The Pallet Recycler 2.0
Project Final Report

For: ArcelorMittal

EDSGN 100

Section 25

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Abstract:

ArcelorMittal has recently started looking for greener and more efficient ways to dispose of their pallets and wood waste. The current way that they dispose of them, by individually breaking apart each pallet/piece of wood and separating the wood and nails, is neither cost efficient nor environmentally friendly. We brainstormed several ideas as a group and then used a customer matrix and a concept selection scoring matrix to decide that a wood shredder and magnetic sorter combination was the best choice. We built a couple of models for better demonstration of our proposal.

Introduction and Problem Statement:

Currently, ArcelorMittal either individually disassembles their pallets and pipe-holders and then landfills the components or gives the pallets and pipe-holders away for free as firewood. But these pallets are too large to carry home and are now just stacked and taking space in the steel plant. We want to find a process or tool that ArcelorMittal can use to dispose of the pallets and pipe-holders in a much more efficient and environmentally friendly way. The process or tool has to be cost effective enough that ArcelorMittal can use it for an extended period of time, but still meet the requirements of being safe and eco-friendly.

Definition of Sustainability:

The ability to undertake a process in an eco-friendly way, and continue such process renewably without long term negative impacts on the environment and the society.

Background:

ArcelorMittal is a steel production company that cast a large amount of steel every year. The raw materials, such as the iron ores and steel pipes that they make steel out of, come with large wooden pallets. Some pipe-holders even have 5-6 inches nails embedded that require a forklift to pry out. One current ways of recycling wooden pallets is to disassemble the original wooden pallet to acquire good wood and eliminate
bad wood, whereas good wood acquired will be used to build new pallets and for other purposes, and bad wood will be disposed or recycled. However this process is conducted by human labor and therefore inefficient, and is extremely dangerous since it requires the disassembler to constantly hold a sawzall to cut through the wooden planks to acquire the wood. Another way to deal with the wooden pallets is to simply landfill it, which is neither cost efficient nor environmentally friendly.

**Customer Needs:**

Our team decided that the criteria our design had to meet were safety, cost, usability, efficiency, durability, environmental friendliness, and simplicity. After using an AHP matrix, we figured that the most important by far was how safe our process or tool was for the user because we doubted that ArcelorMittal would want lawsuits on their hands. The efficiency of how our product disassembles the pallets and wood-holders came in second since we wanted to choose a design that we knew would work better than what they currently use. A close third was how green our design is because we wanted to make sure that we weren’t pitching a design that would pollute the environment. Tied for fourth was durability and simplicity, durability being the ability of our design to last for an extended period of time and simplicity being how simple and easy to repair our process or tool is. Fifth was the cost of our design and last was the usability, or how easy it would be to use our design. Cost was towards the bottom because we wanted to focus on making a more long-term answer to ArcelorMittal’s problems, so initial cost wouldn’t really be as big of a concern.
Table 1. The table above is an AHP matrix that shows our process for determining which criteria were the most important

Concept Generation:

Our concept generation process was thorough and exhaustive. We had many initial ideas ranging from improbable things such as sending the wood to space, to more realistic things such as a wood shredding machine. These all came from individual brainstorming sessions, and then were brought together in a group discussion. Some of our ideas were:

- Magnetic Nail Remover
- Send to the sun
- Wood Shredding Machine
- Send to third world countries
- Chemical melting
- Send back to manufacturer
- Send to charcoal factory
- AM burning the wood
- Individually disassemble wood

The top ideas ended up being the magnetic nail remover, wood shredding machine, chemical melting, and individually disassembling the wood. These all moved
forward because we felt that they best satisfied the requirements of the project, as well as being the most practical.

**Concept Selection:**

<table>
<thead>
<tr>
<th>Feature/Requirement (weight)</th>
<th>Safety</th>
<th>Cost</th>
<th>Usability</th>
<th>Efficiency</th>
<th>Durability</th>
<th>Environmental Friendliness</th>
<th>Simplicity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic Nail Remover</td>
<td>3 (.807)</td>
<td>3 (.27)</td>
<td>5 (.434)</td>
<td>4 (.64)</td>
<td>3 (.369)</td>
<td>5 (.74)</td>
<td>5 (.615)</td>
<td>3.875</td>
</tr>
<tr>
<td>Wood Shredding Machine</td>
<td>3 (.807)</td>
<td>3 (.27)</td>
<td>5 (.434)</td>
<td>5 (.8)</td>
<td>3 (.269)</td>
<td>5 (.74)</td>
<td>5 (.615)</td>
<td>3.935</td>
</tr>
<tr>
<td>Chemical Melting</td>
<td>1 (.269)</td>
<td>3 (.27)</td>
<td>4 (.347)</td>
<td>2 (.32)</td>
<td>1 (.123)</td>
<td>1 (.148)</td>
<td>3 (.369)</td>
<td>1.846</td>
</tr>
<tr>
<td>Send to Charcoal Factory</td>
<td>5 (1.845)</td>
<td>4 (.36)</td>
<td>5 (.434)</td>
<td>2 (.32)</td>
<td>4 (.492)</td>
<td>1 (.148)</td>
<td>5 (.615)</td>
<td>3.723</td>
</tr>
<tr>
<td>Individually Disassemble Wood</td>
<td>4 (1.076)</td>
<td>3 (.27)</td>
<td>1 (.0868)</td>
<td>1 (.16)</td>
<td>3 (.369)</td>
<td>5 (.74)</td>
<td>1 (.123)</td>
<td>2.825</td>
</tr>
</tbody>
</table>

Table 2. The data above supports our decision to pick the Wood Shredding Machine by showing that it is the best option using our criteria.

After discussing all of our options, we put together our best five ideas and put them in a table. The final ideas can be seen above in Table 2. This table put our ideas against the customer needs that we previously determined. The magnetic nail remover, while being the most efficient, wasn’t very safe. The possibility of nails injuring a worker was too great, so that was ruled out. Chemical melting had flaws in most categories, so that idea was quickly dismissed. Sending to a charcoal factory, while being very safe and easy, was probably unrealistic. This would require that nails be extracted and that we could find a company that would always buy our wood. Individually disassembling the wood is the current option, and was used as a control. Finally, our winning idea of a wood shredding machine, came out on top. The only big downfall to the machine is the upfront cost.

The wood shredding machine won because it came out with the greatest final score. Although it was not the safest option we had, there could be preventative measures put into place to help this. It also was not the most cost effective due to its steep upfront cost, but this would be lowered over time, so we felt that it was okay.
machine received the highest possible rating in usability due to the user being able to load wood and press a button for it to operate. Efficiency is another strong point for the machine, as the whole process is streamlined. Nails dulling the saw blades lowered its durability rating, but those would be manageable. The machine excels in environmental friendliness, as it assures that all of the wood waste can be reused. Finally, the machine is simple to manufacture and examine, as there is a lot of synergy among the parts.

ArcelorMittal’s waste footprint would be drastically reduced if they implemented our idea. This would be because they would be able to recycle almost 100% of the material from the wood waste, as opposed to their current methods which leave a lot of wood and nails in a landfill.

Our process would be implemented by either building the machine or purchasing it from a third party. It would then be placed in a location at one of their plants. Workers would then load wood onto the conveyor belt, press the start button, and wait as the machine works. The machine would first shred the wood into small pieces of wood and nails. Next, it would convey past a very large magnet, which would pick up all of the nails and metal pieces. The wood would then be conveyed into a collection bin, which workers could then move to a location where it can be processed. The nails would then be dropped back down on the belt, and pushed into a separate bin for collection. In the same way as the wood, the nails would then be moved to a location for processing.

Design Review:

We reviewed group 5’s design while they reviewed ours. For them, they did not like the idea of how the saws would be grinding the wood and the nails, which may cause wear and tear damage. They thought we would need to replace the saws too often for us to make a profit, as well as stated our startup cost is way too expensive. What they told us did not really affect our final design. We kept it the same. From the start we did not want the cost of our design to be a number one concern. Also, we knew our saws would have to be special so they would not consistently break down. We changed the teeth to work with the wood and nails to prevent more damage to the overall design.
Prototype:

For the prototype, we built both a cardboard model and a SolidWorks model. The SolidWorks Model will be shown below. The pallet recycler is composed of mainly two parts, one that grinds and saws the wood, the other sorts apart the nail bits and the wood block/sawdust.

![Figure 1: Trimetric View](image)

The pallet will be sent into the machine from the front. The conveyer belt will deliver the pallet to the saw, which saws through and grinds down the pallet. Ideally, the saws will cut the pallet into sawdust, and the nails will be either sawed as well or completely removed from the pallets and readied for the sorting process.

![Figure 2: Front View](image)

The sawdust, along with the nails/nail bits, will be delivered to the second part of the machine, where the magnetic sorting will take place.
In the second part of the pallet recycling process, the magnet will drop to a certain height and collects the nails/nail bits. The sawdust will be sent directly into the container in the back, at which point it can be purchased by any company that needs sawdust.
The nails/nail bits will be dropped by the magnet on the belt. The sweeper on the left will push the nails/nail bits on the belt into the container on the right. These nails/nail bits can then be used for iron casting and re-melted down, or can be sold for other purposes.

Theoretically, since this machine will separate wood and nails, it would recycle 100% of the materials used to make a pallet.

This machine is very environmentally friendly, as it recycle all of the wooden pallet. Although the nails may wear down the saw and the machine may need routine maintenance, its profitability should be larger than its long term cost, and therefore it should start making an earning after a certain point.
Cost and Feasibility Analysis:

For our estimated costs, we assume that the startup cost will be very high, near $300,000. The only recurring costs would have to be electricity and maintenance. The design would require five workers to handle it at all times. If they worked a 40 hour week getting paid $10 per hour [1], the total cost to pay the workers for one week would end up totaling $2,000. However, they will be selling the materials they are taking apart. They will be making $15 dollars from the wood [2] and roughly $5 from the metal [3]. Assuming that the machine can process one wooden pallet every two minutes, then it can process at least 200 wooden pallets a day. That will make at least $3,000 dollars a day. Minus the wage that is paid to the five employees who work eight hours every day which is an expense of $500, and the fees for electricity and maintenance at most $250 per day, this machine can profit $2250 every day. Assuming that the employees work five days a week that makes the profit per week at least $10000. This means we can start making a profit on the 31st week, before the sixth month.

Some ways to reduce the cost would be to maintain the machine routinely so that the saws wouldn’t need replacements as often. Also, depending on how many pallets there are, the number of employees in charge of recycling the wooden pallets can be lowered. ArcelorMittal can use this machine, first and foremost, to deal with their pallet storage problem. They can sell the processed sawdust and melt down the nail bits to
make iron, thereafter making a profit. If possible, they can also purchase wooden pallets from other production plants and recycle them to make a profit. The adoption of this machine by ArcelorMittal is fairly feasible because it is able to cover its expenses in a relatively short amount of time, as well as making a considerable amount of extra revenue. Since there are saws involved, ArcelorMittal should be especially careful with the employee’s physical safety. If this design is not yet patented, ArcelorMittal should apply for a patent so that they have its exclusive right of usage for a considerable period of time.

**Life Cycle Analysis:**

Our system will fully reuse both the nails and the wood from the pallets and other wood pieces like the pipe holders. With our process, the wood is ground up and separated. The nails can be melted and repurposed, while the wood can be turned to mulch, wood pellets, paper, or charcoal. This allows ArcelorMittal to reuse the wood and metal in whatever way they choose. They can sell the excess material or reuse them somewhere within their company.

**Conclusions:**

The Pallet Recycler 2.0 is a great idea to help ArcelorMittal with their pallet issue. It allows them to reuse the material from the pallets and pipe holders as well as make a Prophet. It also removes the factor of trashing the wood into landfills which is very eco-friendly. However, the startup cost is the number one concern for our design as it is a very expensive design. If ArcelorMittal chooses our design, they would need to make a long term commitment to it. The design could grow as they could add more accessories to the conveyer line design to aid the disassembly of wood and nails. Our group learned that you really need to think outside the box and brainstorm in order to come up with an idea that is both practical and original. It took us awhile to eventually come up with our design, but we persevered and created it.

**References:**
