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STRUCTURAL INTEGRITY AND OPTIMIZATION OF WELDED STRUCTURE

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ABSTRACT

Almost all operation in any industry requires welding. It is indispensable to enhance the various parameters of welding process so that good quality of structure will be obtain which will be reliable and have good strengthening properties. The welding process parameters such as electrodes, inert gas, current, voltage etc. are being focused by industries. In this research paper we have find the optimum current for electrodes mostly use in industries as the industries now a days are preferring for high quality product in lower cost. ARC Welding is old and commonly used for joining the two metal. The study is carried out to investigate the influence of welding speed, groove angle, Current and Voltage on strength of mechanical properties such as tensile test, impact test. Mechanical testing are carried out to find out the mechanical properties of butt weld joint.

Keywords: Arc welding, Butt weld, Current, Electrodes.

INTRODUCTION

Arc welding process that is being widely used in industry for sheet joining purposes. There are many applications of welding made of carbon steel such as Fencing or Railing done in Ghats, bridge structure, shipbuilding, pressure vessels etc. are subjected to various stresses such as tensile, compressive and thermal stresses etc. Structural integrity of large engineering structures presents a unique challenge in the production of safe and cost-effective means of analysis, inspection and rehabilitation.

1.1. Objectives of This Research

Determination of structural strength of welded structures, obtain the good quality welding and to obtain results by FEA method also to reduce the residual stresses and fatigue.

FINITE ELEMENT ANALYSIS

2.1. Thermal - Mechanical Analysis (Thermomechanical)

In mechanical analysis, the basic equations are the equilibrium equations, constitutive stress–strain relations and geometric compatibility equations. The change in the temperature distribution contributes to the deformation of the body through thermal strains and influences the material properties.

2.2. Calculation for Temperature:

For the Finite Element Analysis, the temperature is being required so the temperature is calculated theoretically by using the formula of heat input.

$$Q = mc_p \Delta T \qquad \text{........ (a)}$$

Where, Q = heat input; m = mass; C_P = specific heat; ΔT= Temperature

$$Q = I \vee T \qquad \text{......... (b)}$$

$$I \vee T = mc_P \Delta T \qquad \text{......... From (a) \& (b)}$$

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$$\Delta T = \frac{Q}{mCp} \quad \text{……….. (c)}$$

Hence, by using above formula eq. (c) the temperature for each plate is calculated and temperature for each plate is as follows.

- **Temp for E6013 Specimen.**

Sr. No	Current	Voltage	Time	Temperature
1	100	20	33	527
2	105	20	33	554
3	110	20	33	580
4	115	20	33	605
5	120	20	33	632
6	125	20	33	659

Table. No. 1: Temp. for E6013 Specimen

- **Temp for E7016 Specimen.**

Sr. No	Current	Voltage	Time	Temperature
1	115	20	30	552
2	120	20	30	576
3	125	20	30	602
4	130	20	30	624
5	135	20	30	645
6	140	20	30	670

Table. No. 2: Temp. for E7016 Specimen

- **Temp for E7018 Specimen.**

Sr. No	Current	Voltage	Time	Temperature
1	150	20	30	720
2	155	20	30	742
3	160	20	30	770
4	165	20	30	794
5	170	20	30	818
6	175	20	30	842

Table. No. 3: Temp for E7018 Specimen.

2.3. Simulation Results for Electrode E6013:

Sr. No.	**Plate Coding**	**Min. Shear Stress**	**Min. Equivalent Stress**	**Remark**
1	A100	78.15	149.94	_
2	A105	95.56	174.64	_
3	A110	103.12	183.01	Optimized

4	A115	96.60	170.08	_
5	A120	89.59	156.05	_
6	A125	82.60	143.43	_

Table. No. 4: Simulation Results for E6013

2.4. Simulation Results for Electrode E7016

Sr. No.	**Plate Coding**	**Min. Shear Stress**	**Min. Equivalent Stress**	**Remark**
1	B115	94.27	172.73	_
2	B120	104.16	185.11	Optimized
3	B125	97.38	171.62	_
4	B130	91.66	160.48	_
5	B135	86.22	150.14	_
6	B140	79.76	138.29	_

Table. No. 5: Simulation Results for E7016

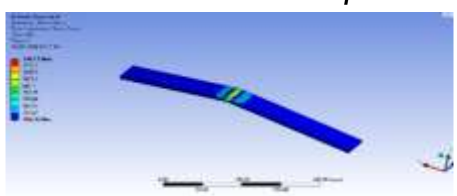

Fig. no. 3- Shear stress of B120

2.5. Simulation Results for Electrode E7018

Sr. No.	**Plate Coding**	**Min. Shear Stress**	**Min. Equivalent Stress**	**Remark**
1	C150	66.95	116.67	Optimized
2	C155	61.37	108.38	_
3	C160	54.36	99.32	_
4	C165	48.44	93.24	_
5	C170	45.52	89.05	_
6	C175	46.56	86.99	_

Table. No.6: Simulation Results for E7018

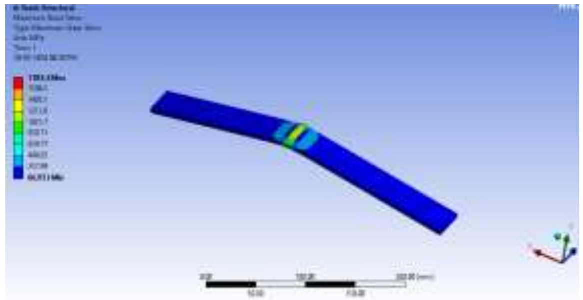

Fig. no. 4- Shear stress of C150

EXPERIMENTAL VALIDATION

The Experimental result are for a Single-V butt weld joint of the dimensions (300 x 40 x 5 mm). The mechanical properties of the weld material and base material are shown in table above.

Table 1. Chemical composition of base material

Element	Carbon, C	Copper, Cu	Iron, Fe	Manganese, Mn	Phosphorous, P	Silicon, Si	Sulphur, S
Weight Max. %	0.25-0.290	0.20	98.0	1.03	0.040	0.280	0.050

Fig no.5 - Actual specimen

EXPERIMENTATION

As we know welding parameter affects the strength of welding we have find the best suitable current for each electrode so we tested on 3 electrodes. There are 18 numbers of specimens were prepared from arc welding process. The first 6 specimens of E6013 electrode at six different values of welding current (specimen code A100 at 100 amps., A105 at 105 amps., A110 at 110 amps., A115 at 1115 amps., A120 at 120 amps., A125 at 125 amps) similarly another 6 of E7016 electrode (specimen code B115, B120, B125, B130, B135, B140) and remaining 6 of E7018 electrode (specimen code C150, C155, C160, C165, C170, C175) were prepared.

4.1. Electrode – 6013 (E-6013)

6013 is a high titanic coated electrode. Its Working Current Range is 100 Amp – 140 Amp.

Chemical Composition of E-6013

Element	C	Mn	Si	P	S
Weight Max. %	0.08 0.05-0.10	0.45 0.3-0.60	0.25 0.30 max	0.03 max	0.03 max

Results for E-6013 conducted on UTM

Sr. No.	Specimen code	Breaking Load (KN)	Remark
1	A100	68.5	Breaks at weld
2	A105	72	Breaks at weld
3	A110	78	Breaks at weld
4	A115	75.5	Breaks at weld
5	A120	73	Breaks at weld
6	A125	71	Breaks at weld

4.2. Electrode – 7016 (E-7016)

7016 is a basic coated low hydrogen electrode suitable for welding heavy structures, high tensile strength jobs where impact strength at sub-zero temperatures are required Working Current Range is 110 Amp - 150 Amp.

Chemical Composition of E-7016

Element	C	Mn	Si	P	S
Weight Max. %	0.09 max	1.10 0.8 - 1.5	0.54 0.25-0.65	0.03 max	0.03 max

Results for E-7016

Sr. No.	Specimen code	Breaking Load (KN)	Remark
1	B115	82	Breaks at weld
2	B120	93	Breaks at weld
3	B125	77.5	Breaks at weld
4	B130	76	Breaks at weld
5	B135	72	Breaks at weld
6	B140	68	Breaks at weld

4.3. Electrode – 7018 (E-7018)

E7018 stick electrodes are a good choice for structural steel applications due to their smooth, stable and quiet arc, and their low spatter levels. Its **Working Current Range is between 140** Amp – 180 Amp

Chemical Composition of E-7018

Element	C	Mn	Si	P	S
Weight Max. %	0.10 max	0.90 – 1.40	0.75 max	0.03 max	0.03 max

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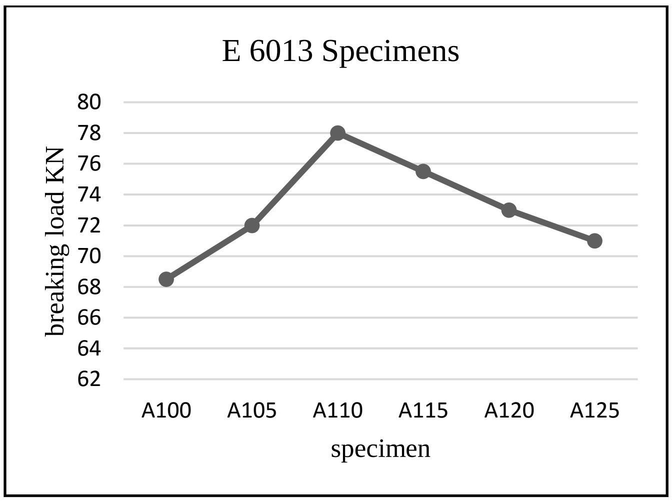
Results for E-7018

Sr. No.	Specimen code	Breaking Load (KN)	Remark
1	C150	78	Breaks at weld
2	C155	76.5	Breaks at weld
3	C160	70	Breaks at weld
4	C165	68.5	Breaks at weld
5	C170	65	Breaks at weld
6	C175	66.5	Breaks at weld

RESULTS

5.1. FOR SPECIMEN of E6013

SPECIMEN	A100	A105	A110	A115	A120	A125
FEA (shear stress)	78.15	95.56	103.12	96.60	89.59	82.60
EXPERIMENTAL (KN)	68.5	72	78	75.5	73	71



Hence, from the graph and the result table we can conclude that the specimen with current of 110 Amp i.e. A110 has the highest load bearing capacity

5.2. FOR SPECIMEN of E7016

SPECIMEN	B115	B120	B125	B130	B135	B140
FEA (shear stress)	94.27	104.16	97.38	91.66	86.22	79.76
EXPERIMENTAL (KN)	82	93	77.5	76	72	68

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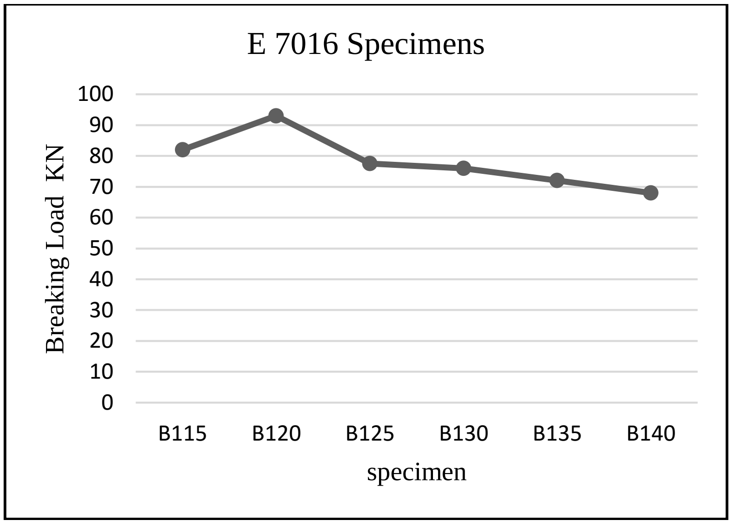
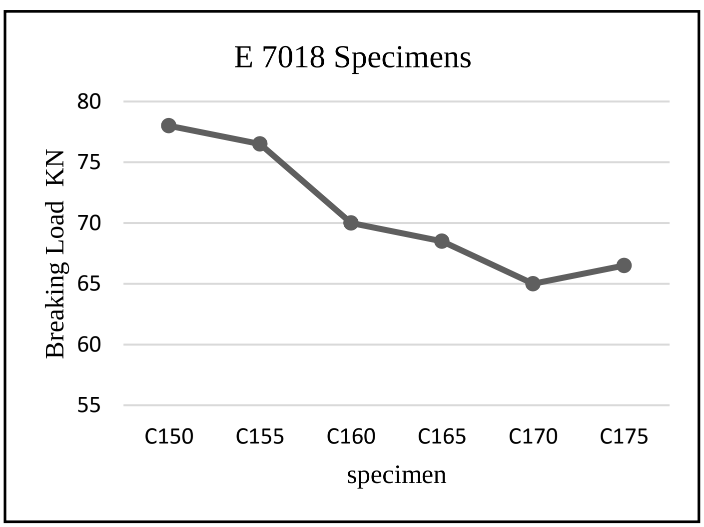


Hence, from the graph and the result table we can conclude that the specimen with current of 120 Amp i.e. B120 has the highest load bearing capacity

5.3. FOR SPECIMEN of E7018

SPECIMEN	C150	C155	C160	C165	C170	C175
FEA (shear stress)	66.95	61.37	54.36	48.44	45.52	48.44
EXPERIMENTAL (KN)	78	76.5	70	68.5	65	66.5



Hence, from the graph and the result table we can conclude that the specimen with current of 150 Amp i.e. C150 has the highest load bearing capacity

CONCLUSION

- Optimized result are been obtained for the three different type of electrode i.e. E6013, E7016, E7018. And for each electrode a fixed value of current is been obtained on which high strength generated.
- 3D FE model has been developed to simulate the arc welding process to find the optimized specimen for a specific current by using FEA software and validated the results by experimental procedure.
- The specimens whose results were obtained by Finite Element Analysis were same as that of the results obtained by experimental procedure.
- Hence by using proper parameters we can achieve good quality of welding with a high strength. And rather than doing actual experiment we can get the results by FEA software.

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