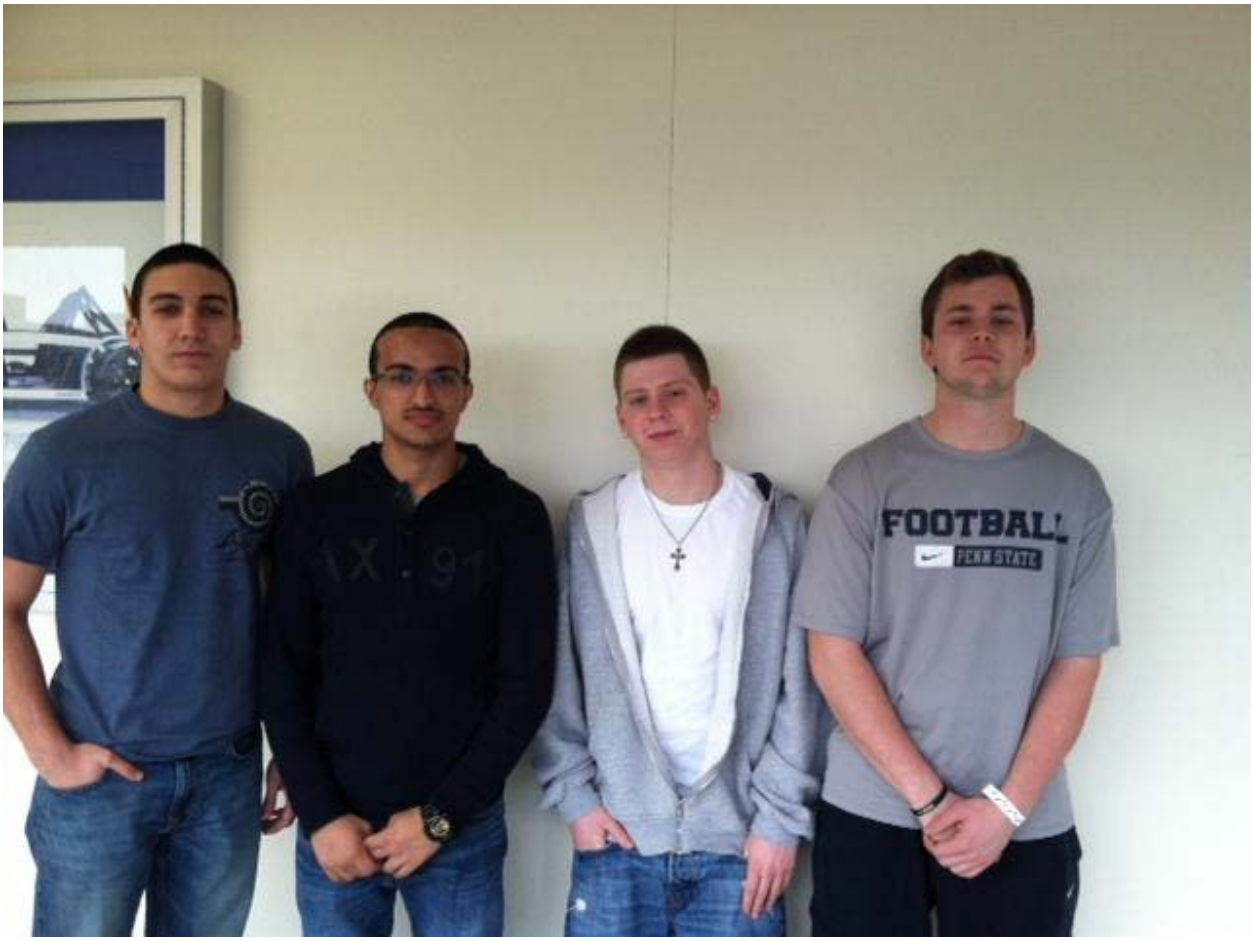
The Automobile-Steel Recycling Process

Engineering Design 100 Section: 10

Team 1 – iTeam

Submitted To: Professor Wallace Catanach

April 23, 2012

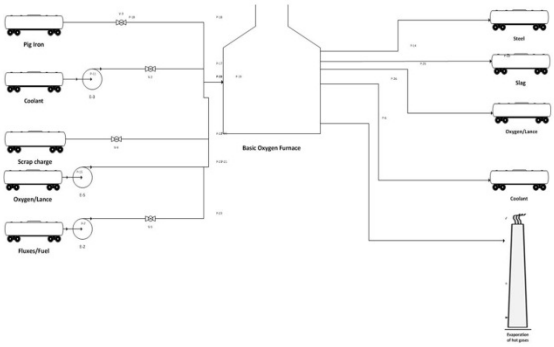


Norbert Sax (mailto:nws5213@psu.edu)
Mike Pannullo (mailto:mjp5548@psu.edu)
David Westley (mailto:dsw5149@psu.edu)
Khaled Alzubaidi (mailto:kaa5314@psu.edu)

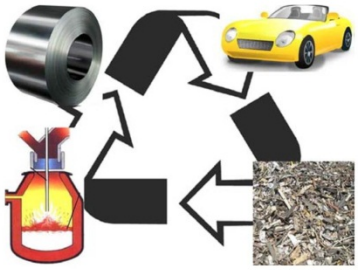
Group Poster:

ArcelorMittal: Automobile-Steel Recycling Process

By Khaled Al-Zubaidi, Mike Pannullo, Norbert Sax, and David Westley



Using this process, we can take used, alloyed steel and convert it to recycled, high-strength steel.



Recycling steel is far more efficient than producing new steel from scratch.

This Basic Oxygen Furnace is the key component for separating the original alloyed steel during the recycling process.

Project Summary:

In order to make an effective steel recycling process, much consideration needs to be taken into account of how to properly burn the steels and optimize the quality output of the recycled steel. We worked on how to design the best possible steel recycling process to bring out the best possible solutions. Many old cars are dumped into landfills every day and lots of good steel from those cars is wasted. The process that we designed will help us to better recycle the good steel from these cars and turn it into advanced high strength steel.

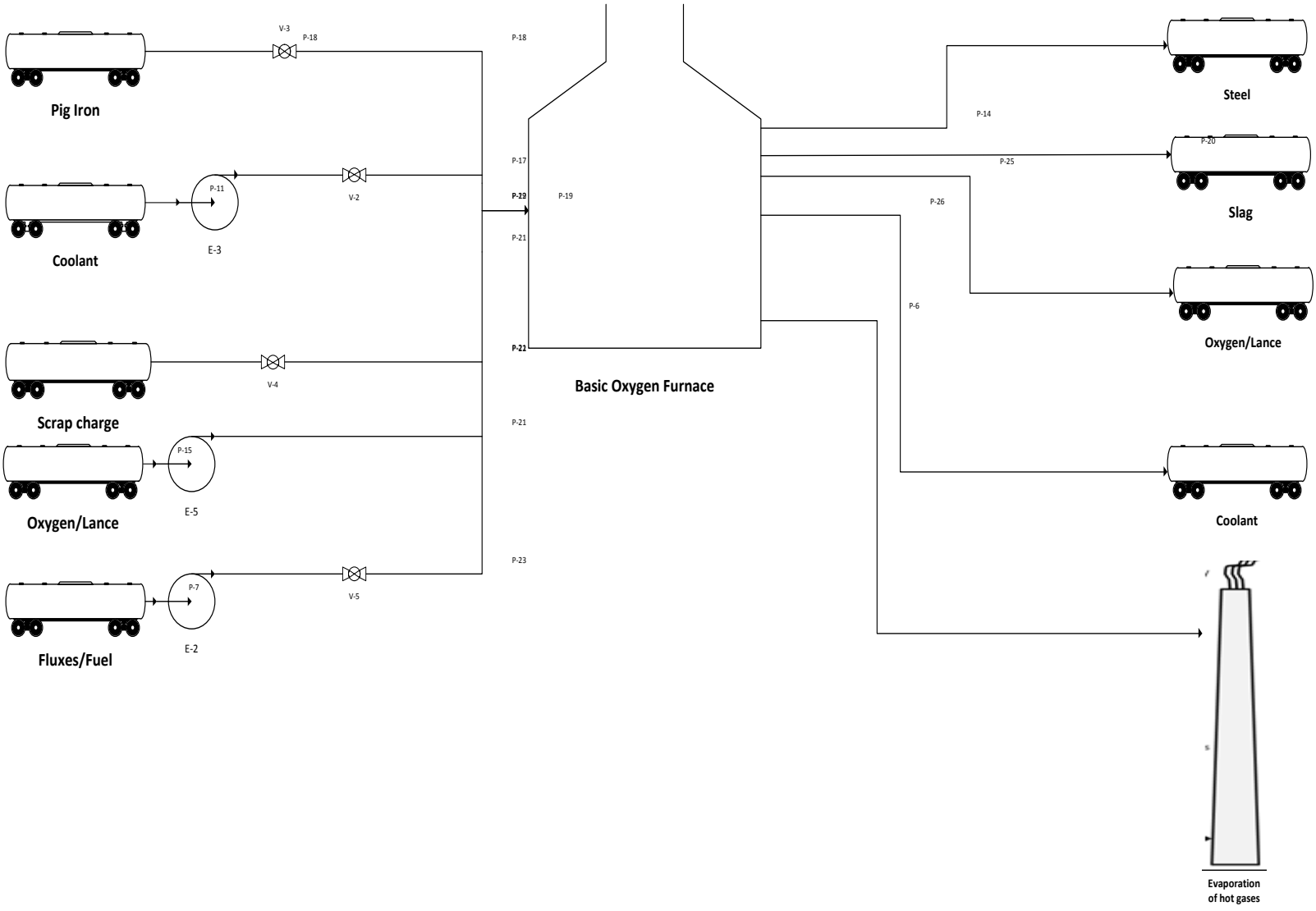
Introduction:

Steel is used in many things throughout the world such as automobiles, the construction of roads, railways, other infrastructure, appliances, and buildings, and several other things. A Basic Oxygen Furnace has proven to be the best system to properly recycle advanced High Strength steel. Arcelor Mittal, one of the leading steel mass production companies in the world, needs a new and better process to effectively recycle steel from old automobiles. The main objective is to recycle the used steel and turn it into advanced high strength without causing any off-chemistry steels. Our team has designed an effective automobile-steel recycling process to satisfy the needs of both the customer and the needs of the company itself.

Mission:

Our team has been hired by Arcelor Mittal to make their steel recycling system better. In order to successfully achieve that, our team must design a process in which no off-chemistry steels are produced, the customer's needs with the recycled steel are satisfied, and the alloy costs be kept to a minimum if necessary.

Process Flow Diagram:



Customer Needs Analysis:

Metrics	40% of Recycled Steel from old cars (Kg)	Separated Alloy content 98% ideal	Annual revenue of partner company at least 1 billion dollars	Low energy recycling process does not exceed the output (J)	Zero energy lost through recycling process (J)	A 97% sustainable system	manufactured to 85% Pure Steel (Kg)	Cost of production to a $500,000,000 budget (dollars annually)	Discard the 3% of scrap metal (Kg)	Heat capacity of steel model at 440,000 lbs	Linked website (html)	Drawing to a 1:1 Scale (meters:centimeters)	Presentation with scaled drawings (cm)	List of 8 organized design concepts
Need														
Recycle steel from old cars to make new cars	x													
The recycled steel should be close to the same quality as when it was originally used		x												
We want a partnership with a very prestigious group			x											
Process that is recyclable and continuous				x										
Lowest possible consumption is ideal during the production process				x										
Find resource with minimum setbacks or negative attributes	x													
Process that uses any form of scrap steel to turn into new materials					x									
Pure resources through the recycling process		x												
Make a process that separates unwanted alloys during recycling		x				x								
Only use more expensive and better quality steel where necessary							x							
Use naturally made steel							x							
Cost efficient product								x						
Eliminate batches of alloys during steel production									x					
Separate as much steel so the steel can be as pure as possible		x					x							
Use the most cost efficient machines to purify scrap alloy								x	x					
The scrap steel will be purified by the addition of alloys		x					x							
Model will have high quality alloy and heat capacity within it										x				
Make sure to balance the pure materials and scrap metal accordingly		x												
PDF report hyperlinked to website											x			
Drawing to display design												x		
Diagram of how the processes and the system function												x	x	
Tangible model of process												x		
Written out and organized design concepts														x

Facts about steel Recycling:

- Each year, The United States recycles more steel than plastic combined.
- Americans use 100 million steel cans every day.
- A typical household appliance is produced using approximately 65 percent steel.
- Due to this enormous amount of consumed steel, the steel industry has been recycling for over 150 years.
- Actually, recycling steel saves 75 percent of the energy that would be used to create steel from raw materials, enough to power 18 million homes.
- One ton of recycled steel saves 2,500 pounds of iron ore, 1,400 pounds of coal and 120 pounds of limestone.
- You can make 20 cans out of recycled material with the same amount of energy it takes to make 1 new one.

- The recycling process for metal is similar to those of other materials. It is best described in four stages:

1. Collection
2. Processing
3. Shredding
4. Selling

Facts about the Basic Oxygen Furnace (BOF):

Swiss engineer Robert Durrer invented the idea of basic oxygen steelmaking which was commercialized by two small steel companies in allied-occupied Austria. Also known as Linz-Donawitz-Verfahren steelmaking or the oxygen converter process is a method of primary steelmaking in which carbon-rich molten pig iron is made into steel. By blowing oxygen through molten pig iron lowers the carbon content of the alloy which changes it into low-carbon steel. The process is known as basic due to the type of refractories (calcium oxide and magnesium oxide) that line the vessel to withstand the high temperature of molten metal.

The LD converter, named after the Austrian towns Linz and Donawitz (a district of Leoben) is a refined version of the Bessemer converter where blowing of air is replaced with blowing oxygen. It reduced capital cost of the plants, time of smelting, and increased labor productivity. Between 1920 and 2000, labor requirements in the industry decreased by a factor of 1,000, from more than 3 worker-hours per tonne to just 0.003. The vast majority of steel manufactured in the world is produced using the basic oxygen furnace; in 2000, 60% of all steel was made using this process. Modern furnaces will take a charge of iron of up to 350 tons and convert it into steel in less than 40 minutes, compared to 10–12 hours in an open hearth furnace.

Global Marketplace:

Top 5 Steel producing companies in the world in 2010:

1. **ArcelorMittal (Luxembourg) 98.2 million tons**
2. **Hebei Iron and Steel (**China) **52.9 million tons**
3. **Baosteel Group (**China) **37.0 million tons**
4. **Wuhan Iron and Steel (**China) **36.6 million tons**
5. **POSCO (South Korea) 35.4 million tons**

Concept Generation – Brainstorming

1.

- Hand-picking steels out with blue collar labor
- Put the same or similar colored steel together
- Magnetic separation
- Chemically separate
- Dissolve unwanted alloys
- Breakdown into consistent steels/metals by shredding metal

2.

- Trap Gases
- Filter omissions
- Use natural energy
- Decrease the amount of CO_2 released and remove batch
- Use electricity for power when available
- Use natural gas over coal burning

3.

- Have someone from the company keep an eye of the steel producers
- To put the percentage of different alloys
- Make them locate the alloys content
- Communicate with steel companies

4.

- Recycle cars without oil or gas still in it
- No rusted parts in the cars
- Dump the 'best' recycled cars into an area zoned for the steel company
- To buy a car from old car owners

- Make a deal with car dumps for providing the steel company
- They can break the junk cars into steel and other non-steel parts
- Make cars out of more easily recycled materials
- Use recycled steel
- Give out cars to steel recycling companies

5.

- Directions for disassembly included
- Use budget to buy machinery with high strength to disassemble parts
- Make less screws, but strong ones
- Make a park click removable but only when authorized personnel can remove

6.

- Engrave an identifiable mark for each type of steel used in the car
- By its mass or density
- Use magnet to separate alloy content
- Their elemental properties, boiling point, heat capacity, ect.

7.

- Giant bins for each car part
- By putting each equally shaped part on a side
- Robots
- Assembly line

8.

- Putting steels into a furnace to find the heat capacities of the steels and identify them
- Sort the steels by finding the alloys percentages compared to pure 100% steel
- If the steel companies mark them
- Color, character other properties

9.

- Shredding will help separate the strong steels from the weak ones
- Break down into same size, which helps extract pure steel
- Makes the large pieces into smaller pieces
- Break down, easier to identify and separate

Concept Selection:

1.

- Chemically separate
- Breakdown into consistent steels/metals by shredding metal

2.

- Use electricity for power when available
- Use natural gas over coal burning

3.

- Have someone from the company keep an eye of the steel producers

4.

- Make a deal with car dumps for providing the steel company

5.

- Use budget to buy machinery with high strength to disassemble parts
- Make less screws, but strong ones

6.

- Use magnet to separate alloy content

7.

- By putting each equally shaped part on a side

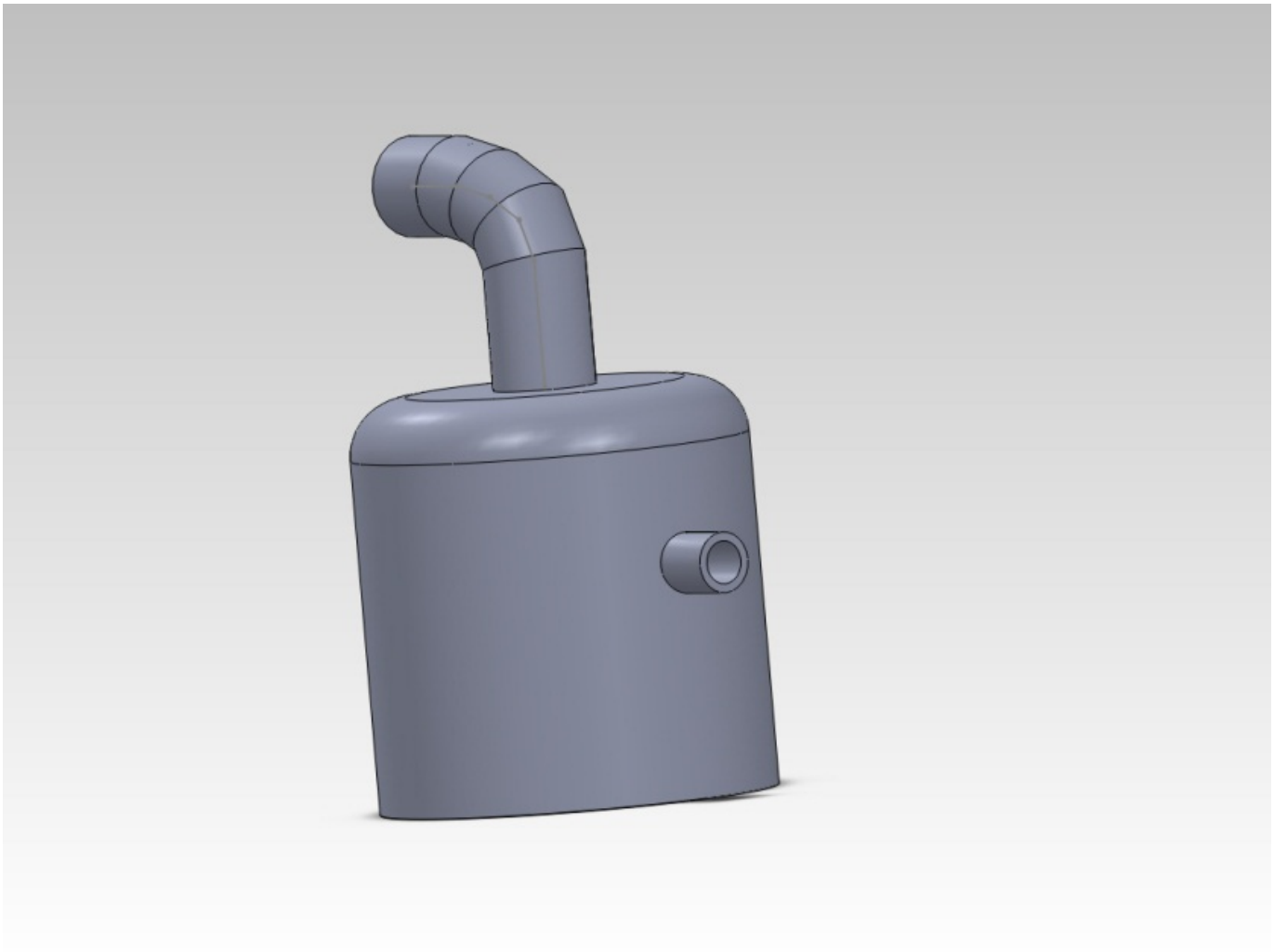
8.

- Sort the steels by finding the alloy percentages compared to pure 100% steel
- If the steel companies mark them

9.

- Shredding will help separate the strong steels from the weak ones
- Break down into same size, which helps extract pure steel

Embodiment Design:



Description of Design:

The Basic Oxygen Furnace that we designed (As seen above) is composed of a main intake at the top and an outtake in order to effectively separate the steels and the slag that is created when burning the steel. At the top is where the lance is put it and where the hot gases can escape and on the side is where the slag comes out. The furnace chamber itself is 60 feet tall with a diameter of 45 feet. To make sure that there will be no off-chemistries, the furnace should be set to 1680 degrees Celsius. Also, within the furnace, the percentages of Carbon, silicon, and Phosphorus should be decreased but Manganese can be left alone. The tapping weight percentages are listed below.

C: 4.5% → .01%
Si: .4% → .25%
Mn: .5% → .85%
P: .08% → .075%

Eliminating Off-Chemistry Heat:

Types of Steel in Scrap Charge(66,000 pounds total)	Initial Weight Percentage	In Kg
C	0.17%	112
Cr	0.20%	132
Cb	0.02%	13
Mn	1.50%	990
Al	1.20%	792

	Final Weight Percentage (after blow)-->LCAK	In Kg
C	0.04%	26.4
Cr	0.10%	66
Cb	0.00%	2.64
Mn	0.20%	132
Al	0.04%	26.4

	Weight of each in slag/gas (Kg)
C	85.6
Cr	66
Cb	10.36
Mn	858
Al	765.6

Conclusion:

Because Steel is a very important substance used in most house appliances, recycling it is very convenient. Steel recycling is a quick and energy saving process. In this project we learned that steel recycling is an energy saving process which uses oxygen to change scrap steel into recycled steel. The amount of steel consumed annually is about 1 billion tons. The basic oxygen furnace is the most common way in the steel recycling industry now.

References

http://en.wikipedia.org/wiki/Basic_oxygen_steelmaking

http://www.headwatersrecycle.com/why.html

http://earth911.com/recycling/metal/steel/facts-about-steel-recycling/

http://en.wikipedia.org/wiki/List_of_steel_producers

http://www.steeluniversity.org/content/html/eng/BOS_UserGuide.pdf