A SOFT IMPACT DAMAGE PREDICTIVE METHODOLOGY FOR HYBRID/COMPOSITE PROPULSION SYSTEMS

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Summary. A methodology has been developed for predicting high velocity soft impact damage in aerospace propulsion systems utilizing composite and hybrid components in the forward jet engine sections. Explicit finite element platform-based numerical models have been developed that capture the lamina-level behaviors, degradation, and disintegration of engine components resulting from impact and subsequent blade/casing interactions that are critical for determining global structural responses of engines to damage initiated by highly dynamic events.

1 INTRODUCTION

Aerospace propulsion systems are frequently subjected to high velocity impact with soft objects, particularly in the form of bird strike. Jet engines are at particular risk for foreign object damage due to the combination of high vehicle speed and fan rotational velocity. Impact with the fan section can cause blade fragmentation and engine casing degradation, as well as damage to downstream sections as fragments are ingestion. To mitigate this threat, engine manufacturers conduct costly physical tests, launching bird carcasses into fully functioning engines to assess the crashworthiness of new engine designs.

Novel engine concepts have been developed that incorporate composite and hybrid metal/composite components into the engine forward section. Composite fan blades and casings are lighter, more corrosion resistant, and possess superior in-plane strength; however, they display a lack of strength in the through-thickness direction and are subject to brittle failure under impact loading. To compensate, metal alloy reinforcements may be utilized to stiffen composites, resulting in hybrid structures.

The objective of this research is to develop a methodology for accurately predicting the intricate mechanisms of soft impact damage in hybrid/composite jet engine forward sections. Three-dimensional explicit finite element models are developed simulating a bird impact event on an engine forward section. Critical components to be modeled include the fan blades, engine casing, and engine supporting structures. Damage will be characterized by the
degradation, fracture and failure of its constituent parts resulting from impact and subsequent destructive interactions among forward section components.

2 MODELING METHODOLOGY

Composite and hybrid structures will be modeled using the Lagrangian finite element approach. Methods for predicting and modeling composite damage will be assessed for consistency of the predicted results with changes in modeling parameters and for their ability to identify damage sources such as composite delamination, matrix fracture, and metal/composite debonding.

Soft objects behave as a fluid during a high velocity impact event. To capture the fluid-solid interactive nature of bird impact, a meshless Lagrangian particle approach will be utilized. Meshless methods are suitable for capturing large deformations of the bird material and have been used successfully in previous studies to model soft body impact damage in a composite aircraft fuselage and wing leading edges [1, 2]. Particle behavior is governed by Navier-Stokes equations modeling fluid behavior.

![Figure 1: Meshless particle bird model capturing fluid-solid interaction](image)

The methodology developed will facilitate evaluating the crashworthiness of advanced hybrid/composite engine forward sections subject to soft impact. Such a tool is invaluable for the design and certification of future propulsion systems in order to reduced reliance on physical testing and develop engines with optimal safety and performance.

REFERENCES
