Sniper Rifle System 99D-Series 2 Anti-Matériel

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Abstract—**The report will discuss the design, analysis, and modeling process of an airsoft replica. This replica can be used by kids as well as adults for their amusement. This project was conducted as a part of independent research in the Illinois Institute of Technology, Amour College of Engineering.**

I. Introduction

The Purpose of this project was to use computer software packages to design, model and analyze an airsoft replica based on an object from a video game. The components of the rifle are a combination of the shelf parts from an airsoft M4 carbine and custom built parts that will make up the body of the rifle. The rifle is designed to be powered by green grass in order co cycle the action. The rifle was to be built using a combination of aluminum, steel, and plastic (See Figure 1).

Figure 1. Render of final design concept.

II. Concept Generation

The concept generation began when we found an object file for the Halo 3 SR and downloaded it. Once it was downloaded, the object file was then opened in a 3D modeling software which enabled us to concert the file into .dxf format. The .dxf format was then opened in Solidworks which allowed us to then save it as a Solidworks file. The file was then opened and the dimensions were calculated using the conversion factor. The conversion factor was determined using the dimensions from the Halo Wiki page. Using the Halo wiki page, we found that the total length is approximately 187.5 cm or 73.82 inches in length. Since this determined the external dimensions, we then moved to the internals. The internal dimensions of the purchased parts were obtained by physically measuring the purchase components of WE M4 gas blow back rifle.

III. Research

Research was a big part of this project which included the material, components, and the alignment of the components and the manufacturing ability of the product. The initial material for this product was aluminum 6061. The issue we faced using the aluminum was that the rifle was about 60 pounds. This caused us to start researching other materials. Thus, using matweb.com, we started researching other alternative materials by the physical properties. We then used the light weighting method to decrease the overall weight of the product. We determined that using a combination of aluminum, steel, and ABS plastic would result in the lightest possible product while still maintaining the structural integrity of the rifle. Table 1 shows the Abaqus material cards used during the FEA (Finite Element Analysis) simulations.

*MATERIAL, NAME=AL6061T6	*MATERIAL, NAME=ABSPC	*MATERIAL, NAME=STEEL304	*MATERIAL, NAME=ASTMA229
*Density	*Density	*Density	*Density
0.0975,	0.0408,	0.289,	0.284,
*ELASTIC	*ELASTIC	*ELASTIC	*ELASTIC
10000000, 0.33	330000, 0.35	28000000, 0.29	29000000, 0.29
*PLASTIC	*PLASTIC	*PLASTIC	
40160.0, 0.0	7879.666667, 0	31234.76571, 0	
48825.0, 0.076697487	12837.5, 0.446606301	98820, 0.296575307	
58788.889, 0.15112486	18242.45152, 0.75565006	196068.0403, 0.523625821	

Table 1. Material cards used in FEA simulations (English units).

The next part of our research was the components, we picked most of our internal component based on their availability. The components that were used were mostly from WE M4 Gas Blowback Rifle since it is a common rifle. Thus the parts were readily available and affordable. This brings us to the alignment of the components.

The alignment of the components was done by trial and error. The internal alignment was based on the external dimensions. Using the external dimensions, the cuts for the internal components were created. Once we found the dimensions of the internals, we then started to research for the components that would fit the best with the design of the body (See Figure 2).

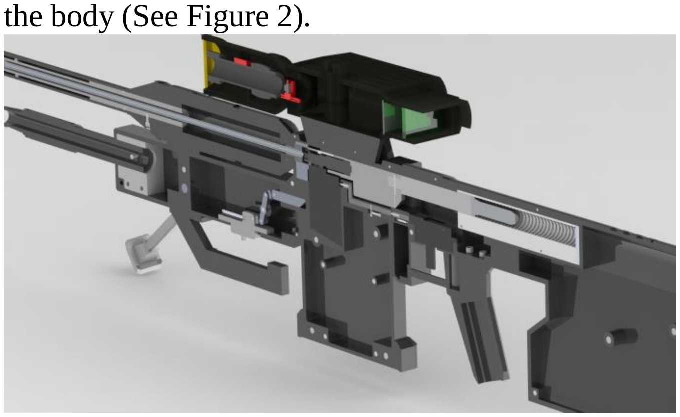

Figure 2. Cut-away showing internal components.

Once we found the perfect match, we then finalized the components for the project. Which finally brings us to the manufacturability of the product.

The process was started by talking to professional engineers that had experience working with the materials that were picked by us. We then started researching the amount of time it would take us to create the product. Once that was done, we started looking into machine shops and the amount of money it would cost.

IV. Cost and Marketability

The total cost of a single prototype would range anywhere from S1500 to $1700. This cost was calculated using the price researched using the internet. The prices of the metals were searched and were estimated. The machining cost of estimated by talking to machining shops and getting a rough verbal costs to machine the parts. The material that we used for estimating was a 24x36x1.5 aluminum sheet that costs about $300. An aluminum pipe for a barrel would costs about $75. The internal components of the products would cost about $300. Which is split evenly between the gas airsoft components and the optic components. The largest cost would be the machining cost which can be estimated anywhere from $800 to $1000. Which makes the total manufacturing cost of about $1700 Dollars. The cost of the product can be minimized by mass production. By mass producing this product we can get whole sale prices on materials which will drop the prices by 15 to 20 percent. The cost for internal components would also go down by 10-20. The machining cost would also go down significantly which would make this product appealing the hard core air softer as well as the halo/cosplay enthusiast. The cost can also be minimized by casting. Casting is much cheaper as that eliminates the use of high speed CNC machines. It would also minimize the manual labor as well as have faster turnaround time.

V. Analysis

Finite element analysis was conducted on multiple components in the assembly. Multiple analyses were conducted on the bolt carrier assembly to check for plastic deformation in components during normal cycling of the replica. Static analysis was conducted on the bolt carrier under a constant spring force being applied by the return spring in the buffer system (See Figure 3).

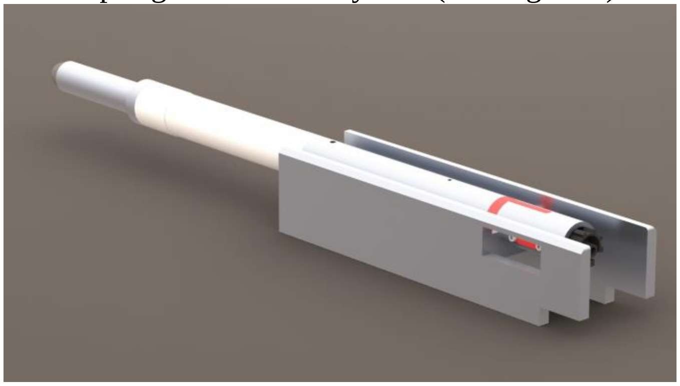

Figure 3. Bolt carrier assembly

The analyses determined that no plastic deformation will take place and even heavier springs than the stock purchased component if needed to cycle the bolt into battery (See Figure 4).

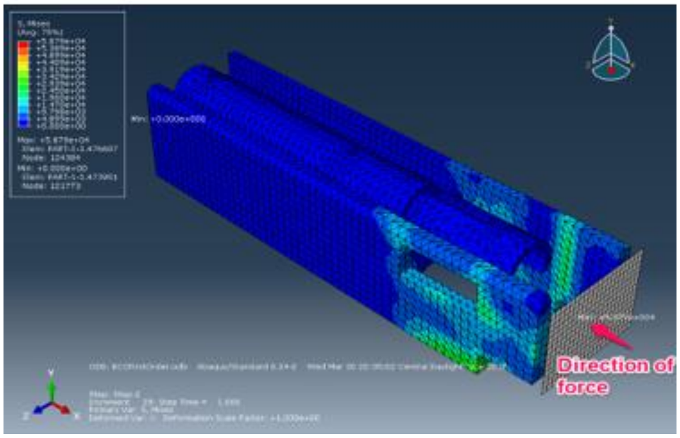

Figure 4. Displacement loading applied to face of bolt carrier.

Dynamic analyses were conducted on the bolt carrier assembly including the bolt carrier assembly by impacting a rigid body in both the forward cycling and rearward cycling motions. The bolt carrier assembly was determined to travel at 3.625 in/s forward into battery, and 10in/s rearward (selected at roughly three times the forward travel speed to simulate over-exaggerated movement).

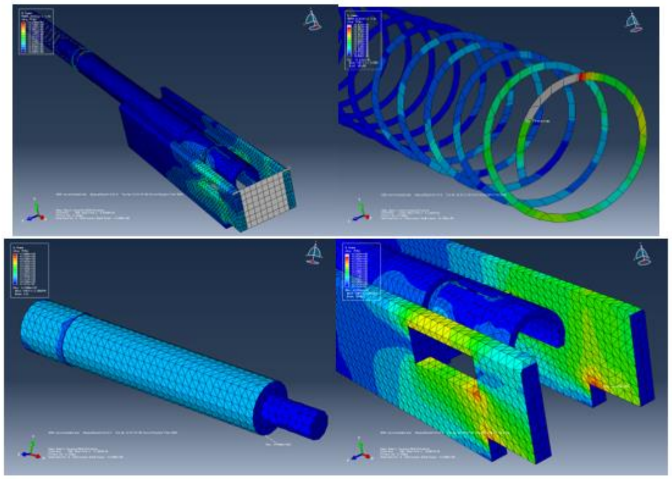

Figure 5. Bolt carrier assembly impacting rigid wall (forward).

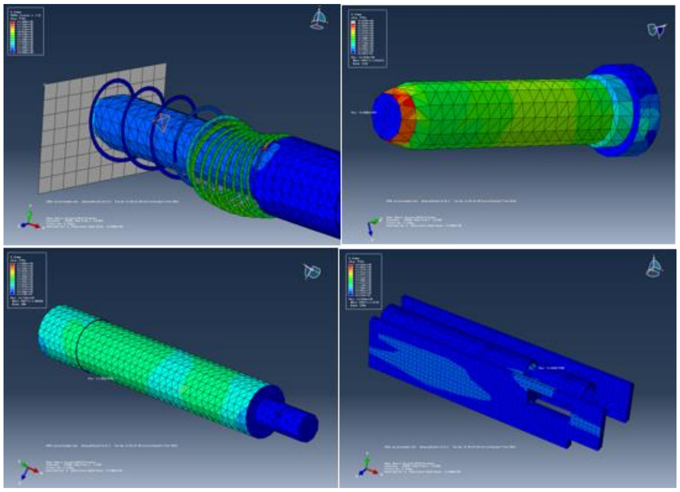

Figure 6. Bolt carrier assembly impacting rigid wall (rearward).

Further analysis was conducted with the bolt carrier assembly impacting the front receiver walls (See Figure 7).

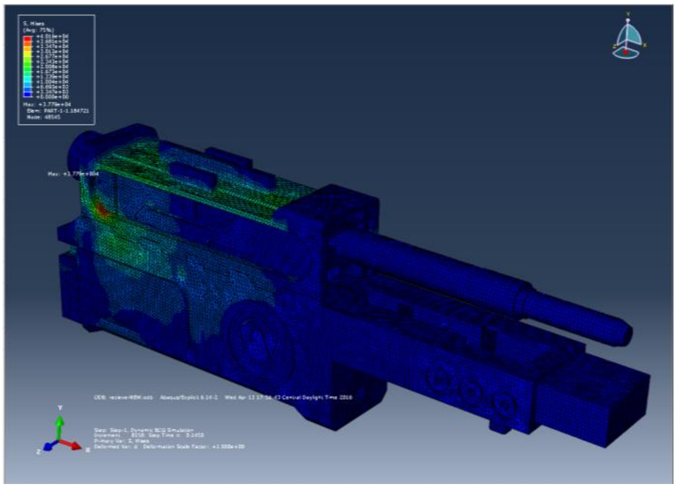

Figure 7. FEA on bolt carrier assembly with front receiver components.

The analyses determined that no plastic deformation would take place during any of the cycling movements on any of the bolt carrier assembly, nor on the receiver components. The components in their current design and material configuration will be able to survive normal cycle impacts.

Several drop tests were attempted: one for the receiver assembly components, one for the barrel assembly components, and one for the two magazine shell components. However, during the .odb file creation an unknown fatal error (found in the .dat file) prevented completion of the conversion. No information was able to be determined from the analyses.

VI. Marketplace

There are many manufacturers of gas blow back airsoft rifles and handguns. Since we are building a custom gas blow back sniper rifle, we are going to focus on high end rifles that will be in a similar price range as ours. The price of a high end airsoft sniper rifle is about $1300 to $2200. This price range is not fixed; there are other rifles that cost upwards of $5000. The high end rifles have a steep price tag stemming from the 1:1 scale replication of real steel firearms that are used by militaries and law enforcement agencies around the world. The rifles are built using CNC machined parts and assembled by hand to ensure the best fit by the parts. The materials that are used are the same materials that are used by firearms manufacturers: an aluminum body, steel barrel, and polymer stock and grips.

Aside from collectors of high end airsoft rifles, there is also another demographic that would be interested in purchasing the rifle. This includes fans of the Halo videogame series and cosplayers. After all, this rifle is a full scale replica of the sniper rifle used in Halo 3 video game.

For comparison, we included a list of five high end airsoft sniper rifles that are in the same price range as the rifle we designed as well as others that above the specified price range. The following rifles are sold by redwolfairsoft.com. The first rifle that is similar to ours is the SOCOM Gear Chetak M200 Shell Ejecting 8mm Airsoft Gas Sniper Rifle. It retails for $1299 and it is currently out of stock on their website. The RWC x Socom Gear Barrett M82A1 (M107) Ver.2 - Digital Desert is also in a similar price range. The rifle retails for $1342 and it is currently in stock. An example of a rifle that is out of the price ranges is the Airsoft Surgeon ADT 300 WIN MAG, which retails for $2165 and is currently out of stock. Also, the Airsoft Surgeon XM2010 is a prime example that some of these airsoft rifle is truly high end. The rifle retails for $5700, and it is currently out of stock. The last rifle is Socom Gear Barrett M107 GBB Shell Ejecting which retails for $1650 and is currently out of stock. The anticipated price range of a full production version of the SRS99D-AM would be between $1500 and $2000. Using

VII. Future Improvements

Additional design considerations have been considered to improve the replica's manufacturability. Removing surface features to decrease the number of cuts made on blocks of aluminum will speed up the manufacture process and decrease machining time cost. Using different manufacturing techniques for mass production such as casting will also decrease machining cost and time for tooling and setup.

VIII. Conclusion

The Sniper Rifle System 99D-Series 2 Anti-Matériel would be a successful product on the airsoft and videogame/prop marketplaces. The components are sufficiently strong enough to handle the repeated impact during normal cycling of the bolt carrier assembly. Based on the CAD files, the internal components will perform in the new housing and can be easily replaced or upgraded. While the price is higher than average airsoft replicas, it is accurately priced for high end gas airsoft replicas.