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Experimental Analysis of Welded Aluminum Plates by Experimentally and FEM

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1 Introduction

Aluminum is ubiquitous in application and is of great relevance in nearly all fields of technological development and research. It is important for the design engineer to understand the mechanical properties and behavior of different joints and furthermore, to incorporate of the static, impact and fatigue strength of these joints in early design stage using computer-aided engineering design tools. Although more and more joints are being used in vehicle assemblies, very limited perfor- mance data on joints have been reported in the open literature. The investigation of the effect of the weld pitch on the stress and strain fields of two weld-bonded joints is carried out by Shijie Dong et al. have shown that for multi-weld weld-bonded joints with low modulus adhesives, the stress and strain at the edge of the weld spot increase with increase of the weld pitch, and a saturation value of weld pitch exists, beyond which the stress and strain no longer vary [1]. Simulations of the welding process for butt and tee joints using finite element analyses have been done by Justin D. Francis [2]. The base metal was aluminum alloy 2519-T87 and the filler material was alloy 2319. The simulations were performed with the commercial software SYSWELD+®, which includes moving heat sources, material deposit, and metallurgy of binary aluminium, temperature dependent material properties, metal plasticity and elasticity [3]. The study of mechanical phenomena in welding

processes was carried by Alberto Cardona and Jose Risso. They implement. A mathematical model to represent the power density distribution of the external heat source and they found that the welding model can be used to predict and minimize deformations due to changes in the weld sequence during the product development stage. A standard finite element formulation limited to the solid domain has been adopted for the mechanical analysis, proving to be effective. [4].

2 Experimentation

Specimens for Tensile Test

The tensile test specimen was designed with the help of different dimensions like gauge length, the width of the specimen for the neck area etc. For tests, the basic dimensions were taken as below,

1. Length of two plates to be welded (L) ¼ 150 mm
2. Thickness of plates (t) ¼ 5 mm
3. The width of the raw material (W) ¼ 90 mm

The gauge length should be calculated which is necessary for the preparation of the specimen. First of all, we had to calculate to gauge length. Then tests were carried out

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Specimens for Bending Test

Bending specimen doesn't require any gauge length. The direct specimen is allowed for the testing. The test of the bend was carried out over the welded area with the hammer attached to the jaw of UTM apparatus.

The dimensions for tensile and bending specimen by using standard formula were calculated. Different properties of aluminium along with different types of aluminium weld have been discussed in the chapter.

Cutting of Plates

The raw material is al 6061 plates with dimensions 200 m100 5m mm. To obtain the exact dimensions, the plates were cut as per length and breadth wise. The plate's dimensions for the different test were:

(a) Tensile Test:

Four plates of 150m90m5 mm

(b) Bending Test:

Four plates of 110m90m5 mm

Machining Operation

The machining was then carried out on the welded plates to remove the extra buds formed on the surface of the welded plates. It includes finishing operation. The extra buds were also removed with the help of hand grinder. The fillet was also given to the edges of plates for smoothness. The Fig. 1 shows the photograph of the grinding process carried on the plates.

Dye Penetrant Testing

Before taking destructive tests, it is necessary to know whether there are any surface defects or not. So it is convenient to use non-destructive testing for The Dye-penetrant examination is a highly sensitive, non-destructive method for detecting minute discontinuities(flaws) such as cracks, pores, and porosity, which are open to the surface of the material being inspected. In this test, the different chemicals were used like cleaner, Red penetrant and Developer.

Fig. 1 Grinding operation

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Procedure for DP Test

Testing surface must be cleaned so that discontinuities must be free from dirt, rust, grease, or paint for enabling the penetrant to enter the surface opening. For the same cleaner was applied on the surface. The surface was then dried. A red penetrant was applied to the surface of the part to be inspected as shown in Fig. 2. The pentrant remains on the surface and seeps into any surface opening by capillary action. The parts could be in any position during the test. After sufficient penetration, the surface was cleaned and excess penetrant was removed. The developer was then applied on the surface as shown in Fig. 3. The developer may drawn out of the crack by reverse capillary action, resulting in a colour indication on the surface that is broader than the actual flaw, and therefore, much more visible. Due to the red color of Penetrant, indication shows up brilliantly against the white background. Even small defects maybe located.

Fig. 2 Application of red penetra

Fig. 3 Application of developer

Ultrasonic Testing

It is a nondestructive examination method that employs mechanical vibrations similar to sound waves but of a higher frequency. The system uses a transducer, which changes electrical energy into mechanical energy, excited by a high-frequency voltage causing a crystal to vibrate mechanically. The crystal probe acts as the source of ultrasonic mechanical vibrations. These vibrations are transmitted into the test piece through a coupling fluid, usually, a film of oil called a couplant. When the pulse of ultrasonic waves strikes a discontinuity in the test piece, it is reflected back to its point of origin.

The transducer serves as a receiver for the reflected energy. The initial signal or main bang, the returned echoes from the discontinuities, and the echo of the rear surface of the test material are all displayed by a trace on the screen of a cathode-ray oscilloscope. The Transverse-Receiver Probe is used for the operation. It has a glass type of front, which is specially used for aluminum metal. The process has been illustrated as in Figs. 4 and 5.

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Fig. 4 At the start of UT

Fig. 5 UT of aluminum welded plate

Specimen for Tensile Test and Bending Test

After the machining operation, the specimen for tensile test and bending test is ready as shown in Figs. 6 and 7.

Experimental Setup

The machine used for the experimentation is universal Tensile Machine. It is of 1000KN capacity widely used for the commercial and industrial use. It has ram

Fig. 6 Specimens for tensile test

Fig. 7 Specimens for bending test

stroke capacity of 250 m. It has a digital result with graphical representation. The UTM machine has upper and lower sections. The bending test was carried on the lower side of the machine. It contains the two rollers which help for allocation of the bending specimens.

Tensile Test

The tensile specimen designed for tests in such a way that the area of gauge length should be out of the jaws provided for the clamping. Area excluding the gauge length of the specimen from both ends is fitted in the jaws. The arrangement for the same is as shown in Figs. 8 and 9.

Bending Test

The arrangement of the bending test on UTM is as shown in Figs. 10 and 11.

Data for ANSYS

FEM is used for Static stress-strain problems, Non-linear problems, Heat transfer problems, Modal analysis, Dynamic analysis, Electricity and magnetism problems

Fig. 8 Testing of tensile specime

Fig. 9 After tensile test

Fig. 10 Arrangement of bending

and Flow problems. The nodal displacement diagram drawn in ANSYS has been given below in Figs. 12 and 13 for tensile and bending test respectively.

3 Results and Discussion

All the destructive tests were carried out and results have been discussed in this chapter. The results from ANSYS software have also been discussed in this chapter.

Fig. 11 Bending test

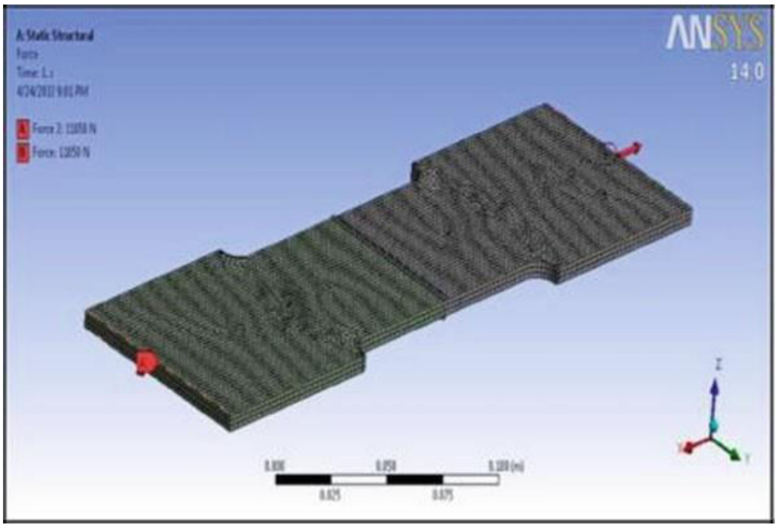

Fig. 12 Nodal diagram for tensile specimen

Result Summary for Tensile Test specimens

The load-displacement data obtained from UTM for the first tensile test specimen has been given in Table 1.

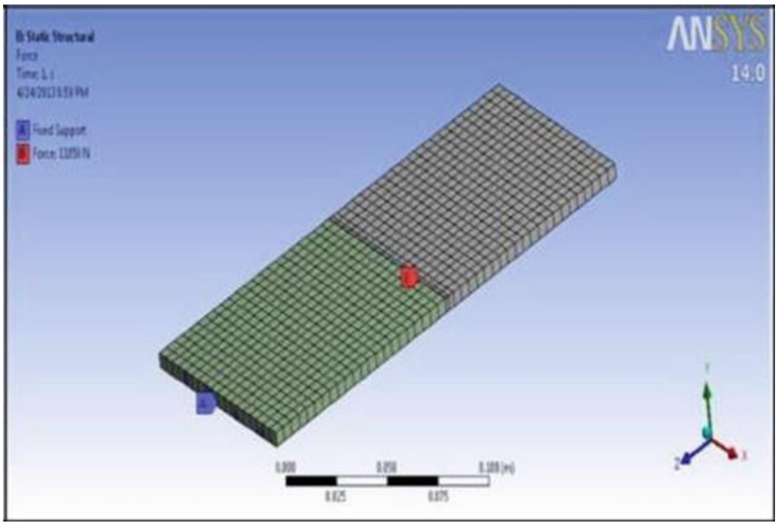

Fig. 13 Nodal diagram for bending test

Table 1 Load displacement data for tensile test specimen 1 and 2

Sr. No	Load (KN)	Displacement(mm)
(Specimen 1)		
1	0	0
2	0.25	0.1
3	0.3	0.2
4	0.45	0.3
5	0.9	0.4
6	1.1	0.6
7	1.6	0.7
8	1.9	0.8
9	2.35	0.9
10	2.25	0.95
(Specimen 2)		
1	0	0
2	0.3	0.1
3	0.4	0.2
4	0.5	0.3
5	0.85	0.4
6	1.2	0.5
7	1.5	0.6
8	1.8	0.7
9	2.45	0.8
10	2.95	0.9

Bending Test of Specimen 1 and 2

The load-displacement data obtained from UTM for the Bending test specimen has been given in Table 2.

Results from ANSYS Software

The results obtained from ANSYS by Finite Element Method for tensile and bending specimen have been given below.

Comparison Between Experimental and ANSYS Result

The results obtained from ANSYS software by FEM Figs. 14 and 15, can be compared with results obtained from experimentally with help of following points.

(a) The Results obtained Experimentation are as Table 3.

Table 2 Load displacement data for bending test specimen 1 and 2

Sr. No	Load (KN)	Displacement (mm)
(Specimen 1)		
1	0	0
2	0.15	0.3
3	1.05	0.7
4	2.7	1.1
5	3.9	1.5
6	4.6	1.9
7	4.95	2.3
8	5.1	2.7
9	5.05	3.1
10	5.2	3.5
(Specimen 2)		
1	0	0
2	0	0.3
3	0.2	0.7
4	1.25	1.1
5	2.75	1.5
6	3.7	1.9
7	3.95	2.3
8	3.95	2.7
9	4.1	3.1
10	4	3.5

Fig. 14 The result of test

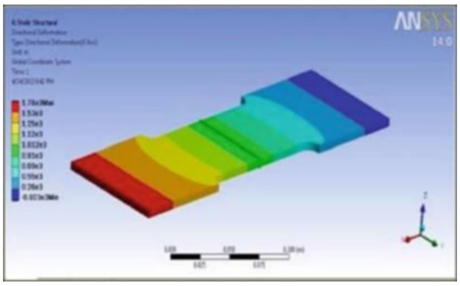

Fig. 15 The result of bending test

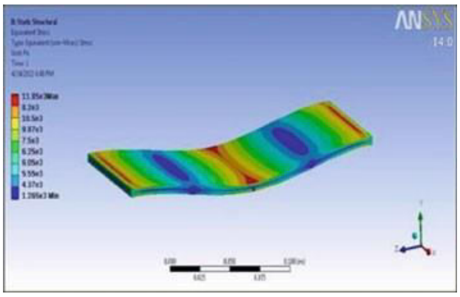

Table 3 Observations from experimentation

Sr. No.	Test	Load	Displacement
1	Tensile	10.95	1.84
2	Bending	5.575	9.15

Table 4 Observations from ANSYS software

Sr. No.	Test	Load	Displacement
1	Tensile	10.95	1.78
2	Bending	5.75	11.85

The Results obtained from FEM carried out by using ANSYS software are as Table 4.
From the above data, we can say that the results by both methods are approxi- mately the same.

4 Conclusion

The project was regarding the analysis of the welded aluminium plates. In this study, the joining of aluminium plates was carried out by using welding and joined specimens were analysed experimentally and by using ANSYS software.

The main outcomes based on the work carried out in this project are as below.

1. Square butt welding can be effectively done on aluminium plates with minimum thickness by using GTAW.
2. From the experimental analysis, it has been found that the aluminium welded plates can sustain the tensile load of 10.95KN with deformation of 1.84 mm and a bending load of 5.75KN with deformation of 9.15 mm.
3. From ANSYS software, it has been found that aluminium welded plates can sustain a tensile load of 10.95KN with deformation of 1.78 mm and can carry a bending load of 5.75KN with deformation of 11.85 mm.
4. The results obtained from experimentation and software are approximately the same.

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