EDSGN 100: Introduction to Engineering Design
Section 10 Team 4

Sustainable Coffee Distribution System

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Abstract:

The team worked together to develop a product and a system that would help to improve sustainability and efficiency around the Penn State campus. The following report gives a detailed analysis of how the team worked to generate the idea and how it was developed.

Introduction:

A Coffee Cup is a simple product that everyone is familiar with. The team was given the task to identify potential applications of Aluminum that would improve the efficiency or sustainability of an existing system. The team came up with a simple concept, a coffee cup with aluminum plating, to improve heat distribution throughout the coffee. The Team also proposed a sustainable system to improve the current Coffee distribution method, which could potentially eliminate the need for disposable and non-recyclable paper cups. There is a need for a reusable coffee cup that is light weight, cost efficient, ideal for students that can be reused or recycled to eliminate the current waste. The team must develop a cup that meets these criteria and a system to utilize the design.

Description of the Design Task:

I. Problem Statement:

The current method of selling and distributing coffee from coffee shops results in non-recyclable paper or polystyrene waste.

II. Mission Statement:

The mission was to design and prototype a coffee cup that is desired by customers while still reducing the need for plastic, polystyrene, and paper coffee cups and remaining cost effective and environmentally friendly.

III. Design Specifications:

Product:

The product will feature an aluminum interior to distribute heat evenly to the coffee, prevent corrosion and be easy to clean. The cup will also have a pocket of foam between the aluminum and the plastic exterior for heat retention, and a handle for gripping the cup and not getting burned. The lid can seal to prevent spills and retain heat. The lid is threaded for extra security. The lid is operated by moving the part in the center to open and close the mouth.

System:

Reusable cups may be rented for a deposit. They may then be returned to any store for a refund. The store will offer a discount to those who use the cups rented or owned. The size of the cup will allow most sizes to be poured in. If a smaller size is requested the cup will not be filled completely. This system works well for people who enjoy sitting in store with their coffee or those who frequent coffee shops.

Design Approach

I. Gantt Chart

Task	Week I	Week II	Week III	Week IV	Week V
Information Gathering					
Brainstorming					
Design Concept Gathering/Creating					
Working Drawings					
Prototype Construction					
Testing and Evaluation					
Design Documentation					
Demonstration and Presentation					

Table 1. Gantt Chart

II.Customer Needs Assessment

We surveyed many potential customers of our product and determined that the following criteria were critical to the success of a reusable Coffee cup and the system within which it operates:

-Safety

-Heat Retention

-Lid

-Handle

-appearance

-Durability

-Cost

III. Concept generation

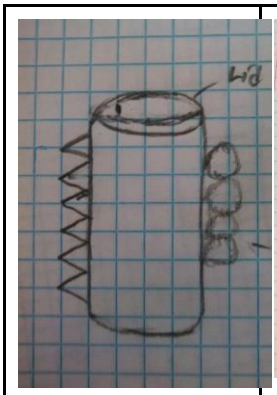
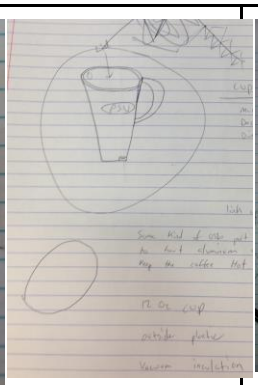
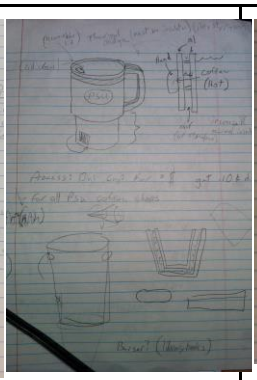
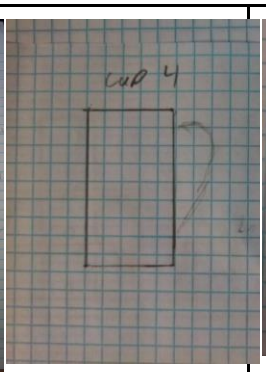
			

FIG. 1. Cup 1	**FIG. 2 Cup 2**	**FIG 3. Cup 3**	**FIG. 4. Cup 4**	**FIG. 5. Cup 5**

Table 2. Concept Generation

1. Cup 1 is a solid aluminum cup that resembles brass knuckles. It features the finger holes and spikes to make it stand out from other coffee cups. it has a lid, but the entire cup is made of aluminum and it may burn the user as aluminum is a good conductor of heat.
2. Cup 2 resembles a standard coffee cup it features an aluminum interior and a plastic exterior for some protection from the heat of the coffee. It resembles current coffee cups so it will be easy to integrate into the existing market.
3. Cup 3 is a hefty mug, it features a three layer design, aluminum interior to distribute the heat to the coffee, a polystyrene middle to retain heat, and a plastic exterior for durability and appearance. It has a lid and handle. The lid features a sliding seal to allow for safe storage
4. Cup 4 is a straight cylinder made of aluminum. It has a handle, but no lid. It suffers from a lack of insulation and safety with the lack of a proper lid.
5. Cup 5 follows the classical truncated-cone shape of current coffee cups. It is made of solid aluminum and features a rubber grip to allow for handling. This cup features a solid lid, but no external handle. This can allow for easier storage in side pockets of backpacks.

IV. Design Selection

Traits	Control	Cup 1	Cup2	Cup 3	Cup 4	Cup 5
Safety	0	-	+	+	-	0
Lid	0	+	+	+	-	0
Renewability	0	+	+	+	+	+
Appearance	0	-	+	+	+	+
Cost	0	-	-	-	-	-
Durability	0	+	+	+	+	+
Heat Retention	0	-	+	+	-	+
Total	**0**	**-1**	**5**	**5**	**-1**	**3**

Table 3. Plus / Minus Chart

Category	Weight	Cup 2		Cup 3		Cup 5	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Safety	0.2	3	0.6	5	1	1	0.2
Renewability	0.2	4	0.8	3	0.6	2	0.4
Apperance	0.1	4	0.4	3	0.3	4	0.4
Cost	0.2	3	0.6	1	0.2	4	0.8
Heat retention	0.2	3	0.6	5	1	1	0.2
Durability	0.1	4	0.4	5	0.5	4	0.4
			3.4		3.6		2.4
Advance?			Merge		Merge		No

Table 4. Weighted Design Selection Matrix

V. Trade Studies

The team decided to combine concepts from Cups 2 and 3. The tri-wall design provided excellent thermal insulation, while the appearance and simple style of cup 2 offered a product that would be easily adapted by the market. The Cup three was too bulky for consumers, customers expressed a need for portability for their coffee cups. Cup 2 did not offer satisfactory thermal insulation. The team mediated these issues by combining cups 2 and 3.

VI. Description of Final Design Concept

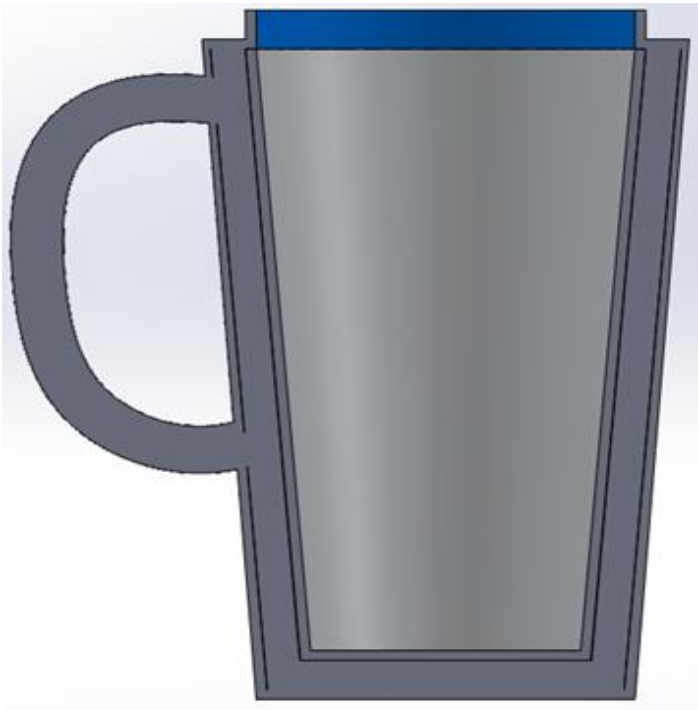
The final design followed the standard coffee cup style, the truncated cone shape. It also features a three layer insulation system, beginning with a 2 mm inner aluminum shell to distribute heat evenly throughout the coffee. This is followed by a 6 mm layer of polystyrene for superior thermal insulation. The final 2 mm plastic layer encases the entire cup, providing a familiar object for coffee consumption.

Final Design and Prototype

CAD Drawings

Cup and lid

Cup section view (tri layer)



Prototype Scale and Images

Prototype scale 1:1

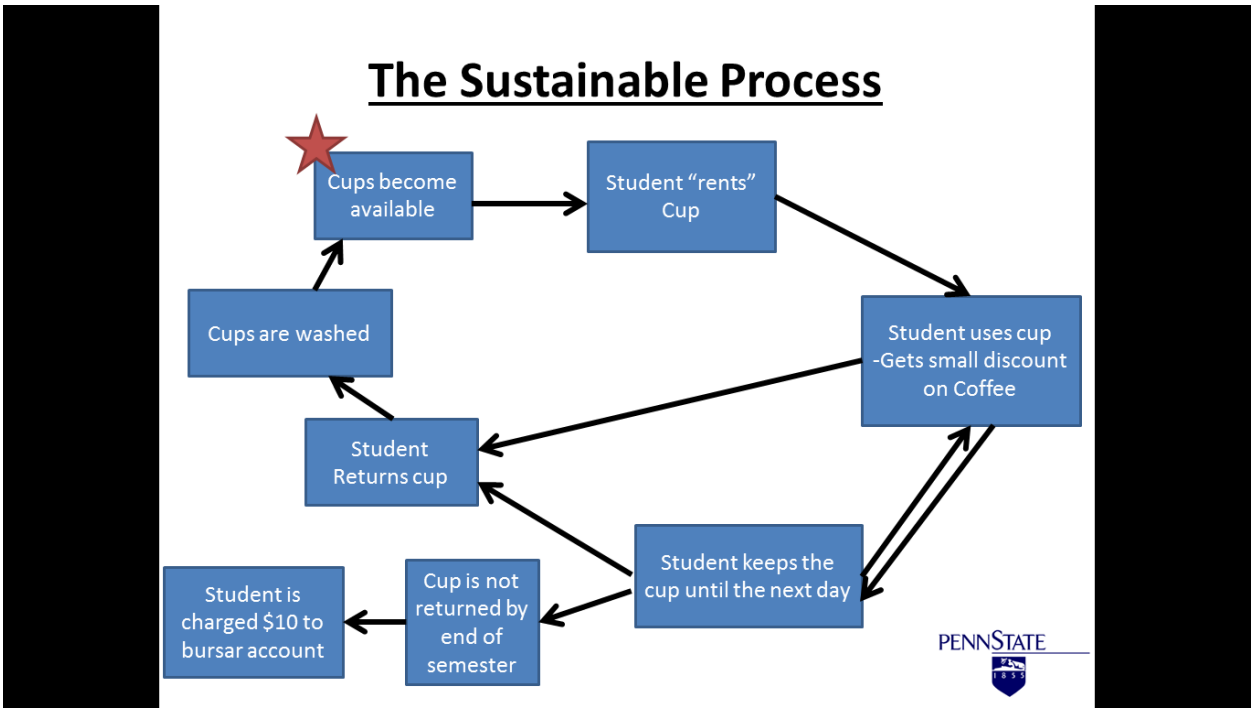
Design features

The Coffee cup that was designed offers many features that will offer a safe and enjoyable coffee drinking experience. The three layer design features a series of aluminum, Styrofoam, and plastic shells, each with its own specific contribution to the performance of the product. The inner aluminum shell will conduct and distribute the heat evenly to keep the coffee at a uniform temperature. This Aluminum layer is surrounded by Styrofoam to keep the aluminum insulated, allowing for a minimization of thermal heat loss, with a low cost. Compared to the more complex structure and design needed for vacuum insulation, the Styrofoam layer performs more that adequately. Also the vacuum insulation idea is threatened by the concept of thermal bridging, where the heat is transferred over the supporting structure, eliminating the benefit of the vacuum insulation. The third and final layer consists of abs plastic, hard and durable, this layer will provide a pleasant interface for users. A Penn State themed design could be implemented to make the product more appealing to the target consumer, which is a college student.

Analysis:

Definition Of Sustainability:

Sustainability is the ability of a system to operate with a low input of resources and energy.



Validation of Concept:

The concept of reusing a coffee cup is not a novel idea. However, the system within which our product will operate, unifies the coffee retailers, and offsets the upfront cost of implementing such a system. Our system ensures that students will have the incentive to use and return the cups, by implementing monetary sanctions or offering a slight reward as described above. With continued use of the reusable cups, both the students and coffee retailer will see a reduction of waste and cost.

Equipment/installation/maintenance cost estimate/analysis:

This system will have a moderate cost to implement, with an upfront investment in the cups themselves. With an upfront cost of just under $5/cup, the venture may seem initially unpleasant. However, after about 100 days, or 100 cups of coffee per cup, the coffee establishments break even and make a 5 cent profit on each cup served into one of these renewable cups. The only other cost that would impact the continuation of the cycle is the establishment's requirement to clean the cups. The cost to clean a single cup is minimal as the cleaning utilities already exist.

Efficiency Advantage:

By renting these cups out and having them returned and washed for the next customer to use hundreds of Styrofoam cups are saved from being thrown out a week. With a 5 cent cost advantage per cup sold, the profit margin would increase dramatically for the Coffee retailers. These reusable cups also improve efficiency because the thermal resistance value is much higher than an average coffee cup meaning that the coffee in the reusable cup will stay hotter for a much longer time and allow the customer to savor their Coffee over a longer span of time.

Conclusion

The reusable coffee cup is a great way to reduce the amount of waste that is produced from everyday coffee drinking. The system that the team developed to be used with the reusable cup will further reduce waste and promote sustainability. The estimated cost of each reusable cup to be five dollars, this is an inexpensive, efficient and effective way to accomplish the goal of reducing Penn State's impact on the environment.

Attachments

Link PPT Slides

Link to Tri-Fold

Acknowledgements

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References

"R-value (insulation)." *Wikipedia*. Wikimedia Foundation, 16 Dec. 2013. Web. 16 Dec. 2013. <http://en.wikipedia.org/wiki/R-value_(insulation)>.

"Thermal Bridge." *Wikipedia*. Wikimedia Foundation, 12 Oct. 2013. Web. 16 Dec. 2013. <http://en.wikipedia.org/wiki/Thermal_bridge>.