the ultimate tensile strength .The all possible values of have been calculated by using MINITAB 17.0 software. Analysis of variance (ANOVA) helps to find out the significance level of the each parameter. The optimum value was predicted using MINITAB-17 software.

The welding parameters are Welding current, welding voltage and welding speed for MIG welding of work piece AISI1050 steel. In this work, the optimal parameters of welding speed are 200m.m/s, 300 m.m/s & 400 m.m/s, Welding current are 180, 230 &280 amps, and welding voltage are 22, 24 &26 volts. Experimental work is conducted by considering the above parameters. Ultimate tensile strength validated experimentally.

The experimental results confirmed the validity of the used Taguchi method for enhancing the welding performance and optimizing the welding parameters in MIG welding at welding speed 400 m.m/s ,welding voltage 26 volts and welding current 180 amps

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