Azov Controls LLC
Ukraine, 49033, Dnipropetrovsk, Krasnopolska str., 9
INN (tax reference nr.): 330125505835
EDRPOU (ID nr.) 33012552, VAT Reference nr. 1504664500427
Bank acc. 260055657 in PJSC «PUMB», Kyiv, MFO 334851
Tel.: +380 629 41 24 24 Fax: +380 629 41 01 24
E-mail:office@azov-controls.com
Web: www.azov-controls.com www.terawatt-group.com

DESCRIPTION OF THE PROJECT SOLUTION "THE BLAST FURNACE#2 REPAIR, 2ND CATEGORY, WITH ELEMENTS OF MODERNIZATION, AT "ZAPORIZHSKIJ MC "ZAPORIZHSTAL" PJSC"

DESCRIPTION OF THE EXISTING PROBLEMS AND REQUIREMENTS TO THE PROJECT SOLUTION

One of the main problems arising during PC injection into the BF hearth is low durability of the cooling elements (plate coolers).

Therefore, it is important to increase the cooling plates maximum lifetime, especially in the peak heat loads area (bosh and two first BF stack rows).

In order to provide the efficient operation of BF2, it has been decided that major elements of it must be upgraded through the cooling system ACS project based on the usage of chemically purified water delivered by "Azov Controls" LLC. This method is aimed at realization of the mode of cooling of BF mantle, stack and bosh cooling plates by means of forced circulation of hot, chemically purified water.

SUMMARY OF THE PROPOSED PROJECT SOLUTION

This project solution allows extending BF campaign up to 15 years and requires minimum rework of the existing cooling systems and minimum capital expenses. Implementation of variable-frequency drives provides power efficiency; it eliminates hearth accretion formation, and lessens coke consumption due to reduction of unreasonable heat loss.

The "M Technology" company applies copper vertical cooling plates with drilled channels along with high conductive lining to the highest heat load areas (bosh, thrust, and first two-three rows of furnace stack) in its BF projects with realization of the pulverized coal insufflation system.

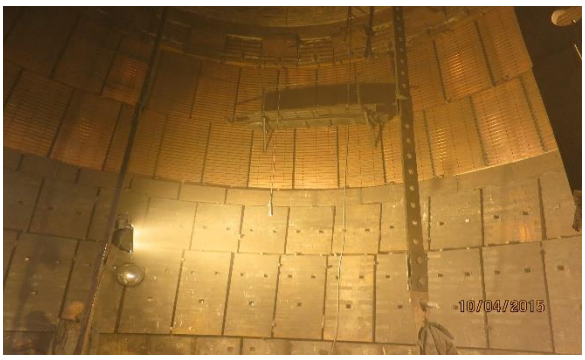

Fig. 1. Ready-mounted copper cooling plates

The provided solution has a wide range of advantages and almost solves cooling problems of the actual BF#2 area.

One of the elements of the project solution is the purified water based cooling system ACS. The system is developed as an independent (self-contained) sub-system of the existing BF#2 APCS and provides the desired level of integration with related hardware and software complexes.

MAIN FEATURES AND VALIDITY OF BF2 REPAIR

Inspection of BF#2 has showed that the refractory body had collapsed. There was also discovered BF2 jacket overheating, which had caused significant warping. Besides, BF#2 appeared to be settling and losing its framework.

Fig. 2. BF#2 settling

Taking into consideration technical state of BF2 and based on the accomplished inspection, "Zaporizhstal" PJSC management decided to hold 2-nd category repair works, which include replacement of the deformed furnace shell tier,

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reinforcement of bearing structure and upgrade of furnace cooling system.

SOLUTIONS TAKEN DURING RECONSTRUCTION OF BF#2 BOSH AND STACK COOLING SYSTEM

1. Installation of copper plates in the highest heat load area of the furnace.
2. Application of silicon-carbide lining to the bosh-belly-stack area.

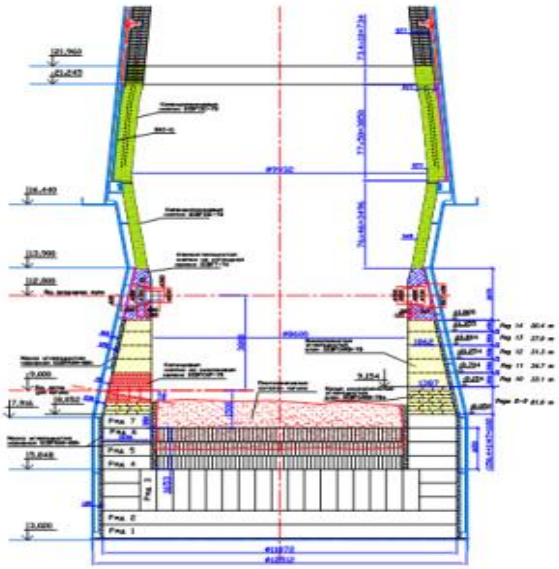

Fig. 3. BF#2 in cut

In order to speed up repair and provide high-quality welding, we have created the large-size bench assembly of the furnace armor tier with partial installation of copper coolers.

Fig. 4. BF2 furnace shell large-scale assembly

After assembly implementation, the armor was divided into 8 fragments, loaded on special railway platforms and hauled to the maintenance area.

Fig. 5. Armor division into 8 fragments

The next phase was step-by-step replacement of 8 fragments of the deformed furnace shell.

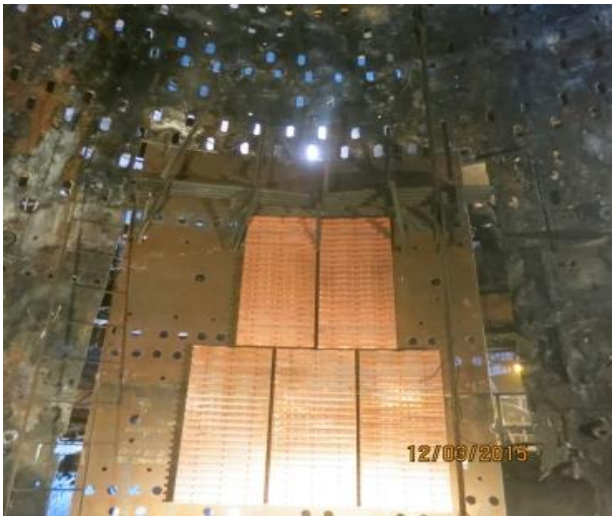

Fig. 6. Replacement of fragments of the deformed furnace shell

3. The cooling system with forced circulation.

The main parameters of the designed cooling system are given below:

Sustained pressure in separator bowls	20 m water column
System evaporative capacity (max)	24 t/h
Feed water consumption (max)	28 m^3/h
Number of sections	2
Circulating pumps (for each section)	2

Pumps with the following parameters were used in the project:

Consumption	440 m^3/h
Head	48 m^3/h
Available power of electric drive	90 kW

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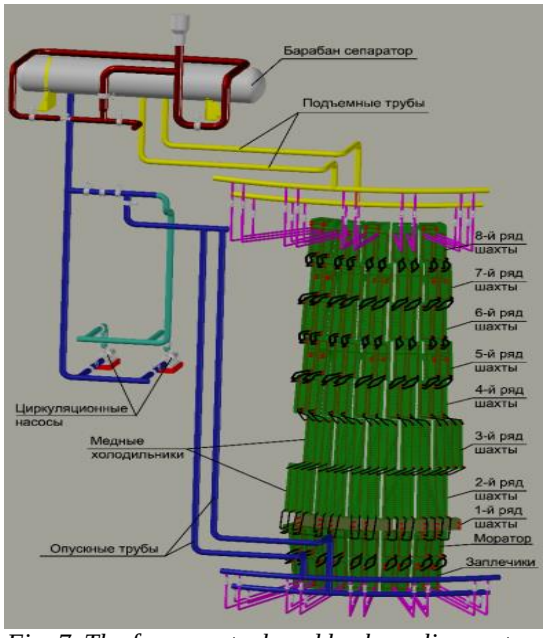

Fig. 7. The furnace stack and bosh cooling system schematic diagram

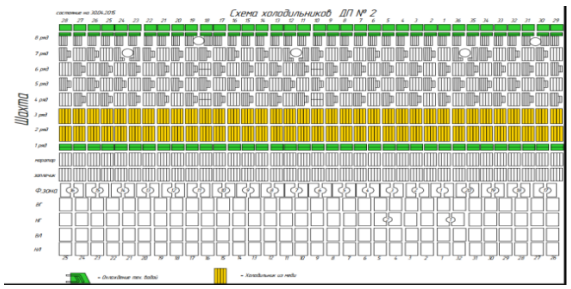

Fig. 8. BF#2 cooling system condition after repair in 2015

4. The cooling plates main operating parameters automated visualization and control system, including stack and bosh cooling plates cooling ACS by means of chemically purified water.

Fig. 9. Element base of APCS – Rockwell Automation (Allen Bradley equipment).

Functions of cooling ACS by means of purified water:

- automatic regulation of pumps efficiency depending on copper coolers heat load and based on temperature measurements along the cooling plates tier;
- automatic engaging of pumping station power supply system feeders in case of collapse of one of the working pumps;
- automatic, remote and local modes of pumps operation;
- regulation of water level in separating tanks 1, 2 by ball valves automatically, remotely or locally;
- visualization of process parameters at the computer-aided working place of BF2 foreman and in the control rooms 1, 2 which are installed in the furnace foreman room and pumping station.

Visualization displays, used in the project:

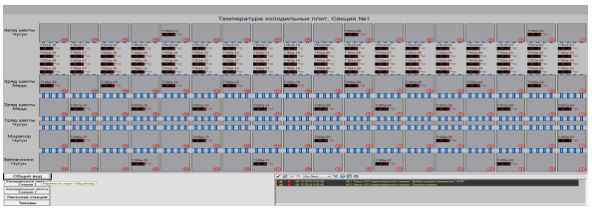

Fig. 10. Cooling plates temperature display

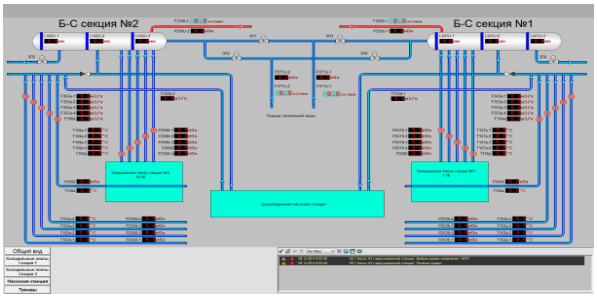

Fig. 11. Main screen

Fig. 12. Pumping station

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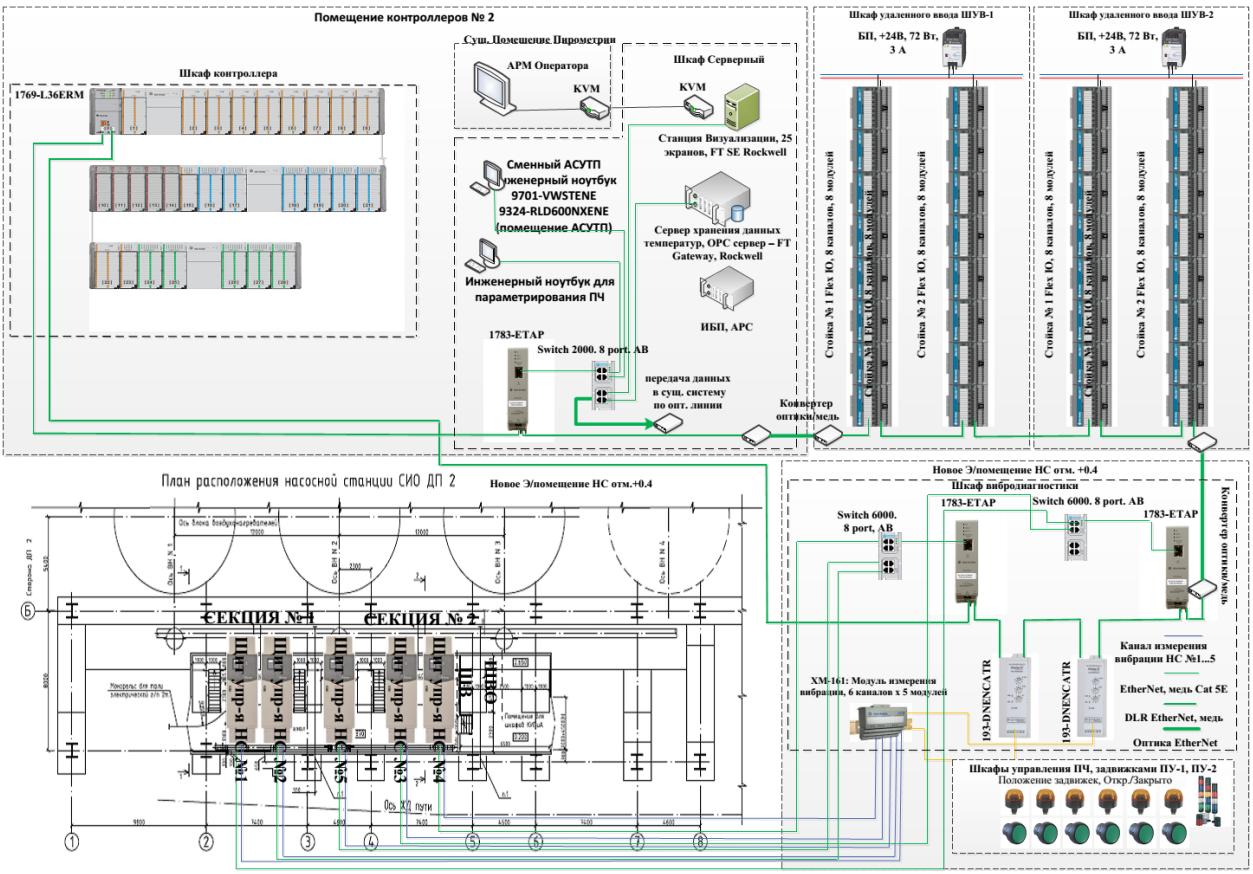

Fig. 13. The structural diagram of BF#2 automation by "Zapirizhskij MK "Zaporizhstal" PJSC"

LIST OF THE SOFTWARE AND HARDWARE USED

1. Pumping equipment

Fig. 14. "Aurum Pupmen" pump used for cooling systems, water supply reverse cycles, and fire control systems

One of the most important components, which provide reliable operation of the cooling system, is the pump. In our projects we use only high-quality European pumps, including those produced by "Aurum Pupmen" GmbH, the leading producer of pumping equipment for specific environment. Among the main features of this equipment, we should mention the following:

- variable frequency feature;
- high maximum pumping temperature – up to 140°C;
- no bearing cooling system when exploited in the above mentioned conditions.

2. Control equipment.

Fig. 15. CompactLogix 5370 L3 Controller

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CompactLogix 5370 L3 1769-L36ERM PLC is used in the automation project. Such controllers are characterized by the following advantages:

- network abilities: by means of two EtherNet ports and embedded EtherNet commutator, the controller keeps the device level ring (DLR) network topology, which simplifies the components integration into control system and reduces the system cost;
- provides fail-safe feature in case of loss of one network connection;
- allows changing of devices one by one without operation stop;
- reduces the number of EtherNet commutators in control system;
- in the automation project there were used local modules of analogue and discrete input/output, series 1769, and remote modules of thermocouples 1794-XT connected using DLR technology by means of 1794-AENTRXT EtherNet reserve communication module. 1794-XT equipment operating temperature range from -25°C to +70°C allows placing it close to the object without providing any special conditions.

3. Variable frequency drives

Fig. 16. PowerFlex 400 frequency drive

Pumps operation control in section 1-2 is performed with the help of EtherNet-compatible PowerFlex 400 frequency drives produced by Rockwell Automation.

PowerFlex frequency drives are considered optimal for any application and provide a wide range of standard control modes.

- Variability of pump sections efficiency and rotation speed.
- PID-instructions parameter setting.
- Frequency drives are provided with some other settings for user convenience: advanced protection, operating parameter measurement, connection via DPI port.
- PowerFlex frequency drives are designed to match any regional standards and power requirements, and are fully compatible with foreign and domestic electric motors.

4. Vibration monitoring.

Fig. 17. XM vibration measurement module

The Vibration Monitoring System (XM vibration measurement modules by Rockwell) is shown on the automation structural diagram below.

- XM vibration general level measurement modules are 6-channel smart devices designed for inexpensive use in real-time monitoring of pump units vibration.
- Each power pump unit is equipped with 4 sets of 9100 vibration sensors. The data from each sensor is received by XM-161 vibration measurement module (6 channels) be means of screened extended cable.
- 9100 sensors are the main components of the vibration monitoring system. The

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sensors are resistant to hostile environment, are characterized by a wide dynamic range and can be produced in various form-factors.

– XM general vibration level measurement module is a cost-effective solution for monitoring with the help of accelerometers or other sensors. The module is EtherNet-compatible with other XM modules, PLC, visualization system, and other state monitoring systems. Data transmission from XM-161 vibration modules to the upper level system is performed by means of 193-DNENCATR communication gateway.

5. Software.

In order to provide man-machine interface (MMI), we have used FT View SE software by Rockwell Automation. This software allows developing visualization systems of any degree of complexity – from touch-screens to complex distributed client-server solutions with quite a number of operator stations. FT View SE has the following advantages in BF#2 automation solutions:

– the project portability – SCADA-developed solution for independent working station allows converting it as a whole or any fragment of it into any other systems (e.g. client-server application) without any expenses;
– direct addressing of controller variables without any need for staging database allows saving the project development time and simplifying the complex exploitation;
– modern alarming system allows setting all the required set points in the controller and does not require any SCADAPack programming. Thanks to this solution, all the operations with alarms are processed by the controller, which increases the general reliability of the system. Besides, in case of connection loss between the controller and SCADA pack (e.g. the reboot of working station), all the occurred processes will be buffered in the controller and after restoration of connection with SCADAPack, they will be forwarded to the visualization system as a single pack.

THE RESULTS ACHIEVED DURING THE PROJECT SOLUTION IMPLEMENTATION

For the first time the described type of BF cooling system was implemented at “NTMK” OJSC BF#5 and BF#6.

The implementation of the above cooling system has helped to avoid BF cooling plates burnouts, i.e. downtimes.

The solution has provided a wide range of advantages to the customer, namely:

– implementation of a modern and reasonably priced cooling system;
– usage of this project solution leads to maximum reliability of the cooling system, which is achieved by means of automatic transfer to the natural circulation mode in case of power cut, industrial water reservation, and cooling rate regulation;
– cooling water heats up less intensively in copper plates than in cast-iron plates. This leads to a conclusion that heat abstraction by copper plates is less intensive than by cast-iron ones. This occur due to better conditions for furnace encrustation forming and keeping of it because of low temperature of copper coolers (140 C) in comparison with cast-iron ones (250 C). The concentration of heat flows on copper coolers is 2.5 times lower, which leads to 30% less evaporation. Thus, we are able to cool furnace mantle in a better way and lessen heat abstraction, which leads to lower coke consumption;
– usage of vertical cooling plates allows to design the cooling system with upstream.

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Such cooling systems can switch to natural circulation made in case of power cutoff, which allows to increase reliability of the system. Also switching to such mode does not require usage of diesel pumps or water tower, which leads to expenses reduction during BF construction;

- usage of drilled channels instead of flooded tubes also has its advantages – there will be no delamination of tube materials and the plate itself, also it helps to avoid formation of air chambers, which causes less heat conductivity of the plate and may be the reason of its destruction;
- usage of high heat-conducting fettling (silicon-carbide brick) lets furnace encrustation grow on fettling instead of the plate, which prevents its abrasion and protects cooling plate with the reduction of furnace's heat takeoff.