A2E Wood

Engineering Design 100

Dr. Ritter – Section 025

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Team Wood

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I. **Summary:**

ArcelorMittal presented our group with a problem; the company as a whole is producing too much excess waste within its different production processes. Three areas where there is an excess amount of waste created was with the bricks, steel drums, and wooden pallets and pipe racks. Our group, group 2, decided to create a process that would successfully reduce and eliminate waste created by the wooden pallets and pipe racks, which are currently taking up space within the company’s factories or being thrown away. The process we created is called A2E Wood.

A2E Wood is a process that we created as a group that will reduce all wooden waste that ArcelorMittal produces within their company. In order to create this process, we needed to come up with specific requirements that our product would need to follow. Using the AHP matrix, we came up with five important requirements that we would base our process off of. From our results, we found that safety was the most important requirement, with ecofriendly close behind. After we made up our requirements, we created a concept summary to evaluate all of our different options. We started with over ten different ideas that we could possibly use for our process. After evaluating each option, we narrowed our choices down to five different processes. These included turning the wood into: paper, pellets, mulch, or reusable lumber. Using the concept selection matrix, our data showed that creating a wood pellet process would be the best option.

A2E Wood is a process that begins within the factory walls of ArcelorMittal. ArcelorMittal workers will take apart the pallets and pipe racks using manual tools, and then they will separate the good, reusable wood from the bad wood, which will be sent home with employees. After that, ArcelorMittal can either sell the good bundles of wood to wood pellet-making companies, or shred the wood and put it through a wood-pellet maker. These pellets can then be sold as bio fuel. In order to represent our process, we created a step-by-step cycle that would explain each step. We also created a wood pallet prototype to demonstrate how much wood could be reused using our method. Our results showed that a little over 75% of wood within the company can be reused and redistributed for a profit. In conclusion, using A2E Wood will allow ArcelorMittal to become an overall more sustainable company, across the globe. Our process is feasible, simple, ecofriendly and profitable. Our data and tests have shown A2E Wood to be an excellent way of eliminating waste within the company as well as benefit the well being of the environment.

II. **Introduction and Problem Statement:**

In the ideal situation, ArcelorMittal would have no waste. Every last piece of wood that comes from the pallets and pipe racks would somehow be recycled and reused or even put back into the company and the wooden pallets and pipe racks would not take up an absurd amount of space within the walls of the company’s factories. By eliminating all waste within the company, ArcelorMittal would be a more sustainable company and would be more ecofriendly. As of now,
there is an immense amount of wood being thrown out or taking up space within the company. This wood comes from the wooden pallets and pipe racks, which are used to ship and transport products to ArcelorMittal. After these pallets and racks are used, they are stacked and stored within the company, or sent home with workers to use as firewood or to use for other personal uses. ArcelorMittal is also disposing of the wood and not recycling it in any way. The pipe racks and pallets are held together by nails, which can be difficult to take out. Because of this, there is no easy or simple way to reuse or recycle the wood. The wood from the pallets and pipe racks is creating a great amount of waste for ArcelorMittal. In order to fix this problem, our group will create a process that will recycle the wood so that it can be reused rather than wasted. To do this, we will follow a specific path in order to create the most efficient process that will reduce the most amount of waste for ArcelorMittal. First, we will evaluate all of our different options of processes to use. We will then narrow down our choices to one process. This process will meet all of our requirements, as well as reach ArcelorMittal’s goal of becoming a more sustainable company. To make sure our process is efficient we will ensure that our output is greater than our inputs. We will create a prototype and a cycle map that will explain all of our different steps of our process. Finally, we will have a feasible and reasonable process in which a very large percentage of the wooden waste within ArcelorMittal’s industry will be reused, while still creating a profit.

III. Definition of Sustainability:

To us sustainability is the ability to reuse and recycle while maintaining and helping the overall well-being of the environment and community.

IV. Background:

In order to come up with a feasible process, our group had to research the different options we had when deciding what process we would use. We decided that we would be creating a process, rather than an actual product, for ArcelorMittal. Because of this, we knew that we would most likely be presenting ArcelorMittal with a process that would use certain products or systems that have already been patented. One of our ideas was to shred the lumber from the pallets and pipe racks. In order to do this, a wood shredder would be required, which is a machine that has already been invented and patented. We also decided that our process would require ArcelorMittal to purchase a wood pellet-making machine. This is also a patented product. After we decided which process we would use, we researched different aspects about our process. While researching, we found that some people have built entire companies out of turning wood waste into wood pellets. ArborPellet is a company that turns wood waste, especially wood pallet waste, into wooden pellets. The founder, Brian Getzelman, started his company in 2008. The Forest Products Laboratory identified 111 operating wood pellet producers in 2009 and the industry has been growing since. A lot of these companies have bought wood pallets from other industries and turned the wood into wood pellets. Wood pellets are small cylinder-shaped pieces of condensed wood that can be used to fuel homes or buildings
or create energy. This is a biofuel. Wood pellets can be burned in pellet stoves, which were invented by Jerry Whitfield. Reusing wood, for example, pallet wood, and turning it into wood pellets to fuel stoves and generate electricity is a popular process that is rapidly growing worldwide.

V. Costumer Needs Matrix:

![Customer Needs](image)

**Figure 1** – Figure 1 is a graph of our Analytical Hierarchy Process (or AHP) matrix. This matrix decided the weights for our Design Selection Matrix in Section VII (Table 1).

Team Wood decided to use the eight important customers’ needs in Figure 1, End Quality, Profitable, Ecofriendly, Sustainable, Safe, Quick, and Transportable. Ecofriendly, sustainable, and safe were all chosen because they all have to do with ArcelorMittal’s problem statement about improving the environment and becoming more of a cradle to cradle company than a cradle to grave company (Reuse and Recycling). End Quality, profit, ease of use, quickness, and transportability were all needs that we thought of that would make our process stand above other process. By reaching those needs, ArcelorMittal will not only benefit the environment and their communities, but they will do so by efficiently making a profit for their company. As seen in Figure 1, ecofriendly and safe were our top two costumer needs while quickness and transportability were not as important. This makes sense because we value sustainability or quality over quantity.
VI. Concept Generation:

![Figure 2](image)

**Figure 2** – This diagram shows the flow of our concept generation stage.

To select our final concept we followed a few simple steps that can easily be seen in Figure 2. Our group got together and brainstormed all of our ideas, good and bad. From our short discussion we came up with a list of about ten possible design ideas. We then thought about these ten ideas and used our logic to weed out five designs that we deemed were either unethical or lacked potential. With our new group of five ideas we applied our Design Selection Matrix (Table 1) with weights that were decided from our Analytical Hierarchy Process Matrix (Figure 1). After running each design through our Design Selection Matrix we discovered our most promising design idea by the design with the highest weighted total. This can easily be seen in Table 1.

Here is a list of our first ten design ideas:

1. Our final design (wood pellets).
2. Turning the wood into pulp for paper.
3. Combining the wood with other materials to make a plastic composite.
4. Shredding the wood into mulch.
5. Repurposing the wood into furniture.
6. Chipping and reforming the wood into plywood or particleboard.
7. Using the wood as energy for electricity.
8. Rebuilding and reselling the pellets.
9. Shredding the wood to use as fertilizer.
10. Cutting the pallets to sell as scrap wood.

The five designs that made it into the concept selection stage were wood pellets, paper, plastic composite, mulch, and furniture. In other words, the first five ideas on that list were moved forward. These five ideas moved on because they shined in many areas compared to the
other five. First, the all were much more promising towards making a profit for ArcelorMittal. They also seemed to be the most sustainable and environmental out of the whole group.

VII. Concept Selection:

Table 1 - Figure 2 is our Design Selection Matrix which helped us decide which design would work the best with our specific consumer needs.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Profitable (weight = .15)</th>
<th>Ecofriendly (weight = .16)</th>
<th>Ease of Production (weight = .1)</th>
<th>Transportable (weight = .07)</th>
<th>Sustainable (weight = .15)</th>
<th>Safety of Production (weight = .164)</th>
<th>Totals:</th>
<th>Weighted Totals:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design 1: Pellets</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>22</td>
<td>2.84</td>
</tr>
<tr>
<td>Design 2: Paper</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>22</td>
<td>2.83</td>
</tr>
<tr>
<td>Design 3: Plastic Composite</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>18</td>
<td>2.49</td>
</tr>
<tr>
<td>Design 4: Mulch</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>19</td>
<td>2.58</td>
</tr>
<tr>
<td>Design 5: Furniture</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>4</td>
<td>18</td>
<td>2.48</td>
</tr>
</tbody>
</table>

From the Concept Generation process discussed in Section VI, we narrowed our selection down to our five most promising designs. These five designs consist of using scrap wood for wood pellets (used in heating), turning scrap wood into wood pulp for paper, combining scrap wood and other materials into a plastic composite used for playground, turning scrap wood into chips for mulch, and finally repurposing the wood pallets for furniture. As you can see from the table, the wood pellet design had the highest weighted table.

The pellets scored highly in profitability and ecofriendly which were both very important to our team. Paper came in a close second because it was very sustainable and ecofriendly because it would help reduce the number of trees cut for paper greatly, however the weights of our needs pushed pellets above paper. The plastic composite design was very sustainable and ecofriendly but not easy to produce at all giving it a very low score. Mulch was possibly the most ecofriendly because not only is it recycled wood, it also plays a good roll in the environment by fertilizing and protecting plants however it lost many points because of its lack of sustainability and the problems with transporting it. Finally, repurposing furniture received the worst score because its profit, environmental benefits, ease of production, and transportability, were all low scores. Like mentioned earlier, pellets received the highest score.

The method of turning scrap wood from pallets and pipe rails into pellets is very ecofriendly because pellets are a compacted biomass and are a very efficient way to release heat energy. Wood pellets are also extremely small and can be bagged up for easy transportation.
Nothing stands out from the safety and ease of production and the sustainability, however pellets were the most profitable option out of all of our designs, which will be discussed in the Cost Analysis section, making it overall our best choice.

Converting scrap pallets into wood pellets greatly helps ArcelorMittal reduce its waste footprint. This method is less of a cradle to grave plan for their previous pallets and more of a cradle to cradle plan. Not only does our final design clean up the factories of ArcelorMittal by finding a new way to get rid of their excess wood scraps, it generates a pretty large profit for them as well. We will also reduce their footprint by turning their old wood scraps into a biofuel (wood pellets) which is a much more efficient and ecofriendly way to heat buildings. More environmental information on wood pellets can be found here: (http://www.ecoheatsolutions.com/heatingsolutions/woodpelletboiler.html)

Implementing this design is easy but fairly expensive. ArcelorMittal will need to purchase a wood chipper and a wood pellet maker. They will also need to dedicate a few workers, or buy a few workers, for this operation. These workers will need to be supplied saws, preferably DeWalt Sawzalls because of their safety, ease of use, and low cost. The estimated cost of these purchases can be found in the Cost Analysis section. Only one ArcelorMittal factory will need to pursue these changes because all other factories can just ship their wood pallets and wood pipes to the factory with the machines.

VIII. Design Review:

Our design review was between us and team “Unbarrelable.” Bouncing our ideas off of another four brains was very helpful because we were already a team of only four people and our opinions were all alike. The review helped us realize that we needed to focus a lot more on the actual process of removing the wood and not the business and the plan afterwards. During this review we also generated the idea to cut apart a prototype pallet and weigh it to see how much could be recycled.
**IX. Process:**

![Figure 3](image)

**Figure 3**— This figure is our prototype pallet to show where to cut when taking apart each pallet. Cut along the dotted lines. The highlighted areas are scrap wood.

Our design process is very easy and simple. In this case, the simplicity of the design does not hurt any of the benefits of the system. The method is still very efficient and profitable. To begin, employees of ArcelorMittal will take a used pallet. This employee will use a saw, preferably a Dewalt Sawzall because of its quickness and low price, to cut around the nails. This cutting process was seen to be 75% efficient, meaning if a pallet weighs 40 pounds there will be 30 pounds of recyclable wood and 10 pounds of waste wood. This waste wood can continue to be passed on to the employees of ArcelorMittal to help them heat their homes. The recyclable wood will continue through a process inside the factory of ArcelorMittal. The next step for the employee is to send the wood through a wood chipper. After being chipped, the chips will be placed into the wood pellet maker. This machine will compact the wood into the organic biomass known as wood pellets. Finally, after being bagged ArcelorMittal can sell the pellets to costumers or to a pellet distributor to bring in a large profit.
X. Systems Diagram:

*Figure 4* – Figure four shows a complete systems diagram for our process.

Our system starts at the inflow of wooden pallets and pipe racks that are used in the transportation of other products. When ArcelorMittal receives this waste they can now immediately begin to process wood pellets. Another input into this system is the initial purchase of saws, a wood chipper, and a pellet maker. As employees put in their time this process will not only generate a profit from their waste, the efficient wood pellets will have a large output of heat energy that can save oil and money for homes to purchase heat.

If this system is used by ArcelorMittal, not only will they benefit from their sales, the community will benefit from cheap, recycled heat energy. Additionally, the ecosystem won’t receive a direct benefit, but it will experience a large benefit in the long run because fewer homes will need additional heat energy and oil and other wood will be able to be saved.
XI. **Cost and Feasibility Analysis:**

**Table 2** - The data below shows the initial investment costs of the machines along with the recurring costs.

<table>
<thead>
<tr>
<th>Initial Investment (Items)</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood Shredder</td>
<td>$250,000 - $300,000</td>
</tr>
<tr>
<td>Wood Pellet Maker</td>
<td>$100,000 - $150,000</td>
</tr>
<tr>
<td><strong>Total Initial Investment</strong></td>
<td><strong>$350,000 - $450,000</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Recurring Costs</th>
<th>Costs/ Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employees</td>
<td>$2137 (Per/ Employee)</td>
</tr>
<tr>
<td>Maintenance</td>
<td>$833</td>
</tr>
<tr>
<td><strong>Total Recurring Costs</strong></td>
<td><strong>$2970</strong></td>
</tr>
</tbody>
</table>

The reason why the costs of the wood shredder and the wood pellet maker are so high is because ArcelorMittal will need to invest in industrial size equipment. The use of this industrial sized equipment will ensure that ArcelorMittal will be able to process their wood waste stream efficiently along them to break even from this investment as fast as possible. The recurring costs were calculated by researching the salary of a wood processor/disposal worker which is $25,891 per year. Also we took into account the routine maintenance costs to keep the machines running smoothly which is around $10,000 a year.

The alternatives to reduce the cost of this process include either buying lower quality equipment and/or hiring less employees to do this task.

Our team actually created two equations that will allow ArcelorMittal to determine how long it’ll take them to break even on their investment. The equation is as followed:

\[
X = 8370(\text{Number of Workers})
\]

\[
\text{Total Profit} = -450,000 + (\text{Months})(X)
\]

How we created this equation is first we figured out the exact amount of dollars each worker would generate by processing and producing wood pellets per month. We first assumed that an employee working at full strength would cut and process 12 pallets per hour. Then each employee would work 9 hours a day, 5 days a week, in 4 weeks. So the total number of pallets an employee would process per month is 2160 pallets. Next the average pallet weights anywhere from 33-48 pounds so roughly 40lbs. With our cutting technique the workers will salvage 75% of the wood which is 30 lbs.

\[
2160 \text{ pallets} \times 30\text{ lbs/pallet} = 64800 \text{ lbs per employee per month}
\]

The price of a 40lb bag of wood pellets markets for around 7 dollars.
64800lbs / (40lbs/bag) = 1620 bags per employee per month

1620 bags * $7 per bag = $11340 of revenue per employee per month

We also accounted for the costs of paying the employees which is mentioned above along with the maintenance cost averaged out per month.

$2137 + $833 = $2970 per month

So the total profit per employee is calculated by taking their net revenue generated each month minus their pay and maintenance cost of the machines.

$11340 - $2970 = $8370 profit per employee per month

This can then be multiplied by the number of employees that ArcelorMittal wants to work because the amount of employees needed to do this job will vary from facility to facility which we called “X”.

The total profit equation was then calculated by including the net investment of the two machines which is at most $450,000. So by taking the profit generated by each employee times the number of employees plus the initial investment cost the total profit or the amount of months can be calculated. For example, we used the data from the ArcelorMittal in Coatesville PA which they have 119 salaried employees so we assumed they would need approximately 20 employees to process the wood and make pellets.

The amount of time to break even is when the company first makes a net gain on the investment which means when the profit first equals 0.

0 = -$450,000 + (Months)(X)

So the amount of time for the Coatesville facility to break even from this investment is as follows.

0 = -$450,000 + (Months)(8370 *20)

Months = 2.68 which is reality it would take Coatesville 3 months to make a profit on this.

Using this equation, ArcelorMittal can adjust the amount of employees they want to hire for this additional process based on the size of the factory, the amount of wood/pipe racks they get in, and also the amount of profit they want to make from investing into the wood shredder and wood pellet maker. Other ways that ArcelorMittal can make money with our proposed system is instead of creating wood pellets, they can sell the left over scrap wood to other companies that process it. This wouldn’t be as profitable as manufacturing wood pellets, but it’s a lower initial investment.
Feasibility -

Our design and process is very feasible for ArcelorMittal to adapt to their facilities for many reasons. For their stake holders wouldn’t have to designate a lot of space for the process since it only requires the wood shredder and pellet maker which would use less than 1 acre of space in a facility that is almost 1000 acres. Also there are no known cultural, security, or privacy issues associated with implementing our process since it only grinds up already disposed wood and turns it into an environmentally friendly bio fuels that offsets the use of non-sustainable fuel sources such as coal or oil. The only part of this process of this that would have to be government regulated is the training of the employees to use the wood shredder and pellet maker because these machines can be dangerous to an unskilled worker who hasn’t passed all the required qualifications.

XII. Life Cycle Analysis:

How our system accounts for the reuse or recycling the waste and converting the process into a cylindrical is through the creation of wood pellets from an already disposed material. ArcelorMittal was originally going to throw out the leftover wood or give it to its employees to burn. This wood would see its grave through a landfill or being burned by ArcelorMittal’s employees. Our process turns this linear process to a cylindrical process by diverting this waste to become a suitable biofuel such as wood pellets. Wood pellets are extremely efficient because it take a large portion of wood and crushes it down to a small wood pellet that can be burned in a wood pellet stove. Since there is a lot of material in a small area, they burn for a long time, produce a lot of energy, and produce a much smaller carbon footprint compared to other alternatives such as wood, coal, or oil. By selling this biofuel, it helps the environment by using a more environmentally friendly fuel and less of a non-environmentally friendly fuel while diverting the wood away from the waste stream. Also if the company decides to just sell the cut wood, then they’re still diverting the waste away from the waste stream since its going back to manufacturers to be used once again instead of thrown away.

XIII. Conclusions:

The upsides to our design are that it solves the problem of diverting the wood waste away from the waste stream. Also it creates a sustainable biofuel that gives a new life to the wood after it is used as pallets or pipe rack. Finally, along with being sustainable, our design will bring a significant profit to ArcelorMittal that can pay for itself in less than three months. The only cons of our project include the expensive initial investment for the wood shredder and wood pellet maker. Also our method of cutting the wood is only 75% efficient as compared to other techniques of cutting which may yield higher efficiencies. Where the design can go is only up from here. The design yields an environmentally sustainable fuel that is also very profitable. Almost every company in the world uses pallets to ship its goods. If they were to adopt our method of reusing these pallets, they would all yield higher profits while helping the
environment with diverting the demand in consumers of less sustainable fuels. Some of the lessons our group learned from this project is to take every single factor accountable when creating a design or manufacturing process. When our group first presented our process to the group “Unbearable” one of the first things they asked is “how much is this going to cost?” We didn’t have a straight answer for them since we didn’t do enough research on the prices of the equipment and estimated net profit of this system. So we made sure we had everything accountable before we presented our final process. Another lesson our group learn is how to be efficient when working in a team. We had to learn this the hard way since our team only consisted of three people as opposed to four. So we had to make sure to each be on top of our share of the work and make sure the team was moving forward as a whole.

XIV. References:

4. http://hardwareonlinestore.com/index.php?option=com_virtuemart&view=productdetails &virtuemart_product_id=36371&virtuemart_category_id=46001&gclid=CjwKEAjw0-epBRDOp7f7IYOG0zI4SjABxJg9q0wBC4DPf1QuVb18kNGITIUXAGzY7t9T_wiUCj9i9LBoCQX7w_wC