World Academy of Science, Engineering and Technology
International Journal of Mechanical and Mechatronics Engineering
Vol:9, No:10, 2015

Accurate Calculation of the Penetration Depth of a Bullet Using ANSYS

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Abstract : In developing an armored ground combat vehicle (AGCV), it is a very important step to analyze the vulnerability (or the survivability) of the AGCV against enemy's attack. In the vulnerability analysis, the penetration equations are usually used to get the penetration depth and check whether a bullet can penetrate the armor of the AGCV, which causes the damage of internal components or crews. The penetration equations are derived from penetration experiments which require long time and great efforts. However, they usually hold only for the specific material of the target and the specific type of the bullet used in experiments. Thus, penetration simulation using ANSYS can be another option to calculate penetration depth. However, it is very important to model the targets and select the input parameters in order to get an accurate penetration depth. This paper performed a sensitivity analysis of input parameters of ANSYS on the accuracy of the calculated penetration depth. Two conflicting objectives need to be achieved in adopting ANSYS in penetration analysis: maximizing the accuracy of calculation and minimizing the calculation time. To maximize the calculation accuracy, the sensitivity analysis of the input parameters for ANSYS was performed and calculated the RMS error with the experimental data. The input parameters include mesh size, boundary condition, material properties, target diameter are tested and selected to minimize the error between the calculated result from simulation and the experiment data from the papers on the penetration equation. To minimize the calculation time, the parameter values obtained from accuracy analysis are adjusted to get optimized overall performance. As result of analysis, the followings were found: 1) As the mesh size gradually decreases from 0.9 mm to 0.5 mm, both the penetration depth and calculation time increase. 2) As diameters of the target decrease from 250mm to 60 mm, both the penetration depth and calculation time decrease. 3) As the yield stress which is one of the material property of the target decreases, the penetration depth increases. 4) The boundary condition with the fixed side surface of the target gives more penetration depth than that with the fixed side and rear surfaces. By using above finding, the input parameters can be tuned to minimize the error between simulation and experiments. By using simulation tool, ANSYS, with delicately tuned input parameters, penetration analysis can be done on computer without actual experiments. The data of penetration experiments are usually hard to get because of security reasons and only published papers provide them in the limited target material. The next step of this research is to generalize this approach to anticipate the penetration depth by interpolating the known penetration experiments. This result may not be accurate enough to be used to replace the penetration experiments, but those simulations can be used in the early stage of the design process of AGCV in modelling and simulation stage.

Keywords : ANSYS, input parameters, penetration depth, sensitivity analysis
Conference Title : ICMEM 2015 : International Conference on Mechanical Engineering and Mechatronics
Conference Location : Barcelona, Spain
Conference Dates : October 26-27, 2015