Ballistic Analysis of 14.5 AP Bullet on Armor Material

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Abstract—**14.5 AP Ballistic impact on armor steel was simulated to investigate the effect of material and obliquity on ballistic resistance performance. The research was conducted with explicit dynamic code and AUTODYN on ANSYS commercial software. The result revealed that single layer of 10 mm V250 steel could not defeat 14.5 mm AP bullet. The second layer of alumina ceramic on V250 steel can increase ballistic resistance of V250 steel and leads troop survivability.**

Keywords— Ballistic simulation, material, 14.5 mm AP bullet

I. INTRODUCTION

Commercial armor steel is one of armor material which traditionally used for building body of armor vehicle. The main performance of commercial armor steel is to defeat armor-piercing (AP) projectiles at appropriate level and usually can readily form to intended shape without any failure. [1]

The research on ballistic performance will be worked on parallel between numerical analysis and experimental approach. There are some differences on advantage/disadvantage among them. The experimental approach usually launches the real and exact information but it needs some established experimental facilities including monitoring and analyzing equipment simultaneously. The numerical analysis is the method which reduces cost of ballistic study and needs resources less than experimental approach however, the result may be deviated from real situation and it is frequently compared to experiment for confirming and correcting analysis technique as well as constitutive material model.

There were several researches devoted to investigate the bullet impact on armor commercial steels. [2]Flis et al (2010) carried out 2D ballistic study of 12.7 bullet impact on 10GHMBA armor steel with explicit finite element code ANSYS-AUTODYN and found the agreement between numerical analysis and experimental observation. The ballistic simulation does not only primarily provide appropriate armor material but it also can analyze structured complicated problems depending on chosen material constitutive model. [3]Narayanamurthy et al (2014) examined the ballistic simulations of cylindrical bullet on military vehicle door using 3D nonlinear dynamic explicit finite element code ANSYS LS-DYNA which performs according to simple plasticity model. Even though the plasticity model revealed the large strain effect, impact parameters, and energy transfer between bullet and target, but it could not predicted the plug formation at test velocities. When the development of higher capable bullet is growing up, the single layer of armor steel is not protectively effective so that layered steel or material is attracted increasingly. [4]Buchar et al (2002) analyzed 7.62 AP numerical ballistic simulation of dual hardness steel utilizing 3D LS-DYNA finite element code and the front of target was made by TENAX tool steel which is higher hardness than 2P armor steel as second layer of target. The dual hardness material well exhibited bullet penetration resistance and the numerical simulation was still excellent agreement between numerical analysis and experiment.

In this study, numerical simulation of 14.5 mm AP bullet impact on armor material was performed in order to analyze ballistic resistance and provide some solution to defeat 14.5 mm AP bullet.

II. MATERIAL MODELING

Material models are the crucial components to define material behaviors being used in numerical analysis. A constitutive model is a mathematical expression that relates flow stress to parameters such as strain, strain rate, temperature and internal state variables. Johnson-Cook strength model was employed in order to define strength of metallic material which subjected to large strains, high strain rates, and high temperatures. An impact phenomenon is classified as an impulsive loading problem which can describes by JC model. The model defines yield stress Y as an explicit function of strain hardening, strain rate hardening, and temperature softening in

$$Y = \left[A + B\varepsilon_p^n\right]\left[1 + C\log\varepsilon_p^*\right]\left[1 - T_H^m\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

ε_p = effective plastic strain

ε_p^* = normalized effective plastic strain rate

T_H = homologous temperature = $(T - T_{room})/(T_{melt} - T_{room})$

This model is easily implemented in computational codes due to its simplicity. All the parameters are coupled due to the multiplicative nature of the model. Furthermore this model assumes that strain rate and temperature sensitivity are independent of each other, while real materials display a strain