CARBONS FOR STEELMAKING

CARBONS FOR STEELMAKING

I.. Materials Used For Steelmaking
- a. Anthracite Coal
- b. Metallurgical Coke
- c. Calcined Petroleum Coke
- d. Fluid Coke
- e. Artificial/Synthetic Graphite

II. Uses of Carbon in Steelmaking
- a. BOF
- b. Induction Furnaces
- c. Electric Arc Furnaces
  - i. Charge Carbon
  - ii. Injection Carbon
  - iii. Recarburizer

III. Company Details

CARBONS FOR STEELMAKING

Materials Used For Steelmaking

a. Anthracite Coal
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CARBONS FOR STEELMAKING

MATERIALS USED FOR STEELMAKING

Anthracite Coal – Found around the world.

- Anthracite is formed when organic carbon, derived from ancient swamps, becomes emplaced in the earth's crust and is subjected to heat and pressure. Coal type is a function how much heat, pressure, and time the the formation is exposed to. Anthracite is considered the highest of coal grades having been exposed to low grade metamorphism.
- Anthracite is mined from seam deposits. The seam is removed and brought to a "Breaker" who processes the Anthracite Coal to different sizes and removes impurities.
- In the USA the majority of commercially available Anthracite Coal is found in Pennsylvania. The Fixed Carbon Content of Pennsylvania Anthracite Coal is 66 – 87%, Volatile Content is 5 – 9% and Sulfur Content is 0.5 – 1%. There are 8 sizes that are of interest to the Steel Industry ranging in size from 2 5/8" down to – 16 mesh

CARBONS FOR STEELMAKING

MATERIALS USED FOR STEELMAKING

Metallurgical Coke

- Carbon produced in Coke Ovens. Most Coke Ovens are located at Integrated Steel Mills for use in the Integrated Steel Making Process. Bituminous Coal is fed into the Coke Oven and heated in an oxygen free atmosphere and devolatized. The heating is done in various steps which subject the coal to different temperatures for varying time periods. During each step different volatile compounds are driven off. These compounds are collected, condensed and purified for sale as chemicals. At the end of the heating process Metallurgical Coke remains.

CARBONS FOR STEELMAKING

MATERIALS USED FOR STEELMAKING

Metallurgical Coke – cont

- It is porous with good strength. Primary purpose is for fuel in Blast Furnaces and for Fuel in Cupola furnaces. For Blast Furnaces the size needed is 1 ½" x ¾" and for Cupola Furnaces the size needed is 5" x 2". The smaller size < ¾" is what is known as Coke Breeze and this is the product used in EAF steelmaking.
- Fixed Carbon Content 80 – 90%, Volatile Content 1 – 5% and Sulfur Content 0.5 – 1.5%.
- Abrasive material compared to other carbons.

CARBONS FOR STEELMAKING

MATERIALS USED FOR STEELMAKING

Calcined Petroleum Coke – CPC – There are 2 methods for CPC Production

Method One

- Byproduct of the oil refining process. Heavy Crude Oil (bottoms) are put into a "Delayed Coking Unit" – DCU, Coker – in order to "drive" off the lighter fractions (jet fuel, gasoline, kerosene) contained in the Heavy Crude Oil. After processing in the DCU a solid carbon mass is left which is called Green Petroleum Coke. The Green Petroleum Coke is removed from the DCU by high power water spray which leaves Green Petroleum Coke with a high moisture level.
- Green Petroleum Coke is used as a fuel source for power plants burning coal or in cement kilns. Another outlet for Green Petroleum Coke is to be Calcined. Calcining is done in a rotary kiln to temperatures of 2800 F. The Calcining process removes moisture and volatile content and the product is called Calcined Petroleum Coke – CPC. CPC has Fixed Carbon Content of 99% + and Volatile Content < 0.5%. Sulfur content varies depending on the crude used to make the Green Petroleum Coke and will vary from 0.5 – 3.0%. There is some CPC with < 0.5% sulfur but tonnage is low since the need for such low sulfur in not required by the major industry using CPC.

CARBONS FOR STEELMAKING

MATERIALS USED FOR STEELMAKING

Calcined Petroleum Coke – CPC

Method Two – Coal tar pitch derived from the coking of bituminous coal is Calcined to remove volatile and moisture. This product is commonly referred to as Pitch Coke and has similar Fixed Carbon and Volatile Levels as CPC derived from Green Petroleum Coke. The main difference between CPC derived from Green Petroleum Coke and CPC derived from Coal is that the Coal CPC will have sulfur levels < 0.5%.

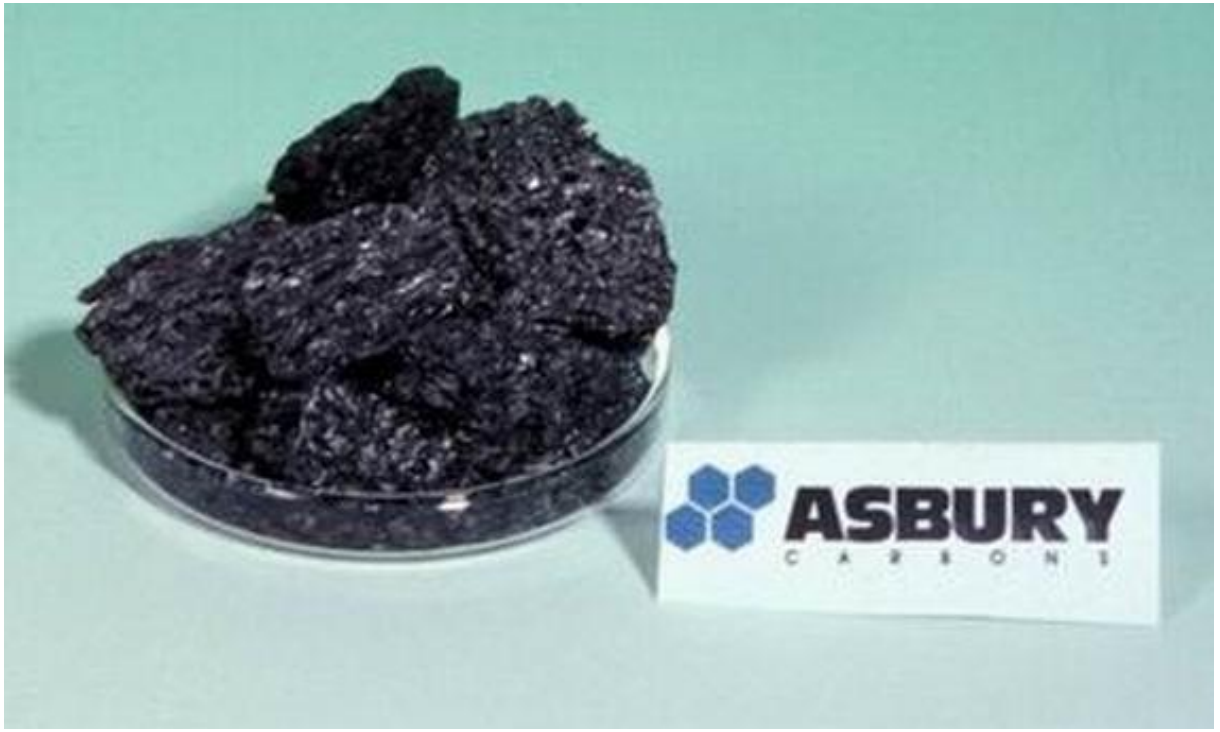
CARBONS FOR STEELMAKING

MATERIALS USED FOR STEELMAKING

Calcined Petroleum Coke – CPC – cont

- The main use of CPC is in the production of anodes for the Aluminum Smelting process. 70 - 80% of CPC is for the Aluminum Industry. The reason for use in the Aluminum Industry is for conductivity.
- Another use for CPC is TiO2 production which accounts for 10 – 15% of the CPC consumption. The reason for use in TiO2 is for it's oxidizing effect.
- Metallurgical Industry is the remaining major area where CPC is used. The reason for use in Metallurgical Industry is the high Fixed Carbon level (low ash level) and moderate sulfur levels.

CARBONS FOR STEELMAKING

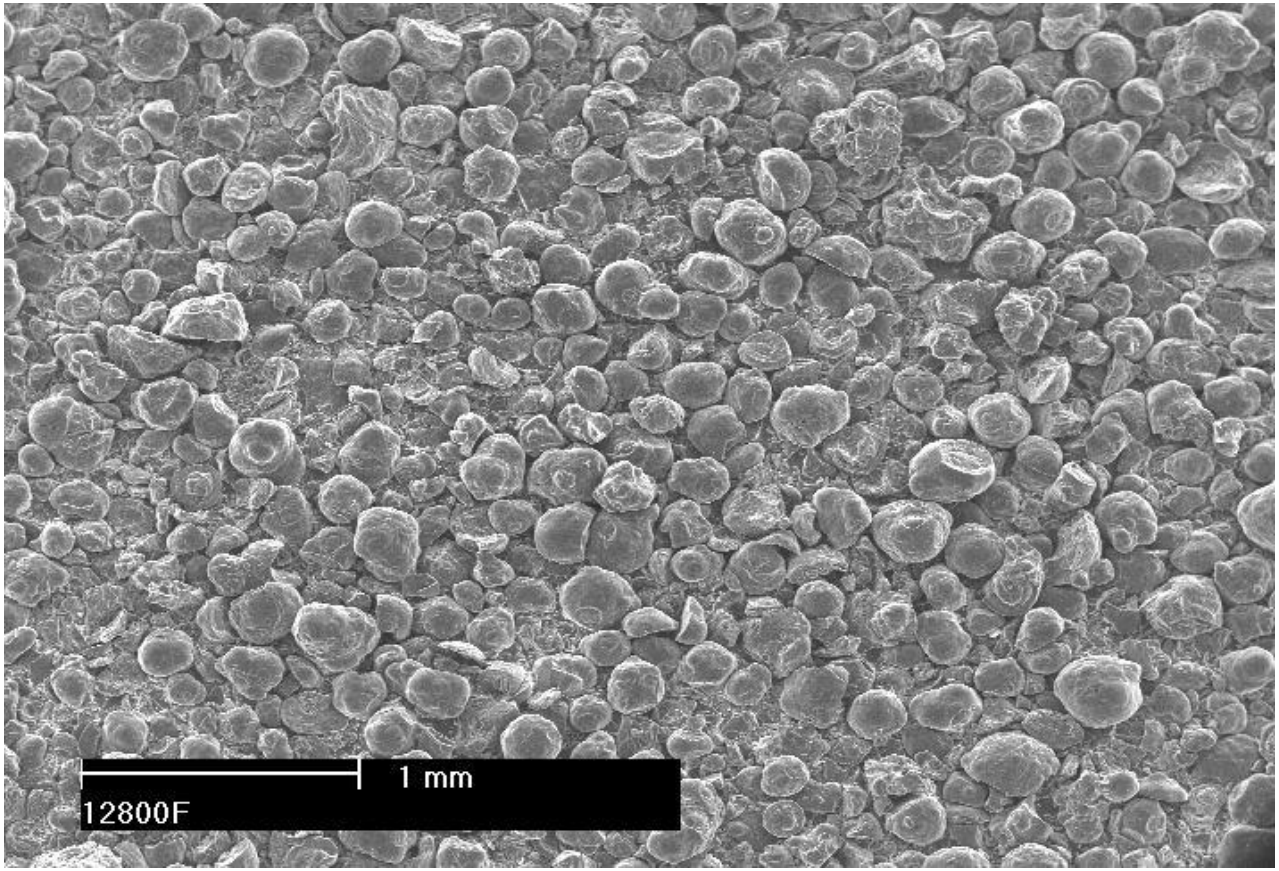


CARBONS FOR STEELMAKING

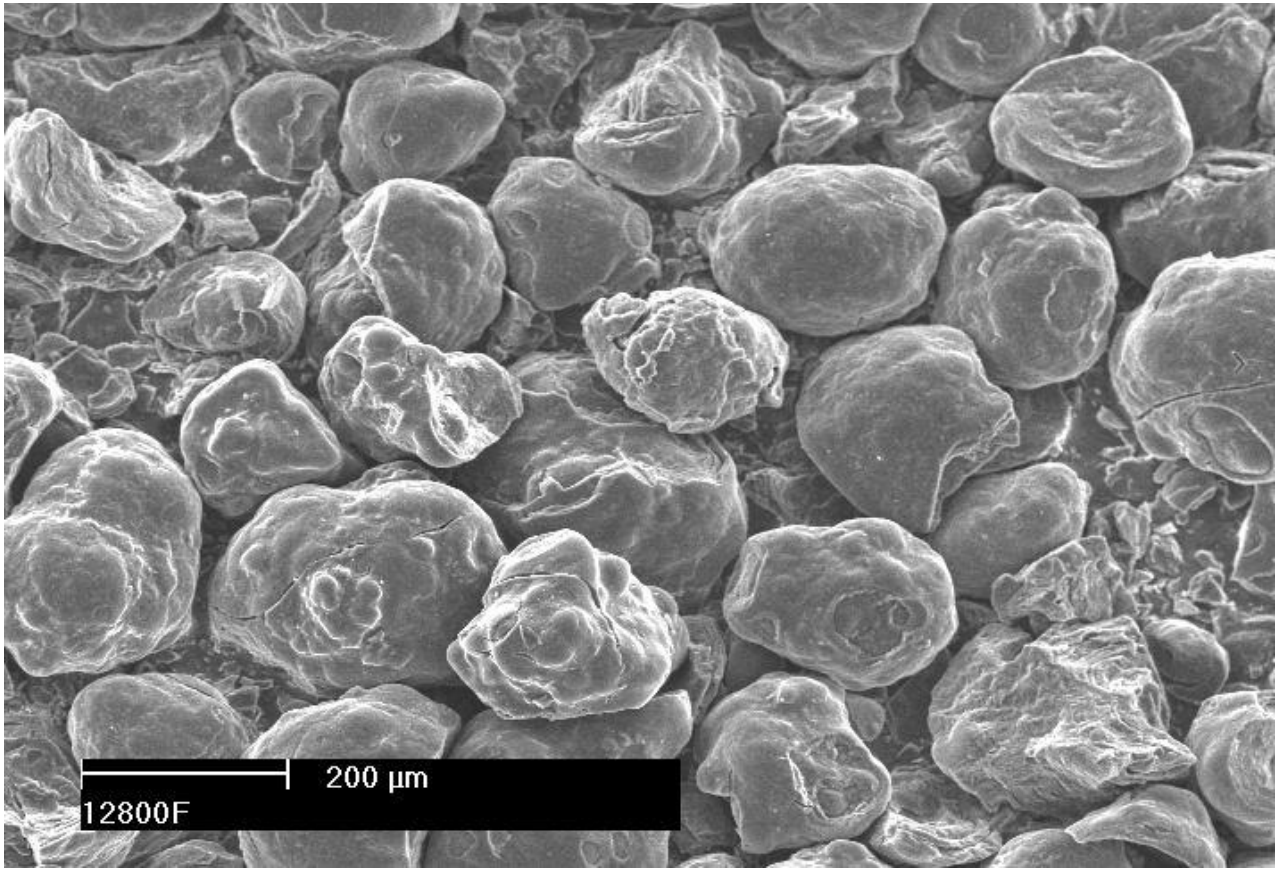
MATERIALS USED FOR STEELMAKING

Fluid Coke – A byproduct of the refining process similar to Green Petroleum Coke. The difference between Fluid Coke and Green Petroleum Coke is the production equipment used to make each product. Fluid Coke is made in a “Fluid Coker” which imparts a round shape on the particle and also a much smaller size. Fluid Coke does not go through the Calcining process. It has Fixed Carbon of 90 – 92%, Volatile of 2-4% and sulfur of 2 – 3%. It also has size of 8 mesh x down which is much smaller than Green Petroleum Coke. Because of it’s round shape Fluid Coke flows like water, hence it’s name – Fluid Coke. There are only a handful of refineries that have Fluid Cokers.

CARBONS FOR STEELMAKING



CARBONS FOR STEELMAKING



CARBONS FOR STEELMAKING

MATERIALS USED FOR STEELMAKING

Artificial Graphite AKA as Synthetic Graphite

Artificial Graphite is graphite that is made by man. There are 2 methods for production of Artificial Graphite.

Method One – CPC is mixed with a pitch based binder and extruded into a shape. The shape can be round (electrode) or block form (mold stock specialty graphite). The extruded shape is then "Baked" to bond the CPC with the pitch based binder. After Baking the material is subjected to high temperatures > 5000 F in order to convert the carbon to graphite. This process can take up to 10 – 12 weeks to complete from start to finish. Artificial Graphite has Fixed Carbon > 99%, Volatile < 0.5% and sulfur < 0.02%. After Graphitization the material is machined to it's final dimensions. It is from these machine turnings that Anthracite Industries gets it's Artificial Graphite for sale into the Metallurgical Industry.

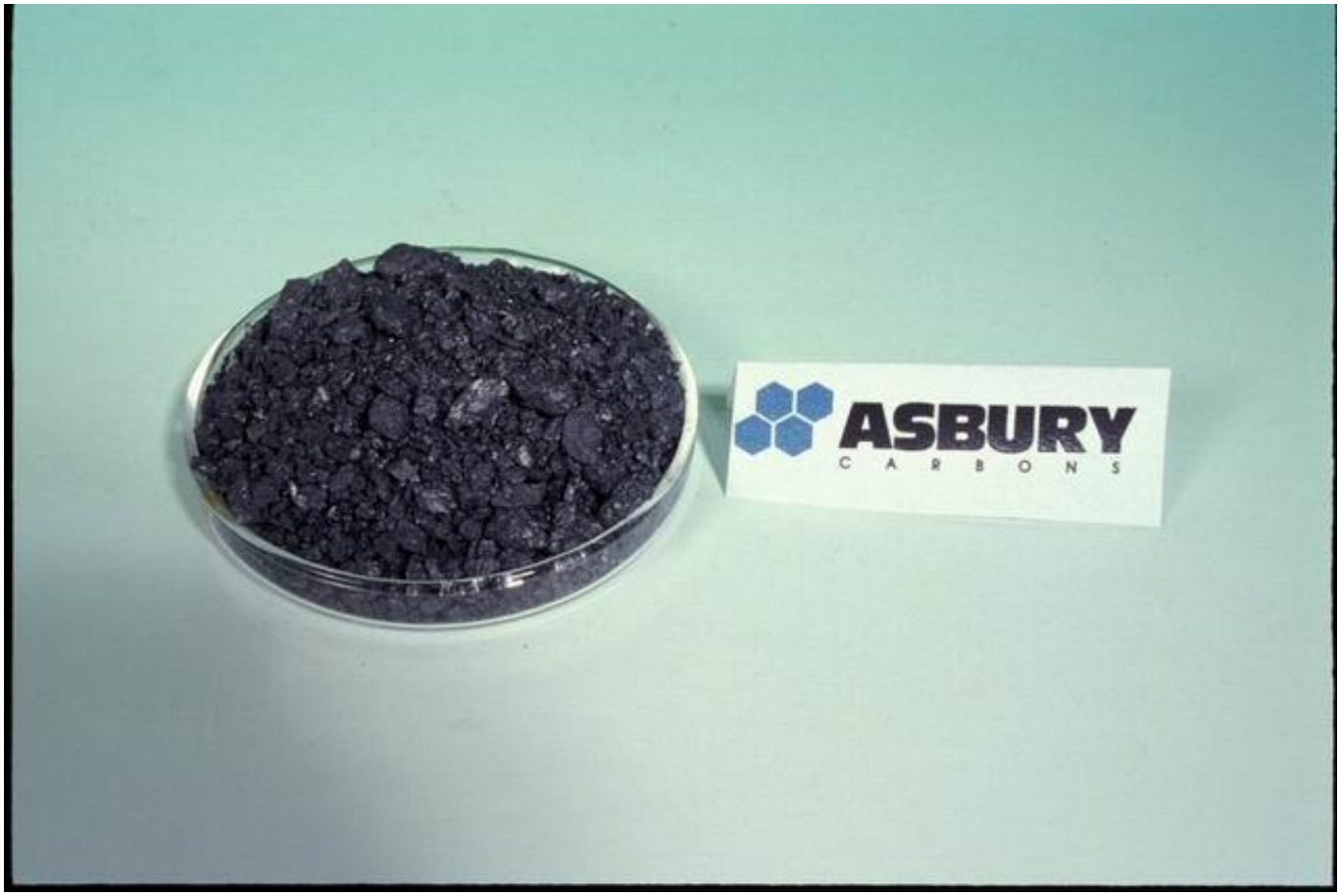
CARBONS FOR STEELMAKING

MATERIALS USED FOR STEELMAKING

Artificial Graphite AKA as Synthetic Graphite

Method Two – Carbon (CPC, Anthracite Coal, Metallurgical Coke) in granular or powder form is put into solid graphite containers and then loaded into a furnace for processing. The processing temperature is 5000 F and converts the carbon to graphite. The resulting Artificial Graphite has Fixed Carbon > 99.5%, Volatile < 0.2% and sulfur < 0.01%. This Artificial Graphite is very expensive and not practical for the Metallurgical Industry.

CARBONS FOR STEELMAKING



CARBONS FOR STEELMAKING

ARE THERE ANY QUESTIONS?

CARBONS FOR STEELMAKING

Uses of Carbon in Steelmaking

- a. BOF
- b. Induction Furnaces
- c. Electric Arc Furnaces
  - i. Charge Carbon
  - ii. Injection Carbon
  - iii. Recarburizer

CARBONS FOR STEELMAKING

USES OF CARBON IN STEELMAKING

BOF – used to add carbon points at end of melt, normally with ladle addition. Calcined Pet Coke, Artificial Graphite, Metallurgical Coke depending on sulfur and gas requirements.

CARBONS FOR STEELMAKING

Induction Furnaces – used to add carbon points in the furnace or the ladle. Calcined Pet Coke or Artificial Graphite depending on sulfur or gas requirements.

CARBONS FOR STEELMAKING

ELECTRIC ARC FURNACE (EAF) – Charge Carbon

Charge Carbons purpose is not strictly a carbon addition. Charge Carbon is added to the Furnace to consume excess oxygen in the melt down period. This means that Charge Carbon is a sacrificed material so minimizing cost of Charge Carbon is important. The primary purpose of Charge Carbon is to provide a reducing atmosphere during melting which minimizes the oxidation of alloys and metallics. During the melting process iron and other metallics oxidize and the presence of carbon provides a means of consuming the oxygen in the furnace (carbon is an oxygen scavenger), minimizing oxidation losses of iron and alloys.

CARBONS FOR STEELMAKING

ELECTRIC ARC FURNACE - Charge Carbon – con’t

Another benefit is the ability of carbon to react with metallic oxide and reduce it to it’s metallic form by producing carbon monoxide or carbon dioxide and pure metal, in the case of iron oxide Fe. By controlling the the oxidation of iron, iron oxide is minimized which helps the refractory. EAF’s are usually lined with basic refractory which are attacked by acid slag. Iron Oxide is an acid constituent in slag chemistry.

CARBONS FOR STEELMAKING

ELECTRIC ARC FURNACE - Charge Carbon – con't

The amount of charge carbon can vary depending on each shop's practice. Typically 25 lbs of charge carbon per ton of steel is added to the bottom of the furnace. This can be done by dumping the Charge Carbon into the furnace or putting the Charge Carbon in the Charging Bucket.

CARBONS FOR STEELMAKING

ELECTRIC ARC FURNACE - Charge Carbon – con't

Materials used for Charge Carbon

- Anthracite Coal – low cost per lb of fixed carbon, low sulfur content.
- Metallurgical Coke – low cost per lb of fixed carbon, low sulfur content.
- Calcined Pet Coke – high fixed carbon content but not normally used because of high price.
- Synthetic Graphite – high fixed carbon content, low sulfur and gas levels but not normally used because of high price.

Remember charge carbon is mostly a sacrificial material so the idea is to use the lowest cost per fixed carbon unit as possible. Anthracite Coal and Metallurgical Coke have traditionally been the material of choice.

CARBONS FOR STEELMAKING

Electric Arc Furnace – Injection Carbon AKA Slag Foaming Carbon.

The technique of Foaming Slag in the EAF is used to increase productivity, lower operating costs and increase the quality of steel produced. The Foamy Slag Practice using carbon has become standard practice for most EAF melting. Carbon combines with oxygen in the slag or in the molten steel (introduced via lance) and generates CO and CO2. This is an exothermic reaction which generates heat – BTU's. The evolved gasses cause the viscous slag to boil and expand dramatically in volume.

Increased productivity comes from:

- Improved electrical energy transfer from the electrodes to the molten bath. A good slag foaming practice allows a longer arc to be used because the electrode tips can be buried in the slag to minimize arc flare. This equals more power/energy to the molten steel bath.
- Chemical Energy introduced with the reaction between carbon and oxygen which is an exothermic reaction producing Chemical Energy.

CARBONS FOR STEELMAKING

Electric Arc Furnace – Injection Carbon AKA Slag Foaming Carbon - cont

Lowering Operation Costs is achieved by:

- Improved tap to tap times because of an increase in electrical and chemical energy into each heat. This will increase production.
- Lower Electrode Consumption because of more production and protection of the electrode tips while buried in the slag. In addition the carbon and carbon monoxide generated from the carbon/oxygen reaction combine with metallic oxides in the slag to deoxidize the slag which decreased the oxidation of graphite electrodes.
- Lower Refractory Consumption because of less Arc Flare from the Electrodes which are buried in the slag. Increased production also benefits Refractory Consumption.
- Carbon and Carbon Monoxide combine with the metallic oxides in the slag to reduce the oxides back to their pure metal state which are returned to the molten bath which enhances alloy recovery during the melt cycle.

CARBONS FOR STEELMAKING

Electric Arc Furnace – Injection Carbon AKA Slag Foaming Carbon – cont

Increase in steel quality is achieved by:

- The carbon oxygen reaction cleans oxides from the melt sweeping them up into the slag. This allows for cleaner steels and simulates a BOF process for steel making.

CARBONS FOR STEELMAKING

Electric Arc Furnace – Injection Carbon AKA Slag Foaming Carbon – cont

- The amount of Injection Carbon will vary by each melt shops practice and equipment. Some shops will use 15 – 20 lbs/ton of steel for injection carbon while others may use 30 – 40 lbs/ton of steel for injection carbon. More and more shops are increasing the use of Injection Carbon while at the same time decreasing the use of Charge Carbon. With the introduction of Oxygen Burners more and more Injection Carbon is being used by EAF.

CARBONS FOR STEELMAKING

Electric Arc Furnace – Injection Carbon AKA Slag Foaming Carbon – cont

Materials used for Injection Carbon

- Anthracite Coal – low cost per lb of fixed carbon, low sulfur content, high volatile content.
- Metallurgical Coke – low cost per lb of fixed carbon, low sulfur content, high volatile content. Most abrasive carbon which gives problems to injection equipment and storage systems.
- Fluid Coke – low cost per lb of fixed carbon, good size for injection, great flow ability which reduces abrasion to equipment. Sulfur can be a problem for steel makers worried about sulfur emissions.
- Calcined Pet Coke – high fixed carbon content but not normally used because of high price.
- Synthetic Graphite – high fixed carbon content, low sulfur and gas levels but not normally used because of high price.

Injection carbon is a sacrificial material so the idea is to use the lowest cost per fixed carbon unit as possible. Anthracite Coal has traditionally been the material of choice but availability problems has caused the use of Metallurgical Coke. However Metallurgical Coke has abrasion problems and is also in short supply at this time. Fluid Cokes are becoming more and more popular but there is a limit to the amount of Fluid Coke available.

CARBONS FOR STEELMAKING

Electric Arc Furnace – Recarburizer

Carbon is used in steel making to add carbon points to the steel. The ideal place to add the carbon for Recarburizer is in the ladle. With the introduction of Ladle Refining Stations (Ladle Met Stations) most EAF steel makers add Recarburizer to the ladle after tapping from the EAF. Depending on the grade of steel being made and the subsequent process the steel will be subject to (casting, rolling, atomizing) considerations for Recarburizer materials can be carbon content, sulfur content and gas content. The application of Recarburizer can be by bag toss, injection or cored wire. The amount of Recarburizer will be determined by the melting practice, grade of steel and subsequent processing.

CARBONS FOR STEELMAKING

Materials used for Recarburizer

- Calcined Pet Coke – high fixed carbon content. Sulfur range from 0.5 – 2%. Used when sulfur and gas content is not critical.
- Synthetic Graphite – high fixed carbon content, low sulfur and gas levels. Used when sulfur (< 0.02%) and gas levels (< 100 ppm) need to be low.
- Anthracite Coal – low cost but high ash level. Not desirable as a Recarburizer
- Metallurgical Coke – low cost but high ash level. Not desirable as a Recarburizer

CARBONS FOR STEELMAKING

ARE THERE ANY QUESTIONS?

CARBONS FOR STEELMAKING

What can we do to make your job easier, improve your operation, increase your production?

CARBONS FOR STEELMAKING

Company Details

CARBONS FOR STEELMAKING

ASBURY CARBONS

- INCORPORATED 1895
- UNDER ONE FAMILY OWNERSHIP SINCE INCORPORATION
- EMPLOYEES - 225 TO 300
- DIVISIONS

ASBURY GRAPHITE MILLS, INC.

- ASBURY, NJ - QS 9000 / ISO 9002 CERTIFIED
- KITTANNING, PA – QS PREAUDUT BY DEC. 1999

ANTHRACITE INDUSTRIES - SUNBURY, PA - ISO 9002

SOUTHWESTERN GRAPHITE - DEQUINCY, LA

CARBONS FOR STEELMAKING

ASBURY CARBONS – con't

Divisions – con't

CUMMINGS MOORE GRAPHITE – DETROIT, MI

ASBURY GRAPHITE OF CALIFORNIA - RODEO, CA

ASBURY FLUXMASTER – THOROLD, ONTARIO CANADA

ASBURY WILKINSON - TORONTO, ONTARIO CANADA

ASBURY EQUIPMENT CO. – KITTANNING, PA

CARBONS FOR STEELMAKING

- BUSINESS PHILOSOPHY
  - Respond swiftly to customer requests
  - Offer creative solutions to customer problems
  - Fierce dedication to quality
  - Put the customer first
  - Operate in a ethical manner
  - Be global in service

CARBONS FOR STEELMAKING

- Markets
  - Cast Metals – Customers where our products go into molten metal such as Steel, Iron, Aluminum, Brass, Bronze.
  - Industrial – Everything else such as PM, Friction, Lubricants, Refractory, Pencils, Seals, Gaskets, Carbon Molded Shapes.

CARBONS FOR STEELMAKING

MATERIALS OFFERED

- GRAPHITE – Natural Flake, Amorphous, Crystalline Vein, Expandable, Synthetic – Primary/Secondary
- COKES –Calcined Petroleum, Calcined Pitch, Semi-Graphitized, Metallurgical, Bed/Fluid, Pitched Out, Needle Coke
- COAL – Anthracite, Electrically Calcined Anthracite, Bituminous/Sea Coal
- OTHER CARBONS – Carbon Black, Activated Carbon, Carbon Fibers-Pitch/Pan Based

CARBONS FOR STEELMAKING

ANTHRACITE INDUSTRIES – A DIVISION OF ASBURY CARBONS

- 1955 Founded – Grinding coal for Hard Rubber, Battery Cases, Bowling Balls, Hockey Pucks
- 1976 Purchased by Asbury Graphite Mills, Inc. – began to service the Metals Industry
- 1980 – 1985 – Added equipment to service the Metals Industry, Crushing, High Speed Screens
- 1990 Pellet Plant Commissioned
- Asbury Carbons main Cast Metals Plant