Stress and Strength Evaluation of Double Lap Adhesive Joint.

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Abstract— This paper summarizes the evaluation of stress and strength of double lap adhesive joint. Stress and deformation of the double lap adhesive joint is obtained by finite element analysis using ANSYS and strength is obtained by experimental method. Joint failure is one of the main causes of interruption of rotating or stationary machinery operation. This generally leads to unscheduled shut down thereby increasing the cost of operations. One of the major concerns in adhesive joint is the detection of the rupture initiation and strength of joint before it develops into a failure of material. The ability to achieve strength of adhesive joint is essential to the optimal maintenance of whole system with respect to cost and productivity. The effects of the length of adherend, width of adherend, the overlapping length of the joint, the thickness of the adhesive layer and the initial impact velocity of the impacted mass on the double lap adhesive joint are studied. Early detection of the stresses and rupture in the joint are crucial for the prevention of damage to the system.

Keywords*- strength, double lap, adhesive, length, stress.*

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I. INTRODUCTION

Following are the applications of adhesive joints:-

1. It is widely used in aircraft industry.
2. It is widely used in automobile industry.
3. It is widely used in space industry.
4. It is used for vehicle structure performance.
5. The mechanism of adhesive joints helps to reduce stress concentration found in bolted, riveted and welded joints.
6. Shock and impact characteristics of the joints are improved.
7. Adhesive joints allow sufficient mechanical compliance in parts subjected to thermal distortion.

An adhesive is a substance which when applied to the surfaces of materials binds that surfaces together and resists separation. The strength of the adhesive joints under impact loads has become more important because of their huge use to the aircraft and automobile industries. In industries, adhesives are used to join the different or same material. But when those joined material comes under use, it may rupture or may not rupture. It depends on the how much load has been applied on the joint, type of adhesive material used for joining and the contact area of the two material. Joint failures contribute major cause of machinery breakdown resulting in costly down time. To prevent that, we should know the strength of the adhesive joint of that two particular material.

The stress distributions in both the adhesive layer and adherends are necessary to be analyzed to determine the material properties. Adhesive joint cannot tolerate misalignment, it need precise alignment between two materials. The continuation in use of two material develops stress on the joint which may cause initiation in rupture of the joint. Hence it becomes necessary to study the stress and strength of adhesive joint to improve its stability.

It is found that no work has been carried on the exact rupture position along the width direction (bond-line) of the double-lap adhesive joint under impact tensile loads. Therefore, three-dimensional finite element method is needed for examining the stress distributions along the width direction. Furthermore, the mechanical properties of the double-lap adhesive joint under impact tensile loads are necessary to be clarified for designing the adhesive joints from a reliable standpoint.

In this paper, the stress distributions in the double-lap adhesive joint subjected to tensile loads are analyzed using three-dimensional finite-element method. The impact tensile loads are applied by a dropping weight-hammer. The FEM code employed is ANSYS. In addition, the effects of the length of adherend, width of adherend, overlapping length and the thickness of the adhesive layer and the initial impact velocity of the impacted mass on the double lap adhesive joint are studied. The characteristics of the double-lap adhesive joint under impact and static loadings are compared with each other. Furthermore, experiments are carried out to measure the strain responses and the strength of the joint subjected to impact tensile loads.

II. OBJECTIVES

A. To design and develop experimental set-up for the impact analysis of stress and strength of double lap adhesive joint.
B. To analyze stress developed in the double lap adhesive joint by FEA.
C. To analyze the effect of overlapping length and the initial impact velocity of the dropping weight-hammer on the double lap adhesive joint.
D. To analyze the strength of the double lap adhesive joint.
E. To analyze the effect of length of adherend, width of adherend and overlapping length of adherends for stress calculation.
F. To calculate elongation in length of double lap adhesive joint.

III. METHODOLOGY

This paper illustrates calculation of stesses by ANSYS and calculation of strength by experimental method.

Study of available literature

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Modeling of double lap adhesive joint.

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Change in parameters of adhesive joints (length, width of adherends, overlapping length of adhesive)

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Calculation of stresses by ANSYS

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Changing the height of dropping weight hammer by experimental method

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Determination of strength of double lap adhesive joint

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Determination of rupture initiation and strength of adhesive joint

Fig. 1 Stages in Work

A. FEA Analysis:

In the present study, stress distribution in double lap adhesive joint is obtained as,

Load = 100N (from both way in opposite direction).

Material Properties:

1. Modulus of elasticity (E) = 206 GPa
2. Poisson's ratio = 0.3
3. Density = 7.843×10^3 kg/m^3

Parameters selected for analysis:

1. Length of adherends are 90mm, 100mm and 110mm.
2. Width of adherends are 10mm, 15mm and 20mm.
3. Length of adhesive layer are 25mm, 27mm and 30mm.

To obtain the stresses developed in the double lap adhesive joint under loading condition, analysis is carried out taking 100N load on both side in opposite direction.

ANSYS analysis is used to determine deformation of adhesive joint and stresses developed in the joint of a structure or a machine component while it is being designed. It also can be a starting point for another or more detail analysis.

ANSYS analysis is carried out on double lap adhesive joint for different adherends of 90mm, 100mm and 110mm. Overlapping length of adhesive layer and width of the adherends are varied for each total length of adherends. Overlapping length of adhesive layer and width of the adherends are taken as 25mm, 27mm and 30mm and 15mm, 20mm and 25mm respectively. Deformation in length of double lap adhesive joint can be obtained. Here the load applied from both the direction is balanced and it is taken as 100N. According to fig. load applied from left hand direction is divided into two parts. It is each 50N on both adherends and on right hand side direction, it is acting 100N on single adherend. Forces acting on both the directions are tensile in nature.

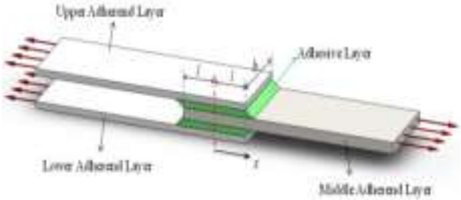

Fig. 2 Double Lap Adhesive Joint

B. Experimetal method:

Experimental work still hasn't carried out. But it will be carried out soon. It will be carried out through following way.

• *Material to be selected:*

There are two adherends (specimens) and adhesive is required for the joining. Material selected for adherend is steel and adhesive is epoxy resin.

Steels are alloy of iron and carbon, widely used in construction and other applications because of their high tensile strengths and low costs. Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxirane group.

Strain gauges and two U-shaped jigs with two pins are also used.

• *To prepare double lap adhesive joint:*

Take three adherends (test specimens) of steel and form double lap adhesive joint by using epoxy resin as follows.

It is as shown in fig. 2.

• *Deciding running parameter:*

Here running parameter we are considering is dropping weight hammer. We are allowing to follow down dropping weight hammer for no. of times on the upper U shaped jig from a certain height and for next time we are changing the height of hammer.

• *Designining experimental set-up:*

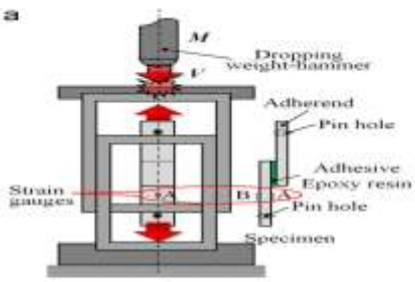

Fig.3 Proposed Experimental set-up

Figure shows the experimental set-up for the impact tensile test for calculation of strength. Two U-shaped jigs are combined and the test specimens are fixed at the two combined jigs using pins. It can be seen clearly from side view that in above fig. single lap adhesive joint is taken. But here we have to take double lap adhesive joint. A and B are the positions of glued strain gauges.

The strength will be estimated by using formula,

$$IE = 1/2 \times MV^2$$

Where IE = impact energy i.e. strength in J.
M = mass of dropping weight hammer in kg.
V = impact velocity in mm/s.

Velocity is estimated by,

$$V = \sqrt{2gH}$$

Where V = impact velocity in mm/s.
g = acceleration of gravity.
H = height of dropping weigth hammer.

IV. RESULT AND DISCUSSIONS

- *ANSYS analysis of double lap adhesive joint:*

Modal analysis is carried out of double lap adhesive joint by taking different length of adherends (90mm, 100mm and 110mm), by taking different width of adherends (10mm,15mm and 20mm) and by taking different overlapping length (25mm, 27mm and 30mm). Through this way deformation in the joint and stresses occurring in the joint can be observed. Following table shows deformation in length and stresses for different joints.

Table 1.Twenty seven cases for ANSYS result.

Case	Specification of joint (length of adherend × overlapping length × width of adherend)	Total deformation (mm)	Stress(MPa)
1	90×25×10	0.00379	1.407
2	90×27×10	0.00350	1.236
3	90×30×10	0.00314	1.114
4	100×25×10	0.00423	1.361
5	100×27×10	0.00391	1.301
6	100×30×10	0.00351	1.120
7	110×25×10	0.00468	1.363
8	110×27×10	0.00415	1.203
9	110×30×10	0.00388	1.158
10	90×25×15	0.00126	0.732
11	90×27×15	0.00116	0.645
12	90×30×15	0.00104	0.580
13	100×25×15	0.00141	0.708
14	100×27×15	0.00130	0.678
15	100×30×15	0.00117	0.584
16	110×25×15	0.00156	0.766
17	110×27×15	0.00144	0.646
18	110×30×15	0.00129	0.605
19	90×25×20	0.00065	0.645
20	90×27×20	0.00059	0.562
21	**90×30×20**	**0.00053**	**0.497**
22	100×25×20	0.00072	0.619
23	100×27×20	0.00066	0.578
24	100×30×20	0.00060	0.502
25	110×25×20	0.00080	0.608
26	110×27×20	0.00074	0.568
27	110×30×20	0.00066	0.498

ANSYS programs were prepared and run for different adherend lengths, overlapping length of adhesive and width of adherends as per above twenty seven cases. The stress with minimum value and minimum elongation in double lap adhesive joint is as shown below.

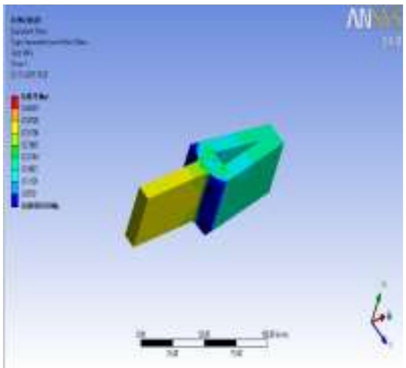

Fig. 4.Case 21. 90×30×20.

V. CONCLUSION

The ANSYS program was successfully carried out which can be used to determine the total deformation and stresses developed in double lap adhesive joint.

1. The double lap adhesive joint of 90×30×20 is most suitable.
2. This joint gives the minimum deformation of joint 0.00053 mm and minimum stress developed 0.497 MPa.
3. The change in the joint structure results in the change in deformation of joint and stresses.
4. The ANASYS analysis proves to be a simple & cost effective method in the judgement of good double lap adhesive joint.
5. The rupture initiates near the middle area along the width direction.

VI. ACKNOWLEDGMENT

I express my deepest gratitude to my project guide Prof. Sachin A. Sonawane, whose encouragement, guidance and support developed an understanding of the subject.

Prof. R. T. Vyavhare, Head of the Mechanical Engineering Department, SKN, Sinhgad College of Engineering, Korti, Pandharpur for providing his valuable advice and for creating an environment to my project successfully.

Finally, I take this opportunity to extend my deep appreciation to my family and friends, for all that they meant to me during the crucial times of my project.

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