Traumatic Brain Injury Reducing Army Combat Helmet

Team 6
Week 4
February 17, 2009
Kristin Ohanian
Work Completed

My fourth week of BME 4910 was used to add more layers of triangles onto the Kevlar shell, remove the shell from the ACH, and do some more research for the team. After several weeks of practice, we are satisfied with our comfort level with working with composite materials and have developed our own techniques. We now have a feel for the amount of epoxy components that must be used and we have developed a method of layering that we find productive.

As of last week, our shell had three layers of triangles on it. We got together this week and put another three layers of triangles on top. We have found that the first layer is the most difficult to lay, as the triangles fall off easily because there is only a smooth surface for them to attach to. We solved this problem by pouring epoxy resin onto wax paper and dipping the triangles into it, instead of painting it on. This method completely covered the triangles in epoxy and gave them the right amount of adhesion to stay on the helmet. After this layer, we went back to the same method of painting the epoxy on the triangles to prevent excess and dripping.

This week we mixed smaller batches of epoxy resin and cure in order to prevent setting while we were still using it. We also used a more strategic approach when deciding where to place the triangles. Last week, the bottom of the helmet was jagged and uneven. This week we worked on making the bottom more uniform, as can be seen in Figure 1. We layered more around the ears and sides in order to have extra strength for when we drill holes for the suspension system and guards.

Figure 1. Outer shell after 6 layers of triangles.
In order to keep the project moving along, we decided it was necessary to remove the shell from the ACH acting as a mold inside. The shell has already taken on its basic form and the ACH is no longer needed. We have also added enough layers such that prying off the ACH would not damage the shell we created.

We began trying to remove the shell by cutting around the inner edge with a knife. Epoxy had settled and cured along the rim of the ACH and we figured that by loosening the edge, it would be a lot easier to remove. The knife didn’t work very well, as the epoxy resin is extremely strong once cured. We then tried several methods that included loosening it by jamming a screw driver into any open areas and trying to pry the helmet out. Hitting the shell against the ground was also unsuccessful in even loosening it.

We decided to go to the machine shop to see if Rich and Serge had any ideas or tools that could help us. Rich found a scraper similar to the putty knife shown in Figure 2. It was thin enough to get between the two surfaces and sharp enough to loosen the epoxy by scraping at it. After going around the entire rim of the helmet with the putty knife, we dropped the helmet on the table and the ACH popped right out. An inside view of the shell is shown in Figure 3.

The mold preparation including all the layers of parting wax were sufficient to keep the shell from sticking to the upper region of the ACH. However, gravity caused most of the extra epoxy to drip down and collect near the rim, which is why we had a difficult time trying to pry it off. For the next mold, we must remember to pay extra attention to waxing around the rim.

Figure 2. Putty knife.
I did some research into molding techniques to create the chin guard and neck guard. I decided that in order to make a 3D freehand shape, the best method was to mold it out of clay. I decided on an air-drying clay, as using kilns and other equipment would cause additional work for us. After all the complications we had removing the ACH from the shell, this was also determined the best method, as it can be broken if necessary. I submitted a purchase order for the following supplies from Dick Blick Art Supplies.

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>25 lb Armaco Marblex gray clay</td>
<td>$23.43</td>
</tr>
<tr>
<td>Wire clay cutter</td>
<td>$1.58</td>
</tr>
<tr>
<td>Total (including taxes, shipping)</td>
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</tr>
<tr>
<td>Total spent so far</td>
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</table>

I also did more research on product testing labs. The following labs appear to be the most applicable to our project:

RIH Orthopaedic Foundation Test Facility, Providence, RI
- Drop test with accelerometer
- Environmental chambers
- Air cannon
- Sports helmet testing facility

Biokinetics, Ottawa, Canada
- Ballistic test
- Helmet compliance testing for military helmets

Head Protection Research Laboratory, California
- DOT, Snell, and other standard drop tests
ICS Laboratories, Ohio
  o Ballistic Tests
  o Flammability
  o MIL standards for head protection

Snell Memorial Foundation, California
  o Impact test
  o Flame resistance
  o Helmet prototype testing

Southern Impact Research Center, Tennessee
  o Motorcycle helmet testing for DOT standard

Southwest Research Institute, Texas

Team Wendy

  I have contacted several of these companies, but have not received responses. I will continue to contact them to find out more information such as costs and testing procedures.

**Future Work**

  Now that the shell has been removed from the ACH, there are several things that we need to do. We need to determine whether or not the 7+ layers of Kevlar are enough and if not, we need to add more. The inside of the shell needs to be cleaned out because there are remnants of the parting wax covering it. After this is done, we can add some more triangles to the inside of the bottom layer, as it did not receive as much coverage as the later layers. The shell will need to be sanded down and cut along the bottom into the desired shape. As shown in Figure 3, a line has been drawn on the inside to show the shape of the ACH and to allow us to make the necessary changes.

  Since the ACH is free again, we need to clean off the remnants of wax and start making a new mold. This time we need to focus on more coverage around the rim. We also need to start cutting layers for the pinwheel design. This shell should be made as soon as possible, as it is a long process. We are also hoping that it is all made at once to make the process easier.

**Hours Worked**

  I spent about 9 hours working on the project this week. About 5.5 hours were spent making the Kevlar shell and removing it from the ACH. I also spent about 3.5 hours researching and contacting testing companies and researching and ordering mold supplies.