

ARCELOR and MITTAL Team FLOPPY NOODLE

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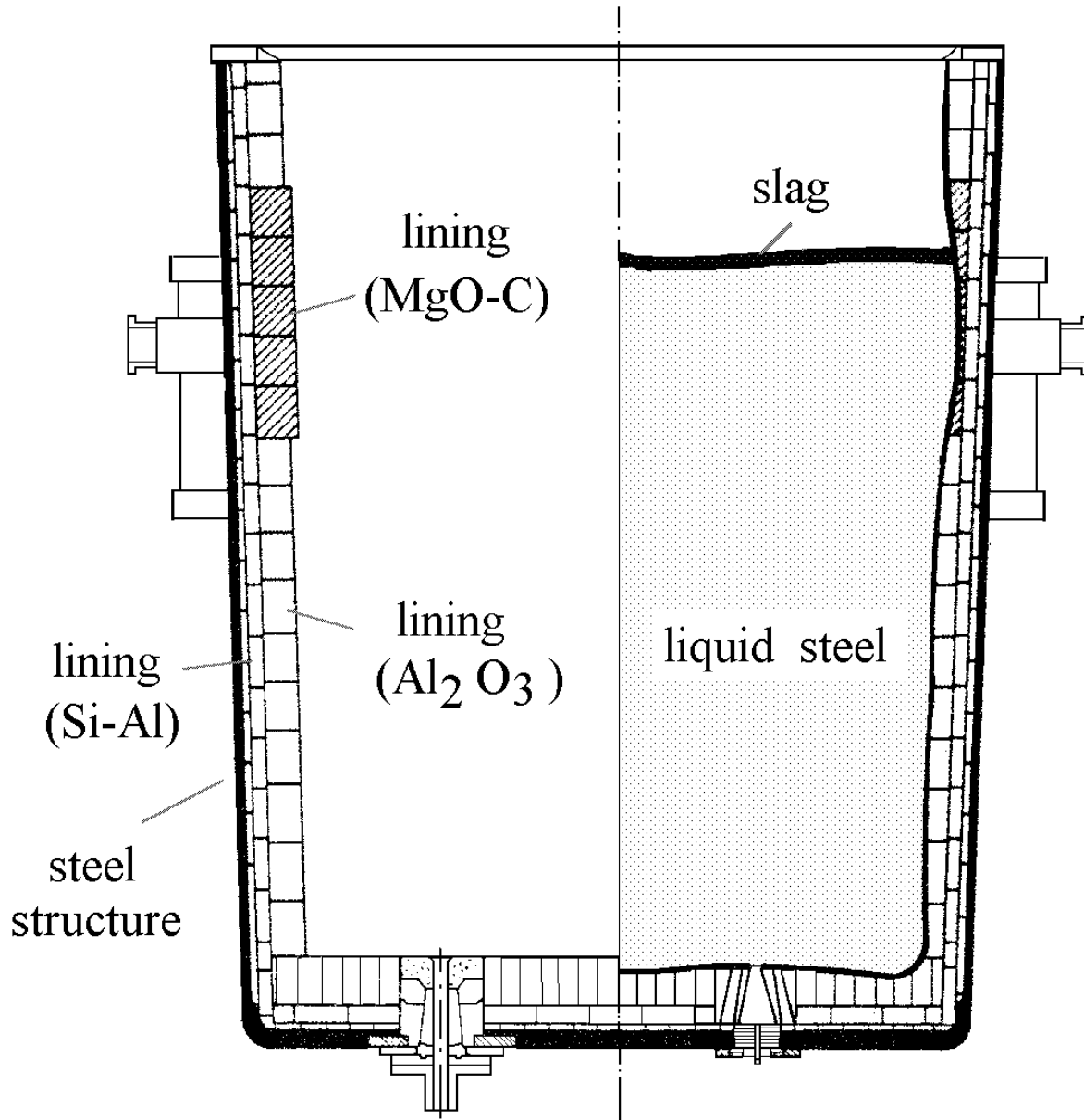


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Abstract:

The purpose of this project was to find a useful and environmentally friendly way of recycling refractory brick that is used in the steel production process. As a group, we considered anything from grinding it up for filler use, to selling it for use in lower heat applications. We decided to focus our research on different ways of reusing the refractory brick in order to create everyday products such as cement or concrete. Overall, the key to our ideas was innovation. Without innovative techniques, the recycling process would be much more difficult.

Introduction:

Refractory brick is a ceramic material used to line furnaces and ladles in the steelmaking industry. The purpose of refractory brick is to insulate and contain the extremely high temperatures used in melting steel. Unfortunately, bricks from the main ladle need to be replaced weekly. The main goal of this assignment was to find a way to divert the refractory brick from the landfill since the brick is being disposed of in such high

quantities. Because of the requirements for this brick to withstand temperatures above 2000 degrees fahrenheit, the brick is composed of very energy intensive materials. The refractory brick used in this manufacturing plant was composed of a high percentage of magnesium oxide, as well as calcium dioxide. Our design for the reuse and recycling of this brick had to be able to incorporate these specific chemicals since the refractory brick is entirely composed of these chemicals to a specific ratio.

Mission Statement:

As a team we were tasked with coming up with a solution concerning the disposal and/or reuse of refractory brick, wooden pallets or plastic containers used in the process of manufacturing of steel. Upon being given this information, our group came to a consensus on choosing to deal with the removal and disposal of the refractory brick. In addition, our group wanted to accomplish the task while simultaneously making the process environmentally conscious while keeping the overall pricing of the process relatively inexpensive.

Concept Generation:

After defining and evaluating the problem at hand, we needed to conceptualize ideas and solutions that would solve the problem. The first step in generating theses

concepts was to brainstorm. This meant a judge free environment that we recorded any and every idea that came to mind, this included wild ideas of making a playground from recycled bricks or more sane ideas such as breaking the brick into very small pieces to use as gravel. We came up with several ideas, including reselling the bricks to be used for lower heat applications, grinding up the brick to be used as gravel and filler in landscaping as well as construction applications. The final idea that was generated was to grind up the brick to be used in the production of cement.

The next step was to conduct external research in order to evaluate and refine our concepts. The first step was to research the specific composition of the refractory brick. The furnace brick and ladle brick was found to have the compositions as seen below in figure 1 and figure 2 respectively.

ANCARBON SX33

Classification	Magnesia-carbon product type MC95/10 ISO 10081-3
Main raw material components	Large crystal sintered magnesia, Graphite
Bonding type	Low emission- pitch bonded
Main Application(s)	Casting/treatment ladle, Converter (BOF), Electric arc furnace
Additional Information	Tempered

Chemical analysis

MgO	Al ₂ O ₃	Fe ₂ O ₃	CaO	SiO ₂
97.0 %	0.2 %	0.4 %	1.8 %	0.6 %

Figure 1

DOLOMAX MD1	A high purity, resin-bonded brick containing ~6% total carbon. Dolomax MD1 contains magnesia in the brick's matrix for improved slag resistance.										
Chemical Analysis	<u>Typical Calcined Chemical Analysis (%)</u>										
	<table> <tr><td>MgO</td><td>47.6</td></tr> <tr><td>CaO</td><td>50.2</td></tr> <tr><td>SiO₂</td><td>0.7</td></tr> <tr><td>Al₂O₃</td><td>0.4</td></tr> <tr><td>Fe₂O₃</td><td>0.9</td></tr> </table>	MgO	47.6	CaO	50.2	SiO ₂	0.7	Al ₂ O ₃	0.4	Fe ₂ O ₃	0.9
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CaO	50.2										
SiO ₂	0.7										
Al ₂ O ₃	0.4										
Fe ₂ O ₃	0.9										

Figure 2

Next, we researched the composition of cement, in order to see whether our idea of using this brick in the production of cement was a possible idea. The oxide composition of portland cement is found below in figure 3.

	CLK cement	Class G* cement	Class G cement + 35% BWOC Silica Flour
Oxide Composition:			
CaO	44.32	63.12	46.76
SiO ₂	31.41	22.55	42.63
Al ₂ O ₃	9.72	3.90	2.89
Fe ₂ O ₃	1.37	4.71	3.49
MgO	6.39	0.75	0.56
C/S Molar Ratio	1.51	3.00	1.17

Figure 3

If the composition of cement is compared to the composition of the refractory brick, one can see that every chemical found in the refractory is also found in cement, only at different ratios. After finding the compositions to be very similar, thus making our solution very possible, we began researching which type of cement would be best to produce.

Portland cement is currently the most commonly used cement. However, there are cements that are much better to use. One possible variation to regular Portland cement, is magnesium oxide based cement. There are countless benefits when it is used. This cement has great strength. The compressive strength of Magnesium Oxide cement is 9,000 to 15,000 psi and can withstand tensile strength of over 800 psi. This is comparable to a compressive and tensile strength of 3,000-6,000 psi, and 300-700 psi respectively, of regular portland cement. By having this incredible strength, it can be used in creative and innovative ways that portland cement cannot.

Besides strength, the chemical composition of it allows it to be a great household cement. It is both water and fire resistant which helps tremendously. If there is a flood or a fire, the house will not get nearly as damaged as portland cement. It is also termite resistant and mold resistant. This helps for the overall health issue of a home as well as the longevity of it. Lastly, it has a low CO₂ footprint which helps greatly since companies are pushing for eco friendly. Another interesting fact is that the Great Wall of China and the

Roman Colosseum were made from Magnesium based cement, and they still stand strong today and have withstood great deals of abuse.

In addition, magnesium oxide cement can be produced as magnesia board, meaning the very essential and beneficial characteristics of the cement can be harnessed as another primary material used in construction. This magnesia board is similar to that of normal sheetrock, used to line the walls of buildings. However, magnesia board is stronger, lighter, and extremely fire resistant when compared to the sheetrock that normal cement is used to produce, making this idea even more attractive and profitable.

Concept Selection:

After we had conducted the research, we found that the possible benefits of this magnesium oxide cement was too great to be ignored. We decided that the best solution to the problem was to grind up the refractory brick, and sell it to any company that produces MgO cement. After further research, we found that most of the ingredients used in cement is mined and quarried independently of one another, and mixed together by the cement manufacturer. This means that the cement manufacturers have the pure ingredients at hand, making it possible to simply add the needed amounts of ingredients to the ground up refractory brick mixture in order to achieve the desired molar ratio. In addition, cement manufacturers already possess the equipment necessary to grind up all other ingredients of cement in as many as 3 stages, meaning the refractory bricks could be sold to the manufacturer without any alteration or use of capital. Reusing the brick in cement

production was found to be a very possible and profitable idea and was selected as our solution.

Conclusion:

After being tasked with the problem of finding a way to reuse refractory brick, and after generating possible solutions, we conducted all necessary research to find that the reuse of refractory brick as the main ingredient in magnesium oxide based cement was the best possible solution. About 1600 metric tons of ladle brick is disposed of weekly and 1600 metric tons could fill about 64,000 50lb bags of cement. Prices of cement range widely, anywhere from \$4-\$30 per 50lb bag. Meaning at minimum, 64,000 bags of cement is sold at approximately \$260,000. This amount of possible profit is possible weekly with no alteration of the brick in any way on Arcelor Mittal's part. Since the manufacturers of cement have control over the ratios of the ingredients they wish to mix the refractory brick mixture to, the refractory brick can be used by any cement manufacturer, making the marketability of this solution very wide. Since the brick needs no alteration by Arcelor Mittal in order to be usable by cement manufacturers, even if no compensation is offered to Arcelor Mittal for their refractory brick, and they simply allow cement manufacturers to take this brick off of their hands, the problem of the disposal of this brick is solved with no cost to Arcelor Mittal.

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Figure 1: Composition of main ladle brick. Pg 4

Figure 2: Composition of main furnace brick. Pg 5

Figure 3: Composition of common cement. Pg 5

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