

Alcoa – Sustainability Final Report

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Client- Alcoa

Course- Engineering Design100

Section- 012

Team name- popping bottles

| | |
|----------------------|--------------------------|
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Link to project website-(<http://sedtapp.psu.edu/design/designproject/edsgn100/fa13/>)

Summary: The goal of the Alcoa project was to find the application of aluminum products to improve energy efficiency or increase sustainability. The team looked around the campus to find products which could be replaced by aluminum, as aluminum is one of the most abundant metals on the Earth's crust and is very light and strong. The team first selected three products(shoe boxes, plastic keyboards and plastic bottles) that can be replaced with aluminum, then the options were down selected using different factors like the energy used in the manufacturing the product, cost of manufacturing and a surveys. The team chose to design a replacement for plastic and glass bottles using aluminum. Our design costs \$.44 per unit (based on run of 500,000 units).

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Introduction:

To increase the sustainability of the campus and to improve the efficiency of energy, the team was asked to find opportunities around campus for the application or expanded use of aluminum. As aluminum is very light and strong metal and is 100% recyclable. Aluminum is the most abundant metal on the earth's crust. So, the team has to find the material which can be replaced by aluminum so that the waste can be reduced and energy can be saved.

Problem:

To find a product in the university setting that can be replaced by aluminum and it benefit the university community and the environment.

Sustainability:

Team 7's definition of sustainability is the ability to endure. It covers a wide range of topics. Sustainability is studied in many contexts of environmental, social and economic organization.

Collect Information:

Aluminum is a metal which is extracted from bauxite ore. Aluminum is the third most abundant element and the most abundant metal on the Earth's crust. The Earth's crust is made of 8% of Aluminum. Aluminum has the ability to resist corrosion. Aluminum is soft, lightweight, malleable and ductile. It can be easily machined, casted and extruded. Aluminum has many isotopes. Aluminum is extracted from bauxite using several chemical processes. Aluminum is almost 100% recyclable. The team first checked the properties of aluminum and then went to different locations on the campus to find the products that can be replaced with aluminum. As the focus of the team was to make aluminum bottles after selecting the idea with the help of selection matrix, some survey was carried out and people liked the idea as the aluminum bottles also had caps which are not there on the aluminum cans.

Concept Development:

Selection criteria:

The team came with the three main ideas for replacing the material by aluminum. The three ideas were replacing the plastic keyboards with the aluminum keyboards, replacing cardboard boxes for shoes with the aluminum boxes, and replacing the plastic and glass beverage bottles with the aluminum bottles. Later different factors like difficulty of manufacturing, cost, recyclability, energy were considered to

choose the two best ideas. (See figure 1.) The aluminum keyboards scored the lowest as they were difficult to manufacture out of the three ideas and the cost of manufacture is also higher than the other two ideas. Also the recyclability is also difficult in this case as the keyboard is composed of many other things like the computer chips, wire and other little small components which are needed to be replaced before recycling the aluminum keyboard whereas recycling the aluminum boxes and the aluminum bottles is easy as their composition is easy and they can be directly put into the recycling machine. The numbers are given to the each idea in different factors in the Figure 1 below:

Rate (hard) — (easy)
1 to 5
Concepts

| Project features | #1 (Keyboards) | #2 (Box Boxes) | #3 (Bottles) |
|---------------------|-------------------|-------------------|-----------------|
| 1. Difficulty | 1 | 2 | 4 |
| 2. Implementation | 1 | 1 | 4 |
| 3. Cost | 2 | 3 | 3 |
| 4. Recyclability | 2 | 3 | 4 |
| 5. Energy | 3 | 3 | 3 |
| | ✓ | ✓ | ✓ |

Figure1 - Design Selection Matrix

Key Stakeholders:

The list of stakeholders is:

1. Alcoa
2. Recycling Companies

3. Bottle Companies
4. Aluminum companies

Alcoa is a large company which use aluminum for different products and the aluminum companies will make a large profit from this idea as the demand of aluminum will increase. The recycling companies will also be affected as the machines in the recycling plants will be changed so a large amount of money will be needed but later the companies can make profit as the cost of recycling will be very less as compared to plastic and glass as the aluminum is recyclable to large extent.

Survey: The ideas that were selected with the help of above design selection matrix were aluminum boxes and aluminum bottles. So, the survey was carried out on these two ideas to get check whether the people like the idea of replacing glass and aluminum bottle with aluminum bottles and what will be the result in the market if these aluminum products are used. These surveys also helped to focus on aluminum bottles. The survey was taken by total 40 people.

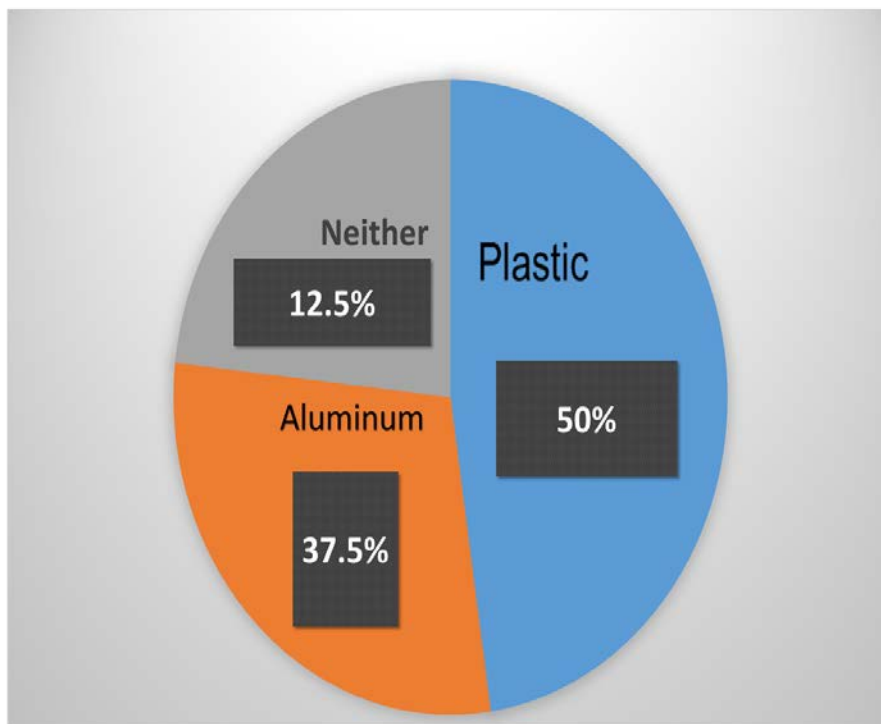
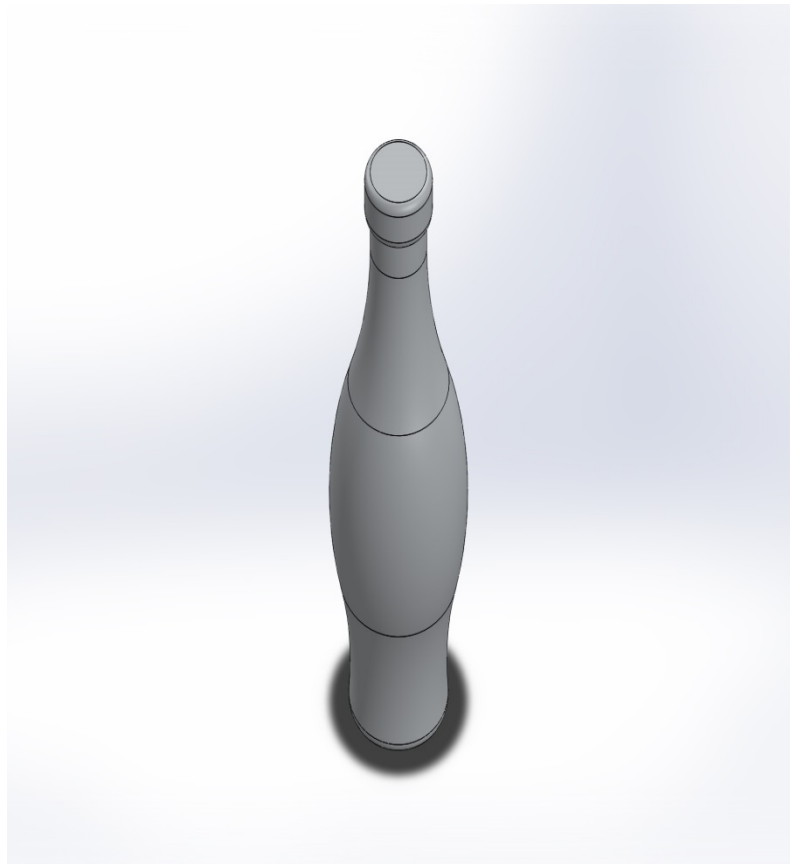


Figure2. – Summary of survey responses in having aluminum bottles replaces plastic bottles.

Detailed Concept Development:

Final Design:

We came up with a design of aluminum bottle below (Figure 3). The bottle itself weighs approximately one ounce, and it is capable of holding 12 ounces of liquid. The bottle has a round top with a cap on it which makes it different from the aluminum cans. The shape of the bottle is similar to the other soda bottles and it is easy to print text and logo on the bottle. The bottle can be used for different beverages like the soda, ice tea, coffee. The initial size of the bottle is 6 inches but it can be provided in different sizes according to the demand of the consumer.



Costing:

The NPOG bottle cost is \$0.44, the profit percentage is 35.1%. We got that by assuming the initial cost of \$118,200 by having two machines. Both of them cost \$75,000 for their lifetime. Also, by having two engineers and a supervisor with a total salary of \$43,2k a year and an annual cost of \$202,500 for electricity and aluminum bottle price which is \$0.25 per bottle. Lastly, the anticipated number of units to be sold annually is \$650,000.

| | | | | |
|------|-------------------------------|-----------------------------|------------------------|--|
| | | | | |
| | | Sample Eng. Econ | | Alcoa Project - Fall 2013 |
| | | | | |
| | Discount rate | | 0.75% | Current U.S. discount rate (2013) |
| | First Cost | | \$118,200 | assumes \$75,000 capital for matching life of 6500,000 units and NRE cost of \$43,500 |
| | Annual Cost | | \$202,500 | assumes fuel & electricity to produce 1 bottle is \$.14, material per can is \$.07 and labor is \$40k/year |
| | Number of units sold annually | | 650,000 | This is the output per machine.... |
| | Cost per Unit | | \$0.44 | this number adjusted to get to ~ 35% profit |
| | | | | |
| Year | First Cost | Annual Cost | Annual Income per Unit | |
| 0 | \$118,200 | \$202,500 | \$288,600 | Note: this example is working with traditional aluminum soda cans (12 oz.) |
| 1 | | \$200,993 | \$286,452 | Teams working with other beverage or food containers will likely be |
| 2 | | \$199,496 | \$284,319 | Working with different amounts or types of aluminum. |
| 3 | | \$198,011 | \$282,203 | |
| 4 | | \$196,537 | \$280,102 | |
| 5 | | \$195,074 | \$278,017 | |

| | | | | |
|----------|-----------|-------------|-------------|--|
| 6 | | \$193,622 | \$275,947 | |
| 7 | | \$192,181 | \$273,893 | |
| 8 | | \$190,750 | \$271,854 | |
| 9 | | \$189,330 | \$269,830 | |
| 10 | | \$187,921 | \$267,822 | |
| NPV | \$118,200 | \$2,146,415 | \$3,059,039 | |
| Profit % | | | 35.1% | |
| | | | | |
| | | | | For First Cost (\$118,200): |
| | | | | 1. new manufacturing machine = \$70,000 initial cost |
| | | | | 2. Cost of land and buildings not included; assume the new machine is installed in existing factory |
| | | | | 3. NRE based on two engineers each working 2 months for \$5000/month wages + one Supervisor working 1/4 time for 2 months for \$8000/month. Total wages = \$24,000 x 1.8 (Overhead) = \$43.2K |
| | | | | |
| | | | | For Annual Cost (\$160,000) : |
| | | | | 1. Energy / electricity used to produce one can: |
| | | | | a) energy saved in recycling one can = 100 watts x 4 hours = 0.4 KWh [1] |
| | | | | b) not recycling a can is equivalent to throwing away 1/2 can (or 6 oz.) of gasoline [1] |
| | | | | 33.41 KWh/gallon of gasoline [2] and 128 ounces per gallon |
| | | | | Effect of not recycling = 33.41 KWh/gallon x 1 gallon/128 ounces x 6 oz. = 1.57 KWh |
| | | | | So energy to produce one can = 1.57KWh - 0.4KWh = 1.17KWh |
| | | | | Average cost of electricity in U.S. is \$.12 / KWh [3] |
| | | | | Electricity Cost to produce one can = \$.12/KWh x 1.17 KWh = \$.14 |
| | | | | 2. Material costs |
| | | | | a) aluminum per can = \$0.07 [4] |
| | | | | b) But virgin aluminum must be added to process because we don't recycle 100% of cans... |
| | | | | c) assume total material cost per can = \$.11 |
| | | | | |
| | | | | 3. Sum of energy and material costs per can = \$.14 + \$.11 = \$.25 |

| | | | | |
|--|--|--|-----------------|---|
| | | | | / can |
| | | | | Cost for production run of 650,000 cans = \$.25/ can x 650,000 cans = \$162,500 |
| | | | | |
| | | | | 4. Annual labor cost: assume one person at \$40,000 /year (overhead included) to run the manufacturing process |
| | | | | Total annual cost = \$162.5K + \$40K = \$202.5K |
| | | | | |
| | | | Sources: | [1] www.earth911.com/recycling/facts-about-aluminum-recycling/ |
| | | | | [2] en.wikipedia.org/wiki/Gasoline_gallon_equivalent |
| | | | | [3] http://www.npr.org/blogs/money/2011/10/27/141766341/the-price-of-electricity-in-your-state |
| | | | | [4] http://wiki.answers.com/Q/What_is_the_price_for_aluminum_per_ounce#slide2 |

Conclusion:

The NPOG (No plastic or glass) aluminum bottle design has many great features:

1. Light weight
2. A bottle cap as caps are generally not found on the aluminum can.
3. The NPOG can hold 12 oz. of liquid.

The design will be accepted, because of its great features, efficiency and it is also easy to adapt.

The only thing to do is to educate people why it is better to use and recycle aluminum rather than plastic and glass.

Throughout this project, the team has learned many lessons. For example, aluminum can be recycled 100%, while plastic and glass can only be partially recycled. Another thing was that it is very difficult to convince people to accept new ideas when they are so used to the “common” idea and that they are ignorant about the introduced idea.

The team made a lot of efforts as they collected the background information before starting the project and managed the time well. Each team person understood the responsibilities and gave their best to complete the project.

References:

1. <http://en.wikipedia.org/wiki/Aluminium>
2. <http://www.alcoa.com/sustainability/en/home.asp>
3. http://www.alcoa.com/primary_na/en/home.asp