Propane—Butane Heating of Coke Batteries

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Abstract—Experience has been gained in propane—butane heating of the first coke batteries of a newly constructed coke plant, where no coke-oven gas or blast-furnace gas is available. Under the guidance of specialists at ZAO Ogneuporkoksservis (OKOS), five coke batteries have been successfully heated and put into operation. For the first time in global practice, a coke battery has been converted to continuous propane—butane heating. Propane—butane heating of the coke battery has been tested and confirmed as a reliable means of preparing the first batteries at a newly constructed coke plant for startup and production. In addition, experience shows that continuous propane—butane heating is possible for a battery with a limited supply of coke-oven gas for heating.

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After the construction of a coke battery and before its startup and operation, the refractory lining must be dried and then heated to the operational temperature (1050–1100°C), at which coal batch is loaded, so as to produce coke and coke-oven gas.

The drying and heating of coke batteries is generally based on a special technology developed by the All-Union Coke-Chemistry Station, Ministry of Ferrous Metallurgy of the USSR. In this technology, various fuels may be used: coke-oven gas, blast-furnace gas, natural gas, or coal. The drying and heating of coke batteries by these fuels has been tested in practice. The simplest is the heating of a newly constructed coke battery at an existing coke plant. When the temperature in the lining is 750–800°C, the coke battery is switched to heating by its own coke-oven gas. The initial heating of coke batteries by coke-oven gas and natural gas and the transition to continuous heating by these fuels has been well developed by the All-Union Coke-Chemistry Station, which has developed comprehensive instructions for the process.

For a newly constructed coke plant, where no coke-oven gas is yet available, we must determine the best fuel to use in heating the first coke battery. In the case of blast—furnace gas, at least two blast furnaces must already be in operation at the enterprise (in order to ensure stable gas supply). When blast-furnace gas or natural gas cannot be used, heating by coal is a possibility. However, experience shows that this is a very complex and laborious process, with significant shortcomings.

(1) Uniform heating of the lining over the battery length is difficult.

(2) Ensuring the specified daily temperature rise is a challenge.

(3) Heating requires great effort from a large crew.

(4) In the final stage before battery startup, there are few options for testing the coke machines and adjusting the machines along the battery (on account of the clogging of the maintenance areas and the adjacent region with temporary equipment and stores required to supply and remove slag), although their reliable operation is critical to battery startup.

(5) In the final stage before battery startup, there are few options for maintaining the minimum temperature required for coking (900–950°C). That reduces the rate of gas liberation in the first furnaces and complicates the startup of gas injection and the transfer of the battery to continuous heating by its own coke-oven gas.

In contrast to heating by coal, the use of gas permits more uniform heating of the refractory lining over the battery length; more precise compliance with the specified daily temperature rise; high temperatures in the final stage of heating (with relatively little effort by a small crew); and better preparation for startup, as well as testing and adjustment of the machines required.

In the 1970s, specialists under the leadership of Chemarda developed a technology for coke-battery heating by propane—butane gas, which was first used at startup of coke battery 1 at Iskenderun Metallurgical Plant, Turkey (1975). Subsequently, propane—butane heating of the first coke batteries was employed at the following plants:

—Altai Coke Plant, USSR (coke battery 1, 1981);
—Visakhapatnam Metallurgical Plant, Andhra Pradesh, India (coke battery 1, 1989);
—Neelachal Ispat Nigam Metallurgical Works (previously Konark Met Coke plant), Kalinganagar.
Industrial Complex, Orissa, India (coke battery 1, 2004);
—Global Ispat Koksna Industrija doo Lukavac (GIKIL) coke plant, Lukavac, Bosnia and Herzegovina (coke battery 4, 2004);
—Bhushan Steel plant, Meramandali, Orissa, India (coke batteries 1 and 2, 2011–2012);
—Jindal Stainless Steel Works, Kalinganagar Industrial Complex, Orissa, India (coke battery 1, 2010–2011), heated and converted to continuous propane–butane heating.

Propane–butane heating of the first coke batteries at a newly constructed coke plant has the following benefits.

(1) Liquefied propane–butane is supplied to the plant in trucks or railroad cars. A regasification station at the plant converts the liquid propane–butane to gas (pressure 3–5 kg/cm² or 0.3–0.5 MPa), which is then supplied through a reducing system to the battery at a pressure of 500–600 mm H₂O (5–6 kPa). This relatively mobile and reliable system permits the use of propane–butane heating at locations distant from the supply, without the expense of pipeline construction. Once battery heating is complete, the regasification station may be used at other plants or for other purposes at the same plant.

(2) Simple gas supply and ignition in temporary furnaces, by means of other gases or else of special burners of relatively simple structure developed by Chemarda so as to ensure practically complete combustion of the pure propane–butane gas (Fig. 1).

(3) The lower heat of combustion of propane–butane gas may fluctuate from 21795 kcal/m³ (11000 kcal/kg) with around 100% propane to 28340 kcal/m³ (10900 kcal/kg) with ~100% butane. Propane–butane heating permits final lining temperatures of 1000–1050°C, which is sufficient for charging of the first 16–20 furnaces with coal and the generation of the coke-oven gas required for conversion to continuous heating by its own coke-oven gas.

(4) In contrast to coke-oven gas, propane–butane is free of impurities (naphthalene, tar, ammonia, etc.) and water vapor (which is very important in severely cold regions). That facilitates its uniform distribution over all the ovens in the battery and correspondingly uniform heating of all the ovens. In contrast to blast-furnace gas and coke-oven gas, propane–butane gas is free of toxic carbon monoxide (CO).

When using propane–butane gas, correct organization of its combustion is important. Note that its combustion requires 6.5–7 times as much air as in the combustion of coke-oven gas. Therefore, the gas and air input to the furnace must be as large as possible, so as to ensure considerable draft and hence sufficient air for combustion. In heating to 100°C (in drying of the lining), the gas consumption is very small, and burner combustion of the gas may be unstable. In some cases, the air flow blows out the flame and combustion stops. Therefore, to maintain stable burner combustion, stainless-steel grids with 1 x 1 mm or 2 x 2 mm cells are introduced (as proposed by Levchenko). With further increase in gas flow rate, at lining temperatures of ~150°C or more, the grids must be removed since they increasingly retard the gas and air fluxes, which may disrupt their mixing and hence produce a smoky flame.

To stabilize the combustion flame at the furnace input, the construction of a brick vent (a small portable furnace) at the threshold of the oven is recommended. The vent thickness is a single brick (230–250 mm) and its height is 8–9 rows (570–650 mm); a 100 x 100 mm window permits the supply of additional air (Fig. 2). The burner is mounted within the vent, so that its front section (the burner façade) is at the mirror line of the façade. Correspondingly, at a lining temperature of 400–450°C, the burner fully enters the aperture in the mirror surface and is not heated deep within the furnace (under the condition that the temporary gas line is fixed with respect to the moving lining on expansion). This is necessary for the following reasons.