

EDSGN 100 Design Project #2 Final Design Report

Recycling of Advanced High Strength Steel Introduction to Engineering Design Engineering Design Section 11

Team 5

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Executive Summary

The objective of this project is to design a process to effectively improving the steel recycling process in order to decrease the amount of off-chemistry steel that is produced. The current process of recycling steel results in off-chemistry steel due to the inaccurate measurements of the composition of scrap steel that is brought to ArcelorMittal and combined with the molten iron in the oxygen furnace. Knowing this it has been determined that the process at which the scrap steel composition has been determined needs to be upgraded. The most effective place to determine the composition of the scrap steel is at the scrapper before brought to ArcelorMittal. Each piece of scrap will have its contents determined by using a large-scale XMF machine. Once this is determined the scrap will be sent into a crate. Once the crate is full it will be shipped to ArcelorMittal along with the average contents and compositions of the entire crate. This will increase accuracy immensely along with increasing efficiency of steel production.

Recycling of Advanced High Strength Steel

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1.0 Introduction

The purpose of this project is to design a process that will effectively improve the recycling process of advanced high strength steel. The issue with the current recycling process is the production of off-chemistry steel as a result of inaccuracy of the known composition of the scrap steel being recycled. Off-chemistry steel describes the fact that the steel being produced from recycling does not meet the standards necessary for introduction to the market. This is a serious issue that is slowing down the rate at which quality steel is being produced.

Mixing iron and the scrap steel produces the new steel. The iron makes up 85% of the new steel, while the scrap steel is combined to make up the remaining 15%. The goal is to combine these materials in order to produce Line Pipe Steel. Line Pipe Steel has a chemistry (in weight percentages) of: 0.05% C, 0.1% Cr, 0.003% Cb, 1.5% Mn and 0.04% Al (1). Due to these small weight percentages it is crucial to have an accurate measure of the scrap steel that is being used.

Currently the scrap steel arrives at the ArcelorMittal facility by railcar with a paper stating the composition of scrap steel (2). However the composition that has been determined is very inaccurate. This scrap is then combined with the iron in an oxygen furnace to produce the Line Pipe Steel (2). Once the steel is produced it is then sent back out to market, mainly automobile industry. The issue lies with the off-chemistry steel because it is not a high enough quality steel to be introduced into automobiles.

The solution to this problem needs to occur before the scrap steel arrives at the ArcelorMittal facility. The steel first arrives at a scrapper, this is the perfect location for fixing the issue. When the steel comes into the scrapper it will be sorted on a series of vibrating conveyor belts by size. Then each individual piece will be run under an XRF to determine its' composition. An XRF is a florescent X-Ray machine that very quickly determines the composition of that piece of steel by injecting electrons into the steel and recoding what elements are in the steel. After each piece has had its composition determined it will be carried to a crate. This process will continue until the crate is full. Once a crate is filled a list of the average composition of its contents will be provided. This list will show each individual pieces' composition and then most importantly the overall average. This process is continually repeated and then the crates are shipped to ArcelorMittal. This radically decreases the production of off-chemistry steel due to the increase in accuracy in determining the scrap steel composition. This will also lead to an increase in efficiency of Line Pipe Steel production.

The incentive for the scrappers to improve their process lies in the fact that increased accuracy of scrap steel will improve the quality of the line pipe steel. This will then increase ArcelorMittals' profits and the profits of the scrappers.

In order to develop this process the true issue had to be discovered in order to establish a need. Then a series of specifications were developed for the process itself along with the product, Line Pipe Steel. Once the specifications were determined and multitude of ideas were devolved and narrowed down to the one chosen above. In order to come to this solution it had to be determined how and why the scrappers would want to improve this system. This was quickly determined so then the smaller

issues had to be resolved. Issues such as how to sort, ship and determine the composition of the scrap steel.

2.0 Project Background

The purpose of this project is to design a new process to effectively recycle steel to prevent the creation of off-chemistry steel. This is the major problem with the current process because off-chemistry steel is not a high enough quality steel to be used in the industrial and automotive markets. Off-chemistry steel is a product of inaccurately combined iron and scrap steel. This results from not knowing the correct composition of the scrap steel that is being added to the iron in the oxygen furnace. Currently the scrap arrives at ArcelorMittal upon a railcar with a paper that states the supposed compositions. This information is used to produce the new steel, which combines 85% iron with 15% scrap steel. The intended product is the Line Pipe Steel, which has an ideal weight composition of: 0.05% C, 0.1% Cr, 0.003% Cb, 1.5% Mn and 0.04% Al. It is crucial for ArcelorMittal to have an accurate knowledge of the scrap composition in order to obtain the desired product.

3.0 Product Objectives

The objective of this project is to upgrade the process for recycling the scrap steel in order to dramatically reduce to chances of producing off-chemistry steel. It is also important to have the scrap steel composition accurately determined and organized upon arrival at the ArcelorMittal facility. This will improve efficiency at ArcelorMittal, especially once the scrap composition is accurately determined. An important objective within the overall process is to make the separation and composition determination as simple and fast as possible. With all of these objectives maximized the entire operation will run much more smoothly.

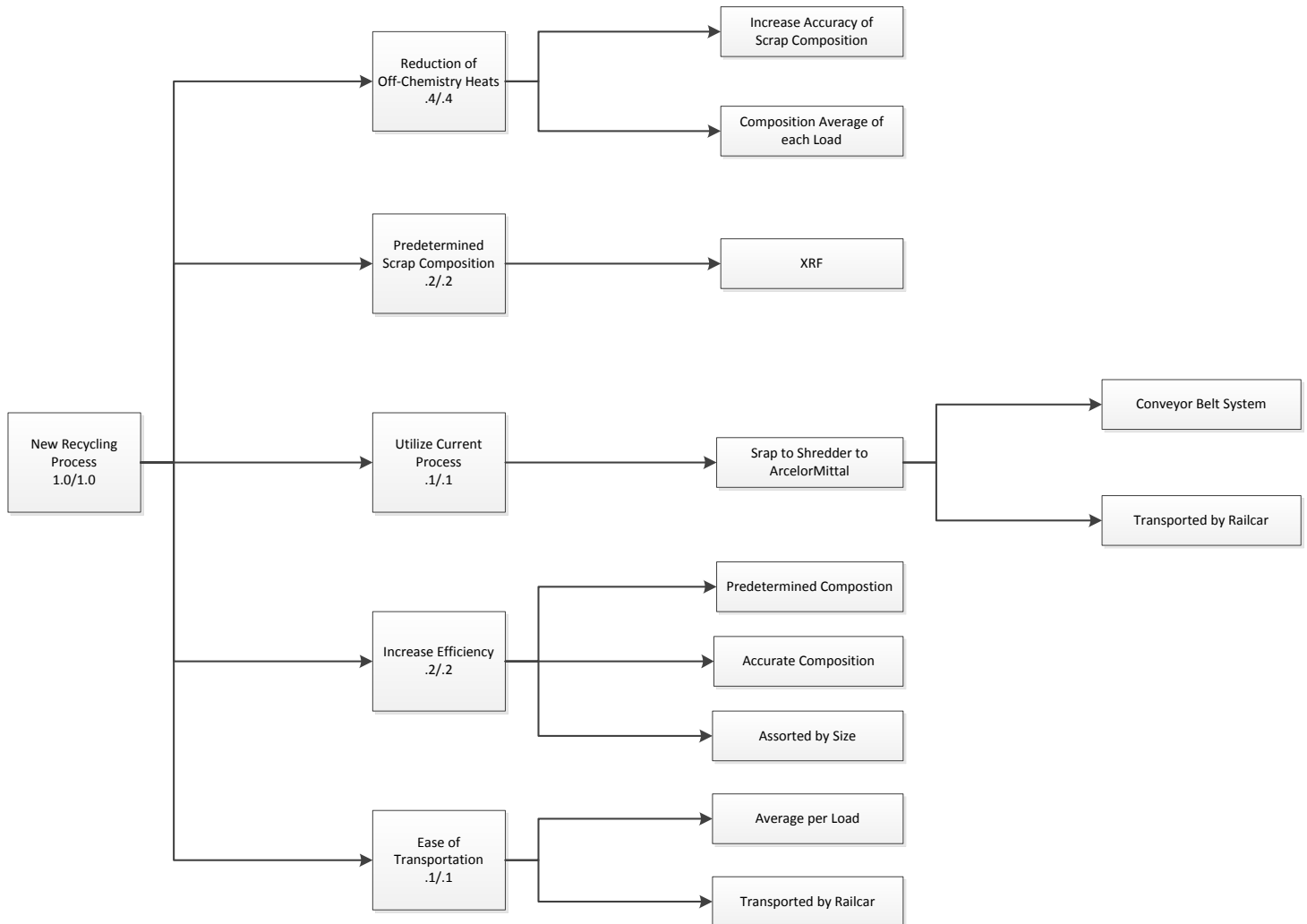
4.0 Conceptual Designs

4.1 Research & Analysis

The XRF scanner analyzes the steel through x-ray fluorescence which injects high energy photons into the scrap piece. The photons cause the electrons of all the elements within the steel to jump energy levels. This change in energy levels emits a light of certain wavelength that creates a charge which is read by the scanner (1). The scanner is capable of determining the composition of most metals with an accuracy of less than 2% error (2).

4.2 Concept Selection

Based on the criteria given by ArcelorMittal and our own intuition, we created a list of specifications for the desired process. These specifications were used to create a weighted objective tree which we used as a guideline to develop different ideas for the process.



After analyzing all of the objectives that need to be completed by the newly designed process, multiple ideas were generated: Having steel stamped by automotive industry based on its composition, using XRF scanners at the shredding facility to determine composition, placing a sensor in the oxygen furnace to control composition as the steel is produced or inserting a microchip into each piece of steel produced that would have the composition of that piece listed within the chip.

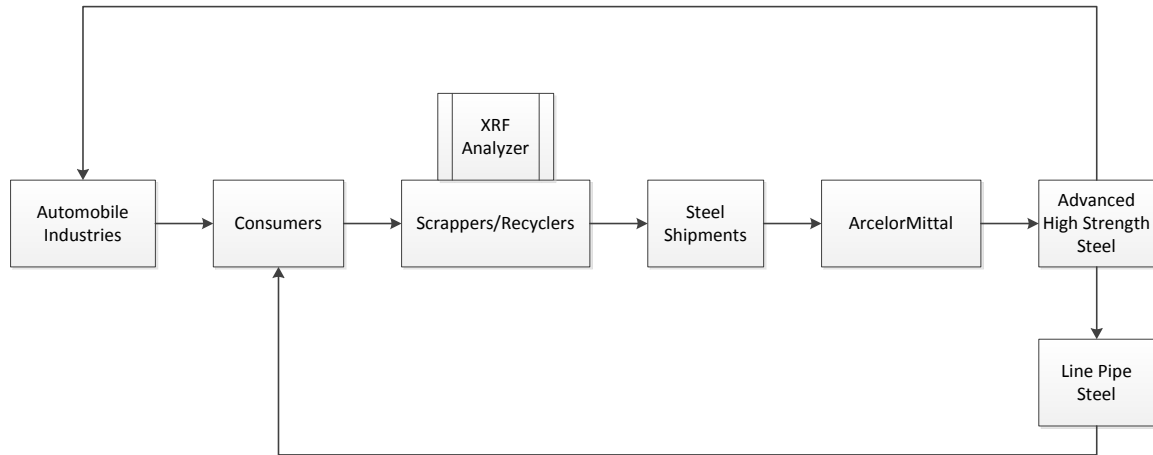
This is the weighted selection matrix for the four ideas listed above.

<u>Criteria</u>	<u>Weights</u>	Steel Stamped	XRF Scan	Composition Sensor	Electronically Stamped
Reduction of Off-Chemistry Heats	0.4	80%/.32	95%/.38	100%/.4	80%/.32
Predetermined Scrap Composition	0.2	70%/.14	90%/.18	0%/0	100%/.2
Utilize Current Process	0.1	100%/.1	100%/.1	100%/.1	80%/.08
Increase Efficiency	0.2	80%/.16	90%/.18	80%/.16	70%/.14
Ease of Transportation	0.1	80%/.08	80%/.08	80%.08	100%/.1
Total	1	0.8	0.92	0.74	0.84

Based on the criteria listed in the matrix it was determined that the XRF scanning method best fit the needs of the process desired.

5.0 Detailed Design

The final process that has been designed will be executed during the shredding process. Once the scrap arrives for shredding it will be placed on a series of conveyor belts. These belts will organize the scrap by size by a vibrating system that will allow for smaller scrap to fall through to other belts, while the larger scrap simply continues on the same belt. Once separated, each individual piece of scrap will be analyzed by an X-Ray fluorescent machine (XRF). This machine injects high energy photons into the piece of scrap, causing a fluorescence of certain wavelength which is then used to determine its elemental composition. After the composition is determined the piece will be carried by the conveyor belts and dropped into a crate. Each piece of scrap that drops into a certain crate will be kept track of. Once the crate becomes full the overall average composition of scrap steel for that crate will be determined and attached to that crate, along with the composition of each piece in the crate. This process will be repeated continually. Then the crates will be shipped to ArcelorMittal. Upon arrival ArcelorMittal will have all scrap organized by relative size along with an accurate average composition of the contents of each crate. This will allow for the production of the desired Line Pipe Steel with a much-decreased change of producing off-chemistry steel.



6.0 Conclusions

The research that has been completed has led to the process that we have developed. This process meets all objectives that were set by ArcelorMittal and is relatively inexpensive compared to other alternatives. Most importantly this process will drastically minimize the main issue of creating off-chemistry heats and it will do so by determining the composition of the scrap and sorting it before arriving at ArcelorMittal. This will also increase the efficiency and quality at which the line pipe steel is produced.

7.0 References

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