Design Project 2
Waste Stream Reuse and Recycling Project
Sponsored by: ArcelorMittal
EDSGN 100 - Intro to Engineering Design (Section 010) – Team 5
Spring 2015
Submitted on: 5/03/2015

Submitted by: Abhishek Tennarangam | Mark Brady | Yuxuan Wu | Matt McDermott | Kibrebeal Ayalew

Submitted to: Xinli Wu
Cover Page by: Abhishek

Link: http://www.personal.psu.edu/akt5197/edsgn100_spring15_section10_team5_dp2.pdf
Executive Summary

This project report documents the process Team 5 went through in order to design a system to reduce one of ArcelorMittal waste streams (Pallets). This report includes the progression from brainstorming ideas towards choosing the best design to fit the design specifications ArcelorMittal provided. Also included are detailed drawings and diagrams of the prototype. Over the course of this project the team work effectively to exceed all the criteria for this project.

Executive Summary by: Abhishek Tennarangam
Table of Contents

Introduction (Abhishek Tennarangam)

Description of Design Task (Matt)
  - Problem Statement
  - Mission Statement
  - Design Specifications

Design Approach (Abhishek and Mark)
  - Project Management – Gantt Chart
  - Concept Generation - Brainstorming
  - Rationale for the opportunity identified
  - Concept Selection - Design Selection Matrices
  - Final Design

Final Design and Prototype (Yuxuan and Matt)
  - Detailed Drawings
  - Prototype Scale and Digital Images
  - Design Features

Analysis (Mark and Yuxuan)
  - Assessment of Waste Diverted
  - Concept of Operations
  - Life Cycle Assessment
  - Economic Viability

Summary and Conclusion (Yuxuan and Mark)

PowerPoint Presentation Slides (Abhishek)

Tri – Fold Brochure (Kibrebeal)

Acknowledgements (Team)

References
**Introduction**

ArcelorMittal is the world’s largest steel producer and their subsidiary company, ArcelorMittal USA, is the largest steel producer in North America. This company is the leader in all major global steel markets, including automotive, construction, household appliances, and packaging. The steel manufacturing process creates a lot of waste and most of it is sent to a landfill. This is called the “cradle to grave” process. In addition to other byproducts already being recycled or sold, ArcellorMittal still wants to reduce its waste footprint in order to reduce disposal costs, improve profitability, sustainability. A sustainable solution is something that is eco-friendly, future proof, and benefits all parties involved.

**Description of Design Task**

**Problem Statement:**

Currently ArcelorMittal’s Steelton plant is producing a great amount of waste in the form of refractory bricks, wooden pallets, and used barrels. They are disposed of by being shipped to a landfill, or in the case of the wooden pallets, are burned in open air. This is neither environmentally friendly nor economically beneficial. There is currently no plan in place to recycle any of the waste produced. ArcellorMittal, in cooperation with Pennsylvania State University, wants to find a sustainable alternative for dealing with this waste.

**Mission Statement:**

Team 5’s goal is to take one of the waste streams generated from ArcelorMittal’s Steelton plant and find an environmentally friendly, revenue producing solution. Currently the Steelton plant is producing waste refractory brick, metal and plastic barrels, and wooden pallets. The bricks and the barrels are both being thrown into landfills, and the wooden pallets are either being burned at home by employees or disposed of in landfills. This team’s mission is to find a useful purpose for at least one of these waste streams that will be environmentally friendly and economically beneficial to ArcelorMittal.

**Design Specifications:**

- Long-term Sustainability
- Environmentally Friendly
- Economically Viable
**Design Approach**

**Project Management (Gantt Chart):**

<table>
<thead>
<tr>
<th>Table 1. Gantt Chart</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GANTT CHART</strong></td>
</tr>
<tr>
<td><strong>Week 1</strong></td>
</tr>
<tr>
<td>(March 30- April 5)</td>
</tr>
<tr>
<td><strong>Week 2</strong></td>
</tr>
<tr>
<td>(April 6-12)</td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
</tr>
<tr>
<td>(April 13-19)</td>
</tr>
<tr>
<td><strong>Week 4</strong></td>
</tr>
<tr>
<td>(April 20-27)</td>
</tr>
<tr>
<td><strong>Week 5</strong></td>
</tr>
<tr>
<td>(April 28-May 1)</td>
</tr>
<tr>
<td><strong>Week 6</strong></td>
</tr>
<tr>
<td>(May 1-4)</td>
</tr>
</tbody>
</table>

- Problem Statement
- Mission Statement
- Brainstorming
- Design Approach
- Concept Selection
- System Diagram
- Concept of Operations
- Life Cycle Analysis
- Prototype
- Project Report

**Concept Generation:**

![Image of 5 different design concepts](image-url)

*Figure 1. Image of 5 different design concepts*
Description of Design Concepts:

- **The Coral Reef** – The idea behind this concept is to recycle refractory brick into more concrete. This concrete would be used to make concrete artificial reefs to promote marine life.
- **The Wood Chips** – The idea behind this concept is to send the wooden pallets into an industrial shredder and turned into wood chips. The output from the shredder is then sifted with a magnet for the nail particles. The remaining wood chips are sold to landscaping companies.
- **The Charcoal** – The idea behind this concept is to send the wooden pallets into a vacuum chamber that is heated and a constant temperature. This will create activated charcoal that can be sold to filtration companies.
- **The Paper** – The idea behind this concept is similar to the wood chip idea but the woodchips are sent to a paper mill which can turn them into pulp and eventually paper.
- **The Wood Ash** – The idea behind this concept is that whole pallets will be burned inside of an industrial furnace. The ash is sifted for nails and sent to fertilizer companies to be used in fertilizer.

Rationale for Opportunity Identified:

Our team decided to utilize the Wooden Pallet waste stream because we thought it was the easiest to implement, environmentally friendly, most economically viable. Wood is a very versatile material; it can be burned, cut, chipped, used in construction etc. This versatility allows us to create more effective and sustainable designs.

Design Selection Matrices:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainability</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Underlying Costs</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Profit</td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Ease of Application</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Eco Friendly</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Net +</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Net -</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Net 0</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Score</td>
<td>-2</td>
<td>1</td>
<td>-2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Rank</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 2. Design Matrix
Table 3. Weighted Chart

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>Weight</th>
<th>The Coral Reef</th>
<th>The Wood Chips</th>
<th>The Charcoal</th>
<th>The Paper</th>
<th>The Wood Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Rating</td>
<td>Score</td>
<td>Rating</td>
<td>Score</td>
<td>Rating</td>
</tr>
<tr>
<td>Sustainability</td>
<td>20%</td>
<td>1</td>
<td>0.2</td>
<td>4</td>
<td>0.8</td>
<td>2</td>
</tr>
<tr>
<td>Underlying Costs</td>
<td>20%</td>
<td>1</td>
<td>0.2</td>
<td>3</td>
<td>0.6</td>
<td>1</td>
</tr>
<tr>
<td>Profit</td>
<td>20%</td>
<td>1</td>
<td>0.2</td>
<td>3</td>
<td>0.6</td>
<td>2</td>
</tr>
<tr>
<td>Ease of Application</td>
<td>20%</td>
<td>1</td>
<td>0.2</td>
<td>4</td>
<td>0.8</td>
<td>2</td>
</tr>
<tr>
<td>Eco Friendly</td>
<td>20%</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>0.6</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1.8</td>
<td>3.4</td>
<td>1.8</td>
<td>3.2</td>
<td>3.8</td>
</tr>
<tr>
<td>Rank</td>
<td></td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

**Description of the Best Design Selected:**

After utilizing design matrices, our team decided to follow through with The Wood Ash concept. Whole pallets will be burned inside of an industrial furnace which will be fitted with a proper filtration system. The ash from the furnace will be sifted in two stages which will remove large debris and nails. The ash will then fall into a storage unit where it will sit until it is shipped via truck to fertilizer companies. Fertilizer companies can use this ash as a component in their products to benefit plant growth. Wood ash has many nutrients that are essential to plant growth and also increases the pH levels. This concept, while it does produce pollution, is the most sustainable and economically viable solution to ArcelorMittal’s problem.
Final Design and Prototype

Drawings and Prototype:

Figure 2. Drawing of Prototype Design

Figure 3. Graphical Representation of Prototype (Scale 1:20)
Design Features:

- Conveyor Belt – Transporting pallets to furnace
- Timed Release Doors – Control the inputs and outputs of the furnace
- Incineration chamber – Burn the pallets
- Mechanical Sifter – Separate ash from nails
- Storage Container – Store the ash.
- Filtration System – Minimize pollution from the furnace
Engineering Analysis

Assessment of Waste Diverted:

This system would eliminate the entire waste stream of pallets produced by the Steelton Plant. When implemented, the system would be capable of turning all pallets received by the plant into organic ash and recyclable steel nails. The system would not only eliminate the source of waste produced by pallets, but could also provide the Steelton Plant with an additional source of revenue from the ash it would be selling to the Fertrell company.

Concept of Operations:

The waste pallets are loaded onto the conveyor belt, which brings them up and drops them into the furnace. From there, a timed release door will open to drop the pallets into the incineration chamber without letting out a ton of smoke. The pallets are then burned into ash inside the incineration chamber, with the nails still intact. The smoke is vented out through a smokestack with a filtration system in order to minimize pollution. Another timed release door will open once combustion is completed, dropping the ash and the nails onto a mechanical sifter, constantly moving to catch nails and sift the ash through. The ash then falls through to a secondary sifter. Once it falls through the secondary sifter, it enters a storage container, where it is kept until it is loaded onto trucks and shipped to Fertrell to be made into fertilizer.

Figure 5. Flow Chart of Concept of Operations
Life Cycle Assessment:

Trees and iron are harvested from the earth to make wood and steel.

Ash is then used in organic fertilizers and returns to the earth to nourish growing plants, while the nails have been made into new steel products.

Pallets are constructed using wood for their structure, and steel for the nails that hold them together.

The ash is then sent to local organic fertilizer company Fertrell, and the nails are recycled and used in the steel-making process.

Pallets are used by the ArcelorMittal Steelton Plant to transport materials.

After their use, the pallets are converted into ash and scrap nails, both are then collected.

Figure 6. Life Cycle Assessment Diagram
Economic Viability:

This system was designed with the best interest of both the environment, and the Steelton Plant in mind. That being said, the system is economically viable, and in the long run very profitable. The system creates organic wood ash to be used in fertilizer, because of this and the fact that Pennsylvania is a very large farming state with over 60,000 farms the product will be desirable and selling it will be possible, and profitable. The initial startup costs of implementing the system would be around $100,000 - $200,000, most of that being the cost of the furnace itself. The shipping cost would be very minimal due to the close proximity of the Steelton Plant to the Fertrell facility, because it is only 14 miles away, which is approximately a 30 minute drive, shipping would only be approximately $66.06 per truckload of ash. The trucks also have a hauling capacity of 26 tons. The ash itself however can be sold for as much as $.60 per pound, or $1,200 per ton. This means that profits over the initial investments could be made as quickly as 84-167 tons of ash sold, or 4 to 7 dump truck loads of ash sold.

Costs:

- Initial investment: $100,000 - $200,000
- Shipping: $66.06 per truck load

Benefits:

- Ash sold at $.60 per pound or $1,200 per ton
- One truck load of ash at 26 tons worth $31,200 ($31,133.94 after shipping costs)
- Profit on initial investment after 84 – 167 tons of ash sold, or 4 – 7 truck loads

<table>
<thead>
<tr>
<th>Motor Carrier Marginal Expenses</th>
<th>Costs Per Mile</th>
<th>Costs Per Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle-based</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuel-Oil Costs</td>
<td>.634</td>
<td>$33.00</td>
</tr>
<tr>
<td>Truck/Trailer Lease or Purchase Payments</td>
<td>.206</td>
<td>$10.72</td>
</tr>
<tr>
<td>Repair and Maintenance</td>
<td>.092</td>
<td>$4.79</td>
</tr>
<tr>
<td>Fuel Taxes</td>
<td>.062</td>
<td>$3.23</td>
</tr>
<tr>
<td>Truck Insurance Premiums</td>
<td>.06</td>
<td>$3.12</td>
</tr>
<tr>
<td>Tires</td>
<td>.03</td>
<td>$1.56</td>
</tr>
<tr>
<td>Licensing and Overweight-Oversize Permits</td>
<td>.024</td>
<td>$1.25</td>
</tr>
<tr>
<td>Tolls</td>
<td>.019</td>
<td>$.99</td>
</tr>
<tr>
<td>Driver-based</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver Pay*</td>
<td>.441</td>
<td>$16.59</td>
</tr>
<tr>
<td>Driver Benefits</td>
<td>.126</td>
<td>$6.56</td>
</tr>
<tr>
<td>Driver Bonus Payments</td>
<td>.036</td>
<td>$1.87</td>
</tr>
<tr>
<td><strong>Total Marginal Costs</strong></td>
<td><strong>$1.73</strong></td>
<td><strong>$83.68</strong></td>
</tr>
</tbody>
</table>

Table 4. Shipping Costs by Truck
Summary and Conclusion

The problem set out by the ArcelorMittal was to develop a system to help reduce or reuse some of the waste that is produced during the steel-making process at the Steelton Plant in Pennsylvania. The design was required to be economically viable, environmentally friendly, and most of all sustainable.

After brainstorming numerous ideas, the idea that was chosen for development was a system that would convert the waste pallets used by the plant into ash to be used in organic fertilizer, and scrap nails to be reused in the steel-making process. A prototype of approximately 1:30 scale was then constructed to demonstrate the system.

The system that was developed would be both environmentally friendly by eliminating a previous source of pollution, and also profitable for the Steelton Plant as it would provide a new source of income from selling ash to a local producer of organic fertilizer, the Fertrell company.
Background on ArcelorMittal

- ArcelorMittal USA is the largest steel producer in North America. ArcelorMittal is the leader in all major global steel markets, including automotive, construction, household appliances, and packaging.

- It is the world's largest and most global steel company by both revenue and production.

- The Steelton, PA, plant manufactures steel from recycled scrap metals and has a liquid steelmaking capacity of about 1.1 million net tons of steel per year.
The Task

- The steel manufacturing process creates a lot of waste and most of it is sent to a landfill. This is called the “cradle to grave” process.

- In addition to other byproducts already being recycled or sold, ArcelorMittal still wants to reduce its waste footprint in order to reduce disposal costs, improve profitability, and increase long-term sustainability.

- ArcelorMittal, in cooperation with Pennsylvania State University, wants to find a sustainable alternative for disposing of tons wooden pallets, steel/plastic drums, and refractory brick.

- With this solution, the conventional “cradle to grave” process is now modified into a cradle to cradle process.

Our Ideas

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sustainability</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Underlying Costs</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>0</td>
</tr>
<tr>
<td>Profit</td>
<td>0</td>
<td>-</td>
<td>+</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Ease of Application</td>
<td>-</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Eco Friendly</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Net +</th>
<th>Net -</th>
<th>Net 0</th>
<th>Score</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Coral Reef</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>-2</td>
<td>4</td>
</tr>
<tr>
<td>The Wood Chips</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>The Charcoal</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>-2</td>
<td>4</td>
</tr>
<tr>
<td>The Paper</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>The Wood Ash</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>
The Final Design

Explain the outputs and the leftovers

- Broken Pallets ➔ Firing and Sifting Broken Pallets ➔ Nails ➔ Recycle or Reuse ➔ Transportation
- Firing and Sifting Broken Pallets ➔ Ash ➔ Fertilizer
Wood Ash in Fertilizer

- The ash will be sold to fertilizer companies and will be used as a component in their fertilizer products.
- A company by the name of Fertrell Company, located in Bainbridge, PA specializes in the manufacture of organic fertilizers.
- This company was founded in 1946 and is one of the oldest fertilizer companies in America.
- The company is located only 14 miles from the Steelton Plant, thus reducing shipping costs and increasing profits.

Benefits of Ash in Fertilizer

- Wood ash is an excellent source of lime, potassium, and many other trace elements that plants need to thrive.
- Wood ash is also useful for pest control. The salt in the wood ash will kill bothersome pests like snails, slugs and some kinds of soft bodied invertebrates.
- Wood ash also increases the pH levels in soil thus decreasing the acidity of the soil environment.
- The ash can be used to break up heavy clay soil thus improving the growing conditions for crops.
Application of this fertilizer

- Pennsylvania is a huge farming state and has over 60,000 farms.

- Modern agricultural production in Pennsylvania includes corn, wheat, oats, barley, sorghum, soybeans, tobacco, sunflowers, potatoes, and sweet potatoes.

- The large presence of farming in Pennsylvania makes selling to local farmers a feasible and sustainable option.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Farms Producing</th>
<th>Acres (km²)</th>
<th>Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corn for grain</td>
<td>16,030</td>
<td>680,793</td>
<td>118,064,970 bushels</td>
</tr>
<tr>
<td>Corn for silage or greenchop</td>
<td>16,230</td>
<td>628,139</td>
<td>117,737,789 bushels</td>
</tr>
<tr>
<td>Wheat for grain</td>
<td>4,377</td>
<td>152,201</td>
<td>8,949,116 bushels</td>
</tr>
<tr>
<td>Oats for grain</td>
<td>5,899</td>
<td>79,541</td>
<td>4,237,273 bushels</td>
</tr>
<tr>
<td>Barley for grain</td>
<td>2,104</td>
<td>41,981</td>
<td>3,053,989 bushels</td>
</tr>
<tr>
<td>Sorghum for grain</td>
<td>117</td>
<td>3,153</td>
<td>177,639 bushels</td>
</tr>
<tr>
<td>Sorghum for silage or greenchop</td>
<td>325</td>
<td>4,471</td>
<td>40,707 tons</td>
</tr>
<tr>
<td>Soybeans for beans</td>
<td>6,174</td>
<td>431,813</td>
<td>17,396,829 bushels</td>
</tr>
<tr>
<td>Dry, edible beans (excluding Lima beans)</td>
<td>17</td>
<td>153</td>
<td>3,045 cwt</td>
</tr>
<tr>
<td>Tobacco</td>
<td>1,152</td>
<td>7,186</td>
<td>18,811,546 lbs</td>
</tr>
<tr>
<td>Sunflower seed</td>
<td>32</td>
<td>660</td>
<td>405,407 lbs</td>
</tr>
</tbody>
</table>

Cost Analysis

- The upfront cost would be the actual furnace unit itself. This money should be in a short time frame.

- The fixed costs would be the cost to run the furnace as well as ship the ash to fertilizer companies.

- Miscellaneous costs can include small labor costs for maintenance and supervision of the whole operation.
Environmental Concerns

- One of the biggest concerns is that burning wood will create a lot of pollution.

- In a controlled factory environment, with the proper steps taken to filter out the smoke, burning the wood can be justified.

- Technologies such as electrostatic precipitators, fabric filters, venturi scrubbers, cyclones and settling chambers can all be used to remove pollutants from emissions.

- Electrostatic precipitators use magnetic attraction to draw smaller sized pollutants out of the emissions stream. The emission gases pass through a specially designed chamber that charges the pollutants.

- These charged particles are drawn to specially charged plates where they are then collected in hoppers. The emission stream exiting the chamber is about 99 percent clean of small pollutants.
Trifold Brochure:

Cost Analysis

- The upfront cost would be the actual furnace unit itself. This money should be in a short time frame.
- The fixed costs would be the cost to run the furnace as well as ship the ash to fertilizer companies.
- Miscellaneous costs can include small labor costs for maintenance and supervision of the whole operation.

Environmental Concerns

- One of the biggest concerns is that burning wood will create a lot of pollution.
- In a controlled factory environment, with the proper steps taken to filter out the smoke, burning the wood can be justified.
- Technologies such as electrostatic precipitators, fabric filters, venturi scrubbers, cyclones and settling chambers can all be used to remove pollutants from emissions.

Wood Ash in Fertilizer

- The ash will be sold to fertilizer companies and will be used as a component in their fertilizer products.
- A company by the name of Fertrell, located in Bath, PA specializes in the manufacture of organic fertilizers.
- This company was founded in 1946 and is one of the oldest fertilizer companies in America.
- The company is located only 14 miles from the Steel Plant, thus reducing shipping costs and increasing profits.

Benefits of Ash in Fertilizer

- Wood ash is an excellent source of lime, potassium, and many other trace elements that plants need to thrive.
- Wood ash is also useful for pest control. The ash in the wood ash will kill bothersome pests like snails, slugs and some kinds of soil-bored invertebrates.
- Wood ash also increases the pH levels in soil thus decreasing the acidity of the soil environment.
- The ash can be used to break up heavy clay soil thus improving the growing conditions for crops.

The Task

- ArcelorMittal, in cooperation with Pennsylvania State University, wants to find a sustainable alternative for disposing of tons of wooden pallets, steel, plastic drums, and refractory bricks.
- In addition to other by-products already being recycled or sold, ArcelorMittal still wants to reduce its waste footprint in order to reduce disposal costs, improve profitability, and increase long-term sustainability.

Pennsylvania State University

Design Project 02
EDSCH 106 — Introduction to Engineering Design Section 010
Prof. Xinli Wu
Team 3
Kshitij Agarwal | Abhishek Tanwar | Matthew McPherson | Yuenne Wu | Mark Brady

ArcelorMittal
Acknowledgements:

Team 5 would like to thank Professor Xinli Wu, P.E., for his help and guidance during the design process and also for providing the opportunity to undertake the project. The success of the group could not have been achieved without his help. The team would also like to thank Jeremy Barnhart for his valuable inputs during the planning and prototype making process.
References:

