Abstract

Modernization of Polish Armed Forces artillery component include implementation of modern RAK (CRAWFISH) mortar as a fast support unit. One of main goals of the mortar is a shooting range above 10 km. Because nowadays used projectile OF-843 B can't ensure the required range the RAK-MUNITION programme have been started. As the programme contractor consortium of Military Institute of Armament Technology and Z. M. DEZAMET S.A. was chosen. The ammunition requirements include: range above 10 km, muzzle velocity above 500 m/s, and mass of the projectile 15,5 kg. The requirements extort advanced analysis of projectile flight at supersonic velocities. Literature review shown a lack of information about supersonic mortar projectiles flight. Therefore author objective is to develop a flight model for supersonic mortar projectile and aerodynamic characteristic determine methodology. At beginning of the work author analyse behaviour of the mortar projectiles. In the analysis, data from the high speed camera and the Doppler radar were used. The movies from high speed camera shown that the projectiles total angle of attack can increase significantly. For better exploit of the radar data, resultant aerodynamic force coefficient calculation program was made. During the ammunition programme developing several shooting tests were made. Author used the data from the tests of four different types of the projectiles. The analysis of the radar data suggest that the developed projectiles can flight with high total angles of attack. That conclusion forced usage of rigid body projectile flight model in further work. 5 degrees of freedom model was developed as a simplified version of standard 6-dof model. The model use a four different aerodynamic coefficients: drag force, lift force, overturning moment and pitch damping moment. To calculate them Computational Fluid Dynamic methods were used. Pitch damping coefficient was calculated from Bryson equation. Then author compared experimental data and generated by 5-dof model. Excluding the first projectile type experimental and calculated values had a very good correlation. For all of the projectile types differences between experimental and calculated values fulfil required by thesis main objective. Also unstable flight of one of the projectiles type were modelled correctly. For the first projectile type shooting author find reason of lower quality of results. The radar data from fourth projectile type shooting shown influence of projectiles temperature at their drag shape. The last chapter of the thesis describe influence of the projectile sections for overall drag coefficients. The main objective of the work was achieved. There was also confirmed that CFD methods can ensure high accuracy of aerodynamic coefficients estimation. The methods were faster, cheaper and more flexible than shooting or wind tunnel tests during early developing stage. Results of the work help to ensure required range for the developed projectile in RAK-MUNITION programme.

Keywords: supersonic mortar projectile, exterior ballistics, experimental tests, CFD, aerodynamic coefficients, drag reduction