DRYING AND WARMING UP OF COKE OVENS

On completion of the construction, prior to commissioning, refractory brickwork of coke oven battery should be dried and then heated up to the operating temperature at which it can be charged with coal blend for production of its own coke and coke oven gas.

Drying and heating of coke oven batteries are separate single-stage processes, which follow one after the other and have the same pattern of gas flow.
Drying is gradual and almost complete removal of moisture from the ovens brickwork.

The upper zones of brickwork (inclined flues’ zone and above) completely dry at the temperature of 100 °C in heating flues on the 10th day after drying start up.

The lower zones (regenerators and sole channels) are dried at the temperature of 130-135 °C in heating walls on the 16-17th day after drying start up. The amount of moisture removed from the entire brickwork of modern coke oven battery is ~ 500-700 t.
Warming up is a gradual increase of brickwork temperature and bringing it in the heating walls up to the level allowing to switch the heating of the battery on to the design (permanent) scheme and start ovens charging with coal blend.

To switch the battery on to the permanent heating regime the temperature in the vertical flues should reach the level of 750-800 °C and 1000-1050 °C for ovens charging with coal.
DIFFICULTIES OF THE PROCESS OF COKE OVEN BATTERY WARMING-UP

Almost ~ 70% of brickwork consists of silica refractories, laid in the most critical zones – inclined flues zones and vertical flues. Silica raw material is quartzite 94-97% consisting of silica (silicon oxide (IV) SiO_2).

In nature, silica exists in three crystalline forms - quartz, tridymite and cristobalite, which differ in crystal structure, temperature ranges in which they are stable and density.

Features of silica material associated with the irreversible expansion of products at warming up to operating temperatures should be considered at warming of a new coke oven battery.
These circumstances require the use of special heating technology, allowing strict maintenance of the settled process conditions on raising the temperature of coke oven battery refractory brickwork. 100-300 °C temperature range is especially dangerous for the integrity of silica brickwork.

In the progress of warming-up coke oven battery brickwork increases by about 1,13-1,19% in volume. Taking into account the size of brickwork, the height of coke oven battery increases by 110-150 mm and up to 150-200 mm in length of coking chamber.

Transformation scheme of silica modifications in the heating process (change in volume%)
Schedule is calculated based on the daily rate of safe linear brickwork expansion in any zone, based on the practical data of up to 0.040% accuracy.
Normal course of drying and warming up and ensuring good condition of brickwork, to a large extent depends on careful observance of a settled regime.
WARMING UP COKE OVEN BATTERIES WITH GAS

Overall picture of temporary ovens brickwork for ovens warming up with gas

Hearthstone before heating
General scheme of temporary gas pipeline for coke oven battery warming up
STARTING UP OF COKE PRODUCTION

For newly constructed coke oven plant, when there is no own coke oven gas, the question arises, what fuel should be used to warm up the first coke oven battery.

Development of oil processing technology and availability of LPG resources (propane, butane, LPG) made possible to carry out warming up of coke oven battery with this fuel.

Housing of coke oven battery under construction inside and out
Merchantable LPG is a mixture of propane and butane in various proportions. Availability of the product, its unique physical properties present significant benefits for the consumers:

- liquid gas occupies little space;
- it is possible to transport it by railway and motor transport;
- simple equipment used for gas flaring;
- no problems with cleaning of gas intake fittings.

It is also necessary to take into account the absence of propane-butane toxic components (unlike coke oven and blast furnace gas) and ecological properties of liquefied gas - minimum of combustion products (as opposed to the ash and soot, typical for other types of fuels).

Main components of propane-butane (LPG)
Technology of CJSC «OKOS» is based on the experience of the soviet experts who used the propane-butane for warming-up of Coke Oven Battery №1 of Iskenderun Steel Plant, Turkey in 1975 (head of warming – up eng. Chemarda N.A.), and later at Altai By-Product Coke Plant (USSR, 1981, the head of warming – up eng. Kurmaev V.A.), Vishakhapatnam Steel Plant (India, 1989, the head of warming – up eng. Chemarda N.A.).

eng. Chemarda Nikolai Alexandrovich

One of the technology inventors, a member of CJSC «OKOS» from the first years of the company foundation. He has the titles of Honourable Builder, Honourable Metallurgist;

1995-2012 – has been working as a Deputy, Director-General of CJSC "OKOS"

2012- up to present - is the Adviser of Director-General for Operations.
Design of the burner for the battery warming up with propane-butane. Installed in each oven of the battery from coke and machine sides.
Scheme of liquefied gas storage, regasification plant and supply of LPG for the battery warming up is also quite simple and its implementation does not require considerable capital expenditures. Integrated cost of the technological system does not exceed $1 million.
Composition of the liquefied gas storage
At warming up of coke oven battery with capacity of 500 thousand - 1 million tons of coke per annum:

• containers 140m3 / each, 2 pcs;
• LPG pumps, 3 pcs;
• compressor, 1 piece;
• evaporators-heat exchangers, 2 pcs (one operating, the other stand by);
• sinking mill, 2 pieces (one operating, the other stand by);
• installation of heavy fraction condensation removal, 1 pc.
Main stages of liquefied gas storage system operation, regasification plant and supply for the battery warming up:

- receiving of liquefied natural gas at the storage; LPG arrives in railroad tank cars or road tankers;
- transfer of LPG from liquid to a gaseous state (implemented in evaporators);
- stabilization of gas pressure at the appropriate use rate at drying and warming up (is executed by means of sinking mill).

Facade of coke oven battery during the heating up
PERMANENT HEATING REGIME WITH LPG of the coke oven battery

Start up of the first (head) coke oven battery at the plant after warming-up without its preliminary switching on to the permanent heating scheme is rather complicated due to:

• overlapping (in time) of the last stage of warming with testing of coke machines and equipment and completion of a large amount of prestart activities;
• part of these ovens' cumulative heat is lost at dismantling of temporary stoves and installation of doors prior to their charging with coal;
• failures, breakdowns of coke machines and equipment, problems with blower and gas path at start up operations can lead to risky or even critical situations due to the lack of gas for pipelines purging and switching on to the permanent heating regime.
Complexity of the battery warming up under the permanent heating scheme with high carbon gases (including propane-butane) is in low temperature of their thermal decomposition. Gas decomposition with intensive deposition of soot carbon on the surface of brickwork elements takes place at the temperature of 800°C and more in the upper gun-flue zone and burners. This leads to rapid clogging of the heating system and heating regime disturbance.

CJSC "OKOS" has developed the technology of the battery heating with propane-butane under the coking gas supply for permanent heating scheme. This excludes all of the above difficulties.

The proposed technology does not require additional equipment. Permanent heating with liquified natural gas envisages utilization of the same gas pipelines as for heating with coke oven gas. The only difference is that atmospheric air is added through the special holes to reduce the gas calorific capacity.
KEY BENEFITS OF WARMING UP WITH PROPANE-BUTANE

• Safety of warming up process, where gas combustion (propane-butane mixture) is executed due to the optimal distribution of air and gas flow in the oven’s stove without its preliminary mixing;

• Autonomy of gas supply system allows safe and accurate adjustment of warming up process throughout the entire length;

• The process is environmentally friendly due to minimal emissions of combustion products into the air, and the absence of toxic components in propane-butane (as opposed to coke oven and blast furnace gas);

• Significant simplification of the start up of the first (head) of coke oven battery by switching it on to the permanent heating regime with propane butane;

• High gas calorific value (propane-butane mixture) and relatively low cost of fuel.
## COMPARATIVE ADVANTAGES OF COKE OVEN BATTERIES WARMING UP WITH VARIOUS TYPES OF FUEL

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Coal</th>
<th>Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coke</td>
<td>Natural</td>
</tr>
<tr>
<td>The possibility of the first (head) coke oven battery start up</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Warming up without recovery of coking products</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Availability of fuel in places remote from the main pipeline and existing coke oven plants</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Simplicity of warming up technology</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Minimum of employed personnel</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Possibility of switching the battery on to the permanent heating regime</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Minimum toxic emissions during warming up</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
According to this technology, Soviet specialists have successfully warmed up and commissioned the following batteries:

<table>
<thead>
<tr>
<th>Country</th>
<th>Enterprise</th>
<th>Facilities where warming up with LPG was implemented</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turkey</td>
<td>Iskenderun Iron and Steel Plant</td>
<td>Coke Oven Battery №1 (the height of chamber 5 m) including CDCP</td>
<td>1975</td>
</tr>
<tr>
<td>USSR</td>
<td>Altai By-Product Coke Plant</td>
<td>Coke Oven Battery №1 (the height of chamber 7 m)</td>
<td>1981</td>
</tr>
<tr>
<td>India</td>
<td>Vishakhapatnam Steel Plant, Andhra Pradesh</td>
<td>Coke Oven Battery №1 (the height of chamber 7 m) along with CDCP</td>
<td>1989</td>
</tr>
</tbody>
</table>
# PROJECTS COMPLETED BY CJSC "OKOS"

in the first decade of the XXI century

<table>
<thead>
<tr>
<th>Country</th>
<th>Customer</th>
<th>Plant location</th>
<th>Facilities where warming up with LPG was implemented</th>
<th>Realization period</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>Bhushan Steel Limited</td>
<td>Meramandali Steel Plant, Orissa</td>
<td>Coke Oven Battery №1 with stamp charging, the height of chamber 4,3 m (Design – China)</td>
<td>2010</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Coke Oven Battery №2 with stamp charging, the height of chamber 4,3 m (Design – China)</td>
<td>2011</td>
</tr>
<tr>
<td></td>
<td>Jindal Stainless Ltd.</td>
<td>Khalinga Nagar Industrial Complex, Orissa</td>
<td>Coke Oven Battery №2 with stamp charging, the height of chamber 4,3 m (Design – China)</td>
<td>2008-2011</td>
</tr>
<tr>
<td></td>
<td>Neelachal Ispat Nigam Limited (former Konark Met Coke Ltd.)</td>
<td>Khalinga Nagar Industrial Complex, Orissa</td>
<td>Coke Oven Battery №1 the height of chamber 7 m, including CDCP</td>
<td>2004</td>
</tr>
<tr>
<td>Bosnia and Herzegovina</td>
<td>Global Ispat Koksna Industrija doo Lukavac (GIKIL)</td>
<td>Lukavac Coke Plant, community Valevo, Kolubarsk region</td>
<td>Coke Oven Battery №5 the height of chamber 5 m</td>
<td>2004-2006</td>
</tr>
</tbody>
</table>
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