УДК 662.74: 811.111

Achinovich V., Barankevich N., Beznis Y.

Coke Production for Blast Furnace Ironmaking

Belarusian National Technical University
Minsk, Belarus

A world class blast furnace operation demands the highest quality of raw materials, operation, and operators. Coke is the most important raw material fed into the blast furnace in terms of its effect on blast furnace operation and hot metal quality [1]. Coke is basically a strong, non–melting material which forms lumps based on a structure of carbonaceous material internally glued together. The average size of the coke particles is much larger than that of the ore burden materials and the coke will remain in a solid state throughout the blast furnace process [2]. A high quality coke should be able to support a smooth descent of the blast furnace burden with as little degradation as possible while providing the lowest amount of impurities, highest thermal energy, highest metal reduction, and optimum permeability for the flow of gaseous and molten products. Introduction of high quality coke to a blast furnace will result in lower coke rate, higher productivity and lower hot metal cost.

The cokemaking process involves carbonization of coal to high temperatures (1100°C) in an oxygen deficient atmosphere in order to concentrate the carbon. The commercial cokemaking process can be broken down into two categories: by-product cokemaking and non-recovery/heat recovery cokemaking. The majority of coke produced in the world comes from wet-charge, by-product coke oven batteries [1]. The entire cokemaking operation is comprised of the following steps: before carbonization, the selected coals from specific mines are blended, pulverized, and oiled for proper bulk density control. The blended coal is charged into a number of slot type ovens wherein each oven shares a common heating flue with the adjacent oven. Coal is carbonized in a reducing atmosphere and the off-gas is collected and sent to the by-product plant where various by-products are recovered.

The coal-to-coke transformation takes place as follows: The heat is transferred from the heated brick walls into the coal charge. From about 375°C to 475°C, the coal decomposes to form plastic layers near each wall. At about 475°C to 600°C, there is a marked evolution of tar, and aromatic hydrocarbon compounds, followed by resolidification of the plastic mass into semi-coke. At 600°C to 1100°C, the coke stabilization phase begins. This is characterized by contraction of coke mass, structural development of coke and final hydrogen evolution. During the plastic stage, the plastic layers move from each wall towards the center of the oven trapping the liberated gas and creating in gas pressure build up which is transferred to the heating wall. Once, the plastic layers have met at the center of the oven, the entire mass has been carbonized [1]. The incandescent coke mass is pushed from the oven and is wet or dry quenched prior to its shipment to the blast furnace.

In non-recovery coke plants, originally referred to as beehive ovens, the coal is carbonized in large oven chambers [3]. The carbonization process takes place from the top by radiant heat transfer and from the bottom by conduction of heat through the sole floor. Primary air for combustion is introduced into the oven chamber through several ports located above the charge level in both pusher and coke side doors of the oven. Partially combusted gases exit the top chamber through *down comer* passages in the oven wall and enter the sole flue, thereby heating the sole of the oven. Combusted gases collect in a common tunnel and exit via a stack which creates a natural draft in the oven. Since the by-products are not recovered, the process is called non-recovery cokemaking. In one case, the waste gas exits into a waste heat recovery boiler which converts the excess heat into steam for power generation; hence, the process is called heat recovery cokemaking.

High quality coke is characterized by a definite set of physical and chemical properties that can vary within narrow limits. The coke properties can be grouped into physical properties and chemical properties. Measurement of physical properties aids in determining coke behavior both inside and outside the blast furnace. In terms of coke strength, the coke stability and coke strength after reaction with CO_2 (CSR) are the most important parameters. The stability measures the ability of coke to withstand breakage at room temperature and reflects coke behavior outside the blast furnace and in the upper part of the blast furnace. CSR measures the potential of the coke to break into smaller size under a high temperature CO/CO_2 environment that exists throughout the lower two-thirds of the blast furnace. A large mean size with narrow size variations helps maintain a stable void fraction in the blast furnace permitting the upward flow of gases and downward of molten iron and slag thus improving blast furnace productivity.

The most important chemical properties of coke are moisture, fixed carbon, ash, sulfur, phosphorus, and alkalies. Fixed carbon is the fuel portion of the coke; the higher the fixed carbon, the higher the thermal value of coke. The other components such as moisture, ash, sulfur, phosphorus, and alkalies are undesirable as they have adverse effects on energy requirements, blast furnace operation, hot metal quality, and/or refractory lining [1].

For blast furnace ironmaking the most important functions of coke are: to provide the structure through which gas can ascend and be distributed through the burden; to generate heat to melt the burden; to generate reducing gases;

to provide the carbon for carburization of the hot metal and to act as a filter for soot and dust [2].

A good quality coke is generally made from carbonization of good quality coking coals. Coking coals are defined as those coals that on carbonization pass through softening, swelling, and resolidification to coke. One important consideration in selecting a coal blend is that it should not exert a high coke oven wall pressure and should contract sufficiently to allow the coke to be pushed from the oven. The properties of coke and coke oven pushing performance are influenced by following coal quality and battery operating variables: rank of coal, petrographic, chemical and rheologic characteristics of coal, particle size, moisture content, bulk density, weathering of coal, coking temperature and coking rate, soaking time, quenching practice, and coke handling. Coke quality variability is low if all these factors are controlled. Coke producers use widely differing coals and employ many procedures to enhance the quality of the coke and to enhance the coke oven productivity and battery life [1].

References:

1. Mode of access: http://www/steel/org/steel-technology/how-its-made/processes/processes-info/coke-production-for-blast -furnace-ironmaking.aspx?siteLocation=88e232e1-d52b- 4048-9b8a-f687fbd5cdcb. – Date of access: 20.02.2018.
2. Mode of access: http://allaboutmetallurgy.com/wp/wp-content/uploads/2016/12/Modern-Blast-Furnace-Ironmaking-an-Introductio-001-2.pdf. – Date of access: 10.03.2018.
3. Mode of access: https://www.ifc.org/wps/wcm/connect/9ecab70048855c048ab4da6a6515bb18/coke_PPAH.pdf?MOD=AJPERES. – Date of access: 12.03.2018.