

Failure Analysis of a 105mm Fin Deployment Mechanism

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Abstract: In order for artillery projectile guidance and control systems to meet precision performance requirements it is necessary to utilize fin stabilization rather than the conventional means of spin stabilization of artillery projectiles. Since the munitions are fired from a gun tube it is necessary for the fins to be stowed and secured during launch and then deploy once the projectile has left the muzzle of the weapon. The gun launch environment which a fin stabilized 105mm projectile can see is upwards of 15,000 G's of axial acceleration as well, it is required to have fins fully deployed within 30 milliseconds after exiting the muzzle brake in order to stabilize the projectile.

During the first test of the XM-1137 VAPP fin deployment mechanism one of the test rounds experienced a structural failure of the fins. Using pressure data from the test as well as material testing of the recovered hardware in finite element analyses using Abaqus the root cause of the failure was identified. Abaqus/CEL was used to model the gun gas flow from the base of the projectile into the pressure orifice and Abaqus/Explicit was used to fit a Johnson-Cook damage model to the actual material test data. The results of these two analyses were then used in a full model of the projectile base and fin assembly in Abaqus Explicit to replicate the failure by fracture of the fins during the dynamic event of gun launch and fin deployment.

Keywords: Projectile, Artillery, Damage, Dynamics, Failure, Johnson-Cook

1. INTRODUCTION

1.1. Introduction

Abaqus 6.9-1 Explicit was used to create a structural model of the VAPP base assembly subjected to gun launch loads. The purpose was to replicate the predicted failure mode in order to confirm the root cause of failure as identified by the investigation team. A 3D CAD model was created of the base/fin deployment mechanism in Pro/E Wildfire 3.0. Material testing was done on the recovered failed hardware in order to match Johnson-Cook parameters in a tensile bar analysis so that a proper damage material model could be used in the detailed analysis. Abaqus's Coupled Eulerian-Lagrangian capability was used to solve for unknown pressure loads based on data acquired by the weapon system's instrumentation. The results of the tensile bar analysis and the CEL pressure loads were used to successfully replicate the failure of the fin during launch as well as validate design improvements implemented to mitigate the failure mode.