40-Quart Cooler Design

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Progress Report 2

Document

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1.

1. PHANTOM LATCH

The latch design is in its finishing stages of development. The final design has been approved, materials have been analyzed, and manufacturers are in contact. The figure below depicts CAD photos of the latch as it progressed through the design phase.

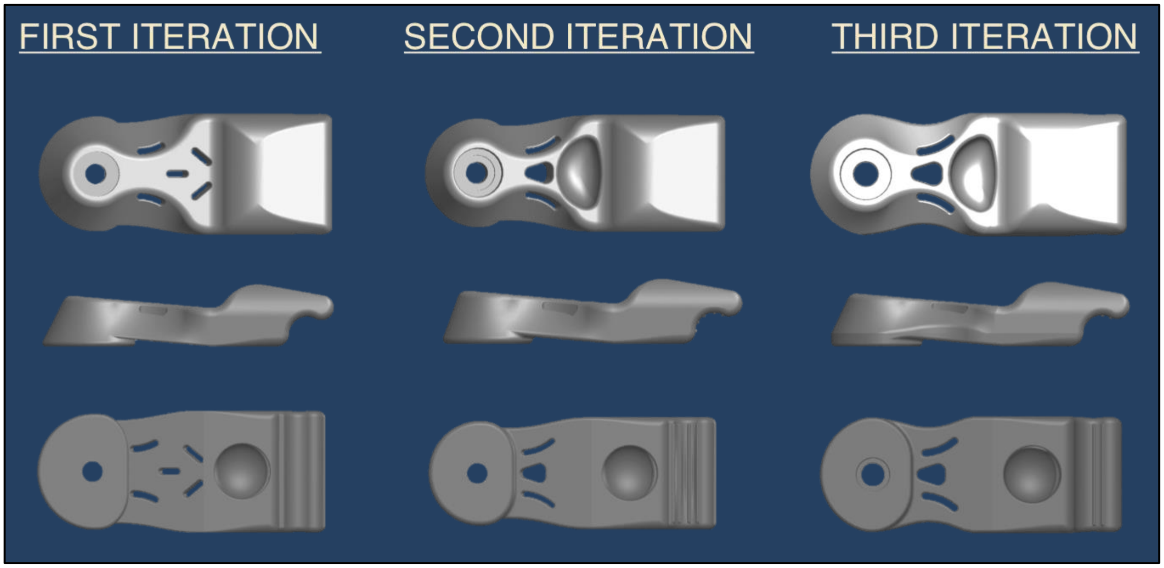


Figure 1 - Top, side, and bottom views of the three latch iterations

The first iteration of the phantom latch was aimed at meeting the needs of the client. These were less overall bulk, and an improved fixture design. Version 1 addresses all of these with some additional improvements. A tapered cross section reduces stresses induced by foreign objects that come in contact with the latch. This in tandem with lower overall height and length reduce the volume of the latch while diminishing its chances to become an obstruction. The rubber at the fixture was increased in thickness to provide a stronger attachment between latch, rivet, and cooler lid. Features such as the ergonomic handle and through slots were also designed into the latch to increase functionality. Version 1 was RAPID prototyped and given to the client for evaluation.

From client feedback, and elementarily simulations Version 2 was produced. The aim of this iteration was to increase the range of applicable cooler models to which the latch could be implemented and to improve ergonomics. The width of the latch was reduced in size by 4 mm, and the nose length and finger lip were each reduced in length to accommodate the geometry of most coolers in Canyon's product line. A thumb insert was introduced to the top of the latch to increase the amount of force, and thus strain, one can apply in a latching motion. The through slots were altered to reduce stress concentrations and to improve overall stretch. An insert for a shoulder washer was added to the fixture hole to stiffen the area of attachment thus providing the rivet a firm surface to engage upon. These improvements were again taken to the client for review and also to mold manufacturers to analyze its manufacturability.

The results that came back indicated a sound design, but a less than optimal parting line. Improvements centered on those manufacturing concerns. The geometry of the latch was first rearranged to fit the criteria for injection and compression molding and then second tweaked to reduce the overall cost of the mold. The fixture location was also improved by reversing the direction that the shoulder washer sits in the latch assembly. This third iteration was then taken back to the professionals and deemed ready for production.

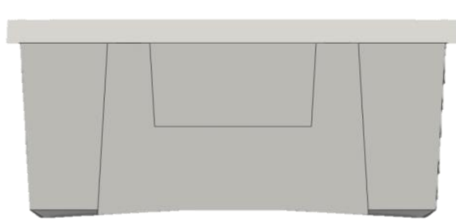
Manufacturer selection, material selection, and production specifications were the next decisions to be made. The capstone team was directed to consult a company based in Phoenix, ACME rubber, about cost estimates while the client discussed manufacturing and potential opportunities for the latch with their manufacturer in Thailand. ACME is in the process of analyzing the engineering drawings, and the client is currently pitching the design in Thailand.

The material that is being considered is an EPDM (ethylene propylene diene monomer) rubber with shore hardness between 40 and 50. The advantages of this material are numerous. One, it is highly weather resistant. It does not dry out when exposed to salt water, it does not photo degrade in sunlight, and it maintains consistent pliability when either hot or cold. Two, it has high a UTS and overall stress resistance. Three, it has a non-slip surface finish. All of these properties make the rubber ideal for the durability and reliability required for the latch.

The client is aiming for a unit quantity of 2000 per run at or less than $2.00 a unit. The one time mold cost needs to be at an affordable rate. Both parties are waiting on estimates to shed light on the expense.

2. CAD PROGRESS

The cooler body is nearing completion as can been seen in the figures below. Some improvements from the last report include a more elaborate bottom; handle ties, and a completely redone hinge section.



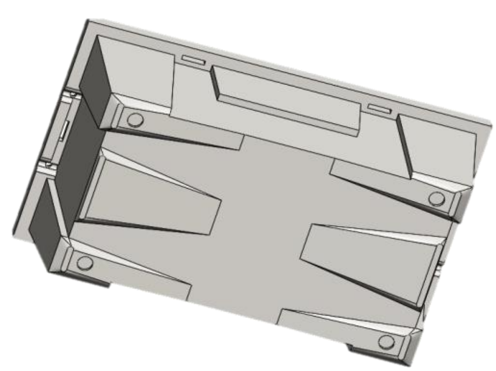


Figure 2 - Cooler body

Some components that need to be added are the hinge, gasket, lock slot and the drain plug. Also the cooler has to pass requirements of the rotational molding process. This includes strict rules on draft angles and parting lines. Another hurdle that need to be overcome is the meshing of the cooler lid and body.

The hinge system has gone through extensive improvements as well. A few iterations were complete that feature the ability to lock at a ninety degree angles, and be able to open while completely up against a wall. A prototype t

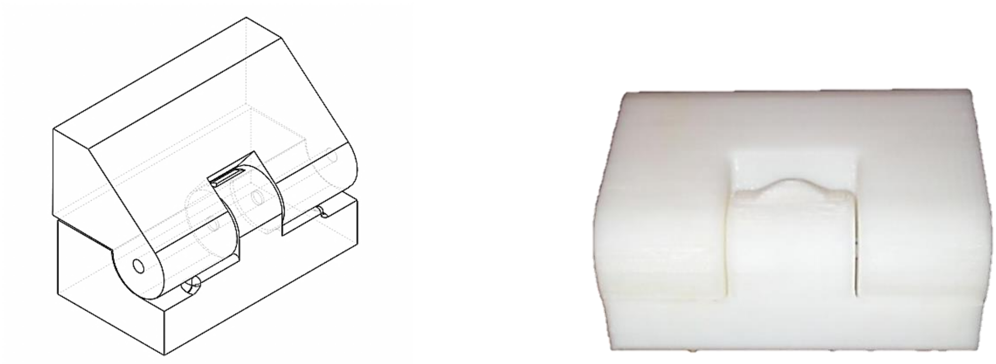


Figure 3 - Hinge prototype

3. EXPERIMENTATION

This test is to collect data on how the current 40qt cooler will perform. We will use this data to validate our simulations. Some real steady state values on how the current Canyon Cooler preforms will be collected.

The test will be conducted in a temperature-controlled environment, the thermo-fluids lab. We will be placing eight type T thermocouples in strategic locations on the cooler. There will be one on the inside and outside of most faces on the cooler including the lid. A visual of this can be seen in the figures below. The walls that were left out were done so because the data acquisition set up only allowed for eight channels. The walls that do not have a thermocouple attached can be assumed to by symmetric.

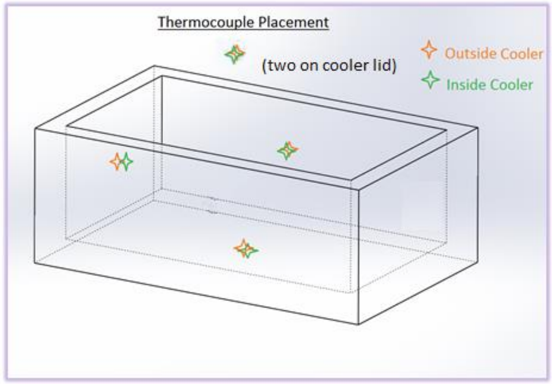


Figure 4 - Thermocouple placements

The test will cover a twenty-four hour period and will start with no ice initially in the cooler. The data acquisition unit will be started then we will put in water until the cooler has about two inches in the bottom. Then ice is placed into the cooler and it is mixed thoroughly. This way the cooler can be observed during the cooling phase. After the ice is placed the cooler was left undisturbed for twenty-four hours. Data will be collected every ten seconds for a twenty-four hour period. Also type T thermocouples will be used that have an accuracy of +/- .5 degrees Celsius. A lot of systematic noise is expected with a uncertainty so high but the data acquisition software will be taking a sample size so large that, with statistical analysis, noise can be filtered out and good data can be acquired.

Results:

From the experiment good data was collected. The experiment was ran for twenty four hours while the data acquisition unit took readings every ten seconds. When the experiment was finished there was around 68,000 data points collected. After statistical analysis was implemented the following figure was produced.

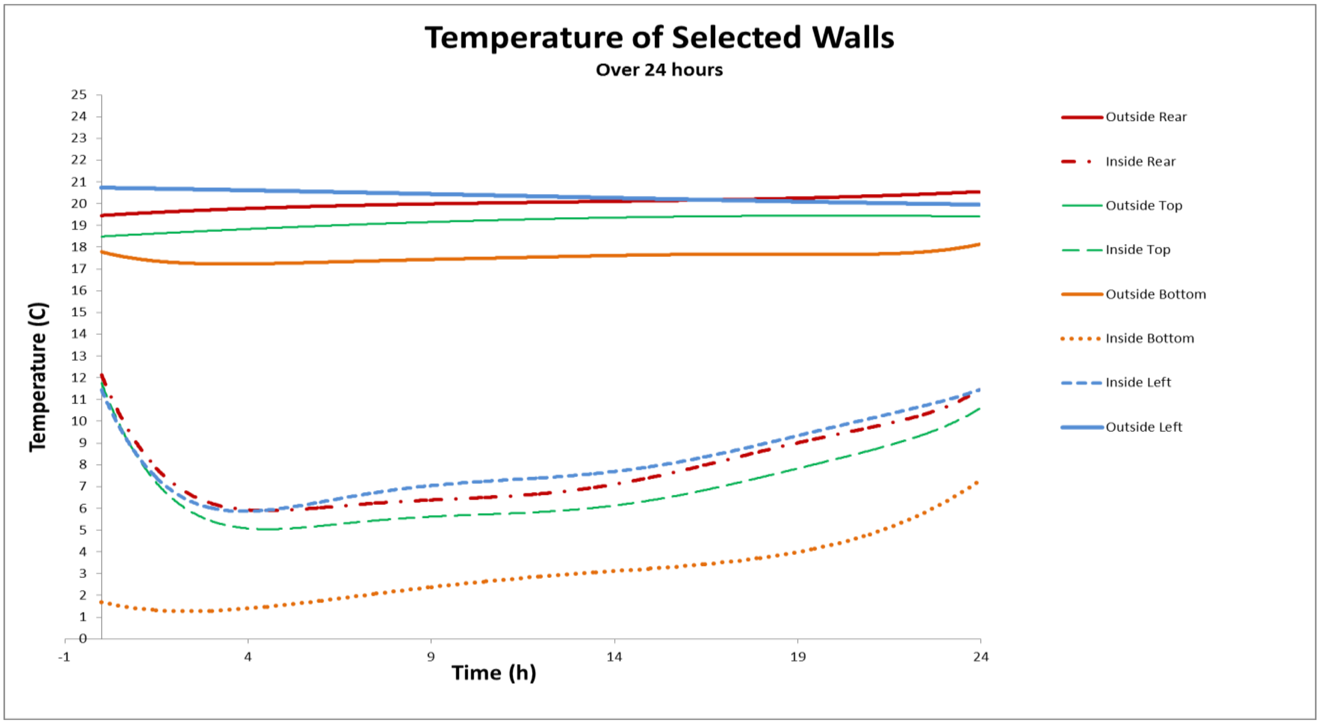


Figure 5 - Temperature data

Some interesting points are that the outside left was actually got colder over the range of the experiment. This is unexpected and a possible explanation is that there was a central ventilation outlet blowing on this side of the cooler. Also one can clearly see the cooling phase that occurred inside the cooler, and when the cooler bottomed out temperature wise and the warming phase began. Also as expected the bottom of the cooler is the coldest part. Not only that the temperature differential between the inside and outside of the walls was greatest on the bottom of the cooler. Since the heat transfer value is based on temperature difference, this is where most of the heat loss occurs.

Extensive data was collected and further analysis is required to get all of the meaning out of it. For now this provides a good baseline model of what is actually going on in and across the walls of the cooler. This can be compared to the cooler model that is going to be complete using CAD software soon. This experiment will verify the design down the road.

4. NUMREICAL SIMULATION

The numerical simulation was carried out preliminarily by using MATLAB. This simulation consists in a steady state approximation of the system that allows to model an equivalent resistance network to numerically model the behavior of the cooler assembly. The resistance values that take part in the simulation are due to the thermal conductivity and thickness of the two polyethylene walls that sandwich the polyurethane foam to allow for better insulation. In addition to these three thermal resistance values we also use a thermal resistance model by using the area of the cooler and the outside convection coefficient.

The program also uses parameters such as interior and exterior wall temperatures, mass of the ice placed inside the cooler for testing, and the cooler's dimensions.
All of these parameters are then used to output how many hours it takes for the energy stored into the cooler under the form of ice to go thru the wall and melt the ice.
The MATLAB code also helps the design team evaluate eventual CAD design changes. These changes affect both the final cost of the product of the cooler assembly as well as its global performance.

This is why the code we wrote plots graphs that represent the thermal conductivity of the polyurethane and polyethylene versus the heat transfer as well as the variation of convection versus heat transfer.

These graphs are done by asking the user to input a range of values for the thermal conductivities as well the convection coefficient. The results are the graphs that can be observed down below. The last graph is meant to help better understand the effect of different climatic conditions such as still air in a room or a windy day on the outside on the rate of heat transfer.

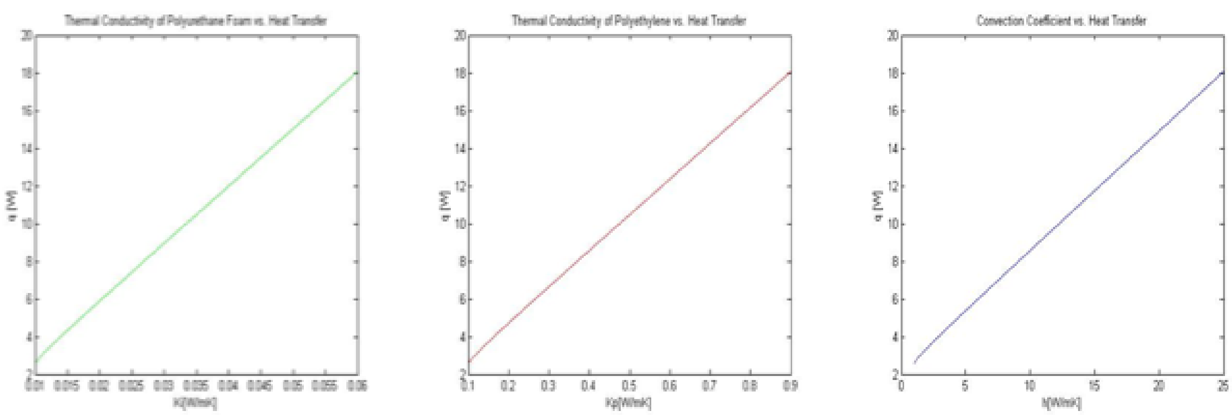


Figure 6 - Thermal conductivities and convection coefficient effects on heat transfer

The next task for improving our numerical simulation is to re-run the MATLAB code by inputting the data (especially the temperatures) there are obtained trough the experimental testing in the thermo fluid lab with thermocouples.
Thermal conductivities and convection coefficient effects on heat transfer.

After completing this test, two team members are going to run more extensive numerical simulation by using a CFD SolidWorks add-on component that is freely available to NAU students.

5. UPCOMING TASKS

For the reminder of the spring semester the team has to complete tasks. Most of the tasks are testing and analyzing the existing cooler. The client will use the data for improving future coolers and establish solid data for marketing purposes.

The tasks are:

1. Conduct experiments, stress/strain thermal expansion and heat transfer, to validate computer simulations.

This task is extremely important to the completion of the project. The analyses that need to be accomplished are the temperature test, and the temperature profile test. The team has decided to use FloEFD software by Mentor Graphics since it is installed in university's computers. FloEFD is an add-in to Solid Works; hence the team will take advantage for analysis without having to export import additional data, saving a significant amount of time and effort. The embedded FloEFD toolset can use the existing 3D CAD geometry and solid model information to simulate designs in real-world conditions. FloEFD is extremely effective at predicting temperature fields in and around the product 3-dimensional design. It also can solve all three modes of heat transfer in 3D.

2. Manufacturing research for injection and rotational molding

The client desires to make coolers to be manufactured in country rather than in Thailand. Hence the team decided to investigate cheap and efficient methods in making the cooler body by rotational molding, and parts by injection molding. There will be a scheduled trip to a manufacturer in Prescott, AZ, which is specialized in molding processing. The trip will discuss costs associated in manufacturing 40QT cooler along will all parts that come with it. Also, the team will work in finding a client for making the improved latch in injection molding.

3. Manufacture a fully functional “Phantom Latch”

As the client want to examine the latch physically after the prototyping is done, the team decided to develop a fully functional “Phantom Latch”. The client is looking forward to provide feedback and recommendation once the latch is completed on time and on budget.

4. Develop a scaled down functional model of the improved hinge assembly.

This model will be dynamic. It features global variables, which are assigned to parameters that control the size on the hinge. The client will be able to adjust the size as desired for each model. The client will be provided with instructions on how to use the assembly.

5. Final cost analysis.

The cost analysis is vital for the project. The client will be provided a detailed bill of costs of materials and labor, as well as manufacturing.

6. Present to client and UGRADS.

At the end of the semester, the team will make a poster and present the project to the Undergraduate Research and Design Symposium. The client will receive an invitation, which will include the time, date, and location.

6. PROJECT PLANNING

Project planning is essential to completing any professional assignment. It pays off to be organized and know what and when things need to be done. Using Gannet chart we can organize our task and task relationships. The red bar represents the progress of tasks. The team is about a week late for most tasks, except for the 3D heat analysis tasks. The reason behind that delay is because the team switched from using COSMOS software to an easier one, called FloEFD Solid Works flow simulation. The team will spend time suring Spring break to get the task done.

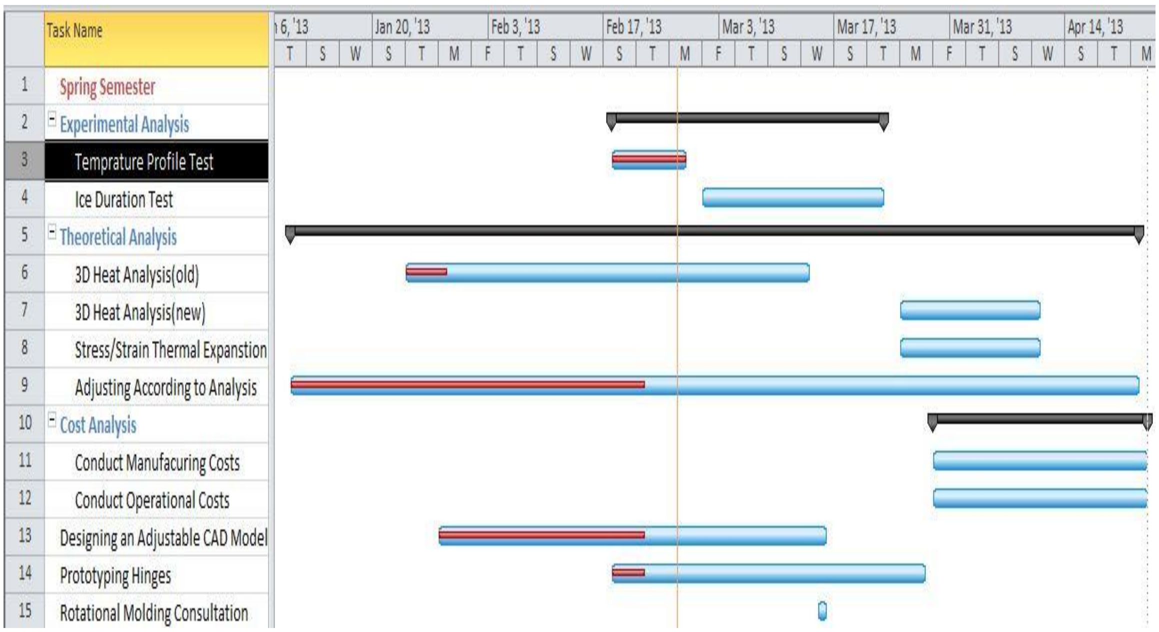


Figure 7- Gantt chart

7. CONCLUSION

Designing a superior cooler is the client's overall goal. The client has told the team that the 40 QT cooler is the most selling, hence the team wanted to bring the best cooler to fully satisfy the client as well as customers. The sponsor, Canyon Coolers, is a small local business, and a product, which economical and reliable is vital to the whole project. It is our goal to use CAD to create a cooler system that can have its proportions altered while maintaining it's primary function, as our client desires.

8. REFERENCES

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