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Problems of Reconstruction of Ferrous Metallurgy Enterprises

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Abstract: The article gives the characteristics of the ferrous metallurgy enterprises with a very high density of placement. As part of such enterprises, there is a large number of multipurpose buildings and structures with complicated space-planning and design solutions and the same time these areas are saturated by underground and transport communications. During the reconstruction of these facilities, the large volumes of works are provided including earthworks, making massive foundations under equipment, reinforcement of reinforced concrete and metal constructions, dismantling and assembling of technological and electrical equipment, special construction works. Performing of reconstructive works requires coordination of their solutions with service departments of the enterprises. In particular, for major industries there were highlighted features that must be considered when drafting and coordinating solutions. The biggest difficulty is mounting of various technological and electrical equipment, devices and means of automation (ranged from heavy equipment to the finest contemporary domain of electronic systems of management of production processes). When this enlarger assembly of heavy equipment is carried out in extremely camped in size sights in the vicinity of the existing slag removers for casting iron, the installation and commissioning of automation tools are manufactured with running technological equipment with its short-term halt or without any. Solution of these problems requires careful shaping options for the organization of construction and installation works on the basis of focused iterating through possible reconstruction methods, priority reconstruction of technological processing shops, the sequence of execution of works, taking into account the technologically possible combination of them. The authors propose the formula for the calculation of the overall duration of the reconstruction project including the duration of

the preparatory and main periods, taking into account before stopping period, stopping and after stopping periods.
The article highlights the features of realization of solutions for the main period of reconstruction of the enterprises and make suggestions on implementation of works and replacement of equipment for agglomeration shops, coke oven batteries, steelmaking shops, rolling shops and blast furnaces. The article also focuses on the ways of safety production work during the reconstruction of the ferrous metallurgy enterprises.

1. Problem Statement

The steel industry enterprises include objects of primary production, secondary production and ancillary purposes. The main objects of industrial purpose have large functional diversity facilities like: coke-chemical, sinter, blast-furnace, steelmaking, rolling and other, which in total occupy more than 60% of the total area of the enterprise. Such production is characterized by complex space-planning and constructive solutions. Typically, manufacturing plants have spans of 24 and 36 m with an area of 300 thousand m^2, where the massive foundations under the equipment have relatively complicated shape and are up to 50x90 m deep. The load-bearing and enclosing structures are mostly metal, overhead cranes have a lifting capacity up to 600 tons.

In addition to these shops, the ferrous metallurgy enterprises have the galleries and overpasses with a length of 500 m, reinforced concrete standpipe wells 40 m deep, concrete silos up to 40 m high, tunnels, cooling towers, cooling pools, power plants, gas compressor stations, etc. The whole area is filled with undergrounds, overhead and transport communications, the density of which reaches 70-75% in areas of the coke shops, sintering shops and sections of the water cycle. The railway tracks are laid throughout the territory with the entries into a separate plants (shops); the length of them is 12-15 km.

On the basis of generalization of many years of domestic experience there were highlighted the individual characteristics of reconstruction, typical only for separate objects of the basic production purpose (table. 1).

Table 1. Characteristics of reconstruction of ferrous metallurgy

Name of object	**Features of reconstruction**
1	2
Coke oven batteries	Full disassembly of refractory masonry, reconstruction of foundations and buttresses, erection of a new refractory masonry, installation of technological equipment for a coke oven battery
Steelmaking shops: oxygen-converter electric steelmaking open-hearth	Replacement of converters, installation of waste heat recovery boilers, reconstruction of units for waste gas purification. Installation of electric furnace, reconstruction of charge sections, transition to continuous casting of steel. Replacement of furnaces with converters
Rolling shops	Dismantling of obsolete machines, installation of powerful stands on blooming mill, blanking mill, roughing and finishing groups of hot rolling machines, replacement of obsolete or installation of additional equipment at the mill line, installation of additional furnaces and wells

Sinter plants	Reconstruction of the feed path of batch, coke, car dumpers and conveyor lines, replacement of sinter machines, screens and coolers
Blast furnace	Sliding furnace with mounted main equipment and lining or trestle way of installation by separate blocks. The transfer and construction of new permanent railways, bypass gas pipelines, industrial lines, electric power lines, the erection of new facilities in exchange for demolitions (buildings, foundations), assembly of units.

Thus, the individual characteristics of the reconstruction of various industries, complex volumetric-planning and structural solutions of buildings and structures, as well as specific conditions for the production of works dictate the need to take into account the sectoral and specific features in the form of an interconnected set of requirements for all participants in the reconstruction of the ferrous metallurgy - the customer, projectors, builders, suppliers of technological equipment and materials, transport organizations [1, 2, 3].

Coke and chemical plants are one of the most complex ferrous metallurgy plants. Reconstruction of them is carried out by repeated cycles in the queue. Each cycle includes works on the start-up complex of reconstruction, providing for the updating of one or two coke batteries and technologically linked objects of the main production and auxiliary purposes (Table 2). In this case, commissioning of each launch complex is carried out in stages.

Table 2. Reconstruction cycle structure and its elements

Name of periods, stages and elements	**Feature of the element**
1	2
Pre-release period, including: - complex of advanced work - stage before shutdown - complex of general preparatory works - complex of works on the construction of analogue objects	All work is provided before the coke oven battery stops Preparatory work is performed by the customer at the reconstruction sites prior to the start of the construction company The customer and the contractor prepare the coke oven battery and related objects to a stop and work on their reconstruction The customer and the contractor prepare the launch complex facilities for reconstruction Preparatory works and the erection of objects are carried out in free territories, in exchange for demolished ones
The stoppage period, including: - stage after the shutdown	All the work of the reconstruction cycle is provided after the coke oven battery is stopped Dismantling and disassembling work in the coke shop, reorganization of the bases and buttresses of the battery, preparation for masonry works

- stage of basic works - stage of final works	Refractory masonry, pre-installation installation of coke oven equipment Drying, heating and later - the installation of the coke oven battery
Complex of works on reconstruction of coke shop facilities	Works on the reconstruction of coke shop facilities
Complex of works on reconstruction of coal preparation and chemical shops	Preparatory and construction works at the facilities of coal preparation and chemical shops

Reconstruction of the coke plant is carried out with a complete stop and temporary decommissioning of the coke oven battery, and reconstruction of the facilities of the coal preparation and chemical shops is planned taking into account the anticipation of the start-up of the coke oven battery.

Process of reconstruction for each cycle consists of the pre-stopping and stopping periods. The pre-stopping period joins preparatory work, and the main installation and construction works on the coke battery and commissioning in general are performed during the stopping period. It must be kept in mind that volumes and terms of performance of reconstructive works directly depend on a goal. So, for example, to preserve the power of enterprises for the coke production, it is enough to make a turn of the coke oven battery in former dimensions using old foundations. In the same time for accumulation of enterprise capacity it is necessary to build new coke batteries with the subsequent demolition former in advance or at first to take down former and build new more productive batteries on their place, but this way will practically lead to a full stop of all steel works.

An important task in the design of reconstruction is to determine its duration in general and by elements, the rationale for the calendar period for stopping the coke oven battery and the optimization of the duration of the pre-stopping and stopping periods [4, 5, 6]. As a rule, the optimal plan is the one in which the coordination of construction and installation works provides the minimum duration of the stop of coke oven battery. Such a plan is chosen from the possible options for the reconstruction of the coke plant on the basis of network models.

2. Materials and Methods

Calculation of the duration of reconstruction by models is based on three main points - the beginning of reconstruction, stopping the battery and ending the reconstruction. In this case, the moment of the beginning of reconstruction is the magnitude of the action, and the one of the two remaining moments is specified, while the another one is calculated on its basis.

The duration of the pre-stopping period is determined by the magnitude of the stopping times of the battery and the beginning of the reconstruction. The value of the battery stop moment is the most important reference point, since by that time the stage of pre-stop works should be accomplished; the complexes of outstripping works, works on the construction of analogical objects,

significant volumes of general works and reconstruction of the coal preparation facilities and the chemical wing must be also completed.

For the pre-stopping period, it is typical to perform a variety of preparatory works, on which a number of technologically uniform ones can be distinguished:

- re-laying of underground engineering communications;
- arrangement of temporary roads and sites;
- dismantling and disassembly work;
- erection of large temporary buildings and structures;
- preparation of the coke oven battery to a stop.

The group technological features of the works are formed under the influence of both the general factors of reconstruction (tightness of the site, combination of the work progress with the main activity of the enterprise), and the branch specifics of coke chemistry.

The high density of building (one of characteristics of the coke-chemical enterprises) creates considerable difficulties at reconstruction (restriction of the sizes and locations of sights of enlarging assembly and warehousing of the constructions, the special organization of transportation of large-size constructions and technological elements over the plant territory, etc.) [7, 8, 9]. Existence of an extensive network of the operating railway tracks demands the providing of additional railroad crossroads and their subsequent service; the saturation of underground and elevated communications limits use of heavy caterpillar hoist engines and mechanisms. Because of constraint, special requirements are imposed to the choice of methods and the production technology of dismantling and disassembling works as well as demolition works at the degraded objects. The majority of cases requires the floorings and grids of shelters and also performance of other works and actions protecting the next objects from damages. The use explosive methods must be provided with the directed falling of the destroyed objects, minimum splinter fragmentation, fast and effective removal of blockages [10, 11].

Combining the main activities with the reconstruction work leads to the need to build the analogues, temporary technological facilities and structures (usually subjects to supply charge furnace), temporarily enhance the coverage and walls of buried structures (tunnels, wells, etc.), transferring overhead, underground and wall communications and industrial electrical cables required for the normal operation of the enterprise.

The specifics of the sectoral reconstruction limits the use of such methods of production as pile driving and piling; at the same time, the following methods are recommended: puncturing, forcing the ground at the intersection of roads and railways, erecting buried structures using the "wall in the ground" method, aggregate assembly of structures, lifting of structures and other similar methods. High gas contamination and the potential explosive nature of production limits the use of an explosion for the destruction of reinforced concrete and other structures. At the same time, in the reconstruction it is expedient to use microexplosions [1, 13].

The peculiarity of the work on the transfer of communications and industrial electrical wires is that rigging, assembly and welding works are carried out in close proximity to production pipe-

lines and pressurized tanks, the disabling of which is impossible for a number of reasons. Such works should be carried out in compliance with special safety measures.

First of all, this concerns a set of shutdown works and among them works on the replacement of industrial electrical wires mounted on highly located supports.

The technology for the production of temporary technological facilities and structures should include the minimum possible volumes of excavation and concrete work, the use of technological pre-engineered designs, and worked out mechanization schemes [5, 14].

During the reconstruction, it is required to erect large temporary buildings and structures in the pre-stopping period to ensure a normal course of construction and installation work (warehouse of refractory and mortar site mortars).

In accordance with the structure of the work of the pre-stopping period, redundant models of the stage of pre-stop works and complexes of advanced and general preparatory works are being developed. Excess models are the result of a generalization of the reconstruction experience.

3. Results of research

Using the established structure of the stage of pre-stopping works, their volumes and labor-capacity, network diagrams of all the stages of the stage operations are constructed and their critical paths are determined, the largest of which is taken as the duration of the stage of pre-stopping works [15]. The start time of the stage is set as:

$$t_{1(1)}^{H} = t_{2}^{H} - \tau_{1(1)}$$

where $t_{1(1)}^{H}$ - moment of the beginning of the pre-stopping work stage;
t_{2}^{H} - stopping time of the coke oven battery;
$\tau_{1(1)}$ - duration of the stage of pre-stopping works

The structure and volume of the part of the complex of general site of preparatory works which must be performed in the pre-stopping period from the beginning is determined according to the project materials, i.eT.:

$$t_{1(2)}^{H} = t_{2}^{H} - \tau_{1(2)}$$

where $t_{1(2)}^{H}$ – moment of starting the complex of general site preparatory works;
$\tau_{1(2)}$ – duration of the complex of general site preparatory works in the pre-stopping period.

With reference to the complex of works on the construction of analogical objects, their beginning is equal to:

$$t_{1(3)}^{H} = t_{2}^{H} - \tau_{1(3)}$$

where $t^H_{1(3)}$ – moment of the beginning of the implementation of the complex of construction works for analogues;

$\tau_{1(3)}$ – duration of the implementation of the complex of construction works for analogues in the pre-stopping period.

Then the beginning of the complex of advanced works is defined as:

$$t^H_{1(4)} = \min\left\{t^H_{1(1)}, t^H_{1(2)}, t^H_{1(3)}\right\} - \tau_{1(4)}$$

where $t^H_{1(4)}$ – moment of the beginning of the implementation of the complex of advanced works;

$\tau_{1(4)}$ – duration of the complex of advanced works.

Since the beginning of the pre-stopping period (t^H_1) coincides with the beginning of the execution of the complex of advanced works and the beginning of the reconstruction cycle (t^H), i.e.:

$$t^H_{1(4)} = t^H_1 = t^H$$

then, consequently, the duration of the post-stop period (T_1) will be:

$$T_1 = t^H_2 - t^H_1 = t^H_2 - t^H$$

The duration of the stopping period (T_2) of each cycle of reconstruction of the coking plant is determined on the basis of processing of the statistical data array based on the existing experience and consists of three components – the durations of the post-stopping stage works $(\tau_{2(1)})$, main works $(\tau_{2(2)})$, finishing works $(\tau_{2(3)})$ as:

$$T_2 = \tau_{2(1)} + \tau_{2(2)} + \tau_{2(3)}$$

As a result, you can now set the exact calendar date of the stopping time of the coke oven battery

$$t^H_2 = t^0 - \left(\tau_{2(1)} + \tau_{2(2)} + \tau_{2(3)}\right)$$

where t^0 – the end of the reconstruction cycle

Consequently, the reduction in the durations $\tau_{2(1)}$, $\tau_{2(2)}$ *and* $\tau_{2(3)}$ is the main reserve for the intensification of the reconstruction of the coke plant.

4. Conclusion

The enterprises of ferrous metallurgy are distinguished by a large number, functional variety and complex space-planning and constructive solutions of the included buildings and structures.

Reconstruction of objects (facilities) of ferrous metallurgy is associated with the implementation of large volumes of work, including excavation, the construction of massive foundations for deep laid equipment, concrete and reinforced concrete works, dismantling and installation of building structures, strengthening of structures, dismantling and installation of technological and electrical equipment, special construction work (fettling, anti-corrosion, heat insulation, etc.).

Taking into account the complexity of solving reconstructive tasks and the role of the customer in their implementation, it is necessary to coordinate the decisions of the project for the production of works with the corresponding services of the enterprise. With regard to the preparatory period, decisions are made and agreed upon for the whole period of the reconstruction of the enterprise. At the same time, for the main period of reconstruction, the specific features of each reconstructed object are defined and taken into account.

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