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STRENGTH ANALYSIS OF WELDING ELECTRODES ON MILD STEEL WELDING UNDER VARING CONDITION OF ARC WELDING PROCESS PARAMETER

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ARTICLE INFO **ABSTRACT** **ORIGINAL RESEARCH ARTICLE**

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Electric Arc welding is a welding process that is used to join metal to metal by using electricity to create enough heat to melt metal, and the melted metals when cool result in a binding of the metals. In these used mild steel grade 1018 as a base material of cross section length, width & thickness as 5cmx5cmx5mm and welded with different filler materials E018, E6013, E9015, E8016, E308L to predict its strength and get comparisons of strength of the welded joint keeping welding current, voltage, heat input rate, welding speed and working temperature constant and left for air, water and sand cooling in normal room temperature. When the base material is welded, it is tested for its mechanical properties such as tensile strength test. This present experiment responses shows comparison of various mechanical properties when welded with different weld filler material to get the optimum result for the strength of the joint as today high quality with correct price is preferable for these TAGUCHI method is used to optimize the values of welding parameters.

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1. INTRODUCTION

Electric Arc welding is the fusion of two pieces of metal by an electric arc between the pieces being joined – the work pieces – and an electrode that is guided along the joint between the pieces. The electrode is either a rod that simply carries current between the tip and the work, or a rod or wire that melts and supplies filler metal to the joint.

The basic arc welding circuit is an alternating current (AC) or direct current (DC) power source connected by a "work" cable to the work piece and by a "hot" cable to an electrode. When the electrode is positioned close to the work piece, an arc is created across the gap between the metal and the hot cable electrode. An ionized column of gas develops to complete the circuit.

The arc produces a temperature of about 3600°C at the tip and melts part of the metal being welded and part of the electrode. This produces a pool of molten metal that cools and solidifies behind the electrode as it is moved along the joint.

There are two types of electrodes. Consumable electrode tips melt, and molten metal droplets detach and mix into the weld pool. Non-consumable electrodes do not melt. Instead, filler metal is melted into the joint from a separate rod or wire.

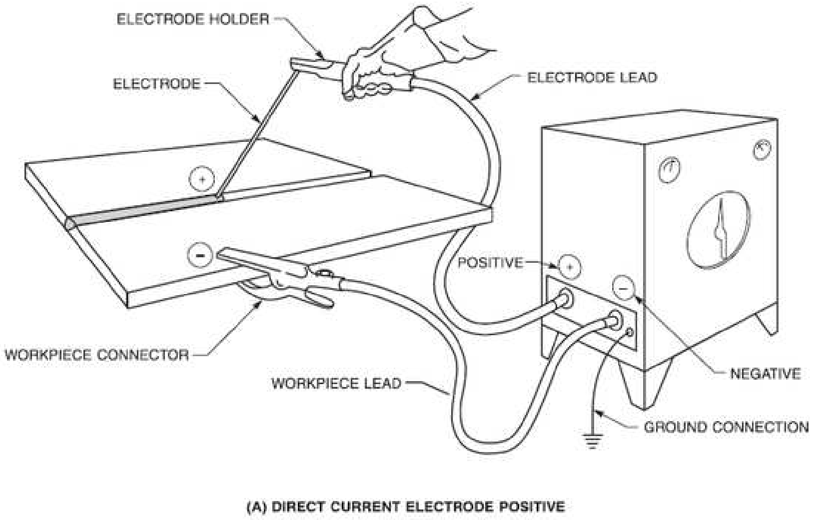

Fig 1: Schematic Drawing of electric arc welding

CONSUMABLE ELECTRODE

Consumable electrodes are those which melt away or consumed during the welding process. These electrodes are of low melting point materials. When electrode and work-piece is struck the arc starts to melt the end of the electrode. The molten electrode is transferred to the work-piece in the form of metal droplets. These are made up of different materials depending upon the need and the chemical composition of metals to be joined. Most commonly used core material is mild steel, low alloy steel and nickel steel. A consumable electrode can aid in the process of better elimination of impurities.

2. LITERATURE REVIEW

Ajay & Gattani, 2013, reviewed on the heat flow rate in welding and controlling the heat input from welding source and subsequent flow into body of work piece by conduction. A limited amount of heat loss is by a way of convection and radiation. Chander et. al. 2013, compared the results of an investigation on a dissimilar weld joint comprising Stainless Steel (SS304) and Mild Steel (MS1144). Welds produced by shielded metal arc-welding with two different electrodes were examined for their tensile strength, hardness& microstructure features. Daniel 2016, reviewed on copper and mild steel using a gas tungsten arc welding (GTAW) process. To determine the weldablity factor,tests are needed to provide information on mechanical strength, potential defects in structure, and nature of failure. Mechanical testing included transverse tensile tests, micro hardness tests, and bend tests. The resultsfor the transverse tensile test revealed failure occurred at the copper heat affected zone (HAZ) with an ultimate tensile strength of 220MPa. The weld metal produced the highest average hardness value of 173HV. Devakumar & Jabaraj, 2014, reviewed on Gas Tungsten Arc welding (GTAW) in these an arc between a non consumable tungsten electrode and the work to be welded. TIG is used very commonly in areas, such as rail car manufacturing, automotive and chemical industries. Stainless steel is extensively used in industries as an important material, because of its excellent corrosion resistance. TIG welding is one of the welding processes, often used to weld similar and dissimilar stainless steel joints. In this paper, an attempt is made to review and consolidate the important research works done on GTAW of stainless steel in the past, by various researchers. Patil & waghmare, 2013, researched on the influence of welding parameters like welding current, welding voltage, welding speed on ultimate tensile strength (UTS) of AISI 1030 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.

3. OBJECTIVE OF WORK

The main objective of present work is to predict weld strength of the various filler material i;e impact test of electric arc welded 1018 grade mild steel. The butt welded samples in particular were included for comparison purposes with the self reacting samples. With this information it should be able to provide input parameter to help reduce the likelihood of failures caused by this phenomenon and predict strong weld in terms of strength and toughness.

Electric Arc Welding Tool

An electrode is an electric conductor used to make contact with a non metallic part of a circuit. The word was coined by William Whewell at the request of the scientist Michael Faraday from two Greek words: elektron, meaning amber and hodos , meaning a way.

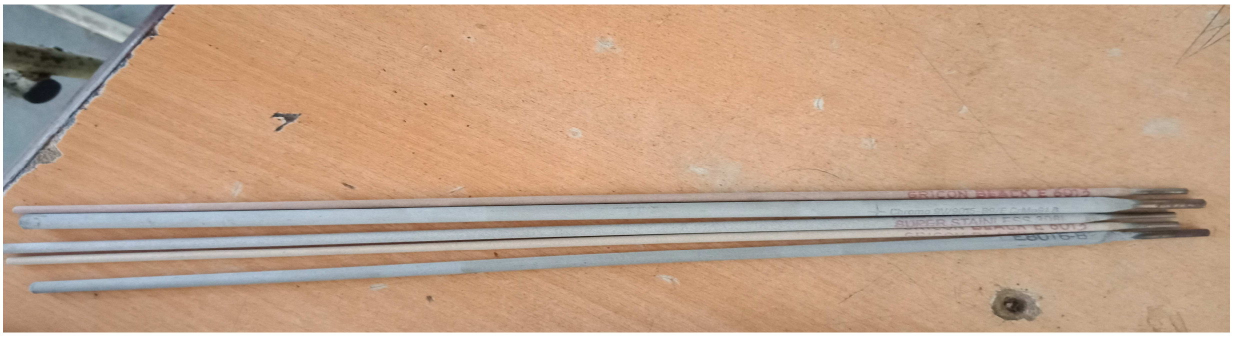

Fig 2: specimen of working electrode (cec bsp)

Chemical Composition

The following table shows the chemical compositions:

Table 1: chemical compositions of electrode E6013

ELEMENTS	CONTENTS (%)
Carbon	.08
Manganese	.45
Silicon	.18
Phosphorus	.012
Sulfur	.009

Table 2: chemical compositions of electrode E8016

ELEMENTS	CONTENTS (%)
Carbon	.08
Manganese	.09
Silicon	.09
Phosphorus	.03
Sulfur	.03
Nickel	.40
Chromium	5
Molybdenum	.5

Table 3: chemical compositions of electrode E018

ELEMENTS	CONTENTS (%)
Carbon	.08
Manganese	1.2
Silicon	.60
Phosphorus	.05
Sulfur	.08

Table 4: chemical compositions of electrode E308L

ELEMENTS	CONTENTS (%)
Carbon	.04
Manganese	2.1
Silicon	.90
Phosphorus	.04
Sulfur	.03
Nickel	10
Chromium	20
Molybdenum	.75

Table 5: chemical compositions of electrode E9015

ELEMENTS	CONTENTS (%)
Carbon	.1
Manganese	.69
Silicon	.3
Phosphorus	.01
Sulfur	.009
Nickel	.75
Chromium	9.3
Molybdenum	.98

Table 6: chemical compositions of mild steel grade1018

ELEMENTS	CONTENTS (%)
Carbon	0.17%
Silicon	0.27%

Manganese	0.80%
Phosphorus	0.050% max
Sulphur	0.050% max

4. DESIGN OF EXPERIMENT

The design of experiment by means of Taguchi method is selected to identify the best set of parameters among the effective factors by cutting down a number of experiments. The major steps to complete an effective designed experiment are:

1. Factor selection
2. Selection of orthogonal array and factor levels
3. Conduct tests described by trials in orthogonal arrays
4. Analyze and interpret results of the experimental trials.

Factor selection

In electric arc welding there are a number of possible factors that produce significant effects on strength which are voltage, working temperature, current, cooling medium, holding time welding speed, depth of weld etc. In this experiment, the factors taken are voltage, cooling medium and cooling time.

Selection of orthogonal array and factor levels

In an L9 (3^2) orthogonal array three levels of each factor are conducted where the selection of the array is because of its suitability for two factors with three Levels. The L9 (3^2) orthogonal array is shown in Table7.

Table 7: control factors and levels for factors

Factors	Levels		
	1	2	3
Voltage(v)	70	100	150
Cooling and holding medium(min)	20(AIR)	15(WATER)	25(SAND)

Conduct tests described by trials in orthogonal arrays

The tests are conducted on charpy machine according to the sets of control factors (processing parameters) obtained from trials of orthogonal array. The control factors and levels of control factors according to orthogonal array are shown in Table.

Table 8: Response of electrode E018

Voltage(v)	Cooling time(min)	Response(j)
70	20	14
70	15	22
70	25	30
100	20	42
100	15	28
100	25	24
150	20	32
150	15	24
150	25	26

Table 9: Response of electrode E6013

Voltage(v)	Cooling time(min)	Response(j)
70	20	22
70	15	80
70	25	42
100	20	82
100	15	22
100	25	26
150	20	72
150	15	24
150	25	26

Table 10: Response of electrode E9015

Voltage(v)	Cooling time(min)	Response(j)
70	20	42
70	15	72
70	25	38
100	20	60
100	15	22
100	25	28
150	20	28
150	15	24
150	25	26

Table 11: Response of electrode E8016

Voltage(v)	Cooling time(min)	Response(j)
70	20	22
70	15	80
70	25	42
100	20	82
100	15	22
100	25	26
150	20	72
150	15	24
150	25	26

Table 12: Response of electrode E308L

Voltage(v)	Cooling time(min)	Response(j)
70	20	72
70	15	20
70	25	42
100	20	42
100	15	80
100	25	48
150	20	22

150	15	28
150	25	32

Analyze and interpret results of the experimental trial

Table 13: S/N ratio of electrode E9015

TRIAL	VOLTAGE	COOLING TIME	RESPONSE	SNRA1
1	70	20	42	32.4650
2	70	15	72	37.1466
3	70	25	38	31.5957
4	100	20	60	35.5630
5	100	15	22	26.8485
6	100	25	28	28.9432
7	150	20	28	28.9432
8	150	15	24	27.6042
9	150	25	26	28.2995

By using minitab18 software the main effects plot for S/N ratios is obtained and shows in fig 3

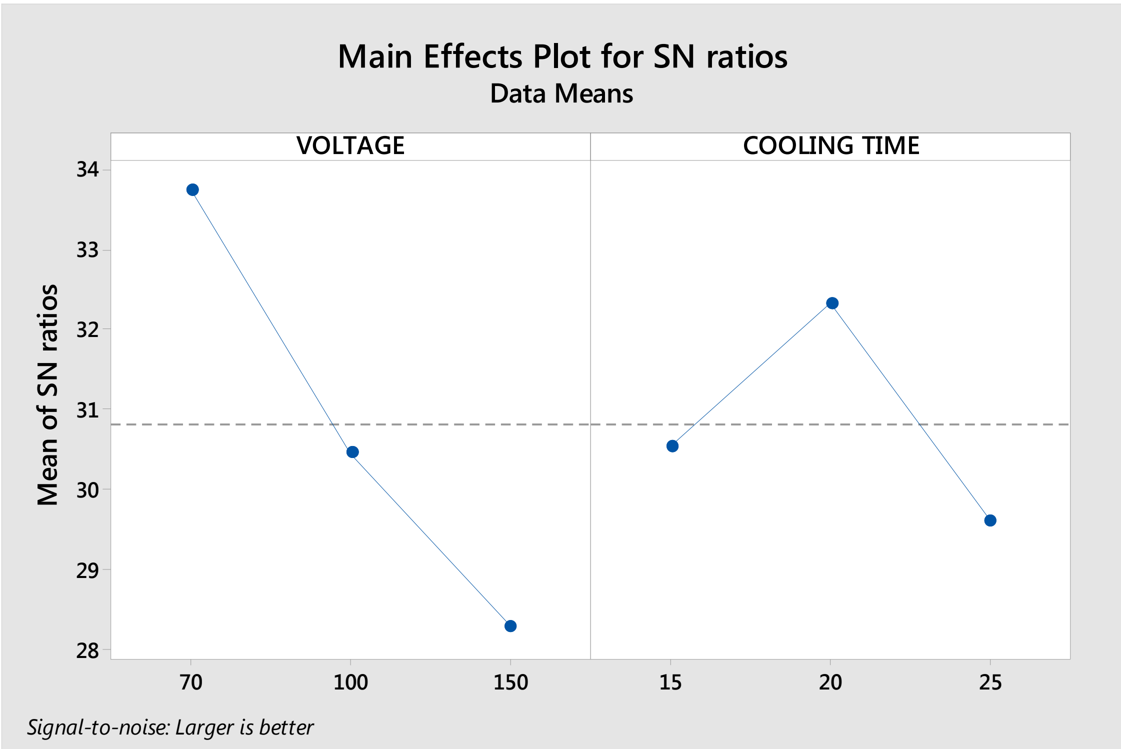

Fig 3: main effects plot for S/N ratios for electrode E9015

Table 14: S/N ratio of electrode E018

TRAIL	A	B	RESPONSE	SNRA1
1	70	20	14	22.9226
2	70	15	22	26.8485
3	70	25	30	29.5424
4	100	20	42	32.4650
5	100	15	28	28.9432
6	100	25	24	27.6042
7	150	20	32	30.1030
8	150	15	24	27.6042
9	150	25	26	28.2995

By using minitab18 software the main effects plot for S/N ratios is obtained and shows in fig 4

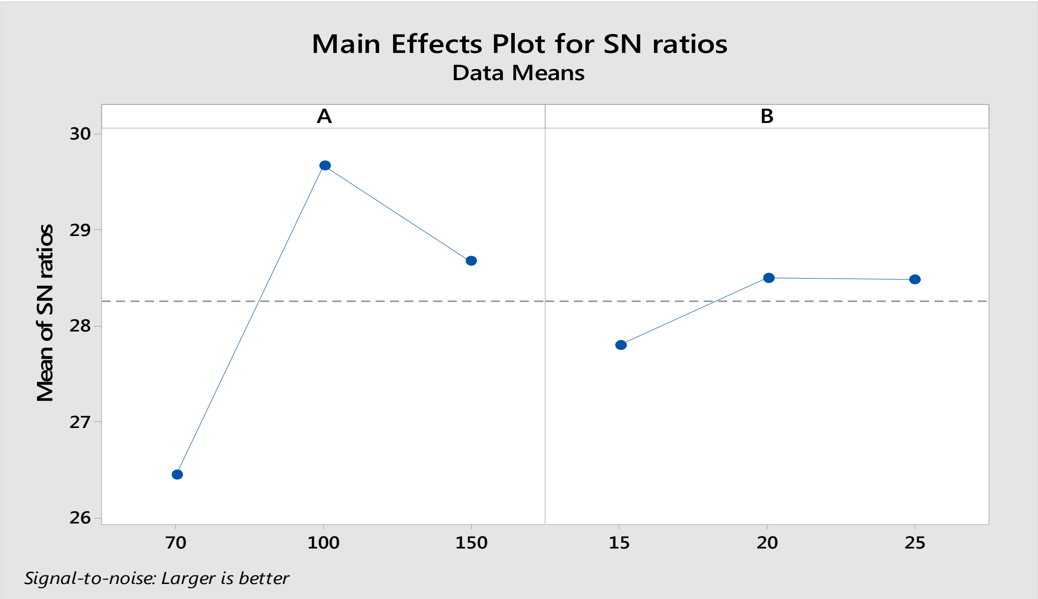

Fig 4: main effects plot for S/N ratios for electrode E018

Table 15: S/N ratio of electrode E6013

TRIAL	VOLTAGE	COOLING TIME	RESPONSE	SNRA1
1	70	20	22	26.8485
2	70	15	80	38.0618
3	70	25	42	32.4650
4	100	20	82	38.2763
5	100	15	22	26.8485
6	100	25	26	28.2995
7	150	20	72	37.1466
8	150	15	24	27.6042
9	150	25	26	28.2995

By using minitab18 software the main effects plot for S/N ratios is obtained and shows in fig 5

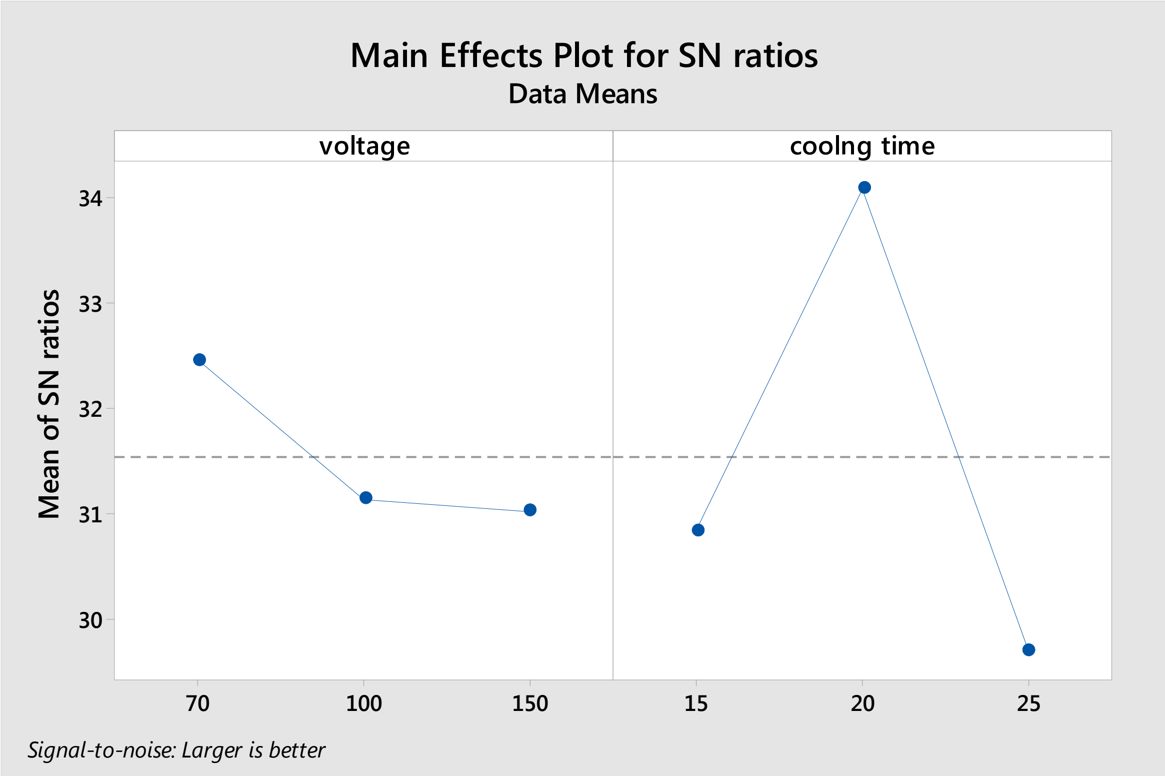

Fig 5: main effects plot for S/N ratios for electrode E6013

Table 16: S/N ratio of electrode E308L

TRIAL	VOLTAGE	COOLING TIME	RESPONSE	SNRA1
1	70	20	72	37.1466
2	70	15	20	26.0206
3	70	25	42	32.4650
4	100	20	42	32.4650
5	100	15	80	38.0618
6	100	25	48	33.6248
7	150	20	22	26.8485
8	150	15	28	28.9432
9	150	25	32	30.1030

By using minitab18 software the main effects plot for S/N ratios is obtained and shows in fig 6

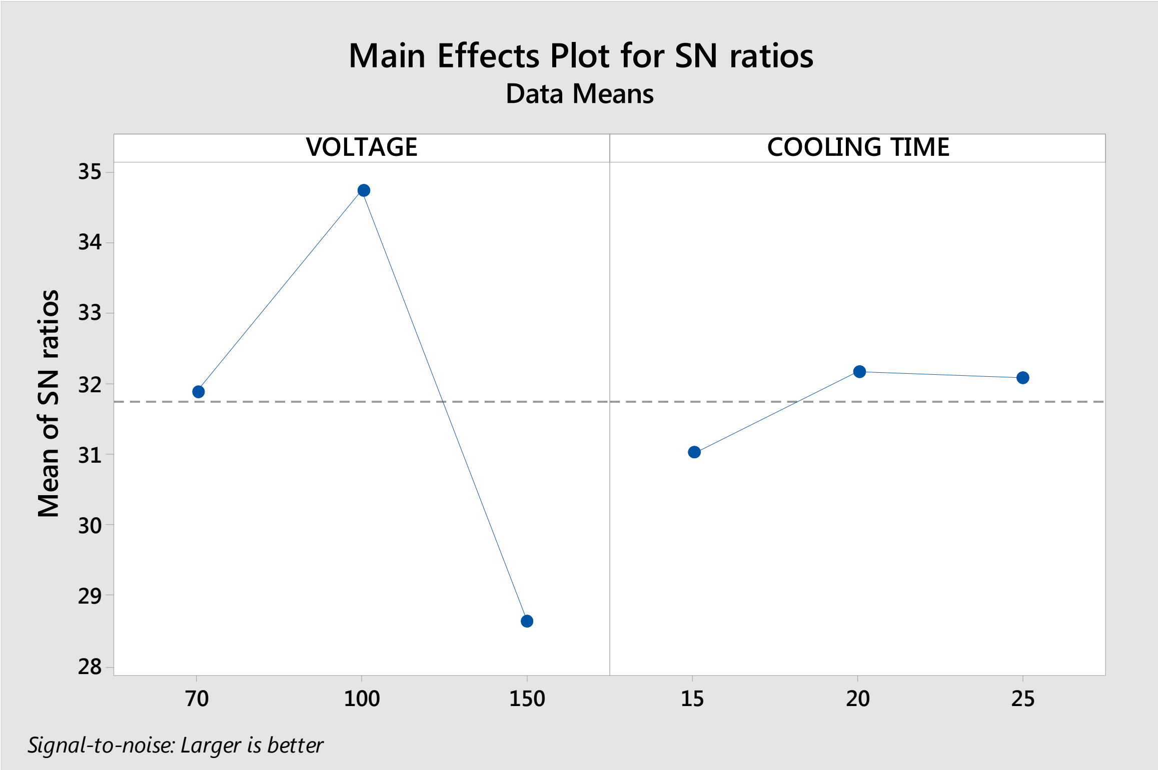

Fig 6: main effects plot for S/N ratios for electrode E308L

Table 17: S/N ratio of electrode E8016

TRIAL	VOLTAGE	COOLING TIME	RESPONSE	SNRA1
1	70	20	32	30.1030
2	70	15	40	32.0412
3	70	25	36	31.1261
4	100	20	16	24.0824
5	100	15	22	26.8485
6	100	25	24	27.6042
7	150	20	14	22.9226
8	150	15	18	25.1055
9	150	25	20	26.0206

By using minitab18 software the main effects plot for S/N ratios is obtained and shows in fig 6

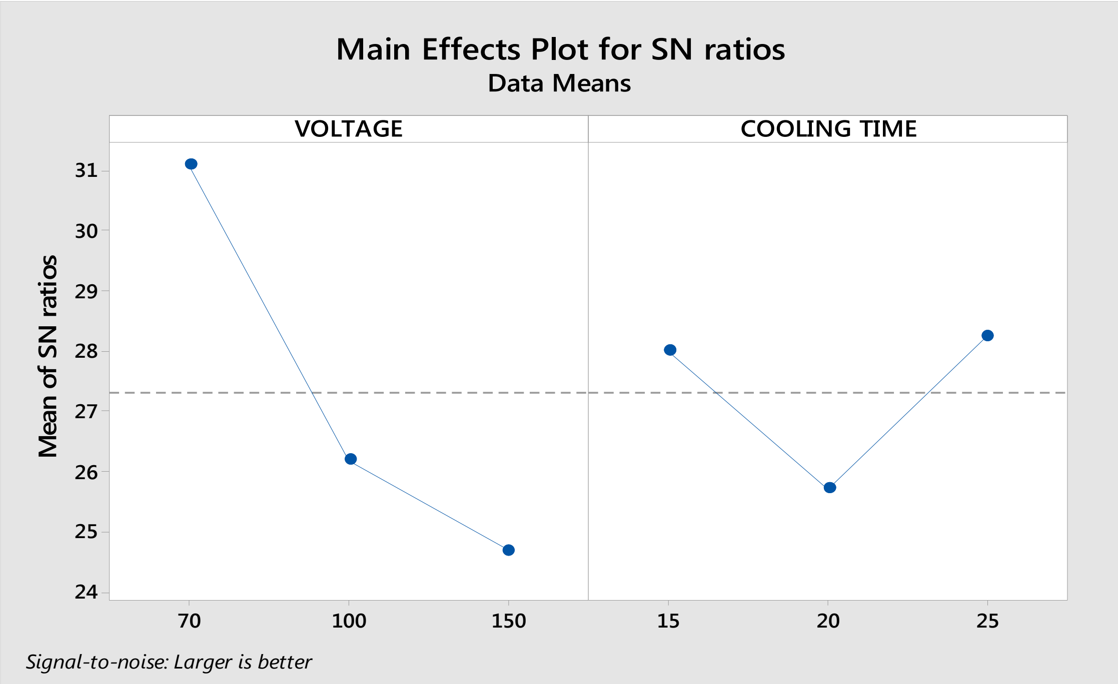

Fig 6: main effects plot for S/N ratios for electrode E8016

COMPARISION OF ALL GRAPHS

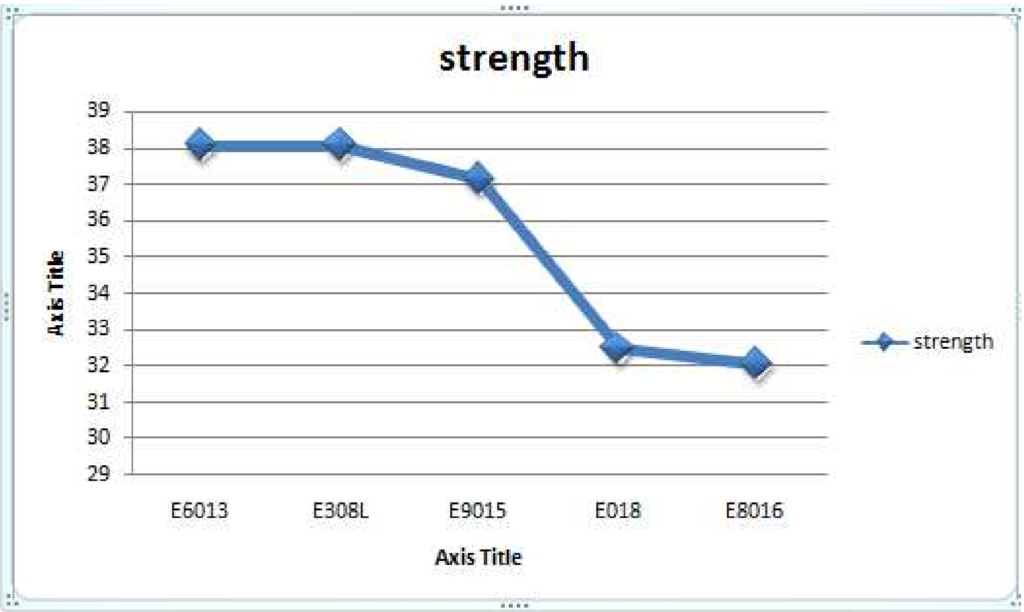

Fig 7: shows the best optimum strength comparison of S/N ratios of electrodes

5. CONCLUSION

In these case the best combination of parameters i.e., voltage and cooling medium with keeping the current constant and found that at 70v and water as a cooling medium for 15 min. and the outcome resulted as 38.0618J for E6013 and at 70v and water as a cooling medium for 15 min. and the outcome resulted as 32.0412J for E8016 .The weld strength is higher as it poses high resistance, so we prefer the higher resistance electrode.

More investigation can be done with different variable; its values at different conditions, and materials. More experimental work has to be done to match the weld quality so that it can act as a original material. Investigate the effect of cooling rate on the process as well as on the resulting weld strength. The combined and main effects of different parameters have been considered in future for finding the more accuracy in welding parameters.

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