Waste Stream Reuse and Recycling Spring 2015, EDSGN 100 Design Project

Shun Him Lau
Sarp Ersoy
Wenxin Tong
Hasan Ali Ozbek

Dr. Bevin Etienne

The Pennsylvania State University

Table of Content

I. Abstract

II. Introduction

III. Mission Statement

IV. Customer Needs Analysis

V. External Research

VI. Legal Issues

VII. Concept Generation

VIII. Concept Selection

IX. Embodiment Design and Final Design Description

X. Conclusion

XI. References

Abstract

For this project, our customer is a steel producing company-ArcelorMittal, who wants to dispose drums. All those drums are used to contain chemicals, so during the whole process, we have to take many aspects into consideration. Following report talks about how we generate out concepts and select the better solution among all these solution to help ArcelorMittal maintain sustainability.

Introduction

The problem we are dealing with is used drums left by a steel producing company. These drums are in the plant of ArcelorMittal because suppliers of ArcelorMittal delivered liquid raw material to it by using drums as storage and transportation. What we are going to do is to figure out a way to get rid of chemical waste and hence recycle drums such that it benefits ArcelorMittal, recyclers and the environment. In doing this project, we mainly look for current models in the market or existing methods in the industry to see the common methods of waste treatment. Then, we will ask for more information, such as emailing associated companies, and requesting quotations. Finally, we will calculate the economic impacts to ArcelorMittal based on our information.

Mission Statement

Our mission in this project is to design a system to help ArceloMittal reduce amount of drum waste thrown to landfill, and even think of ways to fully utilize drums. Also, we try to avoid causing additional work to ArcelorMittal. ArcelorMittal is a steel-making company that we do not want it being distracted from this recycling process. Eventually, we hope to bring

convenience and economic profits to ArcelorMittal, and achieve sustainability. Normally, sustainability means fulfilling current needs while not sacrificing next generations' benefits. To extend the meaning of sustainability, we generate a more specific definition of it to fit the situation in this project. It refers to "given that not much harm is done to the environment, one completely and efficiently makes full use of products while minimizing any extra cost and work associated with them."

Customer Needs Analysis

Our customer is ArcelorMittal, which is a big steel producing company. This company receives a lot of drums, which contain some chemicals. What they want is to dispose all these drums at a reasonable cost. What ArcelorMittal needs is not just crash all these drums, but to dispose all these drums with an environmental-friendly and low-cost way. ArcelorMittal could have just crashed the drums, but doing that way could do a really bad influence on our environment.

Environment is really important, but while dealing with these drums trying to sustain, in the meantime, we should also take budget into consideration. If we can come up with a environment-friendly and low costly solution, that would be a win-win solution

All in all, what our customer needs is to recycle these drums at a low cost with as fewer materials and energy we use as possible.

External Research

America managed to recover 34% of the waste that was generated in 2009 when there were about 9,000 curbside recycling programs. There was 66.2% recycling rate of steel making

steel one of the most recycled product in the country. It means that approximately 20,000 cans of steel are recycled every minute. Yearly statistics shows that steel is recycled even more than plastic, glass, paper and aluminum combined. For the last 50 years, more than 50% of the total steel produced has been recycled.

Currently, different industries employ different strategies for dealing with wastes. Some of the common methods include landfill, incineration, recycling, sustainability, and biological reprocessing, energy and resource recovery methods. Landfills were very common in the past but even today the municipal council still use the method to dispose the hazardous waste, demolition and construction waste and household waste. Combustion is a method that helps in the reduction of the landfill space required through burning the waste and generates electricity (Fray International Symposium, 2012). Composting is a method used in the agriculture industry whereby the microorganisms are allowed to change waste into manure. When such kind of organic manure is applied in the cultivated land, it improves soil fertility. Animal and agricultural waste can be composted to produce manure. For instance, a dairy cow produces about 40 pounds of waste, which can be dried and used as manure.

Disposal of steel drums can have immense negative impacts on the environment that is why it is important to recycle. Recycled steel drums can be used to make a wide range of products. For example, gallon drums made stainless steel 55 can be recycled to produce new mash and boil pots with wood around them that serves as the decoration and insulation, custom made furniture for outdoor and indoor use, roofing tiles among other products.

There are several companies that recycle different kinds of steel drums. For example, Jakacki Bag and Barrel, Incl. that is based in Chicago manufactures, recycle and disposes steel drums of all types and size. The company cleans and disposes drums with capabilities such as

crushing and grinding the drums. New Pig is another company that recycles and disposes steel drums dealing majorly with steel and stainless steel drums such as open head and tight head drums. In a research performed on "Environmental life-cycle comparisons of steel recycling: *sustainability issues, problems and prospects"* covering trends on steel production between 1950 and 2006 in countries such as USA, Ukraine, Japan, Korea and India it was concluded that there are so many environmental benefits associated with recycling steel. Production of Electric Arc Furnace (EAC) steel only produces 9-12.5 GJ/ts (Yellishetty, 2011).

According to U.K Department of the Environment, approximately 6 million steel drums are manufactured yearly in UK of which 5 are recycled. About 800, 000 are cleaned by passing it through high temperatures while the rest is washed. Drums meant for cleaning and reconditioning are usually empty although it is impossible to avoid the residues. One of the operations used is washing of drums using aqueous solution with a soluble material or furnacing process.

Legal Issues

Recycling steel and other metal waste materials must comply with requirements of OSHA Act. According to this Act the employers are expected healthy and safe workplace for the employees. Recycling of the solid waste is a big business in United States. In 2001 alone, the non-ferrous recycling industry reported more than 3,000 injuries of which 701 cases involved several days away from work.

With such alarming statistics employers should evaluate their operations, equipment, and processes to make sure that all hazards in the operations are properly identified and that all members of the organizations are aware of the risks they are exposed to in the workplace. When

a recycling plant is setup those who are responsible must put measures in place to ensure that the employees are safe. Failure to put proper mechanisms to ensure safety in the workplace in a recycling plant attracts a penalty or a lawsuit because it is against business ethics and OSHA Act. Therefore, the challenge with recycling steel is meeting the high standards set by OSHA that every business must meet.

Concept Generation

Waste stream management focuses on the committed and future to the environment. As such designing, the project that will reduce the ArcelorMittal's waste stream is of paramount importance. This is because the waste stream from the company might pollute the environment. It is of importance thus to reduce the waste stream from such a company through the generation of ways that will reduce the bulkiness of the waste from the environment. ArcelorMittal Company is a big company that disposes off the waste into the environment. The waste is of paramount importance and if they are managed well in they will be economical (Ebnesajjad, 2013). EDSGN 100 project is designed to assist in recycling of the wastes. The project is designed to be used in recycling the waste products. This is significant because it will reduce the bulkiness of the ArcelorMittal waste in the environment. The primary objective of the design is to recycle in order to ensure minimum waste being dumped into the environment.

The project also will be a source of employment for many people. The people surrounding the Arcelor Mittal Company will benefit from the recycling of the company. One of the significant benefits to the people surrounding the company concerns the employment that would be provided to those people (Walton, 2002). The priority will be accorded to the people who surround the company as they are adjacent to the company and thus the company should

consider them as adjacent to the company and would be accorded the priority in terms of employment opportunities. Furthermore, the surrounding people will no longer have problems, which relate to the environmental pollution. They will instead enjoy the environment.

To reduce ArceorMittal's waste stream, the project will design in such a way that it results in the largest sources of refuse collection and recycling. Pallets from incoming material delivery, totes or empty drums from the delivery of fluids and waste refractory brick will also be considered essential in creating the recycling project. The project is important, and the stages that will be used in recycling the wastes would be of paramount importance.

The project design would be made in such a way that it would have a vaporization and condensation stage. In this stage, the waste materials that have been collected will be melted first. The melting of the materials will reduce the surface area of such materials. When the surface area has been reduced, the material can easily be made into usable materials. The melted materials are easy to be converted into materials of any shape. Unlike the solid materials, the dissolved materials are transformed into any form would deem fit for the market. The market demands materials of different shapes and sizes, and thus the recycling company will provide the materials in these shapes and sizes. The chemicals from the drum also would be extracted in order to reuse the drum. The design project would be made in such a way that it would ensure there is waste reuse (Walton, 2002). The water is applied in cleaning the drums will be sent to the water treatment center.

Vaporization will involve subjecting the liquid to high temperatures to ease the cleaning of the drums. In this case, the drums will go into the vaporizer where the chemicals are removed. After their vaporization, their condensation will then occur automatically (Ebnesajjad, 2013).

The condensation will result in the collection of cleaner and clear liquid. The machine will be made in such a way that it allows the condensation to occur automatically.

In the De-pressure system, the liquid will be subjected to high pressure. The system will automatically generate pressure that will push the liquid from the drums. The process of the liquid collection will thus be made easy.

When some drums cannot be reused directly, they will be crashed down. The crashed steel drums will be used to make other materials with different shapes. The machine will subject the drums to high temperatures that in turn crash the drums and can easily be made into various materials with different shapes. The system will also be made in such a way that it allows the drum washing to be efficient. The drums machine will have sub-sets that pump water at high pressure to ease the cleaning of the drums.

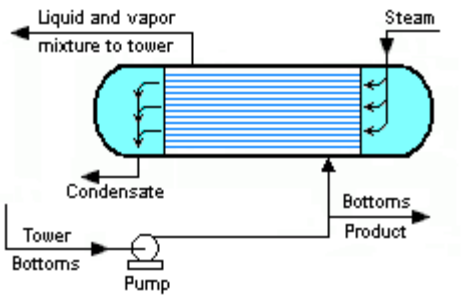
Concept Selection

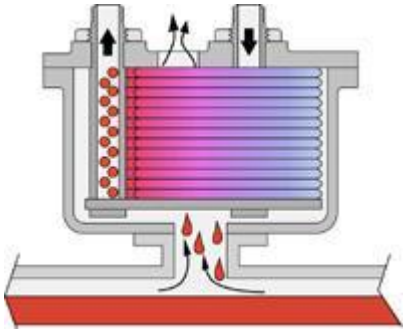
We have generated two concepts, one is to vaporize and condense the drums to get rid of the chemical residuals, another one is to just use water wash the drums and let other companies deal with the residuals and drums.

To solve this problem, to maintain the sustainability of the company, we try to minimize the energy and material we use during the disposal process. Since our customer is ArcelorMittal, who focuses on steel production, we try to make the drums disposal process as easy as possible, so that ArcelorMittal can have more time and capitals to focus on producing steel.

For the first concept, which is vaporizing and condensing drums, this process is like: first, all the used drums go into the vaporizer, in where the temperature are high enough that can vaporize all the chemical as well as water. After vaporizing, condenser automatically collects the

liquid and cools them down depending on the chemical properties, so that we can gain clear chemical ingredients. [1]





This process can recycle the chemical residuals in the drums and ArcelorMittal can reuse them again to lower the cost, and drums are ready to use right after the disposal process, so that ArcelorMittal does not need to worry about ship all the drums to recyclers. However, since this process involves some high technologies, if we want to set the whole process up, we have to deal with a lot of issues, such as the boiling points of chemicals, how to ensure staffs safety during collect the chemicals, and ArcelorMittal is a company producing steel, so, we truly do not want ArcelorMittal to be a recycler expert. What we want is make the disposal process as easy as possible and in the same time maintain sustainability.

For the second solution, which is just washing the drums and have someone else deal with the chemical residuals and drums. The reason why we came up with this idea is we try to make ArcelorMittal focuses on producing steel, rather than focuses on recycling drums. The process is like: first, all the used drums go into washer. For each time, four drums can be washed simultaneously, and the dirty water will be safely collected and sent to wastewater treatment company. After drums are washed, we will have recycler collect drums.

This process is not as advanced as former one, but since ArcelorMittal is a company focus on producing steel; we do not want to get it distracted. Compared to the first solution, this solution cannot recycle all the chemical residuals, but the things is the cost on vaporizing and

condensing chemicals is way higher than the value of chemicals themselves. Sending all the wastewater to a wastewater treatment company can lower our cost on dealing with those chemicals, and also the truth is the chemicals residuals in the drums are not that much, it's not worthwhile for us to recycle them. [2]

Based on all these pros and cons, we select the second concept, which is to use washer to wash the drums, and let other companies deal with wastewater and drums, so that we can fully focus on producing steel and in the meantime maintain the sustainability.

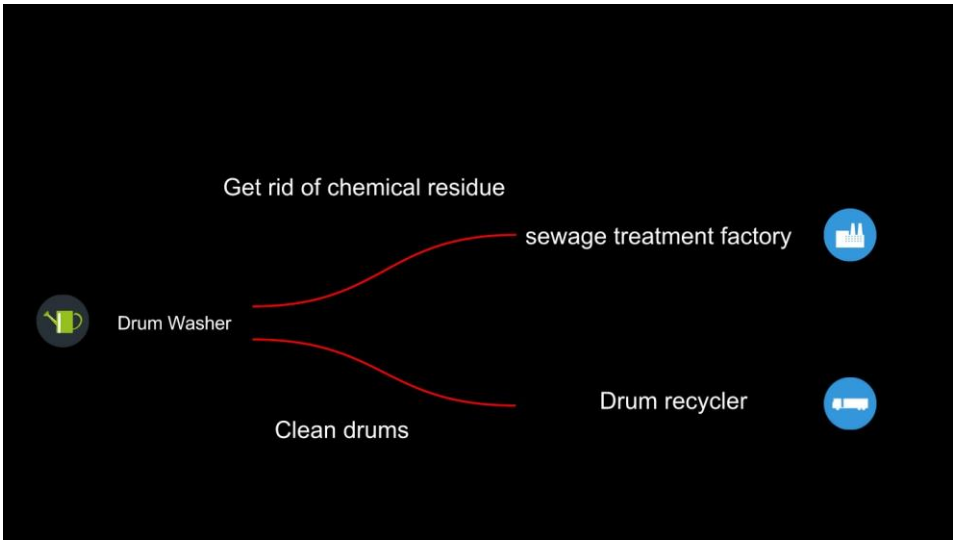
After deciding which solution we are going to follow, we also select which company's washer we should use. Basically, for drums washer, at the very beginning, we have two companies that we can choose. One is Drumbeaters of America Inc. [3] Another one is Rotajet. [4] Drumbeaters of America Inc. is a company located in America. Rotajet is a company located in United Kingdom. We compare the price if these two companies, the prices are pretty much the same, but the question is Rotajet is located in United Kingdom. It will be really costly and troublesome to ship all the equipment and machines to PA. So, eventually, we have our final decision, which is to use washers produced by Drumbeaters of America Inc.

As for wastewater treatment company and drums recycler, there are not many available companies on the market we can choose from, especially, located in PA. After doing some research on line, we found a couple of available companies. Reliable industries llc [5] and Clean Harbors [6], one is a drum recycle company and another one is a wastewater treatment company. The reason we chose these two companies is because all these two companies are located in PA, which let us lower a lot on our cost, and for CleanHarbors, this company has a bunch of wastewater treatment technologies, which ensures the wastewater can be dealt properly.

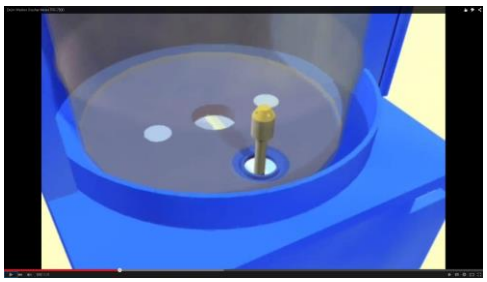
All in all, our final concept is to use washer wash all the drums and collect the wastewater and let specific companies collect wastewater and recycle drums. This solution ensures the sustainability and in the meantime prevents ArcelorMittal from getting distracted.

Embodiment Design and Final Design Description

The final design of our system is as followed: ArcelorMittal will purchase a drum washing machine, and wash drums in factories. These purposes of this washing process are to get rid of chemical residue in drums so that drum recyclers are willing to recycle our drums as well as to facilitate transportation process. After the washing process, all wastewater and chemical residues would be collected, and transferred it to a sewage treatment company. The reason we send the wastewater to other companies but not to directly dispose is that we try to minimize pollution to rivers and lands. We are not entirely sure what kinds of chemicals are in the water. We do not want to risk discharging waste to rivers in exchange of causing pollution and being charged. Next, all the drums, which are washed, would be sent to a drum recycling company. Once drums and chemical residues are sent to other parties, ArcelorMittal are done with the process. (Below is the graphic representation of our recycling system)



We are going to purchase a drum washer from Drumbeaters of America Inc.. Right now, we think the model ITR4S System is suitable for us. It is a set of machinery, which consists of 4 washing station and a tank being connected. Each washing station is capable of washing the interior of one drum sized up to 55 gallons per cycle. The basic washing principle of it is that we attach a drum on the washing station. Then, there is a metal tap immersing inside the drum through the opening hole of the drum. Water (or other cleaning detergent) would be spread out from the tap to rinse the interior of the drum. It takes about 2-3 minutes to wash a drum. The water consumption is adjustable based on the drum size, but the maximum is 75-gallon water per wash. Finally, all waste water from 4 washing stations are transferred to a 1000-gallon tank. Then, we can restart another washing cycle. [3]



Photos of the washing machine and the metal tap

There are three things ArcelorMittal needs to be aware of:

1. Since the washing system has a length of 163 inches, a width of 72.5 inches, and a height of 162 inches, AecelorMittal may need to find a location to place this machine as well as accommodate all washed and unwashed drums.
2. Since there is no conveyer for drums to pass through the washing stations, ArcelorMittal may need to find a few workers to replace drums after every washing cycle.

3. The 1000-gallon tank may not be sufficient to store much wastewater. So, it is better to treat the 1000-gallon tank as a temporary storage. It would be better to find a larger basin or tank to store all wastewater in one location.

As for drum recycler, we decided to work with the Reliable Industrial LLC. The workplace of this company is in Lancaster, PA. It offers steel, plastic, and fiber drums recycling service in Pennsylvania. In terms of transportation convenience, this location of this company is a good option given that the plant of ArcelorMittal is located in Steelton, PA. According to the webpage of this company, they can pick up drums for clients with free transportation. After collecting drums, they resell drums to manufacturers and wholesale users. [5] According to an estimation of drum disposal and recycle rate, ArcelorMittal can receive $32 for every 55-gallon drum. [7]

As for waste water treatment company, we decided to work with the Clean Harbors Inc... This is a nationwide company, which provides hazardous material management and sewage treatment service for many industries, including steel/primary metal industry. The company has three plants in Pennsylvania with one wastewater treatment facility. We would ask the company to pick up/ transfer the wastewater to their plants, and dispose them after further process. To ensure the company properly deals with wastewater, we look for information on its webpage, and we find that it adopts multiple ways to process water, such as acid/base neutralization, filtration, oil/water separation, etc. To be a socially responsible cooperation, we ensure our waste would not pollute the environment finally. And we believe this company is reliable. [6] As an estimation, the total running cost of a wastewater treatment plant to process 100,000-m3 water is about $339,333. By conversion, we approximates that the company would charge us $0.013 per gallon wastewater. [8]

This recycling system can help reduce waste directly disposed into landfills. In our system, no items are dumped directly. Our drums are recycled and reused because we believe once drums are cleaned, they can still be used to store other liquids, and lots of manufacturers need drums for their transportation. This matches our definition of sustainability of "making full use of products". Although there may be more wastewater generated in our system due to the operation of drum washers, it is a prerequisite to allow drums being recycled. So, we are trying to minimize any additional work and procedure.

Finally, here is the total cost and benefits to ArcelorMittal if it adopts this system. We have come up with some equations to help ArcelorMittal analyze this proposal. Our only fixed cost is the purchase price of drum washing machine. It costs $139,900, including acquisition and installation.

Unit variable gain/cost ($) =

D - **W** * ($4.2 cost of water)/ (1000 gallons) - **W** * ($0.013 wastewater treatment cost per gallon)

Note: (i) **D** = recycle rate per drum with certain size (Refer table 1 below)

W (in gallon) = amount of water consumption for washing 1 drum (W: [0 -75])

(ii) We assume the amount of water consumption for washing is the same as the amount of wastewater created per wash

(iii) Wastewater treatment cost per gallon and cost of water per gallon in the equation are based on information in the Internet. (Reference 8 & 9)

Table 1.1

Storage Container	Unit of Issue		Unit Price
5 Gallon Pail	5gallon - (Poly Open Head)	EA	$ 12.00
30 Gallon Drum	30gallon - (Metal New Open Head)	EA	$ 70.00
55 Gallon Drum	55 gallon - (Metal Recon Open Head)	EA	$ 32.00
Cubic Yard Box	Wrangler	EA	$ 85.00
80 Gallon over drum	85gallon - (Metal Steel)	EA	$145.00 avg. 69

Break-even point (number of drums) =

$139,900(fixed cost) / Unit variable cost

Payback period (months) =

Break-even point / number of drums ArcelorMittal deals with per month

For example:

For 55-gallon drum, recycle rate (D) = 32. We assume amount of water consumption (W) = 40. According to equations above, **unit variable gain** = $(32 - 40 * 4.2 / 1000 - 40 * 0.013) = **$31.312. Break-even point** = 139,900 / 31.312 = **4468 drums.** We assume ArcelorMittal needs to deal with 400 drums per month. **Payback period** = 4468 / 400 = **11.17 months.** This means it takes 11.17 months for ArcelorMittal to gain money from this system.

Conclusion

All in all, our system consists of two main parts, washing and recycling. It suggests that ArcelorMittal purchases a drum washing machine, and then transfers wastewater and drums separately to recyclers for further process and resale. This system is environmental-friendly as it reduces waste directly dumped into landfill. More importantly, it helps ArcelorMittal make

profits from this system in a long term. Furthermore, this system can easily be adopted. It does not require much labor, time and money to be carried out. It can certainly minimize extra workload to ArcelorMittal while achieving a desirable profit. Hopefully, this project is under ArcelorMittal's consideration. No matter how, we hope our idea could help ArcelorMittal in daily business operation and help preserve the environment.

References

Adama, O., & Nzeadibe, T. C. (2015). *Dealing with waste: Resource recovery and entrepreneurship in informal solid waste management in African cities*.

Ebnesajjad, S. (2013). Introduction to fluoropolymers: Materials, technology, and applications. Amsterdam: Elsevier Science & Technology.

Fenton, M. D., & Geological Survey (U.S.). (2003). *Iron and steel recycling in the United States in 1998*. Reston, VA: U.S. Dept. of the Interior, U.S. Geological Survey.

Fray International Symposium. (2012). *Metals and materials processing in a clean environment: Proceedings of the Fray International Symposium, Cancun, Mexico, November 27th-December 1st, 2011*. Mont-Royal, QC: FLOGEN.

National Research Council (U.S.). (1978). Recycling materials for highways. Washington: Transportation Research Board, National Research Council.

United Nations (2007). Reducing the solid waste stream: reuse and recycling at Lawrence Livermore National Laboratory.

Walton, R. (2002) World Water & Environmental Resources Congress, American Society of Civil.

Yellishetty Mohan, Gavin m. Mudd, P.G. Ranjith, A. Tharumarajah (2011). Environmental life-cycle comparisons of steel recycling: *sustainability issues, problems, and prospects*

Websites:

[1] Vaporiser and Condenser. (n.d.). Retrieved from http://www.directindustry.com/#myspace-account

[2] Washer Process. (n.d.). Retrieved from https://www.youtube.com/watch?v=FLZ5a5r9U4U

[3] Drumbeaters of America Inc. (n.d.). Retrieved from http://www.drumbeaters.com/drum-washers/drum-washer-dw55-itr

[4] Rotajet. (n.d.). Retrieved April 27, 2015, from http://www.rotajet.co.uk

[5] Reliable Services LLC | Industrial Recycling & Bulk Product Discounts. (n.d.). Retrieved from http://www.relbox.com

[6] Drum Waste Disposal. (n.d.). Retrieved from http://www.cleanharbors.com/browse_by_service/waste_disposal_and_recycling/drum_waste_disposal.html

[7] Document of waste disposal and recycle rate. (n.d.). Retrieved from http://bgs.vermont.gov/sites/bgs/files/pdfs/purchasing/16145-Clean-Harbors-Price-Sheet.pdf

[8] Running cost of wastewater treatment plant- CostWater.com. (n.d.). Retrieved from http://www.costwater.com/runningcostwastewater.htm

[9] Water Consumption Rate. (n.d.). Retrieved from http://www.scbwa.org/billing.php