WAYS TO INCREASE LAUNCH VELOCITIES OF 2-STAGE GAS GUNS

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ABSTRACT

The amount of space debris is rapidly increasing and the debris is distributed over a wide variety of orbits. Satellites, manned space vehicles and space stations will have to pay increasing attention to the dangers of impacts with space debris. Various armoring techniques (i.e., double or triple layer armor) will have to tested extensively to determine the most effective armor per unit weight. Intersecting near-earth orbits can lead to impact velocities up to 15 km/sec. Conventional two-stage light gas guns can launch[1] intact, controlled-shape projectiles with a density of 1.2 gm/cm^3 and length-to-diameter ratios of 0.5-1.0 at velocities up to 8-9 km/sec. Higher velocities (10-11 km/sec) can be obtained[1] for very light projectiles. The higher launch velocities tend to be very severe on the high-pressure coupling and barrel of the gun and lead to short component lifetimes. Clearly, the ability to raise the launch velocity of a gun (for reasonably massive projectile shapes) from 8-9 km/sec to 11-13 km/sec (or higher), without reduction of component lifetimes, would have significant benefits. This would allow much better simulation of the higher velocity debris impacts as well as better simulation of high speed re-entry into planetary atmospheres.

Several techniques for increasing the launcher muzzle velocity above 8-9 km/sec have been studied using CFD simulations and appear to offer the potential for significant gains. The first technique is to use multiple compressions, instead of a single compression, in the pump tube of the light gas gun. In a sense, this is a kind of pre-heating of the gas in the pump tube; other types of pre-heating have yielded disappointing results in the past.[2] The dynamics of the multiple compression pump tube is very different, however, from the earlier techniques, where the pump tube was typically heated ohmically before the gun cycle was started.[2] In this paper, we present CFD calculations that show that significant increases in muzzle velocity can be obtained with multiple compressions in the pump tube.

With a conventional two-stage gun, an important limitation to obtaining higher velocities is friction and heat transfer to the barrel, which typically has a length-to-diameter ratio of 200-400. These viscous losses greatly reduce the effectiveness of the regions of the barrel far removed from the second stage breech. We have studied computationally the effect of adding an additional breech (or breeches) along the barrel to reduce these viscous losses. Velocity increases from 6.5 to 7.2 km/sec have been obtained[3] using the main breech and one additional breech. In these results, both breeches were operated with hydrogen, heated electrothermally. We have also studied a gun geometry where the main breech is operated in the conventional manner, using piston compression. The additional breech is operated either with electrothermal heating or heating by using a high explosive charge in a novel geometry. The latter option provides very effective compression, heating and

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acceleration of the hydrogen working gas and is fully reusable. Calculations are presented which show that very substantial increases in muzzle velocity can be obtained this way, without overstressing the projectile or the gun.

The third technique studied is to add a section of ram accelerator tube after the barrel to further accelerate the projectile. The ram accelerator used here is not the conventional premixed gas ram accelerator,[4] but a new technique using high explosive as the energy source and pure hydrogen as the working gas in a geometry which can be made fully reusable. Preliminary results with this new ram accelerator geometry were presented in Ref. 5 and showed that stable ram accelerator drive can be established. Herein, detailed calculations are presented which show that substantial velocity increases can be obtained using this ram accelerator technique in tandem with a conventional light gas gun.

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