A Concrete Method

ArcelorMittal

Team Susteelable

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**Executive Summary:**

The steel drums that ArcelorMittal receives contain toxic chemicals. Upon emptying the drums during ArcelorMittal’s steel-making process, some residue of these chemicals will remain in the steel drums.

Our design consists of a pressure washer and drain system that an employee will operate with the proper safety equipment and precautions. The operator will wash and rinse the drums with a power hose, turning the residue into a safe and extremely diluted substance which will travel into a drain. After cleaning, the steel drums will be filled with concrete and shipped to various construction companies, while the collected waste liquid will then be sent to water treatment plants. We found that this design would not only be effective in creating an environmentally-friendly method to clean out the drums but also be a cost-efficient process that would provide profit to ArcelorMittal.
Problem Statement:

ArcelorMittal would like to be more environmentally friendly by reducing, recycling or reusing their waste products.

From the months of December to March, the chemicals from the steel drums are used in the steelmaking process at ArcelorMittal factories. Currently, ArcelorMittal has no method in place to reduce, recycle or reuse the steel drums that contain chemicals necessary for the steelmaking process. This lack of recycling affects not only ArcelorMittal and their stakeholders, but the environment and future of planet Earth. Through implementation of our design, ArcelorMittal would be able to increase sustainability of their waste materials in the next few years. It is important that this problem be fixed to improve profitability, help the long term sustainability of ArcelorMittal, and reduce the amount of waste going to landfills.

Through the design process and studying the inputs and outputs of ArcelorMittal steel making process, this project will provide a sustainable solution to reduce the amount of waste stream of the steel drums.
**Sustainability:**

Sustainability is built upon the three interconnected spheres of People, Profit, and Planet. These spheres encompass each of the various areas that impact society. Socially, sustainability functions to raise the standard of living for all and allow equal access for all people to the resources available. From an economic standpoint, sustainability saves time, money, and resources. Environmentally, sustainability presents a positive environmental impact and reduces pollution.
**Background:**

In our patent search, we found patents on various aspects of our design, but not our design in whole. The currently-available products that we found include a cleaning process of chemical containers (US6793740 B1), cleaning machines through vacuum extraction (WO2000038839 A1), cleaning machines through shot blasting chemical drums (US4723377 A), and a cleaning process containing a high pressure spray and drain as well as a sulfuric bath (US3798066). This background search provided us information on the ways that we could move forward with our designs and concept selection processes, without infringing upon other peoples’ ideas.
Customer Needs:

During the brainstorming process, we selected the following eight criteria that was most applicable for a successful design by considering all the stakeholders in this design. We chose to evaluate the designs according to affordability, environmental impact, safety for employees, legality, sustainability (repeatability), time efficiency, profitability, and space efficiency. As seen in our APH matrix, legality, safety for employees, and environmental impact were the highest ranking criteria, scoring 0.24, 0.21, and 0.19 respectively. On the other hand, affordability, time efficiency, and space efficiency were ranked the lowest scoring 0.06, 0.05, and 0.04 respectively. Thus, knowing the most and least important criteria for our design becomes beneficial in the design selection process to determine which design meets the most important requirements.
**Concept Generation:**

For our concept generation, brainstormed multiple ideas for the two parts of our design. The first part of our design was determining a method to clean the steel drums, while the second part was determining how to reuse the cleaned steel drums to give them a new life.

To clean the steel drums of the chemical reside, we brainstormed the following methods: a bush to scrub away the chemicals, a sponge-like material laid into the drums to soak up the chemicals, a vacuum to suck up the chemicals, a pressure washer to rinse of the chemicals, and lastly, a freezer to freeze the drums then scrape the chemicals off. Before we could select a design, we developed a list of requirements and used an APH matrix to rank the most important and the least important requirements for our design. As seen in the previous section titled “Customer Needs” and in the APH matrix, we calculated the weights of each criteria. With the weights of our requirements, we used a design selection matrix to aid us in determining which of our brainstormed ideas met the most requirements necessary for a successful design. As seen in our design selection matrix, our top two designs were the pressure washer which scored a 4 and the brush which scored a 4.03 which are the ideas we decided to chose between.

For the second part, concerning how to reuse the cleaned steel drums, we brainstormed different ideas which included melting the steel to be molded into another product, cutting the drums in half to be reused, or filling the drums with concrete and using them as a building material. While we did discuss the pros and cons of the various steel drum reuse methods, our top idea was to fill the drums with concrete and use them as a building material.

include initial sketches
### Concept Selection:

<table>
<thead>
<tr>
<th>Requirement (Weight)</th>
<th>Affordable (.06)</th>
<th>Environmental Impact (.19)</th>
<th>Safe for Workers (.21)</th>
<th>Sustainable (.10)</th>
<th>Profitable (.12)</th>
<th>Time Efficient (.05)</th>
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**Design Review:**

Our design review with another team provided some valuable feedback that we could use to improve our design. Some of the things for which the group commended us was our ability to reduce the total waste stream of ArcelorMittal as well as our effective use of visual aids in conveying our design. On the other hand, the group recommended that we do a full cost analysis of our design in order to completely understand environmental and economical effects of our design. The other group also suggested that we find a way to test the chemical residue in the drums after washing as well as the concentration of the diluted water that will go to a water treatment plant. Furthermore, the team advised us to investigate the environmental effects of burying the concrete-filled drums underground for construction uses.

We greatly utilized this feedback in order to build upon our strengths as well as improve upon our mistakes. One of the first things we are looking at is a way of easily checking the concentration of chemicals in the waste water. We intended to do this through the use of a chemical indicator that will change color when there is a high concentration of the chemicals are present. A cost analysis of the design reveals that to fill the drums with concrete it will cost ~$17 per drum. Considering the cost of a new steel chemical drum can be in the $100s the selling price of the drums should easily cover the cost to fill them additionally transportation costs can be easily eliminated by either having the buyer transport them or by simply subtracting the cost out of sold drums. Each drum should be able to sell for around $50 leaving $33 to cover transport, anything leftover being profit.
SolidWorks Model:
Systems Diagram:

Inputs
- Steel Drums
- Diethylene Glycol
- Propylene Glycol
- GE Depositrol
- Drum Manufacturers

Power Wash Solution

Outputs
- >.2% chemically diluted solution
- Cleaned out steel drums
- Filled with concrete

Sold to construction companies such as Vulcan, BrockWhite, etc.

Water Treatment Plant

Goes to

Filled with concrete

Goes to
Cost and Feasibility Analysis:

A key component of our design was making our method as profitable as we could. For our method the company will need to purchase several pressure washers and concrete mix but after the initial purchase the cost of maintaining the system low. Good industrial grade pressure washers can cost upwards of $1000. In addition the concrete needed to fill a chemical drum should cost no more than $17. While this seems like a large set up cost it is quickly covered by the price of selling the concrete-filled chemical drums as construction material. On average steel chemical drums cost ~$100 per drum. We assume that we could sell these filled drums at ~$50 a drum. It is hard to calculate the cost of water for this process as without testing we do not know how long it takes to clean the drums. The current cost of water in Pennsylvania is ~69¢ per 100 gallons. The pressure washer we are looking is 4000 PSI Pressure Washer - 13HP, Honda GX Engine, Cat Pump puts out 3.5 gallons per second so the cost to run it for 10 minutes is only 24¢. On average it costs .37¢ to transport 1 ton(weight of a filled drum) 1 mile by truck. So selling one of these concrete filled drums and transporting it 1000 miles by truck would net a profit of $29 per drum. By this estimate if the initial setup cost for the design was $5000(5 pressure washers) ArcelorMittal would only need to sell 172 drums before they started making money.
**Life Cycle Analysis:**

The current life cycle of a steel drum used in ArcelorMittal’s steel making process is very short. The “cradle-to-grave” process that is in place causes countless amounts of steel drums to end up in landfills every year. However, by implementing a “cradle-to-cradle” process, the steel drums can be given another life. Thus, the environment and ArcelorMittal will both be able to benefit.

Our process, A Concrete Method, does just that. Once the chemicals from the drums are used, the drums are then cleaned thoroughly and filled with concrete. These new concrete-filled drums will be sold to construction companies to be used as building materials. Not only will these new drums be versatile in terms of what they can be used to build, but they will also be put to a better and longer-lasting use. Using our process, the total life cycle of the steel drums that ArcelorMittal uses will increase greatly, while decreasing the amount of the steel drums that end up in landfills.
Conclusions:

Our product serves as a cost-effective and eco-friendly solution to ArcelorMittal’s ongoing problem of being unable to recycle or reuse their steel drums containing chemical residue of GE Depositrol, Diethylene Glycol, and Propylene Glycol. Our product solves two major issues for ArcelorMittal: eliminating the chemical residue within the drums as well as reusing the drums to ensure a profit for the company. First, a high-pressure washer would use water to rinse the chemicals from the drums. We would then test the inside of the drums as well as the diluted water to make sure they are not at toxic levels. Finally, we will fill the drums with concrete and ship them to various construction companies in return for a profit per drum. Our product includes many benefits such as being time efficient and profitable. With using the high-pressure washer, each drum will take an estimated ten minutes to fully rinse and clean. However, this is just a rough estimate as we would be unable to record the specific speed of the method without manual testing of our product. Through our cost-analysis, we also estimated a net profit of $20-30 per drum which would provide sufficient revenue for the drums that are currently going straight to landfill after the steelmaking process. We also took into account some of the drawbacks of our solution including finding a buyer of the concrete-filled steel drums as well as the solution required a large initial investment. One of the problems we may run into is finding a customer who will buy the drums from ArcelorMittal. Several construction companies such as Vulcan Materials Company may be interested in such a product, but we would not be able to accurately know the market until we put our product for sale. Another potential issue is that our method requires an estimated $5000 per product. It may seem like a steep initial cost but we feel that our product will provide sufficient profit for the company to earn back this money.
within six months of the product launch. Even with these concerns, we are confident that our product is able to satisfy a majority of ArcelorMittal’s needs and act as an effective method to reusing their steel drums.

The next steps in our design include testing our prototype, setting the final specifications of our product and planning for future development. We must test our prototype in order to get some vital information about the time-efficiency and effectiveness of our product. We would conduct many trials to see approximately how long it would take to wash out the drums. We also would use information from these trials to test the drums to see if any chemical residue remains in the drums after our high-pressure washing method. It is essential that we test the water to make sure it is diluted enough to go down the drain to a water treatment plant. This information would bring some clarity to the exact specifications of our product. It will be essential in effectively marketing our product with its specific details to ArcelorMittal. After this testing process, we would need to develop a marketing scheme with ArcelorMittal to effectively promote and sell our concrete-filled steel drums. We would intensely look at the local demographics and construction companies to see where our product can reach its desired consumers.
References:


