Non-standard equipment for construction of vertical shafts

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Abstract. The article deals with the modern problems of construction and reconstruction of
vertical shafts of mines, which require innovative technical solutions in the mechanization of
mining operations. The examples developed by the authors of the original equipment and
 technologies, are successfully implemented for the mining industry in Russia.

1. Introduction
Vertical shafts are complex engineering structures. The depth of shafts is 2000 m and diameters
exceed 8 m in clear. The set of commercially produced plant equipment, including lifting machines,
winches of different function, fans, compressors, etc., as well as non-standard equipment made on
individual project documentation, has been used to construct them. Non-standard equipment is
developed individually for each barrel depending on its parameters, geological conditions, shaft
sinking and the project of works manufacture [1 - 3]. Equipment and technologies used for
reconstruction of the lining and armouring have distinct characteristics. That fact takes into account
several complicating factors, which are absent in the new construction [4 - 6].

2. The main part
It is necessary to consider the features of non-standard equipment by the examples of a skip lifting
cradle for the reconstruction of the skip shaft of mine "Uzelginsky" and a special container for
lowering and laying concrete for the "Severnaya" mine of OJSC "Vorkutaugol" ventilation shaft
walling No. 3. The skip shaft of mine "Uzelginsky" passed to the depth of 772.5 m, with a diameter of
6.0 m, and with monolithic concrete lining. In the shaft, at the level of -703.0 m, the loading cavities
for loading of skips of ore are constructed. The barrel is equipped with two skip winders with
counterweights mounted on a tower coper [7]. The shaft equipment is cable, including tension load,
placed in the shaft sump. The redesign provides the sinking interposed loading cavity on the horizon
of -340.0 m, the construction of which required the replacement of the cable reinforcement with
the hard one.

Constructive solutions of the rigid armouring are similar to the ones, which exist in the location of
the loading cavity on the horizon of -703.0 m with two-sided location of the conductors box of 180x180 mm, relative to the lifting vessels with a step of 6000 mm [8]. Mount of all buntons in the barrel is provided with anchors (Fig.1).

![Figure 1. The scheme of the rigid armouring of the skip shaft with the mounting buntons with anchors [9].](image)

The sinking of the loading cavities on the horizon -340.0 m is carried out from the existing horizon in the following sequence: in the beginning, the lower working lead of the first cavity sinks, then the top lead generation leaves a protective pillar between the rising workings and shaft. On the basis of the calculations, isofields of equivalent stress in the lining and in the host rocks in the process of cavity sinking were determined. On that basis, zones and parameters of hardening of the lining of the shaft were established [9]. The hardening of the lining and surrounding rocks with concrete anchors is provided above and below the loading cavities, respectively, 4.5 and 6.0 m, and in the areas of loading cavities. In the areas of loading cavities crosscuts, the metal shield and temporary channel lining No. 18 is provided due to prevention of the formation of inrush during disassembly of the safety pillars and lining. Handling operations on the strengthening of the lining and surrounding rocks in the loading cavity area are combined with the installation of armouring. The installation of the armouring shall be directed upwards with simultaneous installation of buntons and conductors with stub headings of 12 m, mounting buntons with anchors, excluding the small holes in the lining. The implementation of the adopted technical and technological solutions required the development of special standard equipment – a skip lifting cradle for the complex execution of works on armouring and hardening of the lining (Fig. 2) in accordance with the project of manufacture of works. The cradle is mounted on the skip and is a metal structure with dimensions of 1480x1570 mm, height - 16150 mm, forming a "skip-cradle". The cradle has 3 floors with hinged mounting platforms that enables the installation of tiers of buntons and guides with a 6000 mm step, as well as maintenance work on the hardening of the lining in the area of crosscuts loading cavity. Handling operations on the installation of the buntons and the conductors are made simultaneously from two adjacent cradles, exposed to the same level. Stabilization of the cradle is provided by the guide rope of the existing rope armour.

Due to the developed technology and non-standard equipment for its implementation, the work on shaft rearmouring and hardening of the lining was completed within three months. The main design decisions of the skip lifting cradle have been successfully applied in several projects of construction and reconstruction of vertical shafts. A project of construction of ventilation shaft No. 3 of the mine "Severnaya" provides the application of concrete with high strength class for cementing that can not be
achieved with the use of the traditional pipe running concrete technology [10].

Figure 2. Skip lifting cradle

Taking the foregoing into consideration, the special container for the lowering of a concrete mix and laying it over the formwork was developed. The container (Fig. 3) consists of a welded hull. The
upper part and the lower conical part are made by the application of commercially manufactured tubs type BPSM-3. The sectors of the shutter 1 and 2, rotating with the help of a cylinder, are welded to the cone. With the shutter closed, the sectors are fixed by a lever with a latch. That prevents accidental gate opening. The pneumatic cylinder 3 and the pneumatic vibrator 5 are attached to the cone by means of bolts. The handle is attached to the upper part, the cylinder with a cone at the top is attached to the lower conical part, designed to permit the flow of concrete coming out of the container. The concrete mixture in the formwork is made in the following sequence (Fig. 4). Loaded with concrete, mix container 1 falls below the sinking stage 2 on the bottom, connects to the pneumatic system, a flexible pipe feeding the concrete mix 3, and rises to a sinking shelf. The flexible pipe winds up the formwork 4. The drifter remotely opens sectors of the shutter, turns on the pneumatic vibrator and starts the runoff of the concrete mixture in the formwork.

3. Conclusion
The test of the container showed its high efficiency during lowering a concrete mix and laying it over the formwork.

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