UNIVERSITI TEKNOLOGI MARA

HYDRODYNAMIC RAM BALLISTIC LIMIT ANALYSIS OF ALUMINIUM TANK

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Thesis submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

Faculty of Mechanical Engineering

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CONFIRMATION BY PANEL OF EXAMINERS

I certify that a panel of examiners has met on 16 March 2016 to conduct the final examination of Mohd Rozaiman Bin Aziz on his Doctor of Philosophy thesis entitled "Hydrodynamic Ram Ballistic Limit Analysis of Aluminium Tank" in accordance with Universiti Teknologi MARA Act 1976 (Akta 173). The Panel of Examiners recommends that the student be awarded the relevant degree. The panel of Examiners was as follows:

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

This thesis presents the ballistic impact study for the non-filled and water-filled aluminium tank. This study combined the ballistic limit (BL) and hydrodynamic ram (HRAM) together. Previously, these two areas were not cross-field. Researchers in BL concentrated on determination of the minimum velocity to perforate a target. Common targets are single plate and double plates either in contact or has a space/air in between. There is less study by using double plates with water in between as the target. Meanwhile in HRAM study, many researchers are concentrated on pressure-time history. Less attention was given towards minimum velocity to perforate target. It is important to determine the BL in HRAM study, otherwise the target will not perforate. As a result, pressure-time history cannot be obtained. The main objective of this research is to investigate the BL in HRAM of an (water-filled) aluminium tank, experimentally and numerically (simulation). Meanwhile the specific objectives of this study are to determine the BL and carry-out HRAM investigation thru experiment associate with analytical model, to develop finite element model for BL and smoothed particle hydrodynamics (SPH) model for HRAM simulation and to validate the mode of failure and wall deformation obtained from simulation with experimental results. The tank was impacted with fragment simulating projectile (FSP) with velocities ranging from 239 m/s up to 972 m/s (experiment) and 2000 m/s (numerical simulation). The aluminium tank was 3 mm thick, 150 mm wide and 750 mm long. The ends of tank were closed with two Polymethyl Methacrylate (PMMA) windows, which were fixed to the tank with four steel bars. The test was conducted at the Science and Technology Research Institute for Defense (STRIDE) Batu Arang, Selangor. A commercial software, Hyperworks, was used to perform the numerical simulation. Smoothed Particle Hydrodynamics (SPH) was selected to couple with finite element analysis to simulate the experiment. The result from the experiment showed that the ballistic limit for the aluminium tank was 257.7 m/s. Good agreement was obtained with the numerical simulation. In HRAM, previous researchers obtained pressure-time history by using pressure transducer. So, data was obtained from different particles. In this study, for the numerical modeling approach, the pressure-time history was extended for a single particle. This is a new perspective of tracing pressure-data history since previous researchers focus on different particles. In addition, current study proposed a new value of coefficient '*a*' in the analytical model by Recht and Ipson. Less attention was given by other researchers towards value of coefficient '*a*' for target double plates with water in between. The coefficient '*a*' of the Recht and Ipson equation proposed was 0.64. Other results that were discussed in details are the relationship of impact velocity with parameters such as residual velocity, wall deformation, velocity drop and energy, and terminal ballistic.

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