WASTE STREAM IMPROVEMENT PROJECT

Team Bazinga
EDSGN 100 Section: 015
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Introduction

The entire human race is amidst an imminent doom. In the world we live in today, urbanization, deforestation and global warming are rampant. In order for us to avert a multitude of catastrophes, we need to change our ways even if they are miniscule in scale. For this project we tried to do our part in saving the environment by examining Arcelor Mittal’s waste stream and coming up with an eco-friendly way to reduce its negative impact on the environment.

Executive Summary

ArcelorMittal needs to create a realistic, efficient recycling stream for their waste. From a report in 2012, Arcelor Mittal dumped 1.8 million tons of secondary waste water and 70,000 tons of blast furnace filter waste next to the Indiana Harbor (ArcelorMittal Settles Toxic Waste Challenge). This is not only a threat to the environment but also a costly process. The objective of our project is to focus on their pallet recycling stream, and figure out a way to convert it from a cradle to grave process, into a cradle to cradle process. In our project, we will strive to create a systematic process in which used and broken pallets along with its nails are reused by a more economical mean rather than being burned down.

In our designing process, we will need determine our customer needs, conduct extensive research and have an understanding of the basic fundamentals of the steel making process. One of our goals is to replace the iron nails that are used in the pallets with wooden nails that can be constructed from the waste pallets. The wooden nails will have the same shrinkage and expansion as the pallets, thus providing better durability than steel nail pallets.

However, this process comes with its fair set of risks and challenges. One such challenge we might face is a high initial cost. The pallets are produced in a pallet manufacturing facility. In order to have the pallets made out of the dowel pins we would have to provide the manufacturer with new specifications. The facility might charge us an initial cost due to a change in product specifications. Moreover, the time taken to construct a pallet is also an issue since the dowel pins have to be glued before they are plugged in as opposed being nailed in by a nail gun.
Mission Statement

Our goal in this project is to reduce Arcelor Mittal’s waste stream of the incoming pallets from deliveries. As always our goal is to not only meet but exceed our customer’s requirements. On a personal level we will strive to learn about the process that goes into recycling waste and also learn about how the steel manufacturing process is conducted.

Customer Needs Analysis

The first step we undertook in our designing process was to analyze and interpret Arcelor Mittal’s needs. We also converted our customer needs into a set of needs statements, in order to make it easier for our team members to comprehend exactly what is required and in return, facilitate the designing process. We also created a needs matrix to identify the criteria for our designing process.
Below you can find a side by side comparisons between the customer needs and needs statements.

<table>
<thead>
<tr>
<th>Customer Need</th>
<th>Needs Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce ArcelorMittal’s waste stream at one of its facilities by designing an opportunity to reuse and/or recycle of its largest sources of refuse</td>
<td>The pallets from the delivery will be reused and once they reach their end of life, they will be recycled</td>
</tr>
<tr>
<td>The system applies a cyclical &quot;cradle to cradle&quot; process.</td>
<td>The recycling process must essentially produce zero “waste”</td>
</tr>
<tr>
<td>The system reduces the strain on resources and on waste disposal.</td>
<td>The wood from the pallets comes from trees and they must essentially return there at the end of the process.</td>
</tr>
<tr>
<td>The system decreases the growth in consumption.</td>
<td>By reusing the pallets effectively, we will be using less pallets overall</td>
</tr>
<tr>
<td>The system reduces disposal costs.</td>
<td>By averting the nail melting process and by either sending our broken pallets back to the pallet manufacturing facility or composting it, we are almost completely eliminating waste going into landfills.</td>
</tr>
<tr>
<td>The systems examines all inputs and outputs.</td>
<td>All incoming resources and out coming waste must be considered in our pallet recycling process.</td>
</tr>
<tr>
<td>The system connects to the plant, city, region, state and country.</td>
<td>We are using the Steelton, PA plant in our recycling cost calculations.</td>
</tr>
<tr>
<td>The system is economically viable</td>
<td>We need to ensure that our pallet recycling process is not overwhelmingly expensive.</td>
</tr>
</tbody>
</table>
# Needs Matrix

<table>
<thead>
<tr>
<th>Needs</th>
<th>Reusability length</th>
<th>Recycling</th>
<th>Implementation of dowel pins in the pallets manufacturing process</th>
<th>Costs-Benefits Analysis</th>
<th>Composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>The pallets from the delivery will be reused and once they reach their end of life, they will be recycled</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The recycling process must essentially produce zero “waste”</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The wood from the pallets comes from trees and they must essentially return there at the end of the process.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>By reusing the pallets effectively, we will be using less pallets overall</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>By averting the nail melting process and by either sending our broken pallets back to the pallet manufacturing facility or composting it, we are almost completely eliminating waste going into landfills.</td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>All incoming resources and outgoing waste must be considered in our pallet recycling process.</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>We are using the Steelton, PA plant in our recycling cost calculations.</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Needs to be relatively inexpensive</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
Concept Generation and External Research

What are Pallets?

A pallet is a transportation structure on which goods are placed. Pallets created out of many types of materials, such as plastic, metal and paper, but AncelorMittal uses the most common form of pallets, which are made out of wood.

http://blog.vita.it/fenomeni/files/2015/03/wpid-wp-1425655240460.jpeg

How are Pallets Manufactured?

As previously stated, the pallets we are focusing are predominantly made out of wood. Once the trees are cut off, they are brought into a lumber mill, which takes care of manufacturing wooden boards.

These wooden boards are then shipped to a pallets-making facility, which then creates the final pallets.

Using Dowel Pins

Pallets are often assembled with iron nails. However, in order to make our recycling process sustainable, we can introduce dowel pins. These are a type of fastener that is made out of wood and can be recycled along with the non-reusable pallets.

http://store.cincinnatidowel.com/images/products/743.jpg
Refractory Bricks

Another idea of ours was to look at the waste stream of refractory bricks and convert them into raw materials to be re-used.

What is Refractory?

Refractory is defined as any solid compound or material which can withstand high temperatures without deformation and has a melting point higher than 1500 °C. Even when exposed to corrosive gases and liquids, refractories remain stable.

Refractory Bricks used by ArcelorMittal

ArcelorMittal mainly uses a ceramic type of refractory bricks. Ceramics are primarily composed of aluminium oxide, Al₂O₃ or alumina, zirconium oxide, ZrO₂ or zirconia, silicon dioxide, SiO₂ or quartz, certain amount of granite etc. Although ceramics are hard, chemically inert and poor thermal and electric conductors, they are also tend to be brittle and crack easily due to thermal shock (experiencing a sudden change of temperatures).

The Recycling Process

The typical processes to recycle the spent steelmaking refractories are as followed:

1. Complete removal of any exterior contamination, predominantly done by hand
2. Classification by chemistry
3. Crushing
4. Screening
Challenges

There are three major obstacles when trying to recycle refractory bricks. They are:

1. Separating and identifying the chemical composition of the used refractories is difficult due to the expansive number of elements and compounds present.

2. Classifying between primary and secondary raw materials is a time-consuming process.

3. Once the refractories are recycled, it is difficult for them to have the same functionality and effectiveness as the benchmark and can negatively impact the steelmaking process.

http://www.exportersindia.com/sonaliinternational/products.htm
http://www.shutterstock.com/s/%22burnt+brick%22/search.html
http://www.chemistryexplained.com/Bo-Ce/Ceramics.html
### Concept Scoring and Selection

In order to decide which source of refuse we would focus, our team rated each concept on a scale of 1-5. With 5 being the best option.

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Weight</th>
<th>Rating</th>
<th>Weighted Score</th>
<th>Rating</th>
<th>Weighted Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of implementation</td>
<td>20%</td>
<td>4</td>
<td>0.8</td>
<td>2</td>
<td>0.4</td>
</tr>
<tr>
<td>Overall cost</td>
<td>15%</td>
<td>5</td>
<td>0.75</td>
<td>3</td>
<td>0.45</td>
</tr>
<tr>
<td>Ease of recycling</td>
<td>10%</td>
<td>5</td>
<td>0.5</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>Ease of composting</td>
<td>10%</td>
<td>4</td>
<td>0.4</td>
<td>2</td>
<td>0.2</td>
</tr>
<tr>
<td>Recycled product effectiveness (compared to benchmark)</td>
<td>20%</td>
<td>4</td>
<td>0.8</td>
<td>3</td>
<td>0.6</td>
</tr>
<tr>
<td>Sustainability of process</td>
<td>25%</td>
<td>5</td>
<td>1.25</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Score</strong></td>
<td></td>
<td>4.5</td>
<td></td>
<td>2.85</td>
<td></td>
</tr>
<tr>
<td><strong>Rank</strong></td>
<td></td>
<td>1</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td><strong>Continue?</strong></td>
<td></td>
<td>Yes</td>
<td></td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Thus, we will be focusing on the pallets in our project.
Implementation

In order for the pallets to be manufactured with dowel pins, ArcelorMittal has to provide the pallets-making facility with this new specification.

Once the pallets reach an end-of-life status, meaning they cannot be reused in the steel manufacturing process, they can be turned into yard mulch. ArcelorMittal will give its non-reusable pallets to a composter company, which will take care of disposing of this waste.

Once compost is created, it is then used to create more trees from which new pallets will be manufactured, creating a 100% infinite sustainable process that reduces the steel facility’s pallet waste stream to zero.

Even though dowel pins may be more expensive to use and may take longer to produce compared to traditional nails, however, the change in cost is greatly trumped by its sustainability and reusability. These new pallets are 100% compostable, which means 100% sustainability. Moreover, a sustainable steel manufacturing process is a great publicity for the company and can open new markets, further increasing profits.

http://chickadeehillfarmservices.com/yahoo_site_admin/assets/images/DSCF1335.82172745_std.jpg
Costs-Benefits Analysis

In this section, we are going to determine the costs and the benefits of implementing our idea into the steel manufacturing process.

One of the ArcelorMittal’s stakeholders’ expectations is that the company cuts down its carbon emission wherever possible (ancelormittal.com). By implementing dowel pins into the pallet manufacturing and by averting the nail melting process, we will be satisfying the stakeholders’ expectations. These dowel pin incorporated whole-wooden pallets are 100% compostable and have no iron or steel components that need to be disposed of when composting.

Cost of Melting Steel Nails

We are going to carry out our calculations assuming that the pallets are used for transporting all of the 1.1 million tons of steel manufactured by the Steelton, PA plant of ArcelorMittal in one year.

We assume that the ArcelorMittal plant uses 48x40” recycled-wood pallets with a carrying capacity of 2,500 lbs. As a result, assuming no pallets were to be reused, the plant would need

\[
\frac{1.1 \times 10^6 tons}{1,125 kg} = 886,844\text{ pallets}
\]

Which means that ArcelorMittal would essentially use 73,904 pallets every month.
We now assume that every month a half of the pallets become non reusable. This means that 36,952 pallets would need to be disposed of. Before composting the wood, however, we need to extract the steel nails out of the broken pallets. Every pallet is put together with 60, 4” long steel nails weighing 0.032 kg each. As a result, every broken pallet generates

\[0.032\text{kg} \times 60 = 1.92\text{kg}\]

Of steel nails that need to be melted. Consequently, since we assumed that 36,952 pallets get broken every month we need to melt

\[1.92\text{kg} \times 36,952\text{pallets} = 70,948\text{kg of steel}\]

In order to melt one ton of steel we need 625 kWh. Therefore, the power required to melt 70,948 kg of steel (78.2 tons) is:

\[P = \frac{625\text{kWh}}{\text{tons}} \times 78.2\text{tons} = 48,875\text{kWh}\]

Since AncelorMittal uses natural gas to generate heat

\[\text{Natural gas} = \frac{10,354\text{Btu}}{\text{kWh}} \times 48,875\text{kWh} = 506,051,750\text{Btu} = 506\text{ MMBtu}\]

The price of natural gas is $3 per MMBtu, so the cost to melt the steel nails every month is

\[C = 3\times 506\text{MMBtu} = 1,518\text{\$}\]

Therefore, every year ArcelorMittal spends

\[C, \text{year} = 1,518 \times 12\text{months} = 18,216\text{\$}\]
Pallets Cost of Manufacturing with Dowel Pins

The price for 20 units of 48x40” recycled-wood made pallets is $15.75 (uline.com). These pallets are made out of recycled wood boards and put together by steel nails. Therefore, the cost of a single pallet is $0.79.

The price for a 250,000 units of dowel pins is $1,400, which means that the price of a single unit is $0.0056 (woodproducts.caldowel.com).

Our design of the new pallet incorporates 30 dowel pins. Thus, the cost of a single pallet, assuming a 10% increase in manufacturing costs because of the new specification, rises to

\[ C_{\text{unit}} = 0.79 + 0.079 + 30 \times 0.0056 = 1.03 \]

As previously stated, AncelorMittal uses 73,904 pallets monthly. Therefore, the company spends

\[ C_{\text{original}} = 0.79 \times 73,904 \text{ pallets} = 58,384.16 \]

The price of the same amount of pallets with the new specification will be

\[ C_{\text{dowel pins}} = 1.03 \times 73,904 \text{ pallets} = 76,121.12 \]
Final Considerations

In order for our design to be profitable, the difference in price between the pallets made with dowel pins and the original pallets must be smaller than the cost of melting the steel nails monthly.

\[
76,121.12\$ - 58,384.16\$ = 17,736.96\$
\]

\[
17,736.96 < 18,216\$
\]

The following graph shows both the curves of ArcelorMittal’s current process and our proposed design.

The gap between the two curves will continue to increase over time. Therefore, if our design is implemented, in the long run, ArcelorMittal will be saving large amounts of capital.
Solidworks Model

Dowel Pin Screenshots from SolidWorks:
Dowel Pin Drawing on SolidWorks

Length: 8 in
Diameter: 0.68 in
Pallet Screenshot from SolidWorks
Dimensions: 48 X 40 X 8 in
Conclusion

The goal of this project was to reduce the waste stream of one of Arcelor Mittal’s’ biggest sources of refuse. After going through an extensive concept scoring phase between refectory bricks and wooden pallets, we decided to go with the latter.

In this project, we examined the waste stream and recycling process of the incoming pallets from deliveries. Initially the pallets were connected by steel nails adjoined using a nail gun. However, once the pallets reached their end of life, the nails were removed and melted creating a cradle-to-grave process. This melting process not only produced carbon emissions but was also costing ArcelorMittal unnecessary capital. Our proposal was to turn this into a cradle-to-cradle process by replacing the steel nails with wooden dowel pins, reducing carbon emissions and also satisfying the stockholders’ expectations. Moreover, by avoiding the melting process and reusing the wooden dowel pins, ArcelorMittal was saving money every month. However, one of the challenges of implementing wooden dowel pins is that it makes the manufacturing of pallets more time consuming, since they need to be glued on before they are plugged in.

Overall, through this process not only did we gain experience on how to implement the Engineering Design Process but also, on a personal level, we realized that small changes can in fact lead to large-scale improvements.
References

http://www.exportersindia.com/sonaliinternational/products.htm

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http://www.chemistryexplained.com/Bo-Ce/Ceramics.html

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