Design Project II: Promoting Sustainability for ArcelorMittal

Engineering Design 100 Section 20
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(CBF Stream Restoration)

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Introduction

Industries and the business world are becoming more and more environmentally conscious. Recent advancements in environmental sciences have revealed the huge negative impacts that human development has on the Earth's environment and the ecological footprint that we are leaving behind. Companies are being pushed to implement plans to reduce their ecological footprint, conserve resources, and promote sustainability. Resources are limited, so recycling, reusing, and reducing the use and waste of materials is essential for reaching a level of sustainability. We have been tasked by ArcelorMittal, the largest steel producing company in the world, to establish a plan to reduce their ecological footprint. ArcelorMittal has an excess amount of refractory brick, wood pallets and beams, metal drums and plastic totes that need to be addressed. We have developed a plan to donate the wood waste products that ArcelorMittal currently throws into landfills to local non-profit organizations that restore Pennsylvania waterways and support aquatic habitats. By implementing this system, ArcelorMittal can conserve resources, reduce their ecological footprint and promote sustainability while minimizing costs.

Mission Statement

Our team must develop a plan to reduce ArcelorMittal's landfill volume while minimizing costs and promoting sustainability by reducing their ecological footprint.

Sustainability

Sustainability is, given limited resources, the ability to maintain a healthy standard of living and business through cyclic and renewable processes. Being self-sufficient without being self-destructive.

Customer Needs Analysis

ArcelorMittal needs to reduce their ecological footprint by recycling and reducing the total amount of waste material that they produce. The company needs a plan to reduce their waste of wood pallets and beams, steel drums, plastic drums and totes, and refractory brick while also minimizing cost.

- Reduce waste contributions to local landfills
- Minimize costs of waste management
- Benefit the local area of Steelton, Pennsylvania by reducing their ecological footprint and being more sustainable

Opportunity Rationale

ArcelorMittal's steel factory in Steelton, Pennsylvania is located in the Chesapeake Bay Watershed, which is a network of waterways that all converge to the Chesapeake Bay. With all of these waterways, many problems arise like erosion and lack of aquatic habitat. In Pennsylvania there are many non-profit organizations that work to solve these problems by restoring stream banks and constructing structures for aquatic life to flourish. These non-profit organizations use scrap wood to complete their goals; because of this, clean waste wood is highly sought after by these environmental organizations.

Along with helping the environment, ArcelorMittal will benefit by having their waste wood taken off their hands and bolster their public image by supporting conservation and recycling ideals and promoting sustainability.

Using these non-profit organizations also allows for ArcelorMittal to maintain its business relations strictly in the steel industry. In other words, ArcelorMittal will not grow horizontally, intruding into other industries, all the while their waste wood will be repurposed with minimal effort on ArcelorMittal's end.

Alternative Concepts and Evaluation

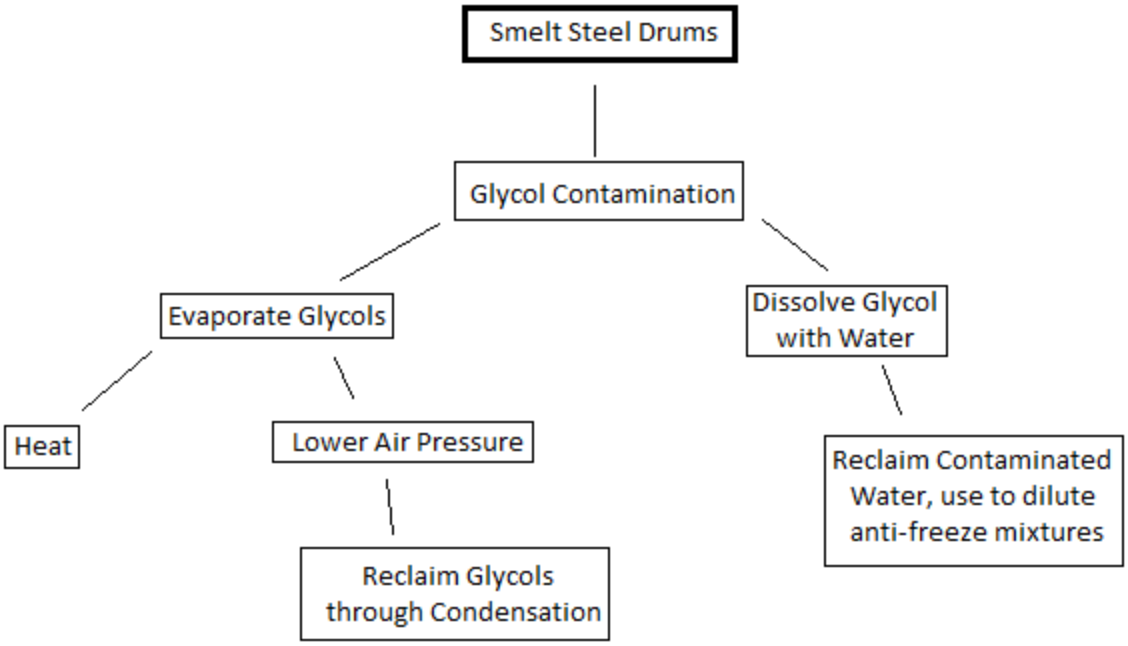
Our design process led us to multiple potential solutions that required evaluation and selection. We arrived at various solutions by first determining and analyzing the customer needs of ArcelorMittal: reducing landfill waste, minimizing waste costs, and reducing any negative environmental footprints. We weighed our concepts against various metrics and the customer needs in order to decide which concept we'd recommend to ArcelorMittal.

By expanding on the general customer needs, we created some specific metrics that we believe an acceptable solution must meet. Many of these metrics are concerned with generating interest from ArcelorMittal and the community the company coexists with.

First off, low cost was a high priority because although every step toward sustainability is necessary, there are still profits and losses to be concerned with. We wanted an idea that was high impact relative to the cost of implementation. One of the major contributors to lowering cost is simplicity. Simplicity lowers costs and the sooner and more easily an environmentally proactive idea can be implemented, the better. All potential solutions needed to be simple and have a high impact to cost ratio.

ArcelorMittal is a steel company; we didn't want our idea to require any horizontal growth of their business model. We can't expect ArcelorMittal to invest large amounts of money or time into new complex systems and equipment that has nothing to do with steel. A good solution won't change day to day operations or create new responsibilities. Every new process complicates the business model and, depending on the nature of the new equipment, can create new safety hazards to workers. New safety accommodations raise costs and time wasted in a safety centric industrial culture.

Finally, our idea had to be sustainable and generate a cycle someplace in the scheme of our planet. We didn't want to be short sighted and look for cycles only within the steel making process. A truly sustainable and contributing idea will generate community support and cast ArcelorMittal in a positive public light. We considered the major sources of waste of ArcelorMittal and generated flow charts for possible solutions. To begin we'll look at one of our ideas involving steel drums.

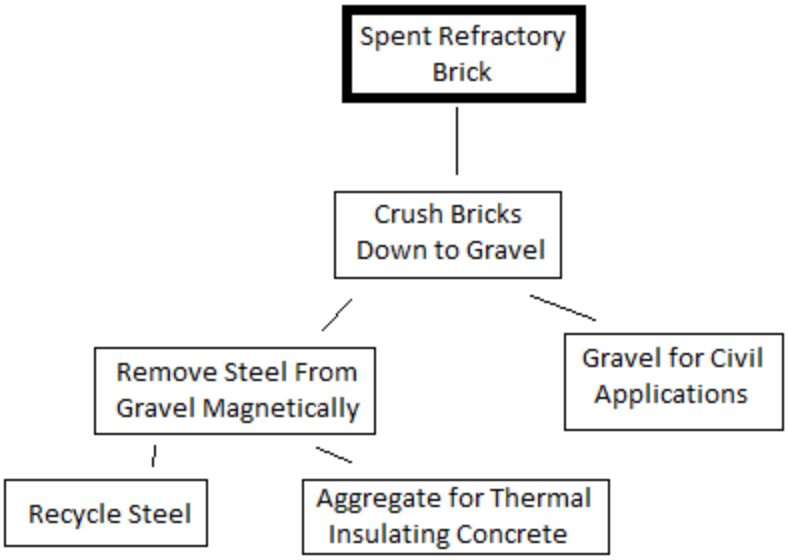


It seemed appropriate to recycle steel drums locally simply by tossing them into the crucible. Concerns arose about contamination due to residual glycols on the inside of the drums since the smelting and purification process is sensitive. Slag is generated based on known and expected chemistry. Simply tossing contaminated barrels into the pot would cause more issues than it would be solving, so we had to develop decontamination techniques.

Glycols are water soluble, dissolved to be used as antifreeze. One decontamination technique involved washing out the inside of the barrel and reclaiming the resulting solution of water and glycol. The clean barrel could be recycled and the reclaimed water would be used for diluting future antifreeze mixtures. Primary concerns included reclamation techniques of contaminated water and storage.

Instead of dissolving the glycols we considered evaporating them through means of heat or lower ambient air pressure. Heat techniques could be larger scale but would require an enclosure and energy costs would be high. By lowering the air pressure the glycols would boil off, and by keeping the system closed, vaporized glycols would be condensed and reclaimed.

Next we considered solutions for what seems to be the most significant contributor to waste: used refractory bricks.



With roughly 2500 metric tons of waste refractory brick generated annually, there was potential to make a significant impact on sustainability. This large sum of material made a simple low cost solution difficult.

Our idea involved first reducing the spent refractory brick down to a gravel. This process would involve new expensive machinery and trained technicians that can facilitate the reduction process. The gravel had potential applications in two areas. One potential application was using the broken down bricks as foundation gravel for civil processes such as road and building construction.

Another potential application for the gravel involved creating a new product, taking advantage of the thermal properties of refractory brick. The gravel would be passed beneath a magnet in an attempt to reclaim steel that had infiltrated the brick throughout its life cycle. This steel compromises the thermal properties of the refractory brick gravel, and once removed can be used as scrap metal in smelting. The purified gravel with renewed thermal properties would then be used as aggregate in cement needing insulating characteristics. The

cement could be used as mortar in construction of high temperature vessels and structures.

We created a table and weighed our ideas against certain metrics. If the idea meets the metric positively, the box is given a “+” mark, a negative correlation receives a “-“ mark, and if the idea correlates neutrally or not at all the box is given a “0” mark. The rows are summed and compared to assist in concept selection.

	Pallet Stream Repurpose	Grog from Bricks	Evaporate Glycols from Drum
Cost	+	-	-
Simplicity	+	-	-
Horizontal Growth?	+	-	0
Sustainable?	+	+	+
Reduces Ecological Footprint	+	+	0
Safety	+	-	-
Reduce Landfill	+	+	0
Community Support	+	-	0
Sum of +'s	8	3	1
Sum of -'s	0	-5	-3
Net Score	8	-2	-2
Use?	Yes	No	No

The steel drum process would be energy intensive and require fabrication of non-commercial vacuum and condensation systems. This leads to costs and complex solutions that make the solution unnecessarily difficult.

Grinding the bricks would require horizontal growth of the business model and may produce too much noise and dust, potentially leading to conflict with the community. The huge number of bricks is a challenge within itself.

After careful consideration it became clear our other ideas were second to our stream restoration concept. Not only did the other solutions not meet many of

our metrics, but brought with them many engineering obstacles and general insufficiencies not worth the effort and time for resolution.

Implementation of Plan

Non-Profit Organizations

In our research, we have found that after contacting many environmental non-profit organizations there is a high demand for the waste wood in any physical condition, as long as there is no chemical contamination for the purpose of waterway restoration. Some of the non-profit organizations that showed interest in the waste wood were Lackawanna County Conservation District, Pennsylvania Environmental Council, Trout Unlimited of Pennsylvania, and the Chesapeake Bay Foundation. These organizations work in conjunction with other organizations to achieve their goal of restoring the aquatic habitats across the state of Pennsylvania. We were not able to make any arrangements or deals with these organizations because we do not want to speak on behalf of ArcelorMittal, and any arrangements will have to be taken case by case by a proper representative of the company. Our intention was simply to gauge the interest and feasibility of collaboration with these non-profit organizations.

Hypothetical Cost Analysis

Because of the fact that this plan is simply an idea, we can not determine concrete cost figures. Therefore, our potential costs must be analyzed at a hypothetical standpoint. Preferably, the non-profit organizations will come to pick up the loads of wood pallets on their own time with their own resources. If this were to be the case, then ArcelorMittal would have no costs to worry about. They would be reducing their landfill volume along with reducing their landfill-dumping costs. According to the Waste Business Journal, the average cost for dumping municipal solid waste in landfills across America is $45.02 per ton (“Waste Business Journal”). The average weight of a wood pallet is approximately 40 pounds. A 50 pallet load is equal in weight to roughly one ton. Therefore, for every 50 pallets given to non-profit organizations, ArcelorMittal would reduce their total costs by about 45 dollars. In the long run, this reducing in cost would benefit the company. To add on to this benefit, donating to non-profit organizations is considered a charitable donation by the IRS. Annual tax

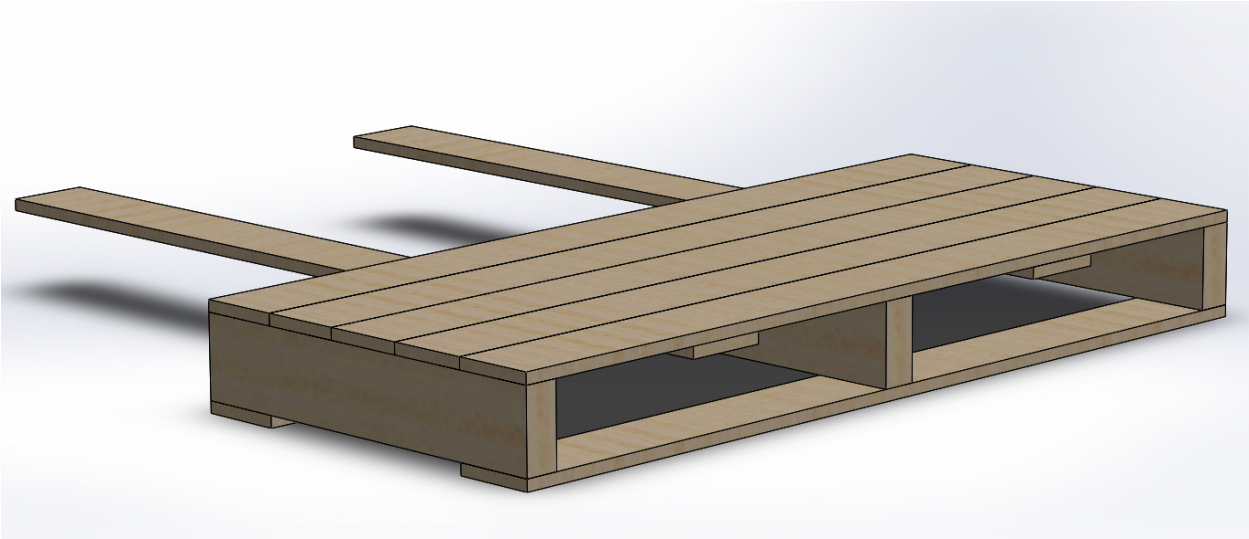
deductions are considered by the government. Of course, the volume of donations and value would have to be appraised by a government official and they, in turn, would determine annual tax deductions for ArcelorMittal.

On the other hand, the non-profit organizations may not have the resources to pick up the pallets themselves. In this case, ArcelorMittal can deliver the pallets to the organizations. Once again, however, we do not have concrete numbers to work with so we will be analyzing costs hypothetically. In a case where ArcelorMittal will be transporting the waste wood to the non-profit organizations, we calculated how far a semi truck can travel to transport a load of 50 pallets with a given cost constraint of what would have been spent to dump the load of 50 pallets in a landfill which is approximately $45.02. This is our break even point. The cost of diesel fuel, truck driver payment per mile traveled, and the fuel economy of a standard semi truck must be taken into consideration in order to determine the potential amount of miles a load of pallets could be transported within the cost constraint of $45.02. The current average cost of diesel fuel is $2.49 per gallon (U.S. EIA). A standard semi truck's fuel economy is 6.5 miles per gallon (Mack Aero…). After dimensional analysis and converting units, it will cost on average $0.38 per mile driven. Truck drivers are usually paid on a "per mile" system. The salary for a typical truck driver ranges from $0.20 to $0.40 per mile driven (Truck Driving Per Mile Salary). Taking the average of this range, the average cost for a truck driver would be $0.34 per mile. Adding this to the cost for fuel gives a total cost per mile of $0.72. Dividing $45.02 by $0.72 equals 62.53. Therefore, assuming that ArcelorMittal already has a means of transportation using semi trucks, ArcelorMittal can transport a load of waste wood 62.53 miles within the cost of dumping one ton of wood pallets into a landfill. So, for every 50 pallets that are diverted from the landfill and donated, ArcelorMittal can transport these pallets 62.53 miles to the non-profit organizations at the break even point of costs. In practice, the cost of transportation may exceed the money saved from diverting the wood waste from the landfill. However, these costs will be manageable for ArcelorMittal. Each non-profit organization will make specific agreements with ArcelorMittal in terms of waste wood volume being donated and transportation arrangements, so costs will have to be looked individually for each case.

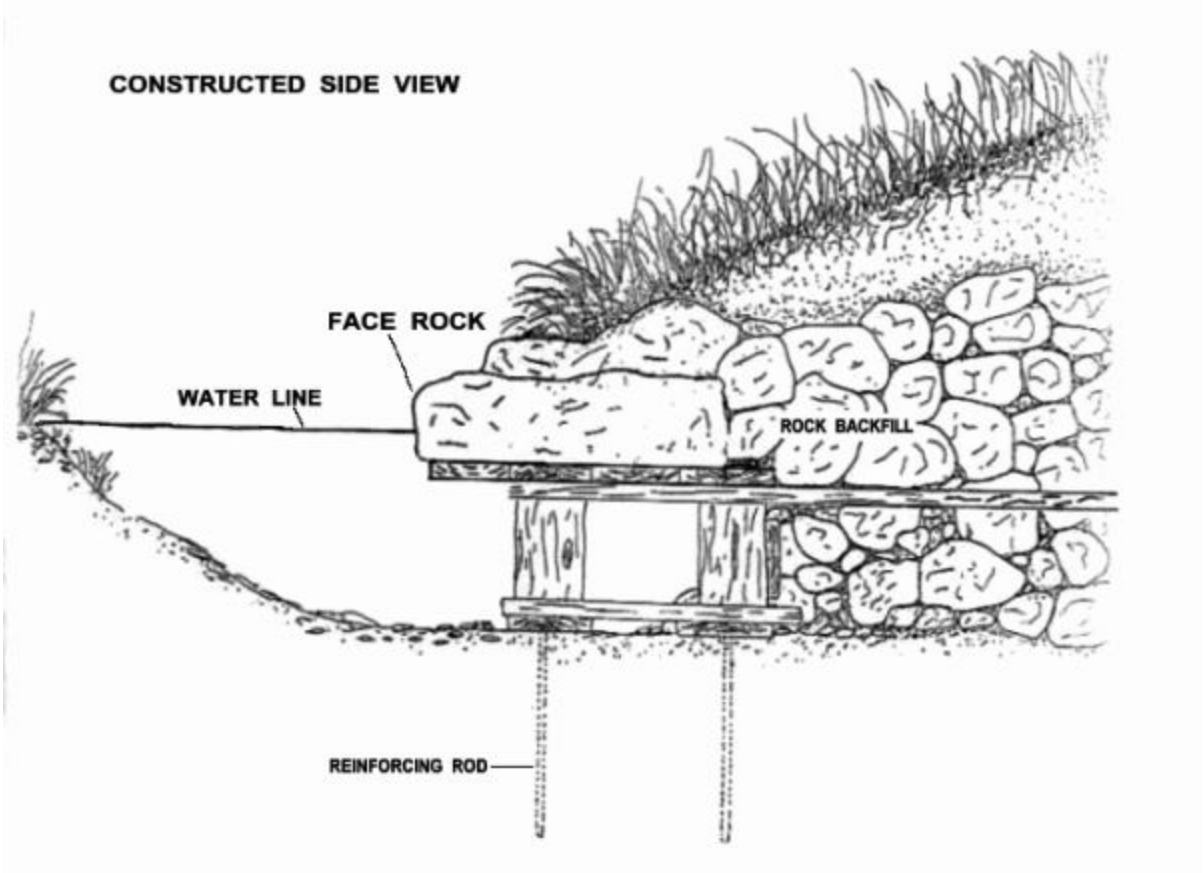
Uses for Waste Wood

The Non-Profit organizations are capable of making better use of the pallets rather than them being sent to a landfill. They would instead be put to use to help with steam conservation and aquatic habitat restoration. With some modification on the part of the nonprofit organizations, the pallets in better condition can be made into LUNKERS. Lunkers stands for "Little Underwater Neighborhood Keepers Encompassing Rheotactic Salmonids." The more damaged and broken up pallets can be either used as stakes for another method of stream restoration or as materials to assist in modifying the pallets to create lunkers.

Lunkers look similar to pallets with the same width but a third or a half of the length. The top surface also has no gaps. This allows no debris or soil to make its way into the interior of the lunker. There are two boards expanding out of the back of the lunker. They will act as anchors when they are dug into the riverbank or streambank. Below is a three dimensional rendering of a completed lunker ready to be used.



The way lunkers work is that they are dug into the side of a stream or river. They are completely submerged underwater. Dirt and stone can also be placed over top of the lunker if it is extruding from the bank slightly. The interior of the lunker is still open and accessible on the side of the stream. It allows fish and other wildlife to enter and take shelter inside as well as providing a home for them.



(Vernon Country)

Pallets can also be used as a strong base for new banks within wide shallow streams. The pallets are placed on the bottom of a stream. Rocks and dirt are built up on top of the pallet building a new stream bank. Plants and small trees are planted on top of the new bank so that the roots create more cohesion and a sturdier mound less susceptible to erosion.

The badly damaged pallets can be broken up to create stakes. Bundles of small wood and twigs known as watling bundles can be placed along the sides of the stream and staked down. They serve two purposes. They help maintain stability in the streambank as well as slowing down the water that passes along the bundles. Slower water helps lessen the amount of soil being carried away.

The large wooden boards can also be used for stream restoration. Usually logs are placed along the edges of stream banks to provide a makeshift barrier between the running water and the stream bank. It prevents the erosion of the dirt bank while acting as a suitable streambank itself. One or two of the large boards can take the place of the logs. This also allows for less trees to have to be

chopped down. Logs are also used to help create small dams within streams. They help moderate the flow of the stream as well as creating calm pools of water where fish and wildlife can thrive. Those logs too can be replace by two or more of the boards stacked on top of each other.

Waste Diverted

Implementation of this plan will divert large amounts of reusable wood from landfills and put it to use in restoring the vast amount of waterways in the state of Pennsylvania. According to Pennsylvania's Department of Environmental Protection, in the counties of Cambria and Wilkes-Barre of Pennsylvania, there are 25 creeks and rivers listed to be restored in the 2014-15 calendar year ("2014-2015 Planning and Design Projects List (PDF)"). With numbers like these in just two counties, the amount of waste wood diverted from landfills in one year would be quite substantial. To give an idea of the amount, 50 wooden pallets is equivalent to about one ton. With hundreds of miles of waterways in Pennsylvania, huge amounts of waste wood tonnage will be needed to restore them. Moreover, because of time and biological processes, the wooden structures will begin to deteriorate and will be in need of repair or restoring. Thus, waste wood will be diverted from landfills for years to come.

Conclusion

Reducing ecological footprints and practicing proper sustainability is crucial for businesses today. With dwindling finite resources, steps towards sustainability need to be taken. Repurposing pallets and waste wood for stream restoration is a step in the right direction of sustainability and is simple enough to easily implement. The future of our world depends on creative solutions, sacrifice, and working together. ArcelorMittal will set an example to fellow corporations and lead the way to a sustainable future.

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