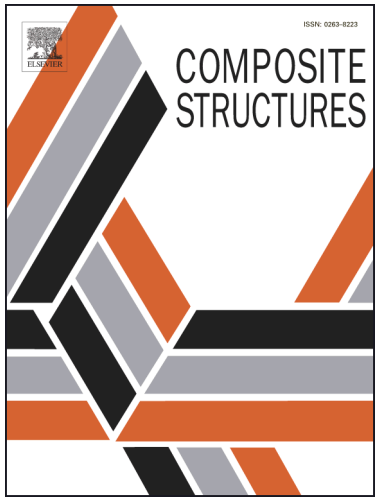

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Evaluation on the interval values of tolerance fit for the composite bolted joint

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Abstract: The bolted joint has frequently been used to join different components together for the composite materials. However, the effect of tolerance fit on mechanical properties of the composite bolted joint is still ambiguous. In this paper, a three-dimensional numerical model is established and validated by reference experiment for the single-lap composite bolted joint. Then the High Dimension Model Representation (HDMR) using Sobol method is employed to analyse the global sensitivity of tolerance fit, bolt clamping force and friction of contact interfaces. The sensitivity index indicates that the tolerance of composite hole is the most crucial parameter for the mechanical properties of composite bolted joint. Finally, the interval values of tolerance behaviours between bolt shank and laminate hole are investigated numerically based on Six Sigma analysis. The tolerance is analysed by considering the influences of perfect fit, clearance fit and interference fit on mechanical properties. This work provides a meaningful reference for selecting the tolerance fit for the composite bolted joint.

Keywords: Composite bolted joint; Tolerance fit; Global sensitivity analysis; Six Sigma analysis.

1. Introduction

Composite structures connected by different joints are being increasingly used in a wide range of engineering applications, such as aerospace, marine and vehicle engineering[1-3]. Generally, the bolted joint, riveted joint, pinned joint and bonded joint are used to join different components of composite material together. The riveted joint is the same as bolted joint except for the applying form of pretension load, and the bolted joint has the advantages of potentially stronger and more reliable than the bonded joint.

Numerous researches have been conducted for the composite bolted or pinned joint [4-8]. According to [9, 10], the design charts of e/d (edge distance to bolt diameter) and w/d (width to bolt diameter) ratios were developed by a series of experiments for the single bolt double-lap joint of Fiber Reinforced Plastic (FRP). Wang et al. [10] acquired the proper design ratio of w/d and e/d based on the ultimate failure strength and the required reliability of the joints. Sun et al, Ascione et al, Esmaeili et al and Liu et al [11-14] studied the effects of clamping area, washer size and bolt initial clamping force on failure and load stiffness; they recommended that the allowable charts of geometric parameters and washer size should be used with bolt pretension load. The influence of stacking sequence on mechanical properties of the composite bolted joint was investigated extensively via experiments and simulations [15-17]. Studies had highlighted that having 0° plies on the surface will reduce the ultimate bearing strength and delamination strength simultaneously, and having 90° plies on the surface was suggested because it helps to improve the strength for quasi-isotropic and orthotropic lay-ups. The theoretical models were also derived to predict the strength at different reliability levels by Khashaba