Development and Validation of a Riflescope Mathematical Model During Recoil

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Abstract *— The design, development, and production of new riflescopes have been driven by research and development into cutting-edge materials, techniques, and technology for use in the sport optics industry. With each evolution, the riflescope should be functionally evaluated to observe and acquire data on the riflescope's behavior during recoil. While assessing, field data is the most accurate and reliable way to certify a new product for commercial use. However, it is expensive to only verify all parameters after having a functional physical sample or prototype. A riflescope mathematical model would allow for more significant innovation while mitigating the risk of project failure. For this, the setup should be modeled, simplified for computational performance, and verified with field data. The Ansys platform will be used to model the design. The rifle/riflescope setup's recoil is fast and usually measured in milli or microseconds. Considering this, the mathematical model will have to be an explicit nonlinear simulation using Ansys Explicit Dynamics.*

Due to the complex phenomena occurring during the propellant ignition, projectile acceleration, and recoil wave traveling through the mechanical parts, the model needed simplification but was created with a rifle and riflescope assembly to absorb all the recoil energy reliably.

This work uses data inputs such as chamber pressure curves to induce recoil for a specific caliber charge. This simplification eliminated the need to model the propellent, ignition, and explosion parameters. The projectile velocity and riflescope acceleration are output parameters used to verify the input chamber pressure curve and the model, respectively.

In order to verify the mathematical model for accuracy, the simulation data results must be compared and approximated to known field data results. In this work, the simulation results are of similar magnitude to the experimental data obtained through data acquisition and analysis. The model is thus acceptable for testing innovative geometries, processes, and materials in riflescopes.

Keywords *— riflescope, recoil, acceleration, displacement, Ansys, explicit dynamics*