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Finite element simulation of impact on PASGT army helmet

Mayank Singh Rajput*, Manish Kumar Bhuarya, Arpan Gupta

School of Engineering, Indian Institute of Technology Mandi, Mandi 175005, India

Abstract

This paper presents the numerical simulations to determine the impact resistance of Personal Armor System Ground Troops (PASGT) helmet. Initially impact of spherical projectile on PASGT helmet travelling at 205 m/s is studied. The result of this simulation was used to verify the material data and compare the work with previous literature. Two standard tests, namely the MIL-H-44099A and NIJ-STD-0106.01 Type II helmet are also simulated. For the simulation on MIL-H-44099A, a fragment-simulating projectile (FSP) strikes the helmet with an impact velocity of 610 m/s. For the simulation on NIJ-STD-0106.01 Type II helmet, the projectile is a 9 mm full-jacketed bullet with a striking velocity of 358 m/s. Results from the simulation show that the KEVLARs helmet is able to resist a 9 mm full-jacketed bullet travelling at 358 m/s. The above simulations were performed using Finite Element Method in explicit formulation, implemented through Ansys AUTODYN-3D.

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Keywords: PASGT helmet; impact; bullet; finite element simulation.

1. Introduction

Helmets are one of the most important and basic personal protective equipment used by soldiers. Any impact on head can cause brain injuries and can have serious consequences. Therefore it is very important to predict the impact response of helmet using simulation. In this research work, dynamic response of helmet and damage threshold in terms of acceleration, stress, strain and other failure criteria for a range of impact locations and velocities is studied. In this Project we developed CAD model of helmet, and performed Finite Element simulation for impact loading.

* Corresponding author.
E-mail address: mayankrajput052@gmail.com

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Helmets have been used since ancient times. Helmets then were used to protect head from sword blows and arrows. They were first made of leather and brass, then iron and bronze were used for making helmets and then steel was used. Their use declined after rifled firearms were introduced in the late 1700s, as they provided inadequate protection. In World War I, helmets were reintroduced as they provided sufficient protection against fragments from artillery shells and indirect firearms. French developed the first modern steel helmet known as Adrian helmet, and introduced it in 1915. Brodie helmet was developed by the British as an attempt to cope up with France in World War I and soon other countries followed them [1].

Later on other advanced materials were used for better protection like nylon, e-glass fiber, stretched polypropylene, aramid etc. Aramid (marketed under the name Kevlar) is a strong and heat-resistant synthetic fiber and it has many desirable properties. It is mostly used in the helmets that are in use today. Other models were developed increasing the safety and also providing additional gears. PASGT, ACH, FAST and ECH are few to name. The problems faced in the previous helmets were weight, chinstrap design, padding and overall fit and they were rectified in later models. Nowadays helmets are equipped with accessories like Night vision device, communication devices, video cameras, masks etc. to provide extra support to soldiers [1].

There are two important soldier-relevant goals while designing helmet:

- Reducing weight for equivalent protection and small increased weight for significantly increased capabilities
- Increasing situational awareness in all environmental and obscurant conditions without sacrificing mobility and agility.

Our objective was to validate the model of helmet and KEVLAR 129 material by doing the impact simulation of impact of spherical projectile on helmet. After confirming it we did two standard simulations on PASGT helmet, namely:

- MIL-H-44099A
- NIJ-STD-0106.01 Type II

In simulation of NIJ-STD-0106.01 Type II, a 9mm FMJ (Full Metal Jacket) bullet with a striking velocity of 358 m/s impacts the helmet. In the simulation on MIL-H-44099A, a 1.1 g FSP (Fragment Simulating Projectile) will strike the top of the helmet with an impact velocity of 610 m/s.

In the past there have been various studies – experimental and numerical related to impact of bullet on helmet. Tham et al. [2] presents a comprehensive work on both aspects. Simulations were performed on AUTODYN and experimentally spherical balls were launched at a velocity with a velocity of 205 *m/s*, 358 *m/s* and 610 *m/s*. It is shown that KEVLAR helmet is able to resist a 9 mm full jacketed bullet travelling at 358 *m/s*. The experiment results have been shown to match well with the simulation results. Design of helmets have been described by Kulkarni et al. [1] against traumatic brain injuries. Various types of helmets have been proposed such as Kevlar, K29, K129, etc. Hoof et al. demonstrated numerically that the interior deformation in helmet is more compared to impact on flat panels [3]. Aare et al. has also studied head response due to ballistic helmet impact using finite element method [4]. They have studied PASGT helmet coupled with human head. Scharine [5] has also showed the design of these helmets may also affect the sound heard by the soldier. David and Samil [6] have studied PASGT helmet from ergonomic perspective to identify potential risk and injuries due to ballistic impact.

Tan et al. [7] has studied the effect of different type of interior cushioning in ballistic impact. The study is conducted experimentally and numerically. Similarly head liner system and impact directions on severity of head injuries have been studied by Tse et al. [8], [9].