A Review on Failure Analysis of Aluminum Alloy Plates With Bolted Joints Using Experimental And Finite Element Method

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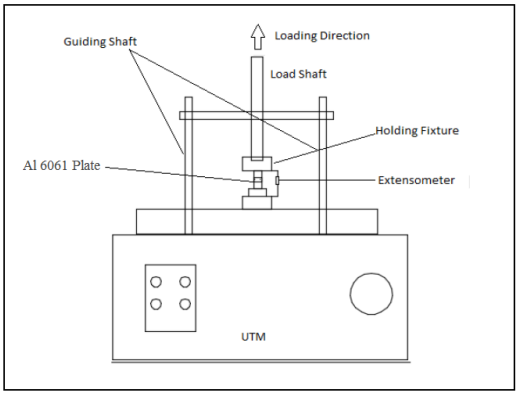
Abstract- *Bolted lap joints are often used in structures and machines to join several elements to one another and to form a structural assembly . It is therefore important to design them safely. Since bolted and riveted parts are stress raisers due to geometrical discontinuities at holes, fatigue cracks often initiate at riveted and bolted joints which results in unexpected failures. This project work will investigate failure modes of aluminum alloy plates with bolted joint with the effect of following parameters like torque(preload), Number of bolts and hole clearance performing experimental testing with help of Universal Testing Machine and validate FEA.*

I. INTRODUCTION

Bolted lap joints are often used in structures and machines to join several elements to one another and to form a structural assembly. Bolted joints have large scale applications in aeronautical and aerospace industries as the joints can be dismantled at any time for maintenance. Bolted joints being very often use in the critical part of the structure, it is therefore important to design them safely. Since bolted and riveted parts are stress raisers due to geometrical discontinuities at holes, fatigue cracks often initiate at riveted and bolted joints which results in unexpected failures. These joints require hole to be drilled in the structure and hence large stress concentration tends to develop around the hole, which can severely reduce the overall strength of the structure. Joints represent potential weak points in the structure. Hence, the design of the joints can have a large influence over the structural integrity and load carrying capacity of overall structure. Several studies in literature have focused on the temporal sequence of events and mechanisms of damage in the bolted joints under tension-shearing. Generally, the cracks begin near the hole due to stress concentration and the rupture stress of the material is exceeded in this area of assembly. Then, the crack propagation phase causes the final failure of the assembly. The rupture may also occur by the shear at joint plane when the tangential stress value reaches its maximum value. The failure modes in the plates of the bolted joint depends on two geometrical parameters describing the edge effects: the plate width W which defines the percentage of the useful area of plate resisting the tensile load and the distance H from the hole's center to the free edges of the plate in the longitudinal direction which define the percentage of the useful area of plate resisting shear load. For bolted (or riveted) joints, the rupture in the plates is always located from the hole's edge. Four failure modes are frequently observed Cleavage failure, Shear-out failure, Net-tension failure, Bearing failure.

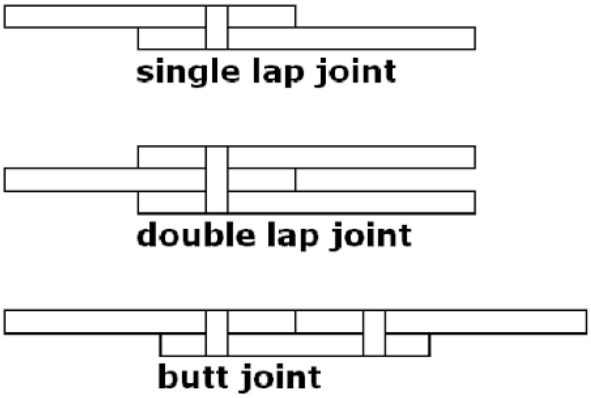
Despite the demonstrated potential for using numerical analysis coefficient of friction depending on the materials in contact, surface ply orientations and the wear of the surfaces caused by cyclic movements.

This variability leads to changes in the maximum load transferred by friction using different plate materials or layups or, with the same joint, during its in-service life. This has a strong impact on the behavior and strength of a joint. A numerical study could significantly contribute to an understanding of how the coefficient of friction influences the joint behavior.



Experimental setup for work

II. TYPES OF JOINTS

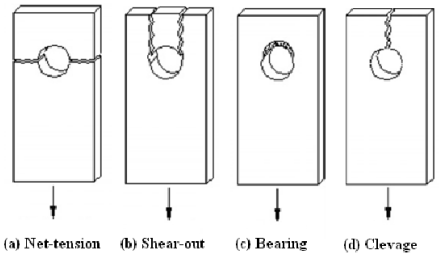


Problem associated with bolted joints:

From the literature review it is observed that level of detail implemented in FE models is still not high enough to fully capture the global and local behavior of the joints and the stress state in their critical locations. In order to have more reliable and accurate results, finer geometrical details, finer meshes, and an accurate definition of the contacts, are needed. In most of the previously published research the joints have been studied in a condition of insignificant bolt pre-load but this case is far from representative of the range of working conditions of composite bolted joints in aviation. For this reason a model able to fully simulate bolt clamping and friction is needed. A few studies have been published on the effect of the clearance but a comprehensive and detailed investigation of the interaction between bolt clamping force, coefficient of friction and clearance and their effect on the joint behavior is still required

Concept Development :

Several studies in literature have focused on the temporal sequence of events and mechanisms of damage in the bolted joints under tension-shearing. Generally, the cracks begin near the hole due to stress concentration and the rupture stress of the material is exceeded in this area of assembly. Then, the crack propagation phase causes the final failure of the assembly. The rupture may also occur by the shear at joint plane when the tangential stress value reaches its maximum value. The failure modes in the plates of the bolted joint depends on two geometrical parameters describing the edge effects: the plate width W which defines the percentage of the useful area of plate resisting the tensile load and the distance H from the hole's center to the free edges of the plate in the longitudinal direction which define the percentage of the useful area of plate resisting shear load. For bolted (or riveted) joints, the rupture in the plates is always located from the hole's edge. Four failure modes are frequently observed Cleavage failure, Shear-out failure, Net-tension failure, Bearing failure.



Failure modes

Scope :

The fastener shapes currently used with composite plates are, in most of the cases, directly derived from the ones used with metal plates. With aluminiumn plates, the final failure is often caused by excessive bearing damage and hole elongation, both under static and fatigue loading. To improve the performance of joints, a deeper understanding of the joint behaviour is needed. The mechanical response of aluminium 6061 bolted joints can be complex due to the interaction between the several parts and the high number of parameters known to influence the behaviour. The mechanical behaviour could be studied with a large amount of experimental tests, which could be both time consuming and very expensive, or, more efficiently, with an integration of selected experimental tests and sufficiently accurate and flexible finite element models

III. CONCLUSION

The main aim of this review paper is to have a proper understanding of different aspects or constraints of bolted joints using plates as well as different failure analysis techniques to reduce the efforts which occurs due to improper selection of joint sizes, hole clearance and proper selection of material for load .This work will investigate failure modes of aluminum alloy plates with bolted joint with the effect of following parameters like torque No of bolts and hole clearance .

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