Wood Shredder 3000 - ArcelorMittal
EDSGN 100 – Section 22 – Professor Ritter – 5/3/2015

Team G-Unit:
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Figure 1. Final Conceptual Design
Executive summary or Abstract:
ArcelorMittal contacted Penn State with the intentions to reduce their waste stream at one of its facilities by designing a method to reuse and/or recycle one of their largest sources of waste [3]. For this project we had to address one of three main problems the company had been facing. These options included steel drum barrels filled with chemicals, the disposal of refractory brick, and the excessive buildup of scrap wood and pallets. ArcelorMittal would like to solve these problems in an ecological manner. Our team took on the wood pallet problem, using the design process to develop and research potential concepts. After creating a design for a shredder, the team analyzed the costs and factors related to the company’s needs.

Introduction and Problem Statement:
ArcelorMittal would like to reduce their ecological footprint they leave on the earth by becoming more efficient and reusing wooden pallets and scrap wood. At this point in time, ArcelorMittal has an excess of wood material which ends up in our landfills. With such a large quantity of waste, there is a substantial, negative effect on the environment [1]. This project will reduce ArcelorMittal’s impact on the environment through the analysis of inputs and outputs in the production, and in return generate revenue for the company.

Definition of Sustainability:
Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony with nature. Sustainability supports the long-term ecological equilibrium by not harming the environment and exhausting natural resources. Sustainability avoids the typical life cycle of a product from cradle to grave as shown in Figure 2.

![Figure 2. The typical life cycle of a product from cradle to grave [5]](image-url)
Background:

When looking for background information to develop our ideas further, we noticed that the refractory bricks were coated in magnesium oxide and that it could be extracted and used in a certain type of ladles. Unfortunately, the ladles that could use the magnesium oxide were not used by ArcelorMittal. When researching the barrels, we had a very tough time trying to find any useful information on how to actually clean and safely dispose of the material collected in the barrels [2]. With the wood pallets, the best course of action seemed to just be to destroy them and then resell the wood chips. SSI Shredding Systems Inc. sells industrial size shredders of various sizes, capable of shredding stronger products such as engine blocks or refrigerators. We felt that a model with fast dual shears would suffice for the wood material we would be breaking apart [4].

Customer needs:

1. Ecological - Ensure that the solution meets all applicable requirements, satisfies relevant regulatory codes, and is economically viable. Reduce ecological impact
2. Cost Effective - Minimize the total cost of revitalization. Company will use the products for means of profit.
3. Reusability - The use of existing materials to be emplaced into another design or concept.
4. Safety - to make sure that there are little possibilities of injury during use
5. Profitable - Total revenue exceeds the marginal cost.
6. Manpower - The requirements to keep the processes running and any extra labor entailed

<table>
<thead>
<tr>
<th>AHP Table</th>
<th>Reusable</th>
<th>Cost Effective</th>
<th>Profitable</th>
<th>Ecological</th>
<th>Safety</th>
<th>Efficient</th>
<th>Durable</th>
<th>Manpower</th>
<th>Total</th>
<th>Weight</th>
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<td>2</td>
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</table>

Grand Total: 81.75

Table 1. AHP Table ranking the customer needs our team chose
Concept Generation:
To begin thinking of possible solutions, we each wrote down our top ideas and concatenated them into the following list:

- Shredder
- Solution to clean drums
- Use bricks as outdoor tiles
- Steel pallets
- Crush bricks for Magnesium Oxide
- Mulch for property
- Company bonfire every month
- Sell bricks for fireplace
- Bricks for houses in 3rd world countries

Further developing our ideas, we were refined and came up with the following:

- Use an industrial shredder to destroy the wood pallets and use an electromagnet to extract the metal nails for the mixture of wood and nails
- Develop a process to completely rinse out the used barrels to remove any residing substance. Dispose of the waste in an ecologically friendly manner.
- Use barrels that have a hydrophobic coating on the interior to avoid any material from remaining inside the barrels after use.
- Crush the furnace brick using a large crushing machine. Use another process to extract the Magnesium Oxide to use in ladles or sell.

In the end, our team decided to move forward with the idea of using a wood shredder to destroy the pallets. This concept was at the top of each of our group members’ list, and we believed this would be the most feasible answer for ArcelorMittal. The use of an industrial shredder, similar to solar panels, would require a one-time startup cost with minimal amounts of maintenance costs.
Concept Selection:

<table>
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<th>Feature/Requirement (Weight)</th>
<th>1. Ecological (x5)</th>
<th>2. Cost Effective (x2)</th>
<th>3. Reusability (x3)</th>
<th>4. Safety (x4)</th>
<th>5. Profitable (x4)</th>
<th>6. Manpower (x2)</th>
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<tr>
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<td>3 (6)</td>
<td>5 (15)</td>
<td>2 (8)</td>
<td>3 (12)</td>
<td>4 (8)</td>
<td>(64)</td>
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<td>5 (10)</td>
<td>2 (6)</td>
<td>2 (8)</td>
<td>1 (4)</td>
<td>1 (2)</td>
<td>(40)</td>
</tr>
<tr>
<td>Design 4: Crush Furnace Bricks</td>
<td>2 (10)</td>
<td>3 (6)</td>
<td>5 (15)</td>
<td>3 (12)</td>
<td>4 (16)</td>
<td>4 (8)</td>
<td>(61)</td>
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</tbody>
</table>

For the pallet shredder, one of the cons that immediately stuck out to us was that the loading of the pallets into the shredder could pose as a potential area for safety hazards. Despite this potential problem, the pros far outweighed the cons. The method of power washing the barrels did not score well because of the cost of water, a facility to safely clean out the barrels, a means of disposing of the chemicals, and the amount of labor required. Using a hydrophobic coating for the inside of the barrels first seemed like a great idea, but with further research we applying the coating to each barrel would cause more harm than good. Crushing the furnace bricks also showed a lot of promise originally, but unfortunately we found a glaring error. Our original idea consisted of crushing the bricks and extracting the Magnesium Oxide for use in ladles. The problem with this method was that the ladles used by ArcelorMittal cannot have the Magnesium Oxide implemented. To use the Magnesium Oxide, ArcelorMittal would need to implement all new and compatible ladles, costing a large sum of money.

Using our concept selection table (Table 2), we found the use of a shredder to be the best idea to effectively repurpose the wood pallets. With this solution, ArcelorMittal can recycle the wood chips and create a smaller ecological footprint.

All in all, the implementation of a shredder would be an easy solution. With only a one-time purchase of a shredder and small cost of upkeep and maintenance, ArcelorMittal can easily see the benefits of taking this route.

Design Review:

What we found out from our design matrix was that the wood pallet shredder won by a small margin against the crushing of the bricks. The reason it won was because ArcelorMittal does not use the necessary types of ladles to put to use the magnesium oxide that would be taken from the crushed refractory bricks, resulting in more of a startup cost.
3D Model / Prototype / Images of process, etc:

Our design shows a simple dual-sheer top-loading shredder that can be used for recycling scrap wood. Pallets are loaded onto conveyor belt 1 where they are dropped into the shredder. The scraps from the shredder travel along conveyor belt 2 where they run underneath an electromagnet. This electromagnet attracts the metal scraps which separates them from the wood. The remaining wood scraps fall into the wood scrap container.

![Figure 3. Process of shredding a wood pallet](image-url)
Systems Diagram:

1. At the moment, ArcelorMittal gets its shipments of steel by companies that use large wooden pallets. Because ArcelorMittal has no use for these pallets, they end up being thrown away in landfills. The company would like to find a use for these used pallets that is both ecologically safe and economically sound.

2. We have come up with a plan that involves putting these no longer useable pallets into a large, industrial shredder to turn them into wood chips.

3. Once the wood pallets have been shredded and the nails magnetically removed, the wood chips are able to be repurposed into numerous things. The wood chips can be sold to companies that make furniture, turned into pressboard, or simply donated to humanitarian organizations such as Habitat for Humanity to help build playgrounds in poorer areas of the world.

Figure 4. Systems diagram showing the inputs, process, and outputs of our design.
Cost and Feasibility Analysis:

The main costs of this plan is the one-time purchase of a shredder which will range between 50,000-75,000 USD. This number was obtained by looking at the cost of other Dual-Shear shredders. With that amount of money being put down at the beginning, ArcelorMittal should start to see profit anywhere from 2-5 years in the future. Second, quality raw wood chips can be sold for around $15 per cubic yard. This grade of wood chips would be the extent of what a shredder like this could produce in a fast, cost effective manner. This means that at an average rate of 30 cubic yards of wood chips sold a week would amount to an annual revenue of about 23,400, allowing for ArcelorMittal to make their money back in 2 years and begin to earn a profit.

What makes this project feasible for ArcelorMittal is the sheer fact that the initial cost for the shredder almost all that is required. Other necessary services would include maintenance to the shredder, electricity for power, and an operator to maintain the systems.

Life Cycle Analysis:

By shredding the pallets we have created an easily shippable product that could be sold or donated to companies that could use at in to create furniture, pressboard, or use the wood chips simply as wood chips. With LCA in mind, we researched the inputs and outputs of the life of pallet and the environmental impacts without the use of recycling. We then assessed the LCA with our design in place and found that with minimal inputs, we were able to significantly reduce the environmental impact.

Conclusions:

This design has the potential to greatly clean and clear out the ArcelorMittal factories and give them a simple means of getting rid of the wood pallets that would end up in landfills. One problem with this idea is that they will have to find buyers to purchase their wood chips. From this rough plan they can try to expand their business and create a good system of either selling or donating their wood chips to put them back into the world. In the end, the implementation of our design seeks to reduce ArcelorMittal’s waste stream while espousing the company values of Sustainability, Quality, and Leadership in the steel making industry.
References:

Appendices:

Figure 5. Our first SolidWorks prototype

Figure 6. Cradle to cradle sketch