NORTHERN ARIZONA UNIVERSITY
Department of Mechanical Engineering

ME 476C Senior Design

Report 1

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## Introduction

Canyon Coolers is a small business located in Flagstaff Arizona. The coolers are produced using high quality components and materials so that the customers get extremely good ice retention and a cooler made to last a lifetime. The company offers an extremely wide range of products, by doing so, they are capable of targeting a wide range of potential customers. Since the various product lines are diversified the result is that the coolers produced have different characteristics that are attractive from different customer's perspectives. The company is capable of producing coolers that are appealing to rafters, hunters, fishermen, casual customers, commercial customers, and many different niche markets such as ice core sampling. Market research shows that the 40 quart size and smaller are the most selling coolers the company offers, but they are also at the lower end of the quality spectrum. This is precisely where the design team can make a significant impact for Canyon Coolers.

## Need Identification

As a team we need to reinvent the existing 40 cooler in order to offer a product that has numerous extra features and maintains a competitive price.

The company is experiencing a few problems with the existing coolers. One, a too high percentage of the coolers are showing up defective. These defects manifest themselves in a couple different forms such as bumps, divets, loose latches, misaligned seals, and flawed drain plugs.Secondly, the existing 40 quart coolers has components that are exposed rather than recessed into the cooler body. This leads to large stress concentrations developing in the latches and handles. After considering these unsatisfactory elements, the client needs a 40 quart sized ice chest that yields low uncertainties in the manufacturing process and provides the features and price that appeal to most customers.

## Problem Statement:

The ideal goal is to produce a 40-quart cooler that shares quality with the best models in the market but at a reduced price. Realistically the cooler will not be able to achieve the peak level of quality while maintaining a low target price. This translates to restricted use of higher quality (more expensive) materials throughout the design process.

Figure 1: List of objectives, their method of measurement, and the corresponding units of measure

| Objective | Basis for Measurement | Units |
|---|---|---|
| Well Insulated | Significant ice retention | Watts & t |
| Sturdy | No major dents upon impact | m |
| Inexpensive | Low MSRP | $ |
| Light Weight | Easily carried by one person | kg |
| Dimensions | Nests into other coolers (shipping), and compatible with common sources of use | m |
| Maintains Shape | No warp from temperature changes | Degrees |
| Low Maintenance | Costly for distributer to fix | $ |

Figure 1 above depicts the chosen objectives for the 40-quart cooler design. The first objective is to maintain a well-insulated body and lid that prolongs the ice melting process. There are two ways to measure insulation and those are ice retention and heat loss. The first method is measure experimentally by calculating how much time elapses by the time all ice has turned to water. The second method is measured theoretically by heat transfer analysis.

The second objective is to have a resilient product. This will be observed from deformation upon impact and the resulting distance the cooler body deflected. The resilience must carry over to all other aspects of design; hinges, latches, feet, handles. The next objective, a very important one at that, is affordability. What keeps canyon coolers in business is their ability to offer similar products as the major companies at a significant price reduction. MSRP (manufacturers suggested retail price) is how all the money put into a product represents itself to the customer at the end of the line.

Light in overall weight is the objective that follows, and it will be determined by how easy it is move even when at maximum storage capacity. This will be measured in kg. The next objective is accurate dimensioning. This will be tested in two ways. One of which is its ability to nest inside of existing products such as a 90-quart or a 100-quart coolers. The other will be its compatibility with common consumer uses. Some examples are strut heights on white water boats, platform hitches for vehicles, cargo boxes for roof racks, common trunk sizes on vehicles, and storage compartments on motorized boats. These dimensions will be measured in meters.

Following the dimensioning is the consistency of shape. Plastics have a tendency to warp under temperature changes. Introducing our prototype to various temperature conditions and measuring the misalignment caused will be the basis of measurement. Most commonly the cooler lids have been exhibiting this warping and this is easily measured by an angle away from normal. The last objective is a design that requires little to no maintenance. This objective will be measured in dollars that correspond to how much a repair costs the client. All of these design objectives are further broken down into their criteria in figures 2 & 3.

## Constraints:

There are five main constraints to be dealt with for designing the cooler. They consist of dimensions, weight, durability, cost and function. Each must be thoroughly explored and considered in the final design to meet the needs of the customer.

When evaluating the criteria for the dimensions there are a few aspects to consider. One of the key aspects of the dimensions is to ensure that the cooler nests side by side top and bottom with other coolers as well as inside of the larger coolers.on the magnitude of 90 – 120 quart sizes. This is to ensure a maximum number of coolers can be shipped in order to save money on shipping costs. This also includes constructing all of the features on the cooler to be flush with the base structure, such as handles, locks, latches or wheels. The cooler must also be able to fit standard items. This includes water jugs, beer bottles etc.

The weight of the cooler must not exceed 7 kg when it is empty. This is a customer requirement and is to ensure that the cooler is easy to maneuver and can easily be lifted by one person.

The cooler also needs to be durable. The design must stand up to typical use. The latches must withstand high stresses and hold an airtight seal. The body and lid must be well integrated and impervious to small stresses. Some typical examples would be sitting or standing on the cooler, dropping it as well as not warping under heat or use.

The cost of the cooler is one of the main concerns. The customer is looking to manufacture the product in the United States instead of the current manufacturer, located in Thailand. Currently, the cost to produce coolers in the U.S. is very expensive compared to overseas. The goal for the MSRP is to be lower than that of the current cooler at $189.99 as well as surpassing its current performance.

Lastly, the function of the cooler is extremely important. The design must hold ice for at least one week with a goal time period of three weeks. In order to do this the cooler will be designed with an air and water tight apparatus. The insulation design and dimensions will be improved as well as a few small improvements such as feet, a porthole and inner compartments.

## Test Environment:

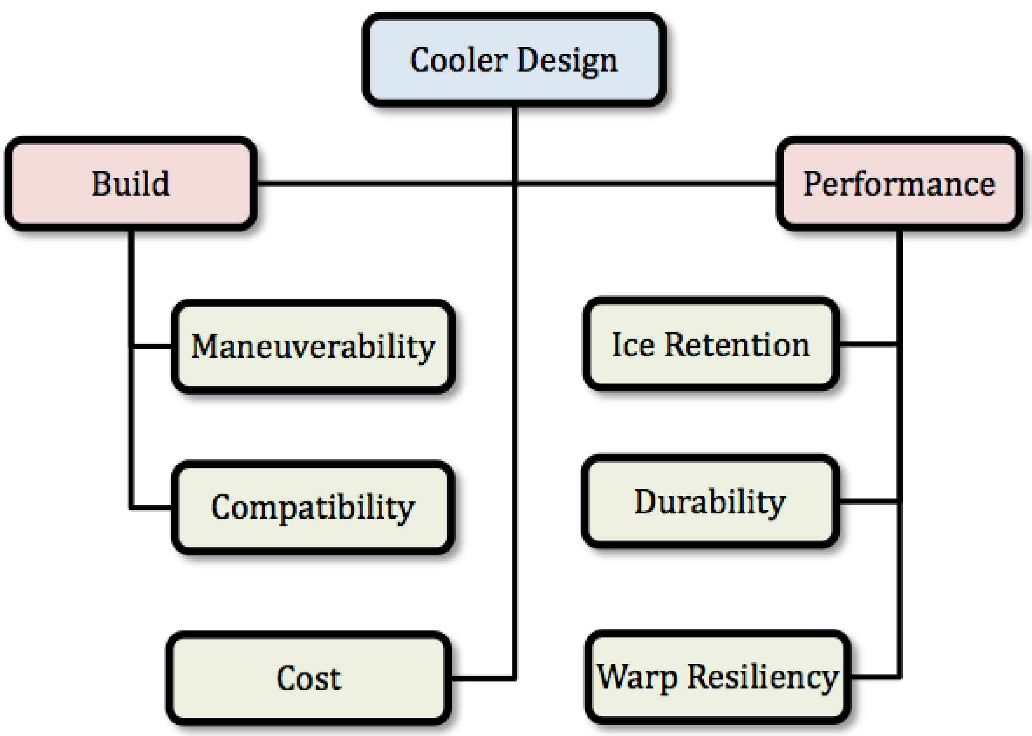
There are two main constraints that will be tested; ice retention and durability. The testing conditions for ice retention will be under typical use and under ideal use. Typical use will include merely placing ice from a bag inside of the cooler and measuring how long it holds said ice for. Ideal conditions would be using a few techniques that ensure longer ice retention. Freezing a layer of ice at the bottom of the cooler or placing the cooler itself in a freezer before use are some examples. The locations of these tests will take place under normal use and standard applications. For instance: in direct sunlight, inside a car during the day, on various surfaces of different temperatures. The test conditions for durability will be purely based on impact. Common objects coming into contact with the cooler body, various drops at common heights such as waist height and off boat edges or truck beds, are some of the projected experiments.These tests will give the best results and point the design in the right direction towards meeting the goal.

**Criteria:**

**Figure 2:** List of objectives and their corresponding criteria.

| *Objective* | *Criteria* |
|---|---|
| *Well Insulated* | *Ice Retention* |
| *Sturdy* | *Durability* |
| *Inexpensive* | *Cost* |
| *Light Weight* | *Maneuverability* |
| *Dimensions* | *Compatibility* |
| *Maintains Shape* | *Deflection/Warp Resiliency* |
| *Low Maintenance* | *Reparability* |

**Figure 3:** Breakdown of criteria in relation to the cooler design.



**Quality Function Deployment (QFD):**

With any design project it is paramount to map out the need of the client/customers with specific engineering design requirements. Because of this we decided to utilize a Quality Function Deployment Chart. The purpose of this chart is to break down user demands into component parts and subsystems, and ultimately to the specific manufacturing requrements. QFD's are used throughout industry and are a very effective way to map out the need of the customer with engineering specification. Another great feature of the QFD is that fact that we can compare some competitor benchmarks for customer needs with the goals that we are trying to set. Please refer to Figure 4 for our analysis of our customer and engineering needs, and the relationships that bind our design specifications.

Each region on the Quality Function Development chart has significance. On the left region of the QFD we have our customer requirements, this is mapped perpendicular to our engineering requirements (top region). Where these two fields cross each other (middle region) we can see the correlation, marked with an X, between the need of the customer and engineering design terms. On the bottom region we have what units these engineering design terms are in and the targets we are trying to achieve. Finally on the far right region we can see some competitor benchmarks. Here we can visually see where each competitor has strengths and weakness that we can compare our product to.

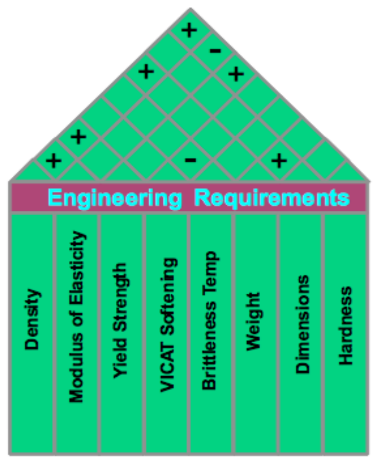
**Figure 5:** Quality Function Deployment

| | | Engineering Requirements | | | | | | | | Benchmarks | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yield Strength | Modulus of elasticity | VICAT Softening Point | Brittleness Temp | Density | Weight | dimensions | Hardness | Yeti Coolers | Engel Coolers |
| Customer Requirements | Looks Good | | | | | | X | X | | 0 | |
| | Keeps Things Cold | | | | X | X | X | | | | 0 |
| | Sturdy | X | X | | | X | | X | X | | 0 |
| | Inexpensive | | | | | X | X | X | | | 0 |
| | Light Weight | | | | | X | X | | | 0 | |
| | Portable | | | | | | X | X | | 0 | |
| | Resists Damage | X | X | X | X | | | | X | 0 | |
| | Units | MPa | Gpa | °C | °C | g/cc | Kg | m*m*m | Shore D | | |
| | | 25 | 0.7 | 120 | -118 | 0.95 | 10 | 0.03785m^3 | 65 | | |
| | | Engineering Targets | | | | | | | | | |

## House of Quality :

Another design tool that we used to determine how our engineering requirements relate to each other is the House of Quality, reference Figure 6. The house of quality takes our engineering requirements and maps them against each other. Where our requirements intersect in the top region we can place a "+" or "-" correlation i.e. modulus of elasticity and density are positively correlated therefore when you increase one you increase the other. A "-" signifies a inverse relationship, when you increase on you decrease the other.

**Figure 6:** House of Quality




## 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. We decided to use an organizational aid the Ganntt Chart. Using this type of chart we can organize our task and task relationships. Also it makes it easier to plan around deadlines and keep our client up to date on our progress. Looking at the chart, it is easy to see that the project is still in its preliminary stages, starting to work on our CAD designs and modeling.

**Figure 6:** Gantt Chart