IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# A REVIEW PAPER ON STRESS AND STRENTH EVALUATION OF DOUBLE LAP ADHESIVE JOINT

[1]Prof. A.G.Jathar, [2]Utkarsha Pawar, [3]Alisha Mulani,

[4]Swapnali Jagdale, [5]Saniya Chougule.

[1]Assistant Professor, [2,3,4,5]B.Tech Student.
[1,2,3,4,5]Mechanical Engineering.
[1,2,3,4,5]Adarsh Institute Of Technology And Research Center Vita, (Maharashtra), India.

*Abstract:* 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 dissimilar 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 for that two particular material.

***Index Terms* - Adhesive Joints, Lap joint, Strength, Epoxy resin, Stress, ANSYS.**

## I. INTRODUCTION

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 noticing 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. An adhesive is a substance which when applied to the surfaces of materials attach 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 for that two particular material. The stress dissemination 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. So it becomes necessary to study the stress and strength of adhesive joint to improve its stability

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 for 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.

## II. LITERATURE REVIEW

Research has been conducted on very vast scale in adhesive joint analysis. The influence of loading with material properties and geometries and their response in the form of displacements and strength are also studied by the researchers.

**L. Liao, *et al.*** [1]have worked on the stress wave propagations and interface stress distribution in the single-lap adhesive joint under impact tensile loading which is analyzed using the three dimensional finite element method (3D-FEM) taking into account the strain rate sensitive of the adhesive using Cowper –Symonds constitutive model. It is found that the rupture of the joint initiates near the middle area of the edges of the interfaces along the width direction. The characteristics are compared with those of the joint under static loads, which show the different properties. Experiments are also carried out for measuring the strain responses and the joint strength. The strength of the single-lap adhesive joint, which is described using impact energy, is obtained between 5.439 and 5.620J for the present joint.

**He Dan, *et al***.[2]in his study the stress distributions in scarf adhesive joints under static tensile loadings are analyzed using three-dimensional finite-element calculations. The effects of adhesive Young's modulus, adhesive thickness and scarf angle in the adherend on the interface stress distribution are examined. The differences in the interface stress distributions between the 2-D and the 3-D FEM results are demonstrated. It is also observed from the 3-D FEM results that the maximum value of the maximum principle stress is the smallest when the scarf angle is around 60 degree, while it is around 52 degree in the 2-D FEM when the singular stress at the edges vanishes. In addition, the joint strength is estimated using the interface stress distribution obtained from the FEM calculations. For verification of the FEM calculations, experiments were carried out to measure the strengths and the strains in the joints under static tensile loadings using strain gauges.

**AlirezaChadegani, Romesh C. Batra, et al.** [3]have used the first-order shear deformation plate theory (FSDT) to analyze stresses in two layers bonded together with an adhesive as recommended by the ASTM D3165 standard, except that we also include a void within the adhesive. Depending upon the number of notches and voids, the specimen is divided into several regions. The inverse transform of the solution of the algebraic equations provides stresses and displacements in the adhesive and the substrates, which are found to agree well with those obtained by the finite element method (FEM). It is also found that the order of the stress singularity at the corner of the free surface of the adhesive and the substrate, and the strain energy release rate computed from the solution of the problem with the FSDT agree well with those determined from the solution of the problem by the FEM. We note that the computational effort required to analyze the problem with the FSDT is considerably less than that needed to solve the problem by the FEM.

**Quantian Luo, et al.** [4]presented analytical nonlinear solutions for composite single-lap adhesive joints. The ply layups of each composite adherend can be arbitrary, but in the overlap region the ply layups of the upper and lower adherends are assumed to be symmetrical about the adhesive layer. In the present formulation, equilibrium equations of the overlap are derived on the basis of geometrical nonlinear analysis. To verify the present analytical solutions for nonlinear analysis of composite single-lap joints, the geometrically nonlinear 2D finite element analysis is conducted using commercial package MSC/NASTRAN. The numerical results of the edge moment factor, deflections and adhesive stresses predicted by the present solutions correlate well with those of the geometrically nonlinear finite element analysis. This indicates that the present analytical solutions capture key features of geometrical nonlinearity of composite single-lap adhesive joints.

**D. Castagnetti, et al.**[5] his paper, documents, ongoing research in the field of stress analysis of adhesive bonded joints and aims at developing efficient and accurate finite element techniques for the simplified calculation of adhesive stresses. Goal of the research is to avoid the major limitations of existing methods, in particular their dependency on special elements or procedures not supported by general purpose analysis packages. Two simplified computational methods, relying on standard modeling tools and regular finite elements are explored and compared with the outcome of theoretical solutions retrieved from the literature and with the results of full, computationally intensive, finite element analyses. Both methods reproduce the adherends by means of structural elements (beams or plates) and the adhesive by a single layer of solid elements (plane-stress or bricks). The difference between the two methods resides in the thickness and in the elastic properties given to the adhesive layer. One of the two simplified methods investigated provides accurate results with minimal computational effort for both 2D and 3D configurations.

**Mr. Somesh.P.Patil1, et al**[6]- This paper dealing with investigations of adhesive layer characteristics and it is a part of our continuous research on adhesively bonded joints. Previous experimental analysis has shown that bonding of different adherend materials using the same adhesive leads to the different behaviour of adhesive. This outcome is more evident in numerical modeling of adhesively bonded joints, especially in bonding of adherends of higher yield strength. To understand how adhesives work, it is necessary to understand their mechanical properties and the chemistry used to create those properties. The object of present investigation is therefore to research cohesive and adhesive characteristics of chosen structural adhesives in correlation with adherend materials to be bonded. In particular, two- component structural epoxy adhesive and aluminium as adherend material have been tested.

**Alireza Chadegani, et al.** [7] We use the first-order shear deformation plate theory (FSDT) to analyze stresses in two layers bonded together with an adhesive as recommended by the ASTM D3165 standard, excluding that we also include a void within the adhesive. Depending upon the number of notches and voids, the specimen is divided into several regions. Assuming that a plane strain state of deformation prevails in the specimen, we write the balance of forces and moments for each section and impose the continuity of displacements, forces and moments at the interfaces between the adjoining sections. By taking the Laplace transform of the resulting ordinary differential equations we get a system of simultaneous linear algebraic equations that can be easily solved. The inverse transform of the solution of the algebraic equations provides stresses and displacements in the adhesive and the substrates, which are found to agree well with those obtained by the finite element method (FEM).

It is also found that the order of the stress singularity at the corner of the free surface of the adhesive and the substrate, and the strain energy release rate computed from the solution of the problem with the FSDT agree well with those determined from the solution of the problem by the FEM. We note that the computational effort required to analyze the problem with the FSDT is considerably less than that needed to solve the problem by the FEM.

**D. Castagnetti** [8].The paper documents ongoing research in the field of stress analysis of adhesive bonded joints and aims at developing efficient and accurate finite element techniques for the simplified calculation of adhesive stresses. Goal of the research is to avoid the major limitations of existing methods, in particular their dependency on special elements or procedures not supported by general purpose analysis packages. Two simplified computational methods, relying on standard modelling tools and regular finite elements are explored and compared with the outcome of theoretical solutions retrieved from the literature and with the results of full, computationally intensive, finite element analyses. Both methods reproduce the adherends by means of structural elements (beams or plates) and the adhesive by a single layer of solid elements (plane-stress or bricks). The difference between the two methods resides in the thickness and in the elastic properties given to the adhesive layer. In one case, the adhesive thickness is extended up to the midplane of the adherends and its elastic modulus is proportionally increased. In the other case, the adhesive layer is maintained at its true properties and the connection to the adherends is enforced by standard kinematic restrictions. The benchmark analyses start from 2D single lap joints and are then extended to 3D configurations, including a wall-bonded square bracket undergoing cantilever loading. One of the two simplified methods investigated provides accurate results with minimal computational effort for both 2D and 3D configurations.

**A. Nor, et al** [9] . Stress analysis of adhesive bonding of urea granulator fluidization bed was performed by using finite element method. The main objective of this project is to develop an alternative joining technique for urea granulator fluidizationbed by using adhesive bonding. The problem can solve by using commercial finite element package ANSYS version 13.0. T-joint and double T-joint are the main adhesive joints which will be focused in this project. The stresses on stainless steel plate can reduce by increasing the thickness of adhesive as demonstrated in numerical analysis results. Different thickness of adhesive will allow different value of maximum von Mises stress. It shows that greater thickness resulted in higher maximum. This analysis proves that increasing the adhesive thickness will reduces the joint strength because stress was concentrated more on the adhesive interfaces. The adhesive bonding on T-joint is stronger than other design of joint because it need lower stress. It followed by first design of double T-joint and second design of double T-joint.

**L. Goglio a, et al** [10] the paper is focused on the static strength of adhesively bonded structural joints and seeks a simple calculation rule that can assist the designer in everyday engineering practice. The work encompasses three steps. In the first step, an experimental campaign is carried out on an assortment of customized bonded joints (single lap and T-peel) made of steel strips bonded by an acrylic structural adhesive. The dimensions of the joints are chosen so as to produce a wide range of combinations of shear and peel stresses in the adhesive layer. In the second step, the stress analysis of the joints is performed by means of a sandwich model that describes the variability of shear and peel stresses over the overlap length but disregards the stress singularities at the corners. In the third step, a design rule is inferred by noting that, in a chart having as axes the peak values of the peel and shear components in the adhesive at failure, the points—calculated for each joint at the 2% (deviation from linearity) proof load—define a limit zone. The inferred design rule is that the adhesive withstands the load if the representative point of the stress state lies inside this zone. For the tested case, the envelope of the limit zone has an approximately rectangular shape. This criterion predicts the failure load of the joints far better than the simplistic approach based on the nominal stress calculated as the ratio of the load to the bonded area. The paper also discusses the response which is obtained by applying, to the same experimental data, the traditional calculation based on the mean stress (force to area ratio), and the more sophisticated approach based on the stress intensity factor, which accounts for the singularity of the stress field. Applied to our experimental data, the performance of both has been disappointing.

## III.CONCLUDING REMARKS

I. Adhesive joint fails because of manufacturing errors, improper assembly, overloading, operation, or because of too harsh an environment. However, even if a adhesive joint is perfectly made, assembled etc., it will eventually fail due to fatigue of the joint.It is necessary to detect the strength to avoid failure and for effective maintenance planning.

II. Use of the adhesive joint under loading develops stresses in the joint and causes initiation of rupture. As load goes on increasing, stresses and consequently rupture initiation goes on increasing and it get distributed along whole overlapping length. So it is necessary to find out the stress distribution and rupture initiation.

III. Early detection of the stresses and rupture in the joint, therefore, is crucial for the prevention of damage to the system.

IV. Overlapping length is a common feature of all adhesive joint. It should be perfectly attached by the two material. There should not be any unbalance between the two adherends. They must be attached to each other face to face

## IV.PROBLEM STATEMENT

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 toughness 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.

## V.PROPOSED WORK

1. The FEA using ANSYS is used to find the stresses developed in the joint. ANSYS is proposed because of its simplicity and computation. A FEA method is most suitable.
2. Under ideal conditions, the ANSYS can be used to identify the strength of the joint.
3. Total deformation of the joint can also be calculated with this way. It also gives the no. of nodes and elements employed for the different variation in the double lap adhesive joint.

## VI. CONCLUSION

There are some disadvantages of welding method. It requires skilled welders, it cannot be used for reactive metals. So to overcome this problem use of adhesive material can be studied. It ts expected to reduce the frictional losses as well as fracture in joints. This study is carried out using ANSYS software.

## VII. REFERENCES


1. L. Liao and T. Kobayashi, Toshiyuki Sawa, Yasuhiro Goda, “3-D FEM stress analysis and strength evaluation of single-lap adhesive joints subjected to impact tensile loads”, International Journal of Adhesion and Adhesives, 31,2011, pp. 612 – 619.
2. He Dan, Toshiyuki Sawa, Takeshi Iwamoto, Yuva Hirayama, “Stress analysis and strength evaluation of scarf adhesive joints subjected to static tensile loadings”, International Journal of Adhesion and Adhesives, 30,2010, pp.387-392.
3. AlirezaChadegani, Romesh C. Batra, “Analysis of adhesive-bonded single-lap joint with an interfacial crack and a void”, International Journal of Adhesion and Adhesives,31,2011, pp. 455-465.
4. Quantian Luo and Liyong Tong, “Analytical solution for nonlinear analysis of composite single-lap adhesive joints”, International Journal of Adhesion and Adhesives, 29, 2009, pp. 144-154.
5. D. Castagnetti and E. Dragoni, “Standard finite element techniques for efficient stress analysis of adhesive joints”, International Journal of Adhesion and Adhesives, 29, 2009, pp. 125-135.
6. Mr. Somesh.P.Patil1, Prof.C.R.Patil2, Prof.Tushar Hingwe3, “Design and Analysis of Hybrid Lap Joint using Clinging Tintur”-Review International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 05 | May-2018.
7. Alireza Chadegani, Romesh C. Batra, “Analysis of adhesive-bonded single-lap joint with an interfacial crack and a void”, Department of Engineering Science and Mechanics, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA.
8. D. Castagnetti E. Dragoni Dipartimento di Scienze e Metodi dell’Ingegneria, Universita` di Modena e Reggio Emilia, Italy, “Standard finite element techniques for efficient stress analysis of adhesive joints”, International Journal of Adhesion & Adhesives.
9. . Nor , M. Afendi , M.S. Abdul Majid A.R. Abdullah d and A.B. Shahriman , “Stress Analysis of Adhesive Bonding of Urea Granulator Fluidization Bed”, Applied Mechanics and Materials Vol. 554 (2014) pp 160-164 © (2014)
10. L. Goglio a, M. Rossetto a , E. Dragoni b, “Design of adhesive joints based on peak elastic stresses”, International Journal of Adhesion & Adhesives.