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Quantification of the Erosion Effect on Small Caliber Guns: Experimental and Numerical Analysis

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Abstract : Effects of erosion and wear on the performance of small caliber guns have been analyzed throughout numerical and experimental studies. Mainly, qualitative observations were performed. Correlations between the volume change of the chamber and the maximum pressure are limited. This paper focuses on the development of a numerical model to predict the maximum pressure evolution when the interior shape of the chamber changes in the different weapon's life phases. To fulfill this goal, an experimental campaign, followed by a numerical simulation study, is carried out. Two test barrels, « 5.56x45mm NATO » and « 7.62x51mm NATO,» are considered. First, a Coordinate Measuring Machine (CMM) with a contact scanning probe is used to measure the interior profile of the barrels after each 300-shots cycle until their worn out. Simultaneously, the EPVAT (Electronic Pressure Velocity and Action Time) method with a special WEIBEL radar are used to measure: (i) the chamber pressure, (ii) the action time, (iii) and the bullet velocity in each barrel. Second, a numerical simulation study is carried out. Thus, a coupled interior ballistic model is developed using the dynamic finite element program LS-DYNA. In this work, two different models are elaborated: (i) coupled Eularien Lagrangian method using fluid-structure interaction (FSI) techniques and a coupled thermo-mechanical finite element using a lumped parameter model (LPM) as a subroutine. Those numerical models are validated and checked through three experimental results, such as (i) the muzzle velocity, (ii) the chamber pressure, and (iii) the surface morphology of fired projectiles. Results show a good agreement between experiments and numerical simulations. Next, a comparison between the two models is conducted. The projectile motions, the dynamic engraving resistances and the maximum pressures are compared and analyzed. Finally, using this obtained database, a statistical correlation between the muzzle velocity, the maximum pressure and the chamber volume is established.

Keywords : engraving process, finite element analysis, gun barrel erosion, interior ballistics, statistical correlation
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