How Steel is Made Using the Basic Oxygen Steelmaking Process

Sean Kennison

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Description Assignment

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Introduction

Basic oxygen steelmaking (BOS) is a method of creating steel that utilizes the blowing of pure oxygen to convert liquid iron and scrap into steel (Basic Oxygen Steelmaking). BOS is the most common and dominant primary steelmaking process used in the world today. A primary steelmaking process refers to the actual process of taking the raw materials and converting them to steel (Steelmaking). A secondary steelmaking process refers to operations that refine the crude steel before converting the liquid steel into a solid. (Steelmaking) The majority of the BOS process usually occurs in large steel processing plants known as steel mills (Steelmaking). This is necessary because steelmaking is a fast-paced process that cannot afford the lengthy transportation time from one plant to another. Due to the extreme high temperatures and large amounts of material that are present within this process, most of it is completed with automated equipment controlled by overseeing operators (Steel). The science behind steelmaking is largely dominated by chemistry (Steel). Chemistry determines everything from the chemical reactions that take place in the furnaces to the chemical composition of the different blends of steels.

Since there are many types of steel that can be created, this specific description will focus on the process of making standard sheet steel. Sheet steel is long, thin steel that is usually shipped to customers in coils. It is one of the most common fundamental forms of steel, with other forms being rods, bars, and wire.

The steps of this process are: obtaining the raw materials, inserting the raw materials into a blast furnace to create liquid iron, putting the liquid iron and scrap steel into a Basic Oxygen Furnace (BOF) to create liquid steel, solidifying the liquid steel via continuous casting, and finally sending the semi-finished casts to various finishing refinements. Below is a picture that displays a simplified version of the BOS process.

The Basic Oxygen Steelmaking Process
Image adapted from <http://www.worldcoal.org/media/jpg/585/1519045_2_steel_page_steel_production_diagram.jpg>
Raw Materials

Before the steelmaking process can begin, like any good recipe, the proper ingredients are needed. In this case, the ingredients are raw materials and include iron-ore, coke, limestone, and other minor constituents. The following materials are gathered together before the next step, which is the Blast Furnace.

Iron-Ore

Iron-ore are rocks and minerals that contain the metal iron (Iron Ore). Iron-ore is harvested in large-scales through various mining techniques (STEEL: From Start to Finish). The iron-ore is ground to a powder and then the ore is separated with strong magnets (STEEL: From Start to Finish). The ore is then heated and formed into marble-sized pellets.

Coke

Coke is a form of coal and is the primary fuel for the blast furnace (STEEL: From Start to Finish). To get coke, coal is crushed, sealed in airtight ovens for 12 to 16 hours, and then removed as solid carbon fuel (STEEL: From Start to Finish).

Limestone

Limestone is a mineral that is also obtained from the earth via various mining techniques (Limestone). After being mined, the limestone is crushed and becomes known as blast furnace flux (STEEL: From Start to Finish). The purpose of limestone is to remove any impurities, such as sulfur, during the Blast Furnace stage. (STEEL: From Start to Finish).

Other Constituents

Other raw materials can be added depending on the type of steel that is being made. An example would be manganese. Manganese is a type of metal that is commonly found in nature by itself and in other minerals (Manganese). For the case of steel, manganese is often added to increase strength, hardness, and durability (Products Traded).

To the right is a picture of iron-ore pellets, coal, and limestone, which are three of the key ingredients, mentioned above.
Blast Furnace

Once the necessary raw materials have been acquired, their next step is to enter the blast furnace. A blast furnace refers to a specialized type of heating device that produces liquid metals from the reaction of adding pressurized air through the bottom while the raw materials are added at the top (Blast Furnace). Within the Blast Furnace, temperatures reach up to 2700 degrees Fahrenheit. The superheated furnace causes the coke to continually combust, which further intensifies the heat. This causes the iron-ore to melt, and molten iron, also known as hot metal, is produced. The molten iron is then placed in a giant ladle, which is a vessel used to transport and pour liquid metals, and then transported to the oxygen shop. Below is a simplified diagram of a standard blast furnace.

Basic Oxygen Furnace

The oxygen shop refers the part of the steel mill where the Basic Oxygen Furnace (BOF) is housed. The BOF is another type of specialized heating device that converts the liquid iron to liquid steel by blowing oxygen into the molten iron (Basic Oxygen Steelmaking). Along with the liquid iron that was produced in the blast furnace, recycled scrap steel is also added to the oxygen furnace. Pure oxygen is then blasted into the furnace at supersonic speeds via an oxygen lance that is lowered from the top. An oxygen lance is a heating tool that is fed by
oxygen that can be used to cut, melt, and burn various substances. (Thermolance). This causes a chemical reaction that converts the molten iron to molten steel. Once the molten steel has been created and is ready for the next step, the BOF tilts and pours its bounty into another ladle. The following picture shows the simplified features of a BOF.

At this point, any secondary steelmaking processes would take place, which is commonly referred to as metallurgy. Metallurgy deals with changing the chemical composition of the steel to meet the specific standards for the designated application (Metallurgy). For standard sheet steel, secondary steelmaking processes are not needed and are skipped by the molten steel. The molten steel is now ready for continuous casting.

**Continuous Casting**

Continuous casting is the process of solidifying molten metal into semi-finished shapes. It is called continuous casting because the actual casting of the steel is subsequently followed by rolling (Continuous Casting). Rolling refers to the process of thinning the steel with a series of rollers. Rollers are just long cylinders that are used to flatten various substances and use the same concept as a simple kitchen rolling pin. The molten steel can be casted into various shapes, which depend on the intended final application of the steel. The mold of the cast
determines the shape of the steel. The molds are usually variations of slabs, billets, and blooms, which are pictured below.

For sheet steel, the molten steel is casted into slabs. The molten steel enters the mold from the ladle and after it is rolled and cooled, it is cut into sections as it exits the caster. The following picture shows a typical continuous casting process.
The blue circles in the picture signify the rollers that the steel passes through. Note that the yellow signifies the liquid state of the steel and the red signifies the solid state. Notice how the steel turns solid as it goes through the rollers. This transition is usually accomplished by the steel being sprayed by water as it travels the length of the rollers.

The steel is now in a semi-finished solid state and can either be sent to customers or undergo finishing refinement processes. Since the end product is sheet steel, the newly formed slabs need some finishing refinements.

**Finishing Refinements**

The primary finishing refinement for sheet steel is being further hot-rolled in the rolling mills. Rolling mills are just a series of rollers and hot-rolling just means that the steel is at a high temperature while it is being rolled. Before the slabs can be rolled, they need to be reheated to about 2400 degrees Fahrenheit and then need descaled. Descaling refers to the removal of process scale, which is just a thin layer of different substances that build up on the surface of the steel throughout the steelmaking process (Steel De-scaling). The slabs then run through the rolling mills until they are thin and long enough for their intended application. An example of how a roller works is seen below:

Notice that the metal entering the rollers is extremely hot. This is why the steel is water-cooled after exiting. After being cooled, the sheet steel is rolled into coils, which are the final shape before distribution. The very last process for the general sheet steel is the pickle line. The pickle line is just an acid bath that cleans the surfaces of the sheet steel so it can be safely
handled by human hands (Steel De-scaling). After the pickle line, the sheet steel is now ready to be sent out to customers. The picture below is what the sheet steel looks like at this point.

![Sheet Steel Image](http://www.allproducts.com/manufacture100/westmetal/product1.jpg)

If the sheet steel needs further refinements, which is often the case, there are many other finishing applications that can be applied. Some common finishing applications include:

- **Cold-rolling**: the same thing as hot-rolling, just at a low temperature.
- **Tinning**: a coating process that coats sheet steel with a thin layer of tin.
- **Annealing**: a heat treatment that makes the sheet steel more flexible.
- **Tempering**: a heat treatment that makes the sheet steel tougher.

**Conclusion**

The steelmaking process begins with acquiring the right raw materials, which include iron-ore, coke, limestone, and other minor elements. The raw materials are combined together to form liquid iron, which is then transported to the Basic Oxygen Furnace (BOF). In the BOF, the liquid iron is combined with scrap steel and then blasted with pure oxygen to create liquid steel. Semi-finished solid parts are then created via continuous casting, which can then undergo various finishing refinements before being shipped to the customers.

Steel is one of the most common materials in the world and is found everywhere from the tallest skyscrapers to the smallest hand-held devices. It makes up the world around us and has over 1500 custom blends (Steel). The process of how steel is made is fascinating and should be introduced to everyone.
References


<http://www.vanche.com/steel-de-scaling>.

<http://www.youtube.com/watch?v=9l7JqonyoKA>.
