ABSTRACT

In the field of materials science, composite materials have gained attraction as scientist and researchers can improve different mechanical properties as per choice. Due to high stiffness and lesser in weight compared to conventional materials, composites are suitable for weight sensitive application in the field of marine, automobile, sports, aeronautic structure and power plant. In recent past extensive use of laminated composites are found in many engineering discipline like aerospace, mechanical, civil, marine, automobile, and power plant. Composite materials are used in structural application due to reduction in weight and enhancement of strength. Therefore it is an important area for researchers and scientist to analyze different structural parameters and their effects.

Turbomachinery blades are fixed at one end on disc or hub and other end is free. Thus it behaves like a cantilever beam fixed at one end and conical in shape with trapezoidal planform. During rotation blades are subjected to centrifugal forces. In power plants, the composite blades are subjected to high operating temperatures. So it is necessary to understand the dynamic behaviour of conical shell operating under thermal and centrifugal loading.

Delamination or separation of layers is one of the failure mode of laminated composite materials. It may occur at any arbitrary location due to manufacturing defect, loading condition, environmental effect etc. Delamination creates geometrical and material discontinuities. It reduces structural strength and stiffness and as a result the load carrying capacity of the material reduces. Therefore it is necessary to study the effect of delamination on structural strength of composite blades.

It is required to predict the maximum safe load in design of a composite material which depend on several structural parameters, size and location of delamination, rotation and environmental condition. The initial separation of any two layers of laminated composite are known as first-ply failure (FPF). There are several established FPF theories available which are maximum strain (independent), maximum stress (independent), maximum stress (polynomial) Hoffman, Tsai-Hill, and Tsai-Wu. The present work illustrates the effect of some vital parameters like stacking sequence, pre-twist angle, aspect ratio, presence and location of delamination, and rotational speed on the FPF in the delaminated composite conical shell with an initial twist. It is found that the FPF strengths increase on increasing the non-dimensional rotational speed whereas

the strength decreases with size and number of delaminations, aspect ratio and pretwist angle. The stresses developed at the FPF loads are lower in non-rotating conical shells compared to rotating shells.

Dynamic behaviour of composite materials under random impact is a serious concern since the impact phenomenon inevitably arises during manufacturing, maintenance, transport and hostile operating conditions. The presence of delamination intensifies the damage caused by impact which in turn significantly reduces the strength and stiffness of the composite structure. The critical impact velocity at which the first-ply failure may initiate is of utmost engineering concern and importance since failure will propagate at an enhanced rate due to reduced strength of the resulting composite structure. The effect of delamination, aspect ratio, fiber orientation angle on contact force, shell displacement, impact or displacement, impactor velocity are significant parameters as it initiates impact induced first-ply failure. Results include the effects of different parameters like delamination length, aspect ratio, fibre-orientation angle and impact location on the dynamic behaviour of conical shell at maximum safe impact velocity beyond which first-ply failure (FPF) will commence. The Tsai-Wu failure criterion which is the most general and consistent criterion for biaxial stresses is used to predict the critical velocity of impact for first-ply failure initiation in composite conical shells. It is observed that critical velocity decreases on increase of aspect ratio and size of delamination. It is also found that contact force, shell displacement, impactor displacement, impactor velocity decreases on increasing the aspect ratio, size & number of delamination. When the impact location moves from near fixed end to near free end, the contact force, shell displacement, impactor displacement, and impactor velocity decreases.

The FEM codes are developed first validated with available benchmark literatures and the percentage variation between current and published results are found to be between 3%. Then the codes are used for present analysis. The FEM codes are developed using MATLAB and FORTRAN and the results are plotted using standard graph plotting software (ORIGIN).