EDSGN100 Design Project #2
Final Design Report

Recycling of Advanced High Strength Steel

Introduction to Engineering Design
EDGSN 100 Section 2

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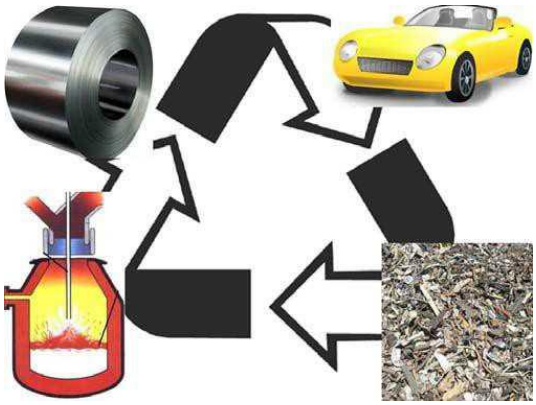

Submitted to: Prof. Jin Jeonghwan
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Executive Summary

Our objective in this report was to create a new way to sort AHSS from other types of metal that the scrap companies obtain. We came up with three different possible ways to improve this process a chemical test, a heating test, a density test. Both the chemical test and heating test were shown to be impractical ways to sort the metal, but the density test was decided to be a very effective and relatively cheap way to sort the metal. The density test consisted of crushing the metal into small quarter sized spherical chunks, then sorting ferrous and nonferrous metals with a magnet. After that the metal is dumped in a viscous liquid, and the difference in densities of the AHSS and other ferrous metals will cause them to fall at different rates, and when they separate enough in the liquid the AHSS will be collected, washed, and transported to ArcelorMittal.

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1.0 Introduction

ArcelorMittal, the powerhouse of the steel industry, wants to recycle and reuse AHSS from scrap metals to save production costs, however, due to AHSS's similarity to iron it is difficult to separate AHSS from other scrap metals. Our goal is to help ArcelorMittal and other steel companies improve the current steel sorting and recycling process through tests that distinguish AHSS from other materials. Before conducting tests, the metal scraps would have to go through process where they were broken down into quarter sized spherical pieces and then sorted by a magnet. We came up with three possible tests: heat test, chemical test, and density test. Through practicality, efficiency, and accuracy we eventually narrowed our selection to the Density Test.

2.0 Project Background

Advanced High Strength Steel (AHSS) is a manufactured steel alloy that is composed of about 96.91% iron, 1.5% manganese, 1.2% aluminum, 0.2% chromium, 0.17% carbon, and 0.02% columbium. The automotive industry is the main consumer of AHSS. They use it to create durable lightweight frames for cars. In the current process, the automobile is crushed into fist-sized pieces and run through an assembly line. Then, a magnet separates all ferrous and non-ferrous materials. Ferrous materials continue on the assembly line, while everything else falls down a chute that carries them to a different assembly line for manual sorting. As the ferrous materials continue, AHSS is picked out by hand and transported to ArcelorMittal. The following data was essential to create new concepts and tests, which would efficiently separate AHSS from other metals.

- The melting point for AHSS is about 1529°C, while the melting point for iron is 1538°C.
- Iron has a density of 7.874 g/mL, while AHSS has a density of about 7.793 g/mL.
- The formula of viscosity:

$$v = \frac{2g(D_{substance} - D_{liquid})r^2}{9(Vis)}$$

3.0 Project Objectives

ArcelorMittal has trouble acquiring recycled AHSS, which is difficult to separate from other metals due to its similarity to iron. Our goal is to help ArcelorMittal and other steel

companies by improving the steel sorting and recycling process through tests that distinguish AHSS from other materials, specifically iron. Success in this goal would be vital to advancing ArcelorMittal's steel recycling industry.

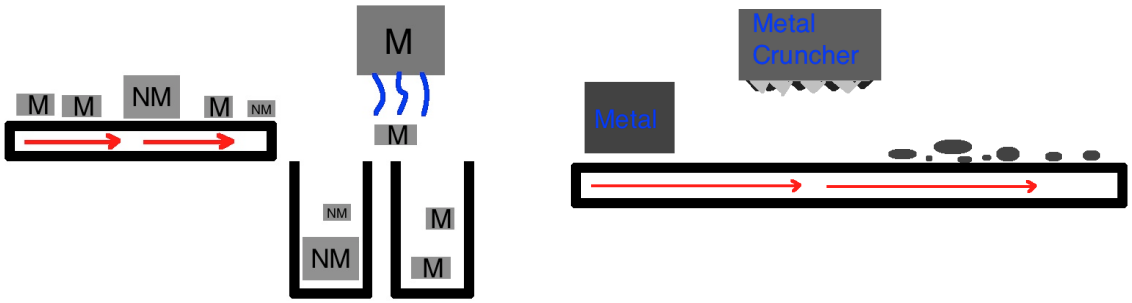
4.0 Conceptual Designs

After much research and consideration, we generated one step to start the process and four alternatives to continue the process. We weighed the pros and cons of each alternative to select the concept with the most potential to be successful.

4.1 Descriptions

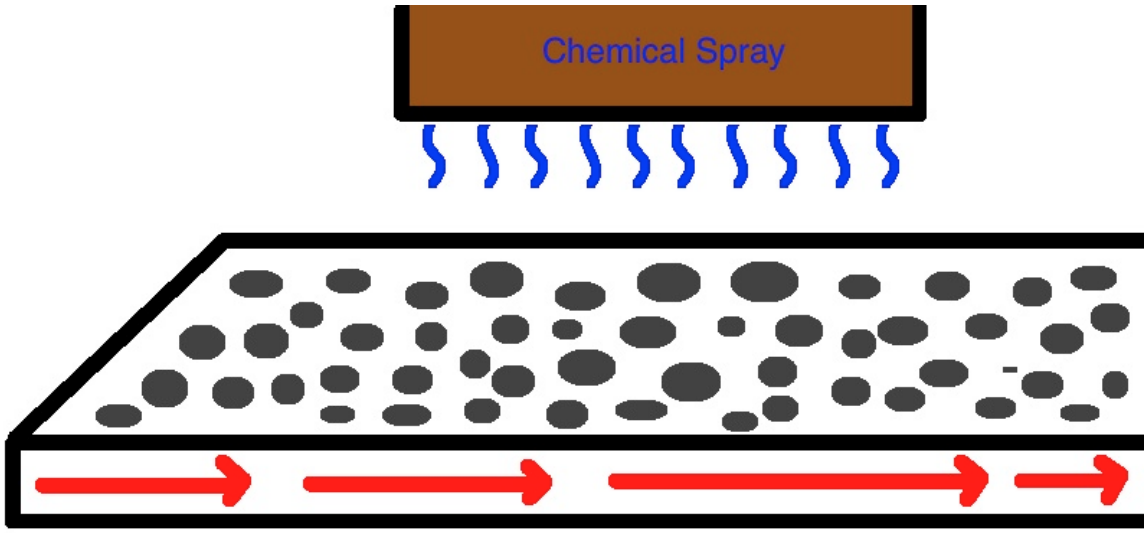
Initial Process

- First, after the automobile is crushed into chunks, the chunks are separated even further into the size of the quarter.
- Then, a magnet separates out the scrap and divides the ferrous materials from the non-ferrous materials.



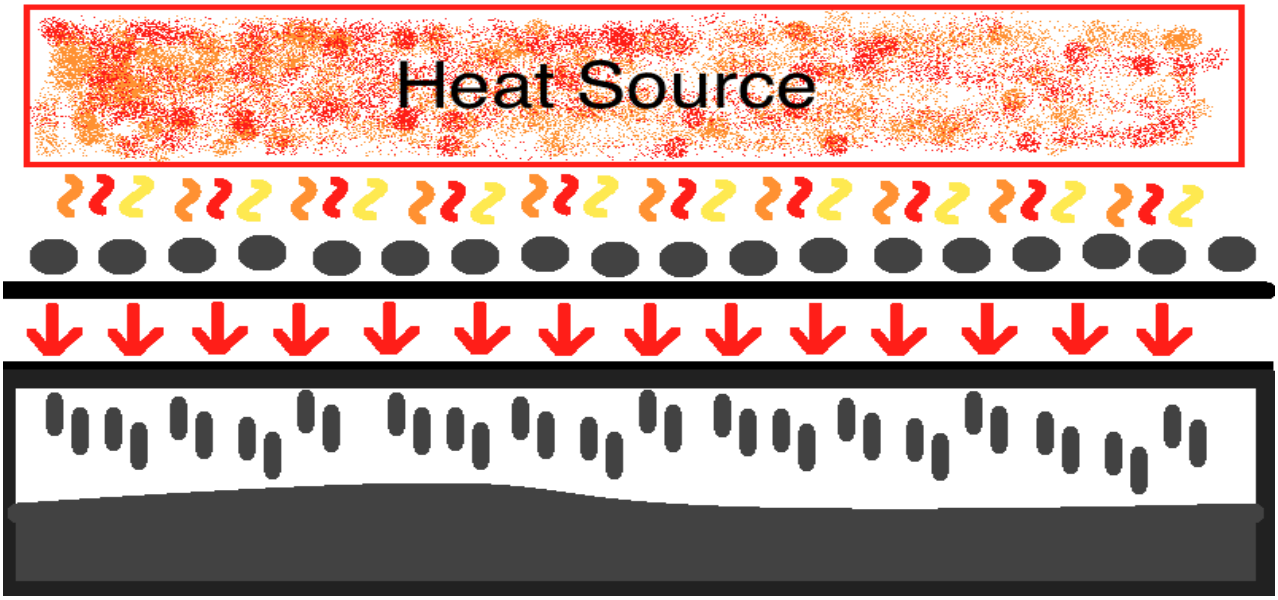
Chemical Test

- Once the ferrous materials are isolated, they are doused with chemicals to find a physical effect that would distinguish AHSS from other metals.
- The AHSS would be manually removed from the assembly line.
- Once the AHSS is separated, the residue is either washed or sanded off, depending on the reaction.



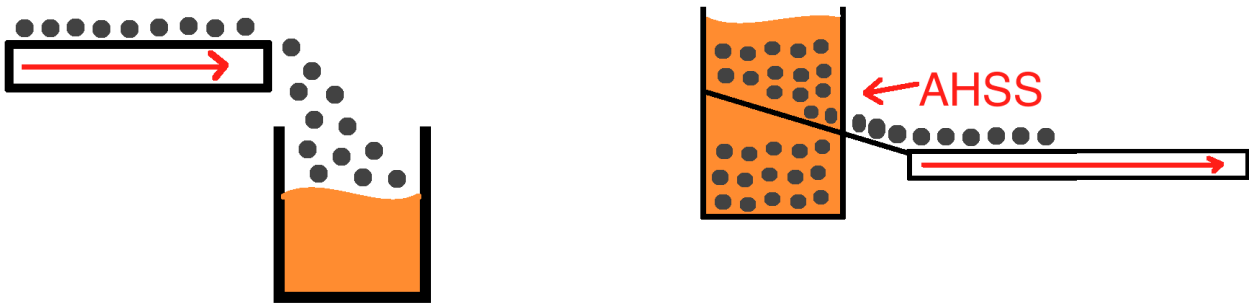
Heat Test

- After the basic separation process, the ferrous materials are sent to a furnace for heating.
- Certain temperatures will be set for the furnace to liquefy any type of metal to separate AHSS.
- The liquid metal would fall through a grated piece into another area.
- The melting point for AHSS is about 1529°C, while the melting point for iron is 1538°C.



Density/Viscosity Test

- After the initial process takes place, the ferrous materials are dropped into a viscous liquid and separated as they fall based on their different densities.
- Once the distance between the pieces has become high enough, a metal slab catches the AHSS and directs it into a different chamber.
- Iron has a density of 7.874 g/mL, while AHSS has a density of about 7.793 g/mL.



4.2 Research And Analysis

Chemical Test

Once we discovered the chemical make-up of AHSS (its 96.91% iron content in particular), all research ended because it would be unlikely that any other metal in AHSS would stand out in a reaction. Also, if we used a chemical that made the iron portion of AHSS precipitate, there would be precipitate on all ferrous materials on the assembly line.

Heat Test

To have a heat test take place in our model, a furnace would have to be built on the site or all ferrous materials would be transported to another furnace. The construction of a furnace that can reach the melting points of iron and AHSS would generally be very expensive. Also, even once these temperatures are reached, the melting points of the two metals are so close that if one metal completely liquefies, then some of the other metal may have liquefied as well; this would significantly alter the chemical make-up of AHSS.

Density/Viscosity Test

Originally, water was our first choice as the liquid for this test because as the metals fall, their differences in density would be seen as the denser metal falls faster than the lighter metal.

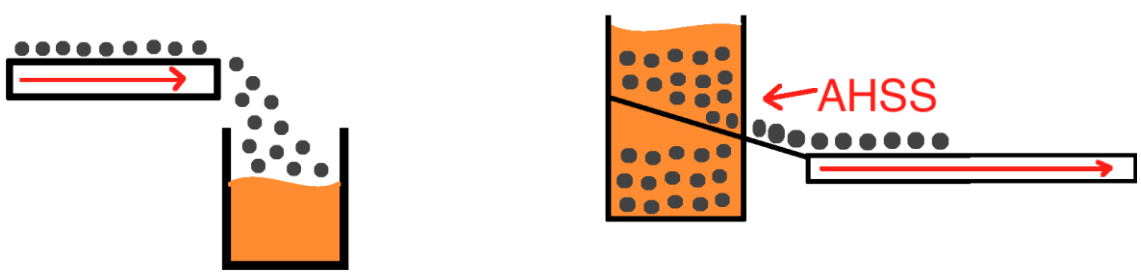
However, because the densities are so similar and as water has a low viscosity, it would still be difficult to differentiate the two metals.

4.3 Concept Review and Selection

After weighing the pros and cons of each alternative and considering how much we could change and control each aspect of each concept, we chose the density/viscosity test. We can change many variables in the alternative, such as the density of the liquid used, the viscosity of the liquid used, the shape of the metals that are dropped in the liquid, and the angle at which the metals are dropped into the liquid. Taking all of these factors into account, we decided to take this concept a step further.

5.0 Detailed Solution

The new process will begin similarly to the current system ArcelorMittal utilizes. First, after the automobile is crushed into chunks, the chunks are separated even further into the size of the quarter. Then all the scrap is sorted out by a magnet, which separates the ferrous materials from the non-ferrous materials. From here, the chunks of metal will undergo a density test. The ferrous materials are dropped into a viscous liquid and separated as they fall based on their different densities. Once the distance between the pieces has become high enough, a metal slab catches the AHSS and directs it into a different chamber. Iron has a density of 7.874 g/mL, while AHSS has a density of about 7.793 g/mL.



The rate at which a substance falls through a liquid depends on the radius of the substance, the density of the substance, the density of the liquid, and the viscosity of the liquid. The formula for finding the velocity of a substance traveling through a viscous liquid is:

$$v = \frac{2g(D_{substance} - D_{liquid})r^2}{9(Vis)}$$

[*The equation above holds true when v is velocity (m/s), g is gravity (m/s2), D is density (kg/m3), r is the radius of the substance (m), and Vis is the viscosity of the liquid (Pa-s)*]

6.0 Conclusion

Our final design was a process where the large pieces of scrap metal were broken down into quarter sized spherical pieces, sorted by a magnet, and finally separated in a viscous liquid by their different fall rates was very successful. It satisfied our objective, which was to create a cheaper or more efficient way to sort scrap than the current system, and since we eliminated the need for manual sorting in the metal the cost would drastically decrease. This way is also more efficient than manual sorting because it would be much quicker, and eliminate the human error factor in the sorting process. On top of being cheap and efficient this process is also very environmentally friendly because it does not involve any toxic or dangerous chemicals, which could harm the environment or the workers in the sorting facility. Overall the density test is the best process for sorting metal scrap, and would be vastly more effective than the current process.

7.0 References

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