Research on A Novel Integral Projectile Combining of Warhead and Armature for The Railgun

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The railgun always launches hypervelocity fin-stabilized projectiles. If it may launch the conventional cannon projectiles, the railgun will have better compatibility and scalability. This paper will study a novel projectile which is similar to the conventional cannon gun projectiles. The spinning stability coefficient:

$$\sigma = \sqrt{1-\frac{\beta}{a^2}} \qquad \sigma_0 = \sqrt{1-\frac{4000}{\pi^2}\frac{\eta^2}{\mu_x C_m g}\frac{h}{d}\frac{J_y}{J_x}k_{mz}(M)}$$

Figure 1. Structure of the novel projectile

The novel projectile for electromagnetic launch is shown in figure 1. The main difference is a tail arm at the rear, similarly adding a C-type armature. We called this structure as an integrated electromagnetic projectile (EMP).

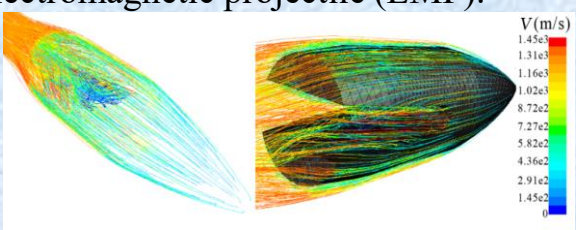

Figure 2. Air flow of the integrated projectile

The main difference is that the tail arm causes the air flowing through the slot of the tail arm, some air flow disturbance will be generated at the tail of the projectile, seen as figure 2.

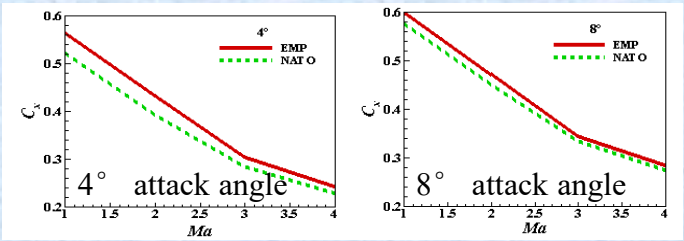

Figure 3. Comparison of the drag coefficient

The drag coefficient of EMP in this paper is slightly higher than the NATO projectile.

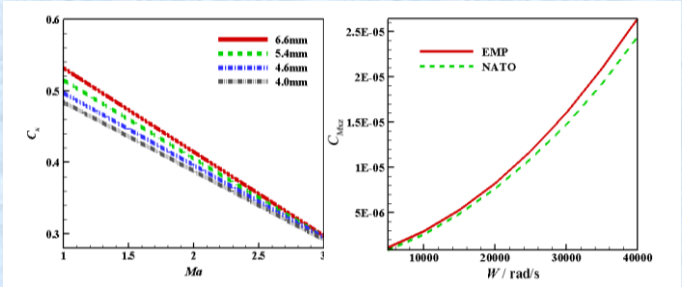

Figure 4. (a)Influence of tail arm size of projectile on the drag coefficient (b)Roll damping moment coefficient.

The smaller the tail arm length, the smaller the influence of the drag coefficient. As the tail arm increases the rotation resistance, the roll damping moment coefficient of the EMP is larger.

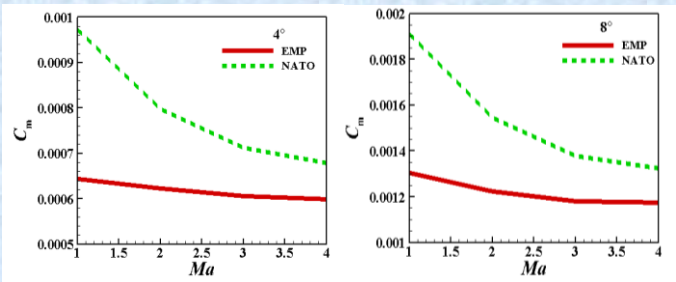

Figure 5. Comparison of pitch moment coefficient

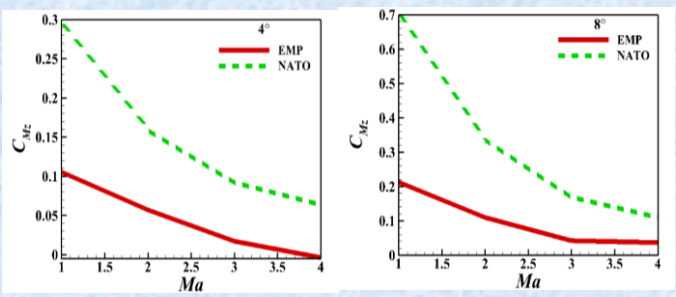

Figure 6. Comparison of Magnus force coefficient

The pitching moment coefficient of the EMP is smaller, means the smaller the overturning moment, and the better the flight stability. The Magnus force of the EMP is much smaller, due to the tail arm, the air can flow through the slot, reducing the velocity difference on both sides.

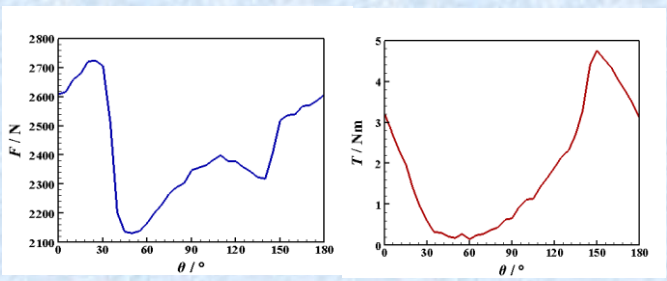

Figure 7. Electromagnetic force and torque

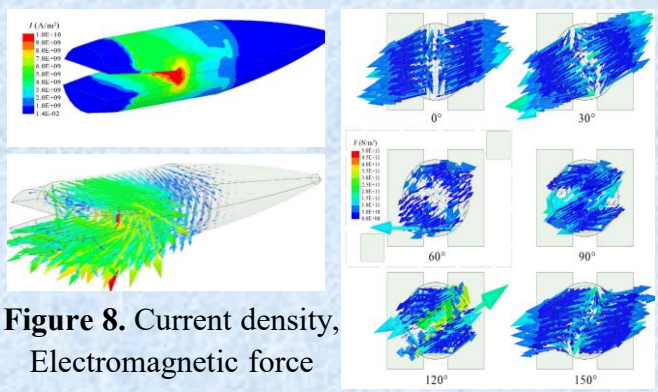

Figure 8. Current density, Electromagnetic force

At different rotation angles, the electromagnetic force and torque of the projectile are changed with rotation angle, means the force, torque, movement are unstable. This is a drawback of the EMP. Increasing the number of tail arms may solve this problem.