USE OF COMPOSITES ON THE FCS-MRAAS SWING CHAMBER LAUNCHER FOR REDUCED SYSTEM WEIGHT

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ABSTRACT

The Future Combat Systems (FCS) is envisioned to be extremely lethal, easily sustainable and highly deployable. The Multi-Role Armament and Ammunition System (MRAAS) is an Advanced Technology Demonstrator, which will demonstrate an armament system that will meet the Army's FCS needs. One of the major hurdles for the FCS will be meeting the target weight of 18 tons. To achieve this goal, composite materials will play a major role in any design. MRAAS's Swing Chamber Launcher, is a good example of the use of composite materials to reduce system weight. The system weight allotted to the launcher is 2450 lbs, the current weight using predominantly conventional materials, is 3300 lbs. The launcher must therefore loose 850 lbs while still meeting its key system requirements of: multi-role capability (direct and indirect) while firing on the move; range of 0 – 4 km direct and 2 – 50 km indirect; -10 to +55 degrees of elevation; and burst rate of fire of 15 – 20 rounds per minute.

1. INTRODUCTION

The FCS-MRAAS Swing Chamber Launcher (Figure 1 and Figure 2) consists of the gun tube assembly, swing chamber, tube support, actuation mechanisms, motors/gear box, and breech ring. The swing chamber design was chosen for its overall benefits to the system. First it enables the gun to be loaded while the tube is elevated and stabilized, as the chamber can rotate to its loading position independent of gun tube elevation. Second it enables a much simplified autoloader design. Both of these allow for higher rates of fire, but the major benefit is the significant weight/space claim reduction for the overall system. Though using a swing chamber helps to achieve these characteristics it does present some potential problems for the system. First, since the chamber is separate from the barrel the connection between the chamber and the barrel must be sealed in addition to sealing the rear of the chamber as in a conventional system. This separation of the chamber from the gun tube also requires a large breech ring. The breech ring surrounds the chamber and provides the rear bearing for the gun tube. The breech ring must therefore withstand the firing loads transmitted by the swing chamber and the gun tube, while minimizing deformation such that the gun seal integrity is maintained. It is not the stresses, but rather the stretch and deformation that present a problem. This has led to a breech ring that is heavier than is desirable.

2. USE OF COMPOSITES

The current design of the breech ring weighs 1400 pounds in order to keep the stretching and deformation to an acceptable level. The goal is to have the breech ring weigh 925 pounds. To accomplish this a composite overwrap is being investigated. High stiffness polymer matrix composites are being investigated as uniaxial wraps. These wraps would provide the stiffness to counteract the stretching problem while the steel provides the strength to handle the firing stresses.

Normally the chamber would be part of the gun tube and the tube could be gripped into two places providing an appropriate wheelbase to help with accuracy. With the swing chamber the tube is screwed into the breech ring and is thus only held in one location. Supporting the tube at only this point is insufficient to keep tube deflections to an acceptable level. To overcome this problem a tube support was designed that rigidly attaches to the tube approximately 40 inches out from the breech ring. The rear part of the tube support attaches to the breech ring. Besides providing additional stiffness to the tube

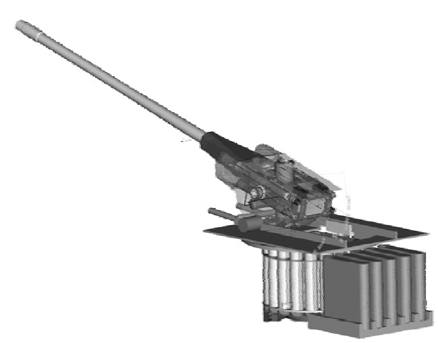

Figure 1 FCS-MRAAS swing chamber gun with autoloader

the support also functions as the rear part of the tube's environmental shroud.

The tube support was envisioned from the beginning as a composite part. Polymer matrix composites are being used for their high stiffness to weight ratios, and easier processing and lower cost as compared to metal matrix components. The tube support is a thin shell changing from the rectangular cross section of the breech ring in the rear to the circular cross section of the tube in the front. This shape change of the support is visible in Figure 2. Titanium fittings are bonded to the shell at both ends to attach the shell to the breech ring and gun tube.

For the first generation of the tube support a monocoque construction is being pursued using IM7 and M55J carbon fibers. Using these fibers a layup has been designed that will have the same deflections as a solid titanium piece but with 1/5 the thickness. Since the composite has a density ¼ that of titanium this presents a substantial weight savings over a titanium piece.

For future generations of the tube support, more advanced structural configurations, such as chamber core and isogrid, are being considered. These could present even greater weight savings with the same or higher stiffnesses but necessitate the move from a rectangular to an oval cross section for support.

The pivot point for the entire launcher assembly is coincident with the rotation axis of the swing chamber. Since the center of gravity of the assembly is 78.9 in from the rear face of the tube this presents a significant imbalance at the trunnions. Besides the imbalance problem the tube assembly presently weighs 925 pounds while its weight goal is 750 pounds. Decreasing the weight of the tube to meet this goal will help with the imbalance, however it also reduces the recoiling mass and thus increases recoil forces. Special care must be taken to balance these to aspects. Ideally one would like to have just enough material to meet the loads imparted to the tube and then place any weight needed for recoil mitigation where it will do the least harm to the balance of the system.

Organic composites are being studied to help combat this imbalance problem by reducing the weight of the middle and muzzle end portions of the tube. Besides the imbalance, composites can also help with increasing the stiffness of the tube. Decreasing weight at the muzzle end of the tube will increase its natural frequency while helping with imbalance. In this section of the tube any composite overwrap is made primarily of hoop wraps, as they will provide the maximum weight loss while helping to contain pressure. Towards the middle of the tube the wraps change to primarily axial as these have the largest effect on overall stiffness. If a residual stress can be built into the composite then the composite to steel ratio can be increased and even greater weight saving can be achieved.

Figure 2 FCS-MRAAS swing chamber launcher

Dynamic strains are an effect where the passage of a fast moving projectile can cause strains to increase to several times what they would be under static loading. Using a composite overwrap may help to alleviate this problem. To test this theory a composite overwrapped tube (XM25 Technology Demonstrator Tube) was fired in Jan of 2002.

This tube was wrapped in 1994 and at the time was the culmination of Benét's efforts in composite tube design. Its design includes most of the features considered for the FCS-MRAAS Swing Chamber tube overwrap plus some additional ones, such as embedded fiber optics, so it presented a unique opportunity to test these ideas without manufacturing a tube. The tube was instrumented and 21 rounds were fired to study the dynamic strain problem. The data shows significant reductions in dynamic strains.

3. CONCLUSION

At present the FCS-MRAAS is 850 pounds over its goal of 2450 pounds. Use of advanced composites on the tube, breech ring, and tube support can significantly reduce the weight of these parts and help to achieve the target system weight. Additionally the composites will help with other issues such as the imbalance of the tube and dynamic strains.