



EDSGN 100
Design Project #2

FINAEL REPORT

ALCOA Redesign

Introduction to Engineering Design

EDSGN 100 Section 24

Team 2

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Executive Summary:

The K-Cups used in Keurig machines are not made out of a recyclable plastic. With our sponsorship from ALOCA, our goal is to redesign the K-Cup out of aluminum to make them more eco-friendly. We hope to keep the convenience of the K-Cups for consumers, but reduce the number of K-Cups that end up in landfills.

K-Cups

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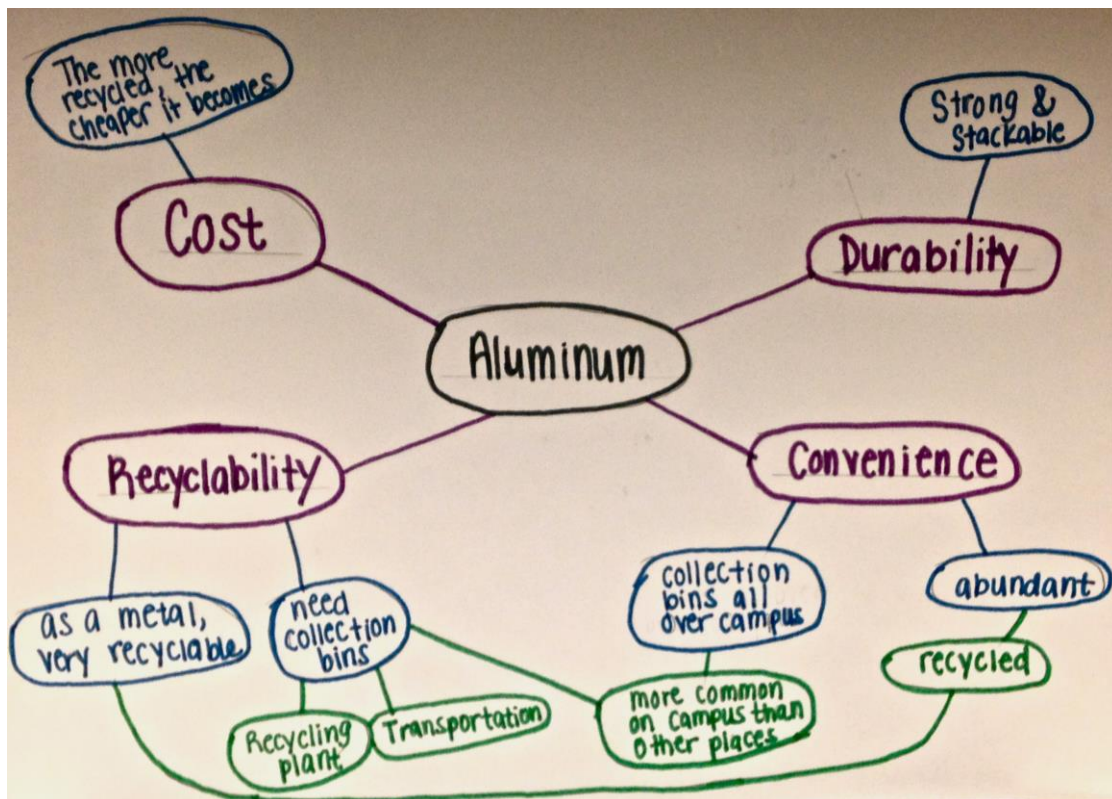
A. Introduction and Problem Statement

For our teams redesign problem, we were tasked to find a product that impacts campus life at Penn State and improve the design through the use of aluminum. We chose to redesign the K-Cup because it is used by many students across campus. To begin the redesign process, we had to dissect a K-Cup and learn how it works. We opened the K-Cup to see how the coffee filters out, and we also compared a new K-Cup to a used one. We also examined the actual Keurig machine and its operating process.

Subsequent to dissection, we surveyed customer needs. We asked consumers what change, if any, they wanted to see in our redesign. Our team acquired the customer needs and ranked what each customer thought was most important. We carefully decided on the modifications we were going to make to the K-Cup and defined multiple concepts to decide from. We chose a concept that most fit the customer's needs. In the following sections, we describe the process of defining the problem, examining customer needs, generating concepts, and choosing our final design.

a. Concept Map

Before we chose to redesign the K-Cup, we made a concept map. We tried to brainstorm items and resources that are commonly used around campus that could be improved by aluminum. We then specifically mapped out the ways in which aluminum would improve these items and resources.



b. Initial Problem Statement

The K-Cups used in the Keurig machines are not a recyclable plastic. We looked at products that students use every day in their dorm rooms and found many use Keurig machines. From that, we realized that K-Cups were just being thrown away with no possibility of being recycled.

B. Concept Generation

To generate our different concepts, we collected customer needs from friends and students around campus. We found people still want the same convenience of the K-Cups with the added benefit of being able to recycle their K-Cups.

a. Customer Needs Analysis

We didn't want to make any modifications without initially asking the users thoughts, so our next order of business was surveying customer needs. Our group used social networking sites, such as Twitter and Facebook, to gather thoughts of our customers. We also questioned friends and students in different dorms around Penn State campus. We chose to use media as one of our forms of surveying because it allowed us to get varied results from different groups of people and can be done with ease. In our surveying, we also asked customers what features they did like in the K-Cups and made ourselves conscious not to change those features.

List of common questions we asked to students:

1. How often do you use your Keurig?
2. Why do you prefer Keurig machines instead of traditional coffee machines?
3. If given aluminum K-Cups, would you be willing to recycle them?
4. Is there any change you want to see in the design of the K-Cups?

b. Weighting of Customer Needs

In order to meet the customer's needs, we must satisfy their most common requests. By the process of making a ranking system in what was replied most often, we can pinpoint what customers ask for the most in their K-Cups. In table 1, we have a full list of customer responses to the four common questions. The most common needs were convenience, recyclability, safety, durability, and cost. In table 2, we ranked customer needs in accordance with the frequency of the response.

Table 1. Initial Customer Needs List Obtained from Media and Other Individuals

Convenience
Durability
Safety
Recyclability
Cost
Similar Design to Original K-Cups
Variety of Drinks
Same Process in Keurig Machine

Table 2. Hierarchal Customer Needs List Obtained from Media and Other Individuals

1. Recyclability
2. Convenience
3. Cost
4. Safety
5. Durability
6. Similar Design to Original K-Cups
7. Same Process in Keurig Machine
8. Variety of Drinks

c. Benchmarking

In order to re-design the K-Cup effectively, we implemented a benchmarking process. We compared our redesigned aluminum K-Cup to the features of original plastic K-Cups and Nespresso capsules. We ranked the three products in the table below on a scale from one to three, with a one being the best. We found our K-Cup is very similar to both products, but better in different aspects. The new K-Cup is better than the Nespresso capsules because although it is

the same material, it would be available in stores while Nespresso capsules cannot be purchased in retail stores. The design of our removable filter will also make our K-Cups more recyclable than Nespresso. The aluminum K-Cup is better than the original plastic because it is much more recyclable and durable.

Table 3. Benchmarking of Three Products

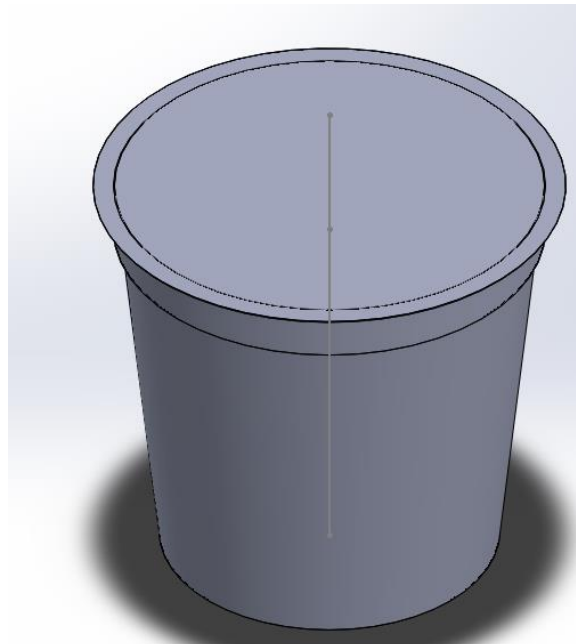
	Aluminum K-Cup	Original Plastic K-Cup	Aluminum Nespresso Capsules
Rating of Costs	2	1	3
Durability	1	3	2
Recyclability	1	3	2
Availability	2	1	3

C. Design Selection

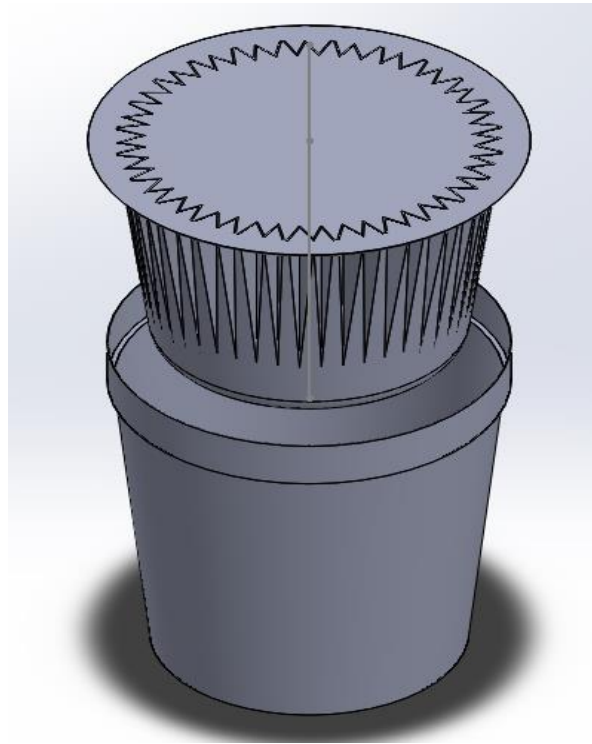
Through many different brainstorming techniques, we generated five different design concepts for our new K-Cups.

a. Design Concepts

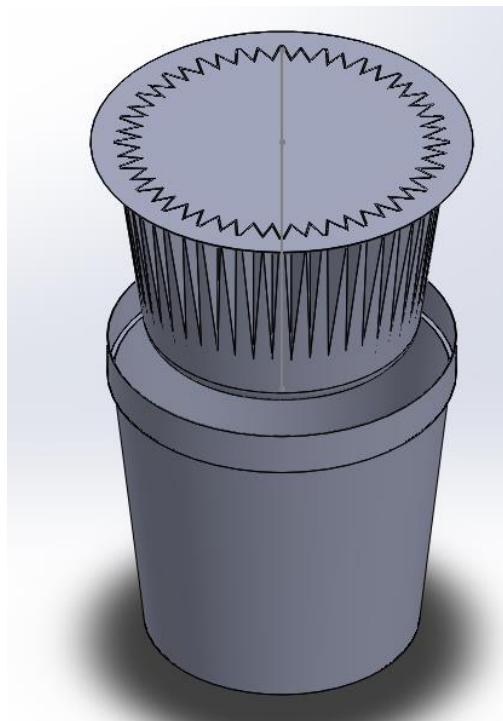
Concept 1: The original K-Cup design with aluminum in place of plastic.



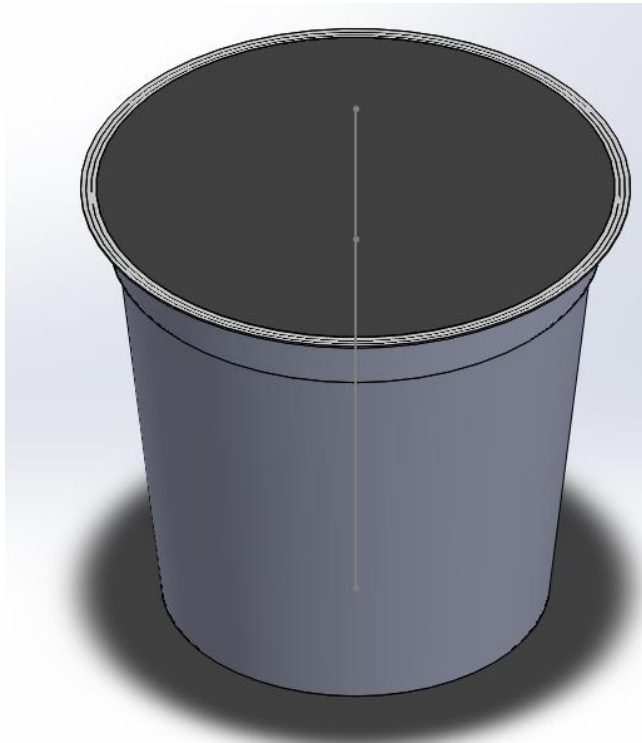
Concept 2: Aluminum K-Cup body with a paper filter attached to the lid. When you pull the lid off the filter goes with it, making the body recyclable.



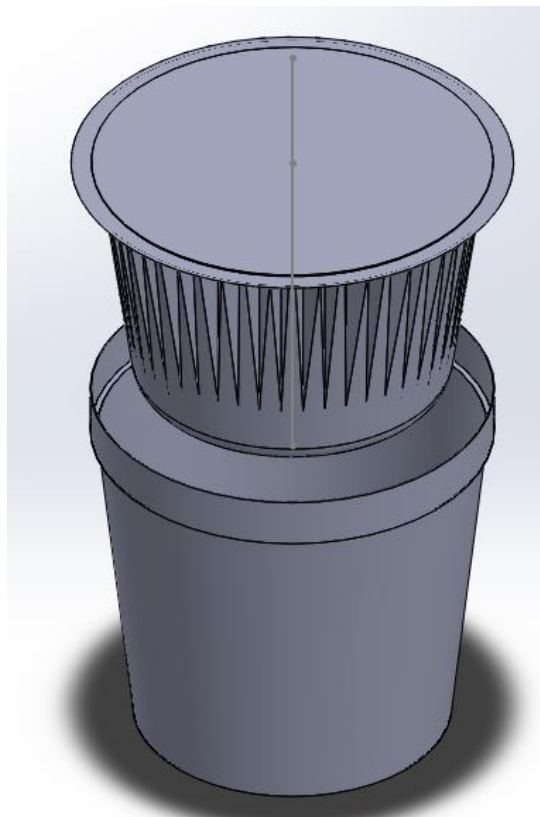
Concept 3: One reusable body with a replaceable lid and filter.



Concept 4: Aluminum recyclable body and plastic around the lid to prevent burning.



Concept 5: Aluminum recyclable body, filter wraps around the outside of the lid to prevent burning.



b. Concept Selection

We chose concept two but also adapted some ideas from other concepts into it. From our data collection of our customer needs, we weighted recyclability the highest, followed by convenience, cost, and safety.

Table 3. Selection Matrix

		A		B		C		D		E		F	
		Concept 1		Concept 2		Concept 3		Concept 4		Concept 5		Plastic K-Cup	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Recyclable	50%	4	2	5	2.5	5	2.5	3	1.5	5	2.5	1	0.5
Convenient	25%	4	1	5	1.25	3	0.75	4	1	3	0.75	5	1.25
Safe	5%	2	0.1	2	0.1	2	0.1	5	0.25	4	0.2	4	0.2
Durable	5%	4	0.2	4	0.2	4	0.2	4	0.2	4	0.2	3	0.15
Cost	15%	2	0.3	4	0.6	5	0.75	3	0.45	4	0.6	5	0.75
	Total Score	3.60		4.65		4.30		3.40		4.25		2.85	
	Rank/Continue	4 / No		1 / Yes		2 / Yes		5 / No		3 / No		6 / x	

Table 4. Screening Matrix

	Concepts					
	A	B	C	D	E	E
Selection Criteria	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5	Plastic K-Cup
Recyclable	+	+	0	0	+	-
Convenient	+	0	-	+	+	+
Safe	-	-	0	+	+	+
Durable	+	+	+	+	+	0
Cost	-	-	0	-	-	+
Sum of +'s	3.00	2.00	1.00	3.00	4.00	3.00
Sum of 0's	0.00	1.00	3.00	1.00	0.00	1.00
Sum of -'s	2	2	1	1	1	1
Net Score	1	0	0	2	3	2
Rank	4	5	5	2	1	2
Continue?	No	Yes	Yes	No	Yes	x

c. Final Concept

The qualities we chose for the final design are a recyclable aluminum body for the K-Cup with a disposable lid. The filter for coffee would be attached to the lid so you can simply dispose of the lid and filter together and also recycle the body.

D. Review of Design Features

Our final design is the exact same dimensions of the original K-Cup, but with a few added features. After a consumer uses the K-Cup, they can peel off the lid and throw it away. The filter is connected to the lid so that it will be disposed of as well. These features keep the convenience of K-Cups that users like because the non-recyclable parts can be thrown out in one step. The body can be recycled as a result. The main weakness of our design is that because the aluminum lid is attached to the filter, the lid will not be recycled along with the body. We chose this option to make recycling as convenient as possible for the consumer.

E. Analysis and Testing

In designing this aluminum K-Cup, we kept the dimensions the same size as existing plastic K-Cups. We did this so users were not forced to purchase new machines in order to fit the new K-Cups. Our goal was to keep the same convenience because that is what customers want.

a. Analysis

The reason we attached the filter to the lid was so that users do not have to take time to clean the aluminum cup before they recycle it, they can simply throw it in the recycling bin. This keeps the same convenience of K-Cups that consumers want. The lid is still recyclable aluminum, but in order to recycle it consumers must clean the lid and detach the filter.

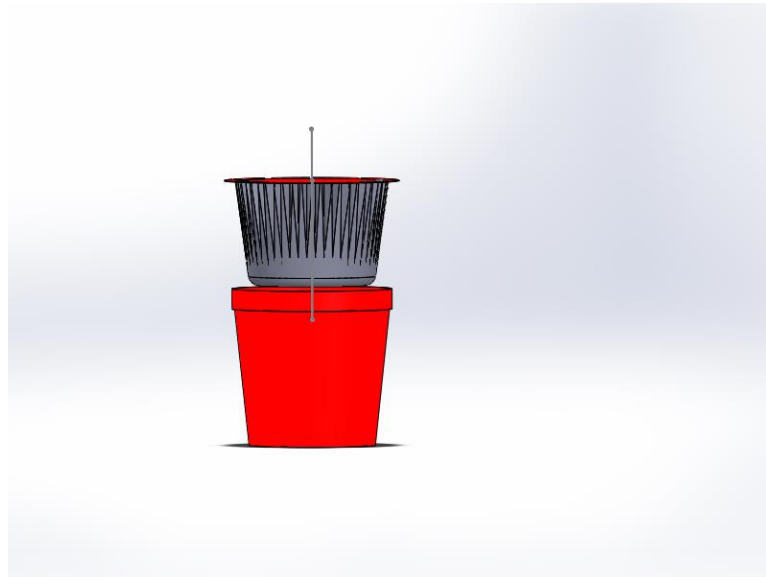
b. Testing

The dimensions of both the original K-Cup and our aluminum K-Cup are the exactly same. The diameter of the lid is 2", the height is 1 13/16", and the bottom diameter is 1 3/8". The new aluminum K-Cup will be able to fit and work in existing Keurig machines.

F. Description of Design Operation

1. Take K-Cup out of package.
2. Put K-Cup in the Keurig machine.
3. Add water.
4. Turn machine on and wait for machine to brew coffee and/or other drink.
5. Wait for K-Cup in the Keurig machine to cool down.
6. Remove K-Cup from Keurig machine.
7. Pull tab to remove lid (and filter) and throw away.
8. Recycle the aluminum K-Cup body.

G. Life Cycle Analysis



Our K-Cup is made out of ABS plastic and 6063 aluminum. For standard plastic K-Cups, the injection molding manufacturing process is used while for the aluminum K-Cups the milling process would be used. They are only produced and sold in the United States and Canada so transportation would be about 2600km.

a. Environmental Impact

If we assume ALOCA is making the K-cups, we can take out the material aspect in the aluminum cup calculations, since ALCOA uses recycled aluminum, not raw. Below are the calculations with material factored in and calculations without material below that.

Carbon footprint

Carbon Footprint



Material:	5.1E-3 kg CO ₂ e
Manufacturing:	2.0E-3 kg CO ₂ e
Use:	0.00 kg CO ₂ e
Transportation:	3.4E-4 kg CO ₂ e
End of Life:	7.3E-4 kg CO ₂ e

8.2E-3 kg CO₂e

Plastic

8.2E-3 kg CO₂e

Carbon Footprint



Material:	0.030 kg CO ₂ e
Manufacturing:	1.5E-3 kg CO ₂ e
Use:	0.00 kg CO ₂ e
Transportation:	6.5E-4 kg CO ₂ e
End of Life:	1.4E-3 kg CO ₂ e

0.033 kg CO₂e

Aluminum

3.35E-3 kg CO₂e

Total Energy consumed

Total Energy Consumed



Material:	0.118 MJ
Manufacturing:	0.029 MJ
Use:	0.00 MJ
Transportation:	5.0E-3 MJ
End of Life:	5.4E-4 MJ

0.153 MJ

Plastic

0.153MJ

Total Energy Consumed



Material:	0.392 MJ
Manufacturing:	0.022 MJ
Use:	0.00 MJ
Transportation:	9.7E-3 MJ
End of Life:	1.0E-3 MJ

0.425 MJ

Aluminum

.0327MJ

Air Acidification

Air Acidification



Material:	1.7E-5 kg SO ₂ e
Manufacturing:	1.3E-5 kg SO ₂ e
Use:	0.00 kg SO ₂ e
Transportation:	1.5E-6 kg SO ₂ e
End of Life:	3.7E-7 kg SO ₂ e

3.2E-5 kg SO₂e

Plastic

3.2E-5 kg SO₂e

Air Acidification



Material:	1.9E-4 kg SO ₂ e
Manufacturing:	1.0E-5 kg SO ₂ e
Use:	0.00 kg SO ₂ e
Transportation:	2.9E-6 kg SO ₂ e
End of Life:	7.2E-7 kg SO ₂ e

2.1E-4 kg SO₂e

Aluminum

2.0E-5 kg SO₂e

Water Eutrophication

Water Eutrophication



Material:	2.1E-6 kg PO ₄ e
Manufacturing:	4.9E-7 kg PO ₄ e
Use:	0.00 kg PO ₄ e
Transportation:	3.4E-7 kg PO ₄ e
End of Life:	9.2E-7 kg PO ₄ e

3.8E-6 kg PO₄e

Plastic

3.8E-6 kg PO₄e

Water Eutrophication



Material:	6.8E-6 kg PO ₄ e
Manufacturing:	3.8E-7 kg PO ₄ e
Use:	0.00 kg PO ₄ e
Transportation:	6.7E-7 kg PO ₄ e
End of Life:	1.8E-6 kg PO ₄ e

9.6E-6 kg PO₄e

Aluminum

2.8E-6 kg PO₄e

b. Sustainability

For our K-cup, it does not matter how many uses the cup could take because you recycle the body after one use and you throw away the lid and filter.

H. Project Summary

The K-Cup must retain the same dimensions as the original; otherwise it would not fit in the Keurig machine. Its strengths are recyclability, efficiency, and strength of the material. Its weaknesses include convenience because you cannot simply recycle the entire cup, and cost because aluminum is more expensive than the original plastic used to create K-Cups.

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