Determination of Critical Flaw Size in Gun Launched 40mm Grenade

Nicholas Payne, Jonathan Jablonski, James Grassi, Dr. Jennifer Cordes

Abstract: The inspection and screening of flaws in high explosive filled gun fired projectiles are crucial to ensure safety for soldiers using these items. In bore failure of structural components are sure to produce lethal consequences, therefore it is of great importance to determine what the maximum permissible crack size is for a given component coming off of the production floor. The analytical process to determine critical flaw size occurs in two stages. First, ABAQUS Explicit finite element analysis code is used to conduct interior ballistic simulation of a 40mm shape charge projectile. The modeling scope includes interior gun tube geometry with drive band engraving and spin up effects. Pressure load inputs, which were derived from live fire test data, are used to drive the model. Secondly, the explicit model results are passed to NASGRO software for critical flaw size determination using linear-elastic fracture mechanics theory. The modeling information and approach to the problem will be presented in this paper as well as explicit model results and proposed inspection criteria.

Keywords: Critical Flaw Size, Engraving, Interior Ballistics, Fracture Mechanics, Gun Launch

1. Introduction

The M433 projectile is a 40mm, low velocity, shaped charge grenade. The grenade carries a fuze device which upon impact, initiates a billet of high-explosive material, which then turns a metal liner into a high speed jet of material that penetrates armor plating. During the launching of the grenade, the body is under intense inertial forces that put significant amounts of stress in the material. Any voids or cracks under this type of loading can propagate and cause a breakup of the grenade in-bore. Because this device is used in a hand held gun system, defective structural parts pose an inherent risk to the soldier and cannot be tolerated. The central objective of the analysis detailed in this report is to determine safe inspection criteria for the structural components of the M433.

Finite element analysis methods are used extensively during the design process of a gun fired projectile to ensure the structural integrity and safety of the design. However, these analyses presuppose that the parts are defect free and uniform in characteristic. Since these items are also intended to be produced at a mass scale, a variety of manufacturing methods are relied upon to achieve cost reduction. Often there is a link between part cost and part quality, with cheaper manufacturing methods being more prone to causing defects in the finished component and thus compromising safety. It is at this point critical flaw size analysis can be utilized to determine acceptable inspection parameters at the end of the production line. Critical flaw size analysis gives an approximation of the largest permissible crack size that can be tolerated for a given part given the stress magnitude and distribution determined in the previous finite element model.