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TENSILE STRENGTH ANALYSIS OF LAP WELDED JOINT OF SIMILAR PLATES WITH F.E.A.

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ABSTRACT

'Welding', the simple process and excellent strength makes it useful in manufacturing of steel structures like ships, ocean structures, automobile, aircraft and bridges. The challenges associated with welding and welded joints are improved tensile strength of welding under variable environmental and working conditions. The parametric study has been carried out, overlap length and gap size are selected as parameters to be varied during experimentation. The range of parameters is decided by referring literature. Design and validation of fixture is carried out for testing purpose. Specimens are prepared with greater accuracy and tests were carried out using UTM. The results obtained from experimentation are compared with result obtained from simulation. It is recommended to keep overlap length 25 mm for 5 mm thick plate with minimum gap size. This will give maximum tensile strength.

KEYWORD: Overlap length, gap size, tensile strength

INTRODUCTION

Welding is the process of joining two pieces of metal by application of heat. The two parts to be joined are placed together, heated, often with the addition of filler metal, until they melt, and solidify on cooling. The heat may be developed in several ways like combustion of fuel gas with oxygen (oxygen-acetylene gas welding), electric arc, electric resistance heating, plasma arc, electron beams, laser beam etc.

LITERATURE REVIEW

Researchers have worked on finding tensile, fatigue, strength of various welded joint, by varying geometry of weld, welding process, loading conditions. Various defect detecting techniques have discussed in some papers. The welded joints used in ship building, automobile, aircraft and bridge are under tensile load. Among all welding processes electric metal arc welding is most common welding which has wide range of application. The geometry of weld has more influence on strength of welded. In literature survey, it is observed that very less work have been carried out for checking the tensile strength of lap welded joint. Welding process parameters such as current and voltage, affects on weld geometry and tensile strength.

FACTORS AFFECTING TENSILE STRENGTH OF WELDED JOINT

After doing literature survey some parameters are observed which affects tensile strength of welded joint. The henceforth chapter discuss the effect of parameters on tensile strength.

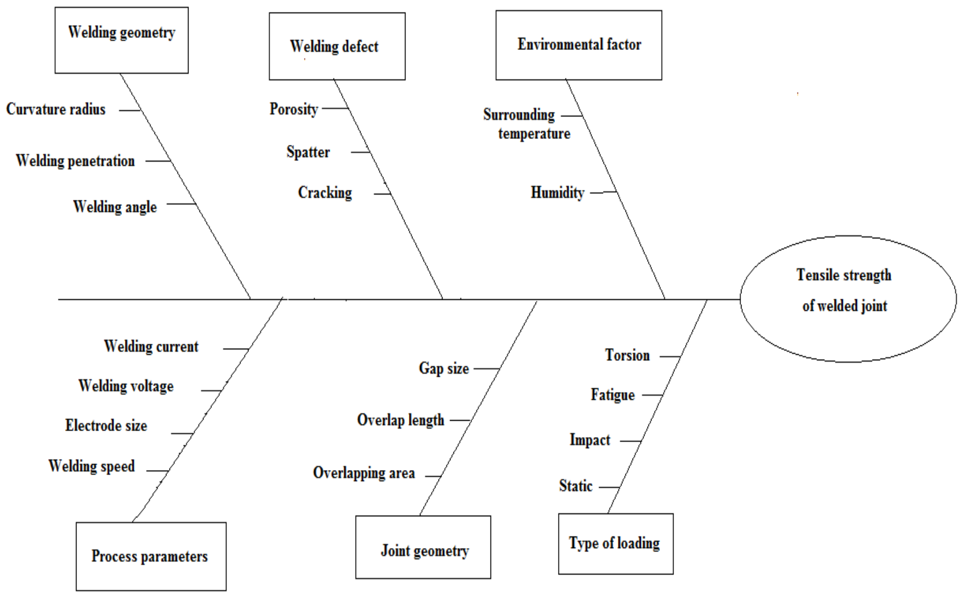

Fig.1 Cause effect diagram for welded joint

PROCESS PARAMETERS

There are various parameters which affects on strength of the weld. In that welding current, welding voltage, electrode size, welding speed. Basically by varying welding current, deposition of welding material may vary. High welding current cause's microstructure become finer and increase in tensile strength and low current caused root of the metal plate not weld completely which weakened the joint. Also the welding voltage is important parameter in welding process. The voltage is necessary for proper arc maintenance. Bead forming is too small due to too high voltage. The size of electrode to be chosen is based on the thickness of the plate. While too big electrode may stick and be hard to start, too small electrode will spatter and even can catch fire. The Speed at which electrode moves or deposition takes place. The increase in welding speed usually decreases the penetration. Due to speed of welding, sufficient is getting for welding because of decreases penetration. At too slow welding speed, results in piling of head. If too fast, bead will be sparse and have poor fusion. The increase in welding speed usually decreases the penetration.

JOINT GEOMETRY

According to researchers study, it is found that the fatigue life is improved by varying gap size. Gap size affects on strength of the weld. Experimentally it is found that Overlap length plays major role in strength of the weld. Stress variation of lap zone changed by the overlap length. The maximum stress decreased when overlap length is increased. Researcher studied that, the gap size is more affective factor to fatigue life. According to study strength of the weld depended on the lap length and gap size and eliminates the stress concentration in overlapping area [13].

TYPES OF LOADING

Welding joints are applicable in wide range of engineering approach such as structural and mechanical engineering. There are various loading condition according to change in application such as the failure of welded joint due to torsion can be seen in flange welded to the hub transmitting torque. In structural application such as bridges the joints are subjected to static as well as fatigue loading. In both the case of structural application the failure mode may be different due to change in loading condition (i.e. Reason for crack initiation in both the cases is different and life span of welded joint too. Automobile uses spot welding for joining various frame components. During a high speed collision, these welded joints are subjected to impact loading. Lot of research has shown that the some kind of welded joint behaves in different manner for different kind of loading condition and by keeping the joint geometry as it is. It gives different values of strength for different kinds of loading.

WELDING GEOMETRY

Welding geometry is also affecting factor on the strength of the welding joint. In that, curvature radius affects on Stress concentration phenomenon. It is found that, the value of stress decreases when curvature radius increases. It is experimentally proved that, the curvature radius influenced on the variation of stress and fatigue life. A welding process having greater penetrating power calls for a narrow groove, lesser heat affected zone and distortion and lesser filler metal consumption. Due to full penetration lead to decrease in quality. The over penetration of electrode causes the melting or burning away of the base metal at the toe of the weld. This resulting from fundamental difficulties in a welding operation such as cracking and porosity. In some research paper it is found that, stress also decreased by increasing welding angle. Too great travel angle results into a bead with poor penetration. The quality of the weld metal may be determined to a marked degree by the angular deposition of the electrode to the work [21].

WELDING DEFECT

During the welding process, there are some welding defects which mainly affect on strength of welding joint. There are some defects are discussed such that porosity, spatter, cracking. Porosity may be caused by excessive welding heat. Porosity scattered along the entire weld length may be due to dirt on surface of material, excessive moisture in covering on electrode, improper arc length and excessive current, high welding speed etc. Spatter refers to small particles or globules of metal scattered around the vicinity of the weld along its length. It occurs due to use of too long arc or too high arc voltage and use of an excessive current. Cracking may occur due to incorrect welding techniques [22].

ENVIRONMENTAL FACTOR

There are many factors which are affecting on strength of welded joint. In that environmental factor is comes in consideration. During the welding process, Surrounding temperature mainly affect on the welding joint. If welding process is carried out in hot region, residual stresses generates in welding joint. It weakens the welded joint. Humidity is another factor which also create defect in weld. If moisture content in air is more than due to the moisture, bubbles in welding joint created. These defect weaken the weld and decreases strength of the welded joint.

SPECIMEN PREPARATION

Lot of research has been carried out for finding the effect of varying various parameters on strength of welded joint. These parameters are loading conditions, welding defects, environmental effects and process parameters. Maximum results are obtained with the help of ANSYS software. Very less amount of work carried out experimentally. It is observed that in some literature, the researcher worked on the weld geometry in which varying the gap size and overlapping length for same plate and same loading conditions gives different tensile strength. This work was carried out with the help of ANSYS. Hence it is decided to find out effect of varying these two geometric parameters on strength of welded joint experimentally.

Table.1. Parameters and its selection

Sr. No	Parameter	Selection	Reason for selection
1	Type of loading	Tensile loading	Maximum components are observed under tensile loading.[09]
2	Type of material	Mild steel	Wide range of application.[11]
3	Geometry of joint	Overlap length and gap size	Varying this parameters affect the strength of the joint.[13]
4	Type of joint	Lap welded joint	The parameters under study are overlap length and gap size.[13]
5	Specimen size	5 mm thickness mild steel plate	Application ranges from 2 mm to 10 mm.[11]

Due to versatility of application a welded joint, it can be used with varieties of materials like stainless steel, mild steel, titanium, aluminium. During the literature review, it is observed that mild steel rolled sheet thickness varies from 2 mm to 10 mm are used for welded construction of ship, bridges and transport vehicles. According to researchers study, it is found that the fatigue life is improved by varying gap size. Gap size affects on strength of the weld. Experimentally it is found that Overlap length plays major role in strength of the weld. Stress variation of lap zone changed by the overlap length. The maximum stress decreased when overlap length is increased. Researcher studied that, the gap size is more affective factor to fatigue life. According to study strength of the weld depended on the lap length and gap size and eliminates the stress concentration in overlapping area.

OVERLAP LENGTH

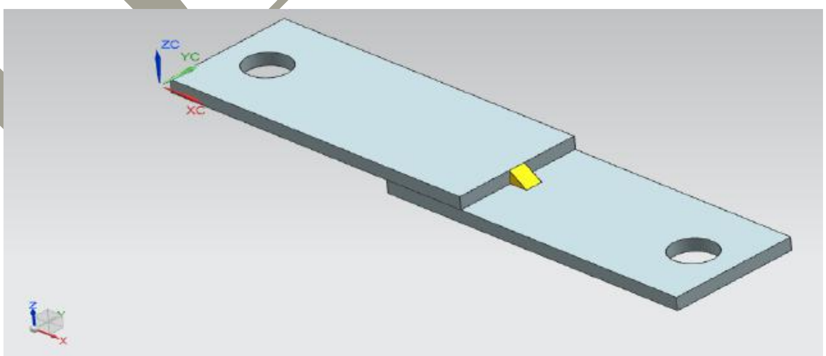

Fig.6 Cad model of overlap length specimen

The overlap length is marked on specimen and precise welding is done by holding the specimen in C clamp so that accurate overlap length can be obtained. Specimen held in C clamp and measurement of length.

Table.2 Specimen details (Overlap length)

Specimen number	Overlap length
1	21 mm
2	23 mm
3	25 mm
4	27 mm
5	29 mm

GAP SIZE

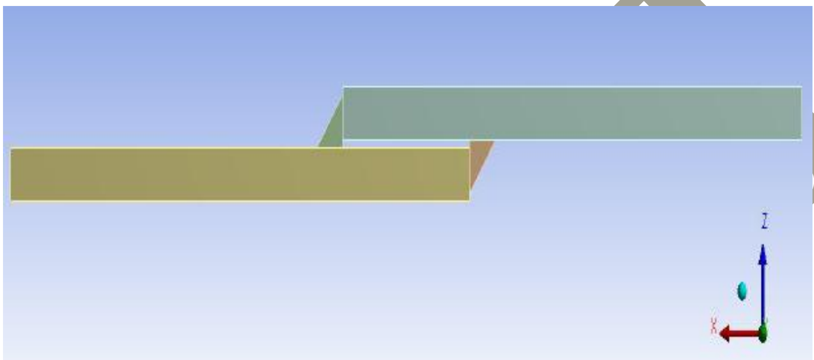

Fig.8 Cad model of gap size specimen

The gap size is maintained by filler gauge. One metal placed over other by sandwiching the filler gauge between plates and plates with filler gauge is held by clamp and welding is done then filler gauge is removed. This maintains gap between the plates equal to filler gauge failures

Table.3 Specimen details (Gap size)

Specimen number	Gap size
6	0.2 mm
7	0.4 mm
8	0.6 mm
9	0.8 mm
10	1 mm

EXPERIMENTATION

EXPERIMENTATION BY VARYING OVERLAP LENGTH

To see what happens if overlap length varied? Five specimens are prepared as per table and testing was carried out that are discussed below.

TESTING OF SPECIMEN 1

Fig.10 Photo of specimen 1

The specimen with overlap length 21 mm is tested and following fig.11 shows the graph of load and displacement.

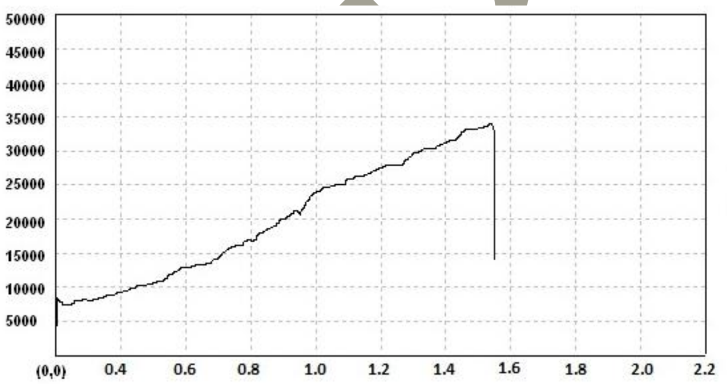

Fig.11 Graph of specimen 1

This specimen fails at 34.5 KN and 1.57 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.12

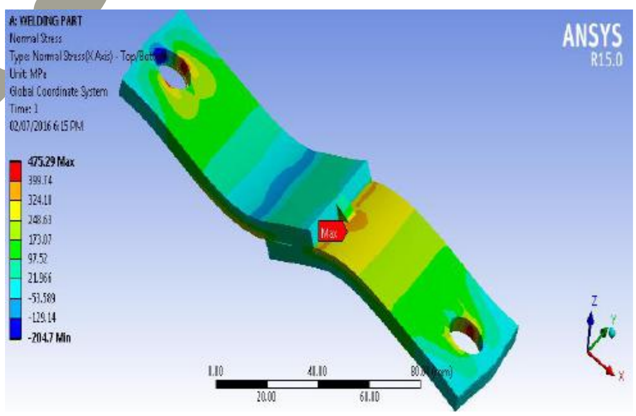

Fig.12 Simulation of specimen 1

Sr. No	**Tensile strength (KN)**		**Percentage deviation**
1	**Value calculated by experimentally**	**Value calculated by simulation**	
	34.5	32.41	6.05

TESTING OF SPECIMEN 2

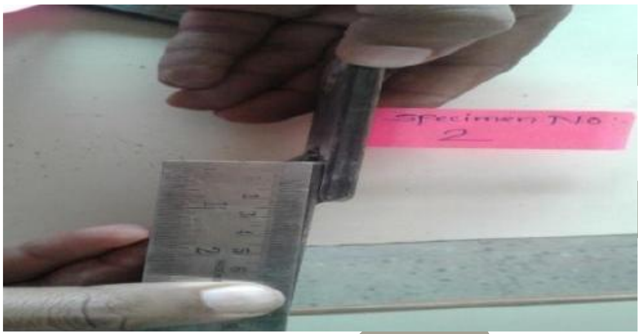

Fig.13 Photo of specimen 2

The specimen with overlap length 23 mm is tested and following fig.14 shows the graph of load and displacement and results are shown in fig.14

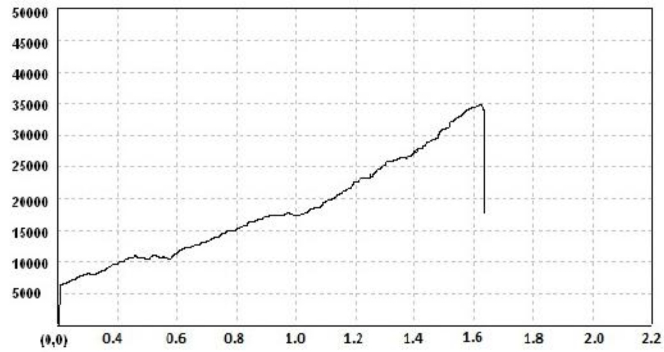

Fig.14 Graph of specimen 2

This specimen fails at 35 KN and 1.75 mm elongation. The same condition is simulated in ANSYS as shown in fig.15

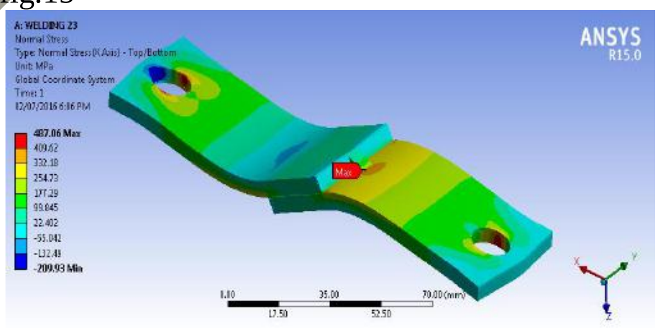

Fig.15 Simulation of specimen 2

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Sr. No	Tensile strength (KN)		Percentage deviation
1	Value calculated by experimentally	Value calculated by simulation	
	35	33.21	5.11

TESTING OF SPECIMEN 3

Fig.16 Photo of specimen 3

The specimen with overlap length 25 mm is tested and following fig.17 shows the graph of load and displacement.

Fig.17 Graph of specimen 3

This specimen fails at 36 KN and 1.69 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.18

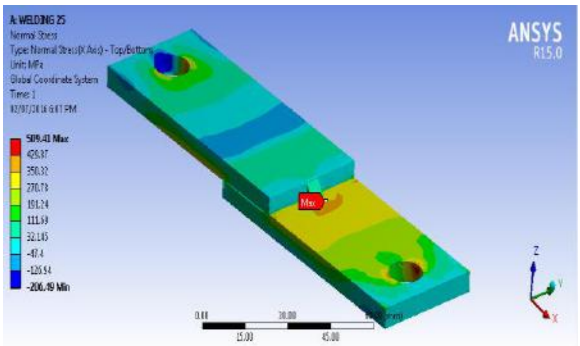

Fig.18 Simulation of specimen 3

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Sr. No	Tensile strength (KN)		
	Value calculated by experimentally	**Value calculated by simulation**	**Percentage deviation**
1	36	35.03	2.69

TESTING OF SPECIMEN 4

Fig.19 Photo of specimen 4

The specimen with overlap length 27 mm is tested and following fig.20 shows the graph of load and displacement.

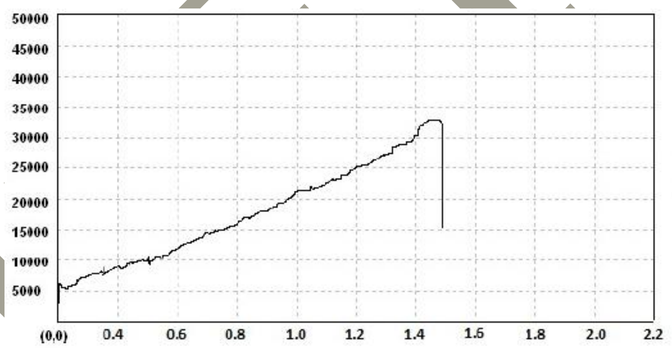

Fig.20 Graph of specimen 4

This specimen fails at 34.1 KN and 1.50 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.21.

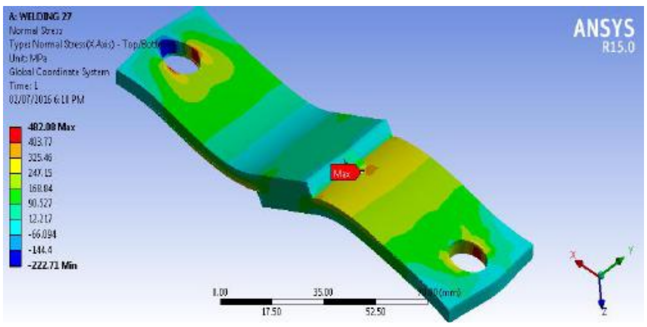

Fig.21 Simulation of specimen 4

Sr. No	Tensile strength (KN)		Percentage deviation
1	Value calculated by experimentally	Value calculated by simulation	
	34.1	32.54	4.57

TESTING OF SPECIMEN 5

Fig.22 Photo of specimen 5

The specimen with overlap length 29 mm is tested and following fig.23 shows the graph of load and displacement.

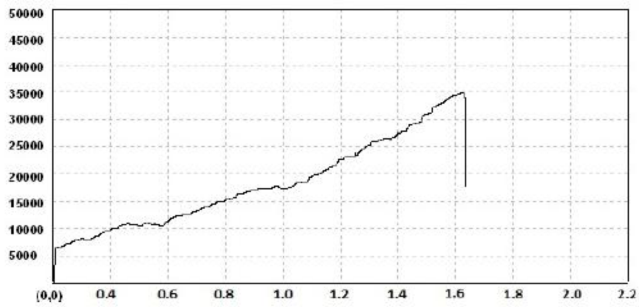

Fig.23 Graph of specimen 5

This specimen fails at 35.1 and 1.63 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.25

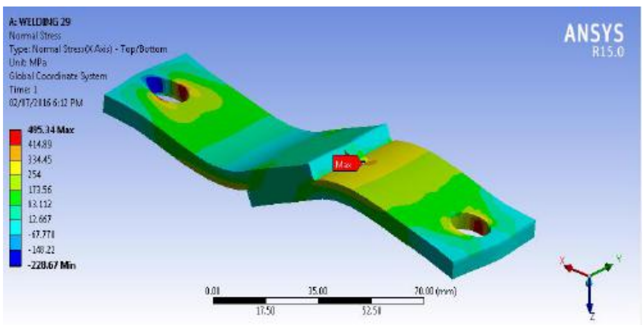

Fig.24 Simulation of specimen 5

Sr. No	Tensile strength (KN)		Percentage deviation
	Value calculated by experimentally	Value calculated by simulation	
1	35.3	33.44	4.72

The maximum deviation obtain is 6.03. Hence we can say that results obtained by experimentally are validated successfully.

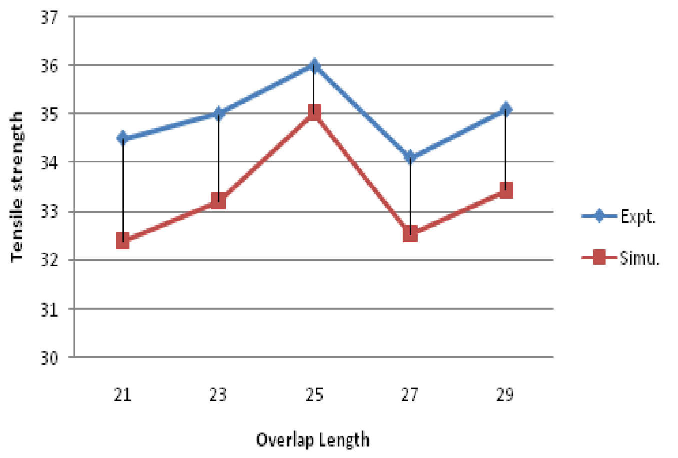

Fig.25 Comparison between experimental and simulation results

Above fig shows that the joint gives maximum tensile strength of 36 KN at 25 mm overlap length. Hence 25 mm overlap must be consider while using 5 mm plate lap welded joint this overlap length will be considered for further experimentation.

TESTING WITH VARIATION IN GAP SIZE

TESTING OF SPECIMEN 6

Fig.26 Photo of specimen 6

The specimen with gap size 0.2 mm is tested and following fig.27 shows the graph of load and displacement.

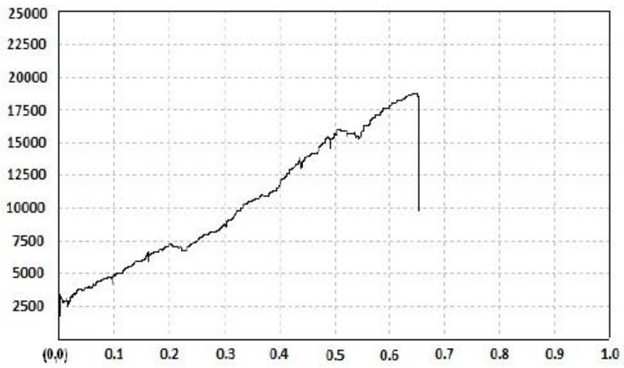

Fig.27 Graph of specimen 6

This specimen fails at 18.214 KN at 0.65 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.28

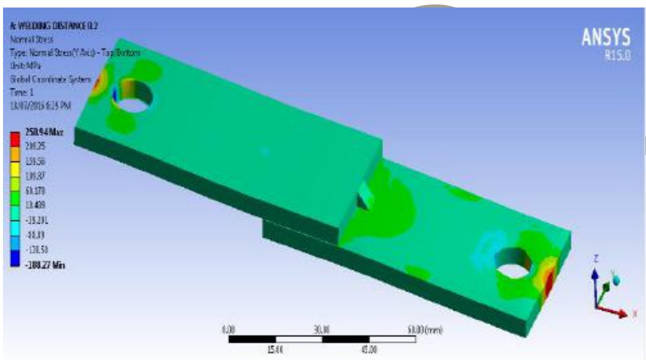

Fig.28 Simulation of specimen 6

Sr. No	Tensile strength (KN)		Percentage deviation
1	**Value calculated by experimentally**	**Value calculated by simulation**	
	18.214	15.956	12.39

TESTING OF SPECIMEN 7

Fig.29 Photo of specimen 7

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The specimen with gap size 0.4 mm is tested and following fig.30 shows the graph of load and displacement.

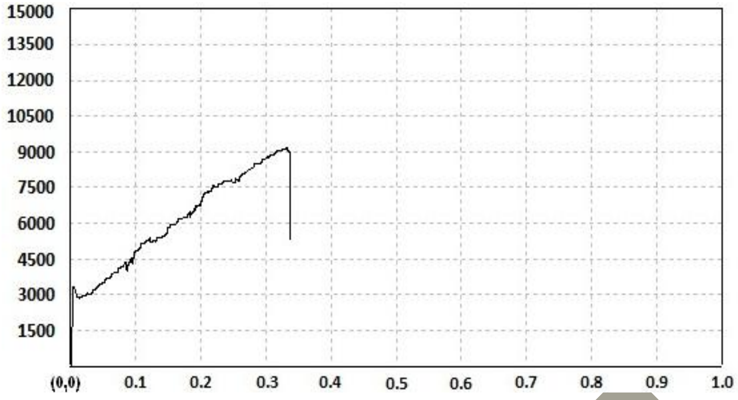

Fig.30 Graph of specimen 7

This specimen fails at 9.104 KN at 0.34 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.31.

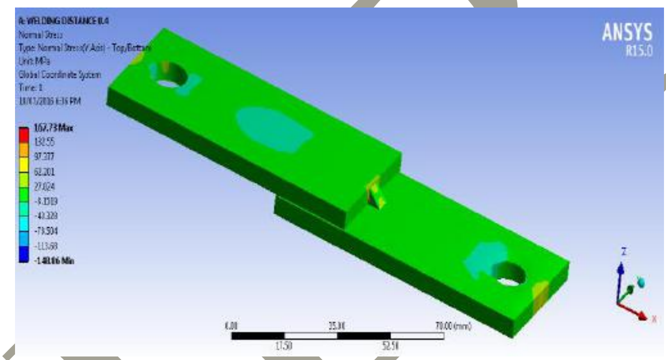

Fig.31 Simulation of specimen 7

Sr. No	Tensile strength (KN)		Percentage deviation
	Value calculated by experimentally	**Value calculated by simulation**	
1	9.104	6.27	31.12

TESTING OF SPECIMEN 8

Fig.32 Photo of specimen 8

The specimen with gap size 0.6 mm is tested and following fig.33 shows the graph of load and displacement.

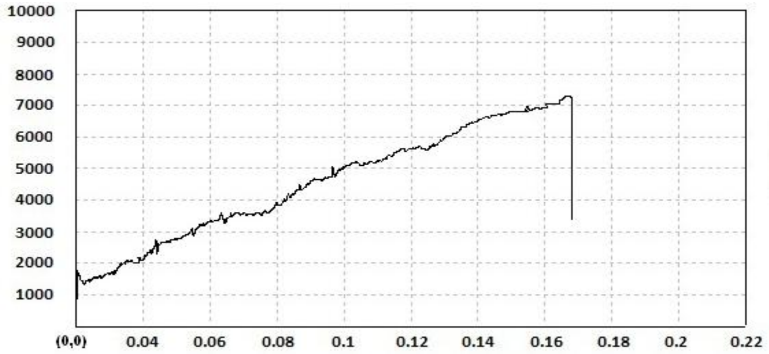

Fig.33 Graph of specimen 8

This specimen fails at 7.253 KN at 0.167 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.34

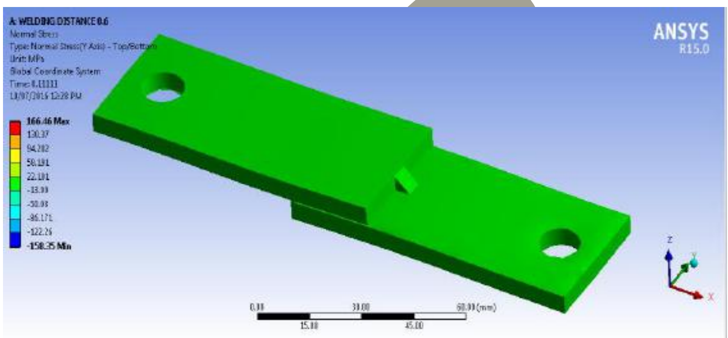

Fig.34 Simulation of specimen 8

Sr. No	Tensile strength (KN)		Percentage deviation
	Value calculated by experimentally	**Value calculated by simulation**	
1	7.253	5.819	19.77

TESTING OF SPECIMEN 9

Fig.35 Photo of specimen 9

The specimen with gap size 0.8 mm is tested and following fig.36 shows the graph of load and displacement.

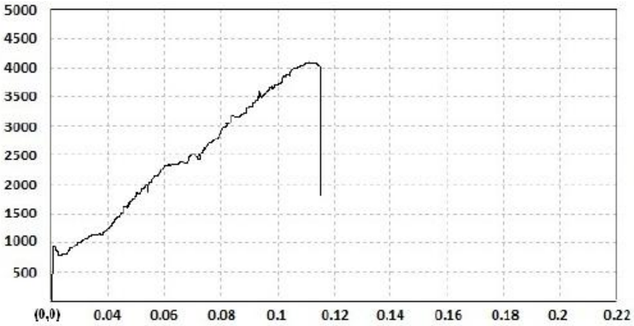

Fig.36 Graph of specimen 9

This specimen fails at 4.467 KN at 0.118 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.37

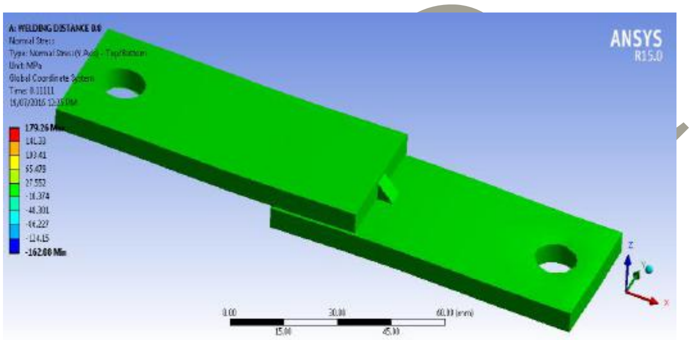

Fig.37 Simulation of specimen 9

Sr. No	**Tensile strength (KN)**		**Percentage deviation**
	Value calculated by experimentally	**Value calculated by simulation**	
1	4.467	2.755	38.325

TESTING OF SPECIMEN 10

Fig.38 Photo of specimen 10

The specimen with gap size 1 mm is tested and following fig.39 shows the graph of load and displacement.

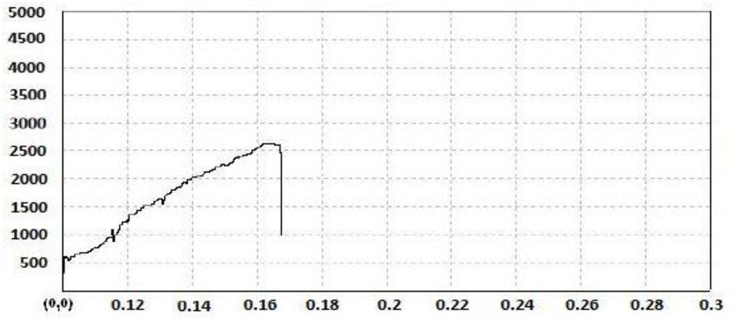

Fig.39 Graph of specimen 10

This specimen fails at 2.631 KN at 0.167 mm elongation. The same condition is simulated in ANSYS and results are shown in fig.40

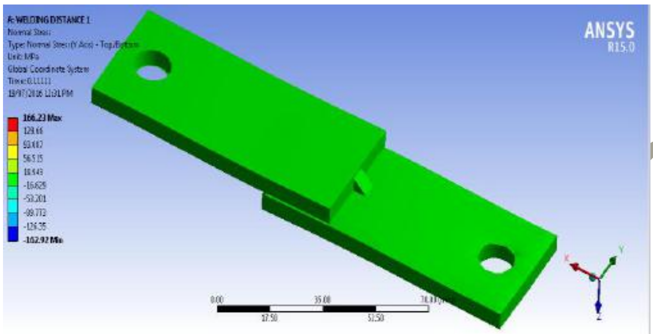

Fig.40 Simulations of specimen 10

Sr. No	Tensile strength (KN)		Percentage deviation
	Value calculated by experimentally	Value calculated by simulation	
1	2.631	1.994	24.21

Maximum deviation is obtained is 38.325 KN. Hence we can say that the values of tensile strength obtained by varying gap size are validated by ANSYS.

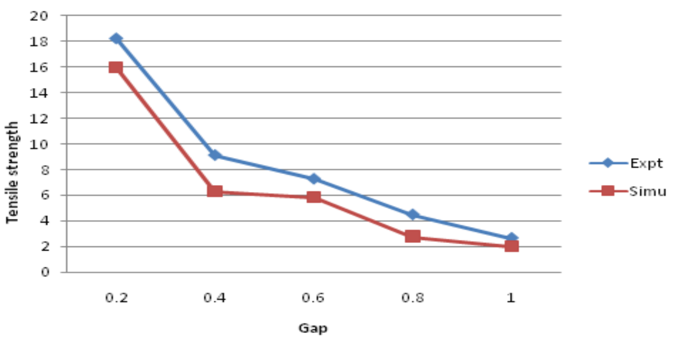

Fig.41 Comparison between experimental and simulation result

The graph shows that increasing the gap size reduces the tensile strength.

CONCLUSION

Various design parameters are considered and effect of these parameters on tensile strength of lap welded joint is discussed. Analytical design procedure was adopted for designing fixture to hold the specimen. The specimen dimensions were finalized and specimens were prepared by varying overlap length and gap size. The values of stress obtained from experimentation and values obtained by simulation are compared for validation of experimentation.

a) The tensile strength obtained by variation of overlap length shows maximum tensile strength of 36 KN with 25 mm overlaps length. This implies that while using 5 mm plates for welded joint 25 mm overlap is recommended.

b) Increasing the overlap length above 25 mm results in poor tensile strength and decreasing overlap length below 25 mm will also reduce tensile strength.

c) Variation in gap size shows maximum tensile strength of 18.214 KN with 0.2 mm gap size. Increasing ahead the gap size decreases the tensile strength. So it is recommended that keep the gap size as minimum as possible.

d) With minimum gap size the chance of work piece rotation is also reduced. Because of reduction in gap size reduces eccentricity in loading.

SCOPE OF WORK IN FUTURE

Experimentation for testing of lap joint by variation of welding voltage, welding current and welding speed can be done. Mathematical model can developed for expressing relation between plate thickness and overlap length for the purpose of standardization.

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