Maximizing First Frequency Of E-Glass Epoxy Composite Panels Using RSM Design

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Abstract—

In the current paper, the response surface methodology (RSM) has been applied to maximize the fundamental frequency of composite panels. In total 4 different input parameters namely aspect ratio (b/a), thickness ratio (h/a), number of plies (n) and ply angle (θ) are considered. The effect of these parameters on natural frequency is studied in detail. The dataset used for building the RSM model is obtained from FEA simulations. The FEA, in turn, are first compared with experimental data to validate the accuracy of the numerical schemes. It is found that for maximizing the fundamental frequency, thickness ratio should be high. Low aspect ratio and fewer number of plies are desirable.

Keywords— Optimization, RSM design, Composite, Vibration.

I. INTRODUCTION

The vibration of plates is a special case of the more general problem of mechanical vibrations. The equations governing the motion of plates are simpler than those for general three-dimensional objects because one of the dimensions of a plate is much smaller than the other two. This suggests that a two-dimensional plate theory will give an excellent approximation to the actual three-dimensional motion of a plate-like object, and indeed that is found to be true. There are several theories that have been developed to describe the motion of plates. The most commonly used are the Kirchhoff-Love theory and the Mindlin-Reissner theory. Solutions to the governing equations predicted by these theories can give us insight into the behavior of plate-like objects both under free and forced conditions. This includes the propagation of waves and the study of standing waves and vibration modes in plates.

Therefore, the utility of the study carried out in this thesis is very important and diverse. The knowledge generated out of this thesis could be helpful for practicing engineers in domains like aerospace engineering, structural engineering, off-shore and ship building industry, mechanical engineering etc.

A. Problem Definition

Earlier aircrafts were entirely made with aluminum or other such low weight alloys. As one of the most lightweight, malleable metals, aluminum has been used extensively throughout the modern world, most notably in aerospace applications. In recent years, however, composites have begun to supplant aluminum: Half of the Boeing 787 is made from advanced composites, while the remainder of the plane is constructed primarily of a combination of aluminum, steel and titanium. Because they are non-elastic, composites dissipate the energy of vibrations, making them well-suited for applications ranging from equipment mounts to athletic shoe insoles. Aluminum doesn't absorb vibrations as well as composites. Fabricating a product in one piece, whether it's an airplane wing or a wind blade, reduces maintenance because there aren't any fasteners or joints. In highly tension-loaded applications, such as the fuselage of airplanes, this helps decrease fatigue and maintenance. The instruments and sensors mounted on an aircraft need to be precise. Therefore it is desired that the natural frequency of the instruments and the composite dash board panel should not match. Otherwise it would lead to resonance, and hence inaccurate readings.

B. Objective

This work aims to study the effects of the arrangements of the various layers of the laminate, number of layers and the fiber orientations on the first three natural frequencies of a composite aircraft instrument panel board made of E-glass/Poly vinyl ester with a fiber content of around 50%. A parametric study is conducted to study the effect of various material and geometric properties on the natural frequency.

II. Literature survey

Dozio (2011) carried out a comprehensive study on the use of a set of trigonometric functions as admissible solutions in the Ritz method for general vibration analysis of rectangular orthotropic Kirchhoff plates. The method predicted natural flexural frequencies of plates with various complicating factors, including in-plane loads, elastically restrained edges, rigid/elastic concentrated masses, intermediate line and point supports or their combinations.

Manna (2012) presented the first six modes of free vibration for isotropic rectangular plates linearly varying in one direction. He used a high order triangular element to analyse the problem for various taper ratio, aspect ratio and different boundary conditions.