Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

BUCKLING ANALYSIS IN UNI DIRECTIONAL GLASS EPOXY LAMINATED PLATE

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ABSTRACT

Testing the buckling behavior of plates is a well-established method in research to find the stability of composite structures. Determination of buckling behavior of laminated composite plates subjected to in-plane loads is an important consideration in the preliminary design of aircraft and launch-vehicle components. Composite plates with circular, square and rectangular cut-outs are widely used as structural members in aircraft and launch-vehicle design. In this study, buckling experiments were carried out on Uni- Directional Laminated composite plate specimens and the influence of different cut-out shapes , length to thickness ratio, orientation and aspect ratio are examined and determined experimentally. The thicknesses of plates were changed by increasing the number of layers.After the buckling experiments, Comparisons were made between these two test results. These results show the effect of various cut-out shapes, orientation of fiber, length to thickness ratio and aspect ratio on the buckling load.

Keywords–buckling, composite plate, laminated specimen, cut-out shapes

INTRODUCTION

In many engineering structures such as columns, beams, or plates, their failure develops not only from excessive stresses but also from buckling. Only rectangular thin plates are considered in the present study. When a flat plate is subjected to low in-plane compressive loads, it remains flat and is in equilibrium condition. As the magnitude of the in-plane compressive load increases, however, the equilibrium configuration of the plate is eventually changed to a non-flat configuration and the plate becomes unstable. The magnitude of the compressive load at which the plate becomes unstable is called the "critical buckling load." A composite material consist of two or more materials and offers a significant weight saving in structures in view of its high strength to weight and high stiffness to weight ratios. Further, in a fibrous composite, the mechanical properties can be varied as required by suitably orienting the fibers. Due to the excellent stiffness and weight characteristics, composites have been receiving more attention from engineers, scientists, and designers. During operation the composite laminate plates are commonly subjected to compression loads that may cause buckling if overloaded. Hence their buckling behaviours are important factors in safe and reliable design of these structures.

In view of difficulty of theoretical and numerical analysis for laminated structure behaviours experimental methods have become important in solving the buckling problem of laminated composite plates. This work deals with buckling analysis of symmetrically and laminated composite plates under clamped -free – clamped- free boundary condition. The effects on buckling load by cut out size, length/thickness ratio, ply orientation, and length/breadth ratio are investigated.

COMPOSITE MATERIALS: AN OVERVIEW

Basic requirements for the better performance efficiency of an aircraft are high strength, high stiffness and low weight. The conventional materials such as metals and alloys could satisfy these requirements only to a certain extent. This lead to the need for developing new materials that can whose properties were superior to conventional metals and alloys, were developed.

A composite is a structural material which consists of two or more constituents combined at a macroscopic level. The constituents of a composite material are a continuous phase called matrix and a discontinuous phase called reinforcement.

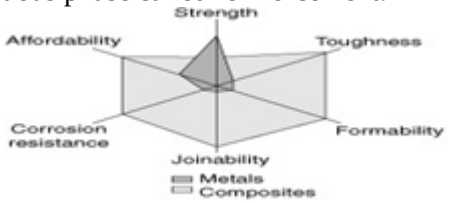

Fig 2.1 Mechanical properties

Fig 2.2 long columns fail due to material failure

The factor which influences the mechanical performance of composites other than the fiber and the matrix is the fiber-matrix interface. It predicts how well the matrix transfers load to the fibers.

Composites are classified by the geometry of the reinforcement as particulate, flakes and fibers2. the type of matrix as polymer, metal, ceramic and carbon. The most commonly used advanced composites are polymer matrix composites. These composites consists of a polymer such as epoxy, polyester, urethane etc., reinforced by thin diameter fibers such as carbon, graphite, aramids, boron, glass etc. Low cost, high strength and simple manufacturing principles are the reason why they are most commonly used in the repair of aircraft structures.

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

Epoxies: Epoxies are polymer materials, which begin life as liquid and are converted to the solid polymer by a chemical reaction. An epoxy based polymer is mechanically strong, chemically resistant to degradation in the solid form and highly adhesive during conversion from liquid to solid. These properties, together with the wide range of basic epoxy chemicals from which an epoxy system can be formulated, make them very versatile.

Buckling – Introduction: There are two major categories leading to the sudden failure of a mechanical component: material failure and structural instability, which is often called buckling. For material failures you need to consider the yield stress for ductile materials and the ultimate stress for brittle materials. Those material properties are determined by axial tension tests and axial compression tests of short column of the material.

Resin: Resin is to transfer stress between the reinforcement fibers, act as a glue to hold the fiber together. Commonly used resin are: Epoxy, polyester and vinyl ester, Epoxy LY556 is selected.

Moulding preparation: Two rectangular mild steel plate having dimensions of 100mm × 100mm x 4 mm. Chromium plated to give a smooth finished as well as to protect from rusting. Four beading are used to cover compress the fiber after the epoxy is applied. Bolt and nuts are used to lock the plate.

Types of hardener: HY951 – at room temperature, HT927 – temperature ranging from 80˚C - 130˚C, HT974 - temperature ranging from 70˚C - 80˚C, HZ978 - temperature ranging from above 100˚C, Preparation of Epoxy and Hardener, Epoxy LY556 and it mixed with Hardener HY951, Ratio of mixing epoxy and hardener is 10:1

SOFTWARE OVERVIEW

ANSYS: ANSYS is a complete FEA simulation software package developed by ANSYS Inc –USA. It is used by engineers worldwide in virtually all fields of engineering. Structural,Thermal, Fluid (CFD, Acoustics, and other fluid analyses), Low-and High-Frequency Electromagnetic.

Types of solution methods: Two solution methods are available for solving structural problems in the ANSYS family of products: the h-method and the p-method. The h-method can be used for any type of analysis, but the p-method can be used only for linear structural static analyses. Depending on the problem to be solved, the h-method usually requires a finer mesh than the p-method. The p- method provides an excellent way to solve a problem to a desired level of accuracy while using a coarse mesh. In general, the discussions in this manual focus on the procedures required for the h-method of solution.

ANSYS results and discussions: Von mises stress of circular notch having more stress capability than the rectangular and plain notch.and moreover deformation results of the circular notch is more less than the plain and rectangular notch.

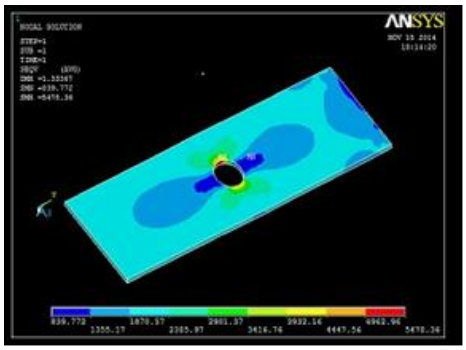

Fig.4.1.Vonmises stress of circular notch

From the various notches are evaluated with testing and ansys results .The comparisons of the both ansys and experimentals results are presented in the below table.These reults are favourable for the circular notchs than the rectangular notchrs and plain notches in terms of deformation , vonmises stress and displacement vector sum. Because of the curved section of the notches having more strength than the other flate notches .Only curved notches are deviates the path of load obtaining at any point and other plain and rectangular notches does not resist the load.

Table.4.1.Testing results of a notch

Contents	Plain notch	Rectangular notch	Circular notch
Maximum displacement	0.0580	0.0099	0.00717
Displacement vector sum	1.0265	1.0995	1.3336
Von mises stress	2020.53	3525.04	5478.36

CONCLUSION

From the obtained ansys results it was found that, the different notches in glass fibre reinforced composites results were found. From those results, the displacement is higher for rectangular notched plate than the others like plain and circular notched plates. Also it was absorbed that, the well-defined notches in composite plates, will provide more strength than the plain structures. It will also optimize the weight of the materials. When some

Journal of Chemical and Pharmaceutical Sciences ISSN: 0974-2115

amount of materials id removed from the structures, then by default manner the weight has reduced of the materials. Also from the results, it was concluded the mechanical strength is increased. Also this study considers the buckling response of laminated rectangular plates with clamped free boundary conditons. The laminated composite plates having varying l/t ratio, aspect ratio cut out shape and ply orientation.

The following conclusions were made

1. Due to making the special notches, the strength was increased.
2. Also due to the notches, the weight of the specimen may be reduced.
3. We will carry out the experimental work and testing of the material behaviours of the fibres in the next phase .

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