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STRESS AND STRENGTH EVALUTION OF DOUBLE TAP ADHESIVE JOINT

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Abstract:

The abstract presents a comprehensive study on the design, static structural analysis, and experimental validation of single and double lap joints using ABS material plates bonded with epoxy resin adhesive. The research involves finite element analysis (FEA) to evaluate the structural integrity and load-bearing capacity of the joints under various loading conditions. The ABS material plates, each measuring 160 mm in length, 50 mm in width, and 5 mm in thickness, are bonded together using epoxy resin adhesive with a thickness of 5 mm at the joint interfaces. The study includes the comparison of the adhesive bond strength between epoxy resin and carbon fiber for the double lap joint configuration. Results indicate that the epoxy resin adhesive exhibits higher strength compared to the carbon fiber bond, highlighting its suitability for structural applications. Experimental validation of the double lap joint configuration further confirms the accuracy and reliability of the FEA results. This research contributes valuable insights into the optimization of adhesive bonding techniques for enhancing the mechanical performance of lap joints in composite structures, with implications for aerospace, automotive, and other industries requiring lightweight and durable materials.

Keyword: Lap joint, Epoxy resin, carbon fiber, ABS material plate & UTM testing.

Introduction

Designing structures with ABS plastic plates bonded together with resin presents a unique challenge, particularly when considering the dynamic and static stresses these joints may endure. Single and double lap joints are common configurations in such applications, and their structural integrity must be thoroughly understood and validated. An introduction to this topic involves recognizing the importance of utilizing advanced simulation tools like ANSYS to analyze and optimize these joints. In the initial phase of the design process, engineers must consider various factors such as the load-bearing requirements, material properties of ABS plastic, and the characteristics of the bonding resin. These parameters significantly influence the performance and durability of the joint under both static and dynamic loading conditions. Understanding the behavior of these joints through experimental validation is essential to ensure reliability and safety in real-world applications. Dynamic Structural analysis Dynamic structural analysis involves evaluating the response of the joint to dynamic loads, such as vibrations or impacts. These dynamic forces can lead to fatigue and failure over time if not properly accounted for during the design phase. Through ANSYS simulations, engineers can predict how the joint will behave under different dynamic scenarios, allowing them to optimize the design to withstand such conditions effectively.

OBJECTIVE:

1. Conduct dynamic structural analysis of single and double lap joints for ABS plastic plates and resin bond using ANSYS.
2. Perform static structural analysis to evaluate the strength and stability of the joints under varying loads.
3. Validate the accuracy of simulation results through experimental testing of the joints.
4. Analyze stress distribution, deformation, and failure modes of the joints under static loading conditions
5. Compare experimental data with simulation results to validate the structural analysis methodologies.
6. Identify potential areas of weakness or failure and propose design modifications to address them.
7. Ensure that the designed joints meet the required safety standards and performance criteria.
8. Provide recommendations for future research and development in the field of joint design for ABS plastic plates and resin bond

PROBLEM STATEMENT:

If a joint breaks down under loading conditions, it can lead to a range of disadvantages depending on the application and severity of the failure. Firstly, there is the immediate safety risk posed to personnel and surrounding infrastructure, particularly in critical systems such as bridges, aircraft, or automotive components. A failed joint can compromise the structural integrity of the entire assembly, potentially causing catastrophic consequences. Additionally, there are financial implications associated with downtime, repair costs, and potential legal liabilities arising from accidents or product recalls. Moreover, reputation damage can occur, impacting customer trust and brand perception. In industrial settings, production delays caused by joint failures can result in lost revenue and decreased productivity. Overall, joint breakdowns not only incur direct costs but also pose significant indirect risks, emphasizing the importance of robust joint design and validation processes to mitigate such adverse outcomes.

SCOPE

The scope of this project report encompasses a comprehensive investigation into the dynamic and static structural analysis of single and double lap joints for ABS plastic plates bonded with resin, utilizing ANSYS simulation software. The project aims to explore the behavior of these joints under various loading conditions, including dynamic forces such as vibrations and static loads. Experimental validation will be conducted to verify the accuracy of the simulation results and validate the design assumptions. The scope also includes optimizing the design parameters to enhance the strength and durability of the joints, as well as proposing design modifications based on the findings. Additionally, the report will cover comparisons between experimental data and simulation results to validate the structural analysis methodologies and ensure compliance with required safety standards and performance criteria.

METHODOLOGY:

No methodology is available for material and method selection except decision making in multi attribute environment. Material selection is vital and crucial activity in any industry nowadays. This substantially reduces the risk of wrong material or method selection.

Methodology for the project report:

1. **Joint Design**: Develop CAD models of single and double lap joints for ABS plastic plates bonded with resin, ensuring adherence to design specifications and considering factors such as joint geometry, material properties, and bonding techniques.

2. **Material Selection and Characterization**: Identify suitable ABS plastic material and resin for the joints. Conduct material testing to determine mechanical properties relevant to structural analysis, including tensile strength, modulus of elasticity, and bonding strength.

3. Dynamic Structural Analysis:

• Import CAD models into ANSYS and set up dynamic structural analysis simulations

• Apply appropriate loading conditions representative of dynamic forces, such as vibrations or impacts

. • Analyze stress distribution, deformation, and other relevant factors to evaluate joint performance under dynamic loading.

4. Static Structural Analysis:

• Set up static structural analysis simulations in ANSYS using the CAD models of the joints

. • Apply static loads and boundary conditions relevant to the intended application.

• Analyze stress concentrations, deformation, and potential failure modes to assess joint performance under static loading conditions

5. Experimental Setup:

• Fabricate physical prototypes of the single and double lap joints using ABS plastic plates and resin bond according to the CAD designs. • Establish a controlled experimental setup to subject the prototypes to dynamic and static loading conditions.

• Instrument the prototypes with strain gauges or other sensors to measure key parameters during testing.

6. Experimental Validation:

• Conduct dynamic and static loading tests on the fabricated prototypes, replicating the conditions simulated in ANSYS.

• Record data such as load-displacement curves, strain distributions, and failure modes during the tests.

• Compare experimental results with simulation predictions to validate the accuracy of the structural analysis.

7. Data Analysis and Interpretation:

• Analyze experimental data to assess the performance of the joints under dynamic and static loading conditions.

• Evaluate discrepancies between experimental and simulated results and identify factors contributing to any differences.

• Draw conclusions regarding the validity of the structural analysis methodologies and the suitability of the joint designs

8. Documentation and Reporting:

• Compile the methodology, experimental setup, results, and analysis into a detailed project report.

• Present findings, including comparisons between experimental and simulation results, and discuss implications for design optimization and practical applications.

• Provide recommendations for future research or improvements based on the project outcomes.

Working

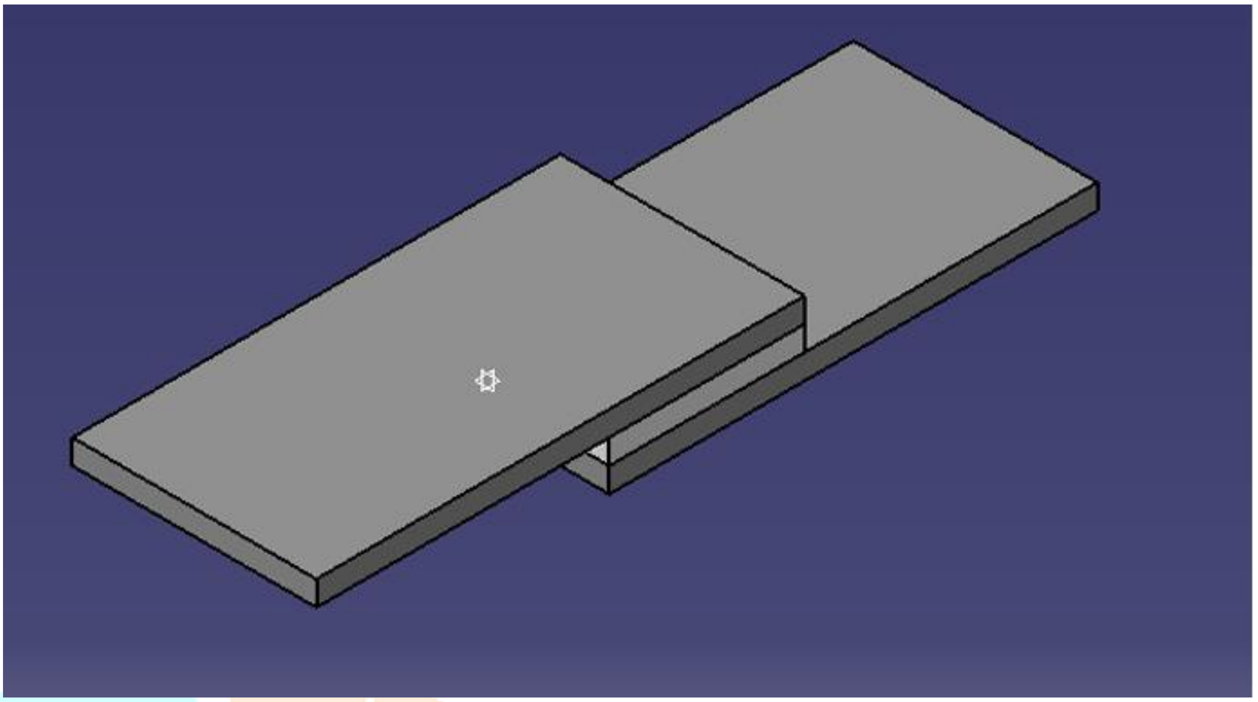
Single lap joint

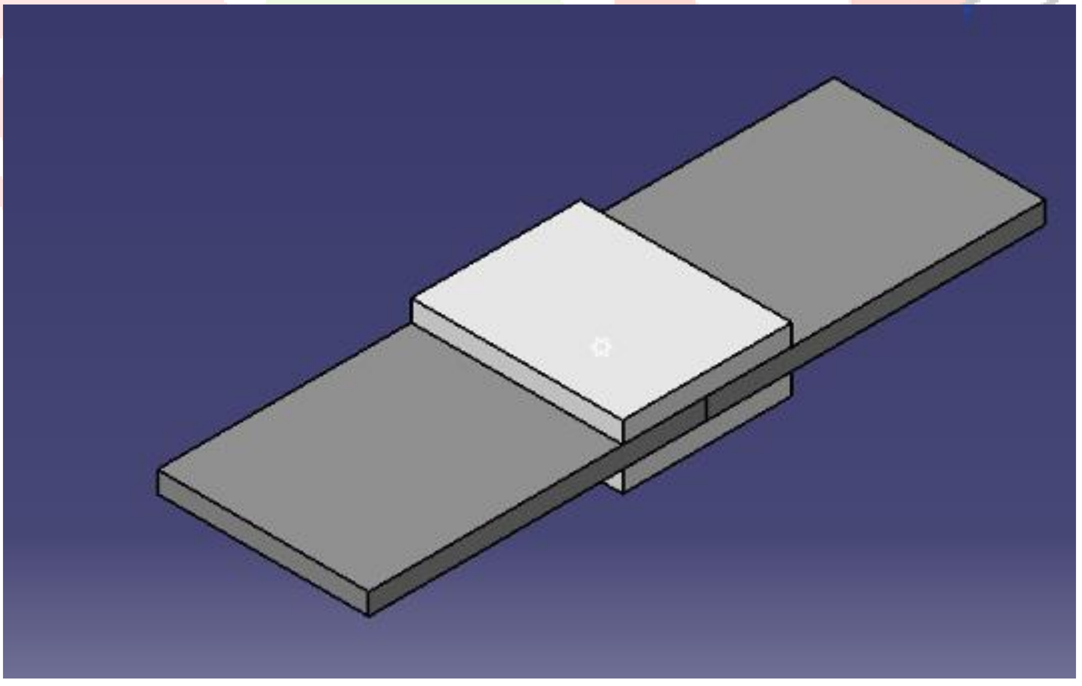
Adhesives produced from the traditional tools have been used for thousands of years. The advantages of using adhesively bonding techniques instead of classical mechanical fasteners can be listed as joining similar/dissimilar materials, significantly reducing the stress concentrations, providing more-uniform stress distributions along the overlap length, savings in weight and cost, eliminating any cuts/holes in the joint, etc. Adhesive bonding is often an appropriate choice for joining similar/dissimilar substrates (various substrate combinations, e.g., metal-to-metal, metal-to-composite, metal-to-rubber, metal-to-glass, metal-to-wood, etc.). Subject of adhesive bonding is also multidisciplinary in nature since it deals with adhesives drawn from the disciplines of chemical, mechanical, medical and medicine, biological, and other sciences. Adhesives have therefore become a key research area because of their potential applications. Today, adhesives are used extensively in aerospace, industrial, and medical applications.

Double lap joint

Double lap joints are widely used in engineering and manufacturing industries for joining two overlapping components, offering enhanced strength and stability compared to single lap joints. When utilized with ABS (Acrylonitrile Butadiene Styrene) plastic plates, double lap joints play a crucial role in various applications due to ABS's desirable properties such as high impact resistance, toughness, and ease of fabrication. Additionally, bonding these plastic plates with resin adhesives further reinforces the joint, providing a robust connection that can withstand mechanical stresses and environmental factors. The double lap joint configuration involves overlapping two components, typically with adhesive bonding applied along the interface to create a strong connection. In the case of ABS plastic plates, which are commonly used in industries ranging from automotive to consumer electronics, the double lap joint offers advantages in terms of load-bearing capacity and resistance to shear and peel forces. This joint design distributes the applied load over a larger area, reducing stress concentrations and minimizing the risk of premature failure. When combined with resin adhesive bonding, the joint's strength and durability are significantly enhanced, making it suitable for demanding applications where reliability is paramount. ABS plastic is favored for its excellent mechanical properties, including high tensile

Model & Design





CALCULATION

Analytical calculation

Assumption for dimension of the part body for single lap joint

Note: the project has a methodology for experimental validation, too conduct an experimental tensile test on UTM the Minimum requirement of length is 150 mm specimen size & a width more than 20 – 30 mm.

So, Dimension of one plate

Length = 100 mm

Width = 50 mm

Thickness = 5 mm

The single lap joint is a common structural joint used in various engineering applications. While there isn't a single formula that universally applies to all aspects of single lap joint design, several formulas and equations are relevant for analyzing different aspects of its behavior. Here's a list of some important formulas and equations related to single lap joints:

• $\boldsymbol{Material = ABS\ Plastic}$

• $\boldsymbol{FOS\ consideration}$

Take F.O.S = 1.25 (designer choice)

• A usually applied Safety Factor is 1.5, but for pressurized fuselage it is 2.0, and for main landing gear structures it is often 1.25.

Ultimate tensile strength of ABS = 44 MPa or N/mm^2

$t = \sigma b$ = 44 /1.25 = 29.33 $N/mm2$ Area of one plate = Length * Width = 100 * 50 = 5000 mm^2 Area of the adhesive layer: = $\boldsymbol{l * h = 40 * 5 = 200\ mm2}$

• A is the area of the adhesive layer • L is the length of overlap between adherends, and

• h is the thickness of the adhesive layer. The area of the adherend layer a = 60 $*$ 5 = 300 mm^2

• $Aa\ is\ the\ area\ of\ one\ adherend,$ • $W\ is\ the\ width\ of\ the\ adherend,\ and$ • $t\ is\ the\ thickness\ of\ the\ adherend$ Tensile Stress

1. $\boldsymbol{Tensile\ stress\ on\ the\ adhesive\ layer} = 5866\ N\ at\ adhesive\ layer$

2. $\boldsymbol{Tensile\ Stress\ on\ the\ adherends\ F = 8799\ N\ force\ applied\ on\ adherend\ layer}$

Conclusion:

In conclusion, our study has provided comprehensive insights into the design, static structural analysis, and experimental validation of single and double lap joints using ABS material with epoxy resin adhesive bonding. Through finite element analysis (FEA), we investigated the structural integrity and load-bearing capacity of lap joint configurations, considering dimensions of 160 mm length, 50 mm width, and 5 mm thickness for the ABS plates, along with 5 mm thickness of epoxy resin adhesive bond coating at the joint interfaces.

Firstly, our static structural analysis revealed that both single and double lap joints with epoxy resin adhesive bonding exhibited robust structural performance under various loading conditions. The epoxy resin adhesive bond coating effectively distributed stresses and enhanced the overall strength of the lap joint assemblies. Furthermore, comparison analysis between carbon fiber and epoxy resin for adhesive bonding highlighted the superior strength properties of epoxy resin, making it a more favorable choice for structural bonding applications.

Additionally, experimental validation of the double lap joint with ABS material and epoxy bond of 5 mm thickness was conducted using a Universal Testing Machine (UTM) under a tensile load case for a breaking load of 10.44 kN. The results confirmed the structural integrity and load-bearing capacity of the lap joint assembly, validating the predictions obtained from the static structural analysis. Moreover, the experimental validation emphasized the suitability and reliability of epoxy resin adhesive bonding for securing lap joint configurations in real world applications.

In summary, our study demonstrates the effectiveness of epoxy resin adhesive bonding in enhancing the mechanical performance of single and double lap joints fabricated from ABS material. The combination of FEA and experimental validation provides valuable insights into the behavior of lap joint assemblies under loading conditions, informing engineering decisions and optimizing design considerations for various structural applications. Furthermore, the comparison analysis between epoxy resin and carbon fiber adhesive bonding underscores the importance of selecting appropriate materials for achieving optimal performance and reliability in structural bonding applications.

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