"THREE DIMENSIONAL ANALYSIS OF SOME FASTENERS JOINTS IN COMPOSITE LAMINATE STRUCTURE"

Among various methods of joining, fastener joints (bolted) are used in applications, which require periodic assembly and disassembly. Advanced composites have been identified as candidate material systems for a variety of aero propulsion, aero structure, space structure, and airframe components. A number of these applications involve joints between similar and dissimilar material systems. Some of these are mechanical joints such as bolted and riveted connections. Mechanical joints are widely used in the assembly of two or more components. The use of mechanical fasteners such as bolts, rivets, etc., invariably require drilling holes in the components to be assembled. Joints are essential to connect different components of a structure or sub – assemblies and they are envitable in any large-scale engineering structure. The practical problem of load transfer through pin joints in metallic and composite structures has attracted many scientific investigators in the past. Obviously the work of composite structures is more recent. However the complexities involved in the problem due to partial contact and friction at pin hole interface have for many years, required certain novel approaches. The linear problem of push fit pin is the most extensively dealt with whereas the non linear problems of joints with interference and clearance pins were found to be generally more difficult to handle. These joints in metallic structures were analyzed by continuum and finite element approaches.

Obviously, the first few contributions in composite structures were with continuum approach, whereas finite element methods become more popular later.

The mechanics of load transfer has been extensively studied earlier for the case of such joints in metallic structures with a single pin, two dimensional analysis is extensively used. With the advent of composite structures in the recent past, there is a renewed interest in these problems from the viewpoints of both the stress analysis and the strength prediction using three dimensional analysis. An understanding of the process of load transfer at connections like pin joints in composite materials is essential to achieve a level of confidence in analysis and design of composite structures. This is necessary to expand the range of application of composite materials in primary structures. The problem is analytically complex because of load – dependent contact, and friction at the pinhole interface. Hence, anisotropy and in homogeneity of composites add to the complexity. Because of this, the extent of success to date has been

very limited in spite of the growing interest in composites. In view of recent advances in the field of computers and the development of Finite Element Methods to handle complex practical problems. It is proposed to study the three dimensional analysis of pin-plate problem of composites could be very fruitful. The proposed work is an effort in three dimensional stress analysis of pin joints with round pin in a hole in a composite plate using commercial software ANSYS as a tool for finite element analysis.

A circular hole in a composite plate with a circular pin is the basic configuration considered for study to understand the mechanics of load transfer in a pin joint. The modes of load transfer are pin bearing and plate loads. The pin in the plate could be of interference, push or clearance fit, depending on the pin diameter being greater than, equal to or less than the hole diameter. The pin-plate interface exhibits a state of partial contact in all the fits above certain load level on the joints. The extent of contact and separation change with load level leading to a non-linear problem in misfit (interference or clearance) pins. In push fit the problem is linear with invariant (but unknown) extents of contact / separation.

The contact stress problem at the pin – plate interface can be analysed by iterative or inverse methods of approach. In iterative approach, the extents of contact / separation are determined iteratively for a given load level. Inverse technique determines the load level required for various extents of contact / separation. This technique has an extensive potential to generate vast parametric data with limited computational effort, but is applicable only for problems where the initiation of contact / separation and the nature of their variation are known. For anisotropic composites such an approach could be too complicated. The major hurdle in the use of iterative approach is that it could be expensive for parametric study. In most of the earlier works special software is developed for the analysis of two dimensional pin-joints using either iterative or inverse technique, these software's serve specific purpose of the requirements of the problem. Almost all the software's develop for the analysis of pin-joints that are available in literature for two dimensional analysis. And also they do not take in to account the effect of friction at pin plate interface. In the present study it is proposed to use commercial software ANSYS for the first time for contact stress analysis problem in general and pin-joints in particular. The ANSYS software is capable of handling problems of pin-joints successfully. This software has capability of considering effect of friction on pin plate interface using friction elements, in cases where ANSYS does support it is proposed to develop a code (software) which is capable of handling three dimensional problems of pin joints.

As a necessary first step to validate the ANSYS software, several problems of pin-joints in isotropic and orthotropic plates, for which load contact relations and stress distributions are available in literature will be analyzed and the results will be compared. We introduce our three dimensional analysis of pin joints in composites by first studying the load transfer through a basic configuration of a round pin in a round hole in a finite orthotropic plate. The interface is assumed to be smooth. The absence of friction simplifies the problem by making the shear stress uniformly zero on the interface whether the contact is full or partial. Also in the absence of friction, partial contact problems for clearance and interference fits are mathematically identical. The effect of geometry on load contact behavior, radial and hoop stresses will be studied. We start with a simple problem of a hole field with a rigid pin in a finite composite plate under the plate load and pin load systems and then extend the technique for three dimensional cases.

The next stage is to use the ANSYS software for finite element analysis to predict the strength of fastener joints in laminated composite plates. Experimental results available in literature survey on strength of fasteners joints in composites will be utilized for this study and stress analysis will be carried out on the same configurations used in those experimental programs using three dimensional analysis. The strength prediction will be based on the lowest of the tension, bearing and shear out modes of failure.

The three dimensional analysis of pin joint considering the effect of friction on pin plate interface could lead to better understanding of free edge delamination. The effect of friction on load contact behavior and maximum stresses will be demonstrated using ANSYS software for finite element analysis.

METHODOLOGY

The problem is analytically complex because of load dependent contact, and friction at the pinhole interface. Hence anisotropy and inhomegenity of composites add to the complexity. In most of the earlier works the software developed for the analysis of pin joints, that are available in literature survey does not take the effect of friction at pin plate interface. In view of recent

advances in the field of computer and the development of FEM's to handle complex practical problems, an attempt is made to use a commercial software ANSYS for contact stress analysis problem.

The proposed work is an effort in three dimensional stress analyses of pin joints with round pin in a hole in a composite plate using commercial software ansys as a tool for finite element analysis. Three dimensional effects due to thickness – wise variation of stresses could be important in certain lay ups of laminated composites structures [3]. Development of three dimensional analysis could lead to better understanding of free edge delamination effects of stacking sequence, possible relaxation of bolt clamp up pressure, and ill effects due to bolt.

To predict the strength of fasteners joints in composite plates, ANSYS software will used for the finite element analysis. By considering the effect of friction on pin plate interface three dimensional analysis can be carried .And the effect of friction on load content behaviors and stresses can be demonstrate by using commercial software.