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Equipping the Schwind shaft with a vertical transport device

The article presents the construction of an inter-level shaft between levels II lower and level III and equipping it with a transport system. The purpose of the project was to provide transport of loose materials and long items from level III to level II lower, which was necessary to secure the mining excavations. Before the investment, only a limited amount of materials could be transported manually by means of ramps.

Key words: *shaft, construction, vertical transport, composites*

1. INTRODUCTION

The Schwind shaft was made between level II lower and level III of the Wieliczka Salt Mine. The pit at level II lower of the shaft is parallel to the Schwind transverse, and the pit at level III is located on the Karol transverse extension (Fig. 1).

The Schwind shaft cross-section is rectangular with dimensions of approx. 4.4 m × 2.8 m (in the gap) and approx. 3.78 m × 2.24 m (clear opening). The total depth of the shaft reaches ca 32 m.

Level III in the Schwind shaft is ventilated with a streamlined air current. The upper part of the shaft at level II lower together with the passage leading to the Schwind transverse is separated with air locks. The area of the level II lower and level III in the Schwind shaft is categorized as class "A" methane explosion hazard in the 1st category methane field.

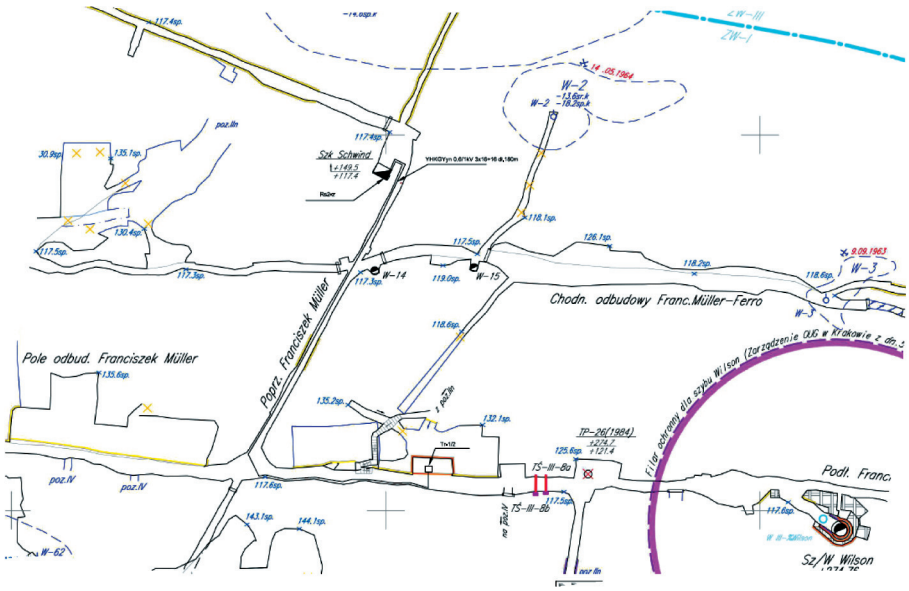

Fig. 1. Location of the Schwind shaft [1]

The shaft cover is a wooden frame (crown) made of solid pine beams. Wreath beams corners ae connected by a carpentry joint – simple lap joint – notched joint at an angle, and fastened with carpentry clamps from the outside of the beams. The shaft has three compartments (Fig. 2):

- ladder: equipped with wooden ladders and resting platforms, which facilitate the inspections, repairs and maintenance of the transport system;
- rope (eastern): for guiding the transport rope;
- transport (western): for materials transportation.

The purpose of the investment was to enable transportation of materials from the Kinga shaft through the existing Schwind shaft between level III and level II lower. In the future it is supposed to connect levels II upper and II lower in the eastern part of the mine, where the Crystal Cave is located. The purpose was to provide a route for transporting materials necessary to protect the Crystal Cave area (the complex of the Baum, Schmidt and Ferro, Ksawer, Leopold, Schwind chambers). The basic materials to be transported are: lumber, including lumber up to 6m long, and loose materials in bags [1]. Previously, a limited amount of material was transported manually by means of ramps. The possibility of further usage of the historic Schwind shaft for material transport was analyzed. The excavation was subjected to expert analysis and its facilities examined in terms of their adaptation for the needs of vertical transport in the shaft.

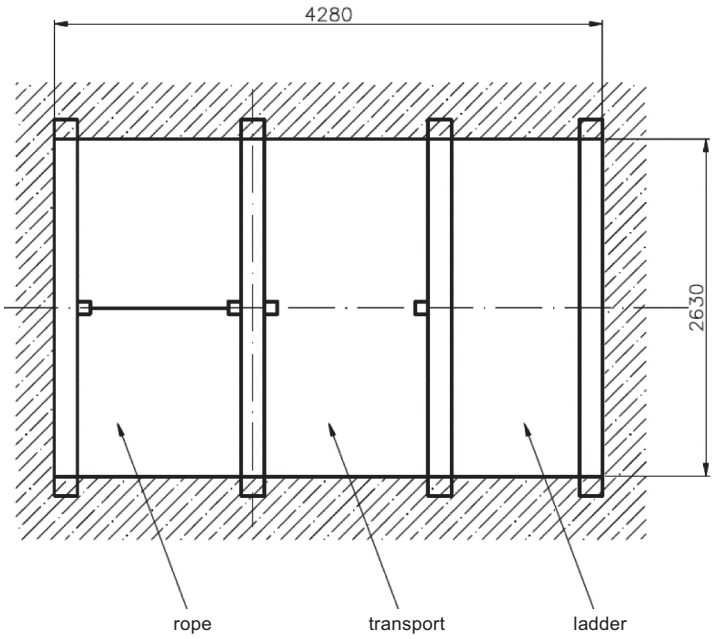

Fig. 2. Shaft shield

Based on the conducted analysis, it was concluded that the shaft and the remains of its equipment could be used to install a new mechanized vertical transport.

For this purpose, the shaft was equipped with a transport system and associated infrastructure in accordance with applicable law.

2. SCHWIND SHAFT FACILITIES

2.1. Low speed winch type KAZ-WWB 30

The system was based on the KAZ WWB 30 slow-speed winch. It is intended to be used in underground excavations with class "A" methane explosion hazard and class "A" coal dust explosion hazard or in non-hazardous areas [2]. The device was built in a way that the rope coming out of the winch drum was guided in the rope compartment of the shaft within the help of two directional wheels introduced into the transport compartment. The rope finishes with a hook that allows. For connecting the platform for transporting long materials or bags with loose materials.

The slow-speed drum winch type KAZ-WWB 30 consists of the following components (Fig. 3):

- Frame: rigid welded structure where parts of the mechanical winch are installed; the only part that is located outside the frame is the electrical equipment for steering the winch.

– Winding drum: drum of the welded structure that is attached to the same roller as the gear. The roller is secured to two self-aligning rolling bearings, which are in brackets (housings) and are bolted to the winch support frame. From the inside, a two-piece ratchet wheel is screwed to one of the drum rims, and from the outside, a parking brake has been mounted.
– Parking brake: a steel housing with a hydraulic cylinder and a friction cover. The brake is released (opened) hydraulically.
– Ratchet mechanism: a system of two pawls connected by a tie, activated by a hydraulic cylinder. During the unwinding and winding of the rope the hydraulic cylinder is extended, which causes the pawl teeth to be pulled back from the ratchet wheel. The retraction of the ratchet teeth from the ratchet wheel is controlled by an inductive proximity sensor of the ratchet position.
– Drive unit: an electric motor with an electromagnetic brake, gear, clutch.
– Hydraulic unit: is designed to control the hydraulic components of the parking brake and pawl. It consists of a tank with accessories, electrically controlled valve blocks, control and measuring instruments and emergency valves (manual stop of the winch/ transport system).
– Fifth coil control system: implemented by an encoder which is mounted on the winch motor shaft and cooperates with the controller.

2.2. Power supply and control system

The KAZ-WWB type 30 slow-speed winch is supplied with a voltage of 500 V AC (IT). The power supply network is equipped with central leakage protection and a system of protective earth conductors (PEC). The main electrical equipment of the winch consists of: Rs2-z switchgear (with an inverter), motor control elements and an industrial controller for monitoring the winch operation. The presence of 24 V AC auxiliary voltage and 24 V DC control voltage (separately for solenoid valve and controller power supplies) as well as the state of overcurrent protection and insulation monitoring relays are signaled. Also, the activation of outlets for the winch drive motors and the hydraulic pump is signaled on the switchgear façade. The basic functions of the Rs2-z switchgear include: control and protection of electric motors for the winch drive and hydraulic unit,

– cooperation with the control panel,
– control of winch operation by built-in sensors.

The winch control system consists of an industrial controller with an input and output unit, which works with an inverter via an Ethernet connection, controlling the winch motor operation, electromagnetic brake and fan.

The winch operation is controlled from the control panel (Fig. 4), where special elements have been installed for that purpose. The winch desktop is equipped with a key switch for desktop authorization, a two-position analog keypad with a self-return joystick, a button for starting the winch and an emergency stop button. The control panel has been additionally equipped with an operator panel cooperating with the controller. The operator panel displays information about the winch operating parameters and emergency conditions. The panel is operated with dedicated screen selection and deleting buttons.

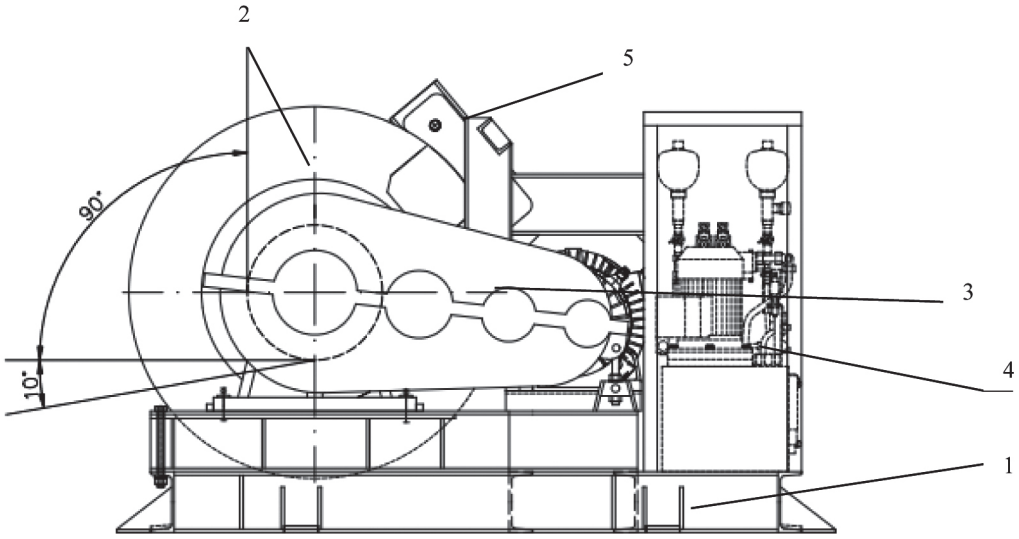

Fig. 3. Type KAZ-WWB 30 winch: 1 – frame, 2 – cylinder, 3 – transmission, 4 – hydraulic unit, 5 – parking brake

Fig. 4. Control panel view

The winch has a built-in warning, communication and loudspeaker signaling set. For this purpose, a loudspeaker signaling device that can communicate with other signaling devices has been installed next to the control panel. Additionally, the signaling devices are equipped with an emergency switch. Their additional function is advance warning signaling.

2.3. Transport platform

The transport platform (Fig. 5) is a construction that needs to be bolted and welded. Its upper part will be equipped with special slings enabling connection with the winch rope hook. The platform is guided by a system of rollers in slides located in the transport compartment of the shaft. To protect the staff during the loading / unloading of loose materials, the platform has been equipped with the so-called roof cover. The cover is half disassembled, which enables the transport of long materials.

2.4. Infrastructure

To enable transport works using devices furnished in the Schwind shaft, the excavation was equipped with a shaft gate (Fig. 6) in all its parts, in both the top and pit of the shaft. The metal structure of the gate was encased in wooden timber and, next, fitted on hinges to the wooden structure of the shaft.

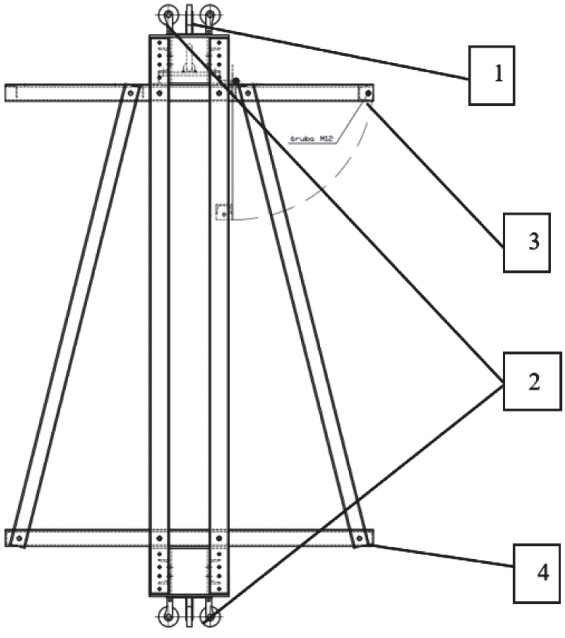

Fig. 5. Transport platform: 1 – sling, 2 – guide roller system, 3 – so-called cover peak, 4 – platform construction

Fig. 6. Shaft gate (historical look – picture on the right)

Other works related to this investment, such as renovation of the ladder compartment or recessing in the rock mass, were also carried out in order to install the winch, power supply and the control switchgear. As there is no method for controlling and indicating the wear of the ladder compartment components made of composites, the ladder compartment has been made of a traditional material – wood.

3. SYSTEM OPERATION

The system does not provide possibility to transport people as it was designed to carry materials with a weight of no more than 1 ton (the system is equipped with weight control). Transport can be handled in two basic systems:

– **Automatic**: adapted to the transport of loose materials in bags by means of a transport platform. When the platform is moving up, the gate is blocked and cannot be opened. After it reaches the upper final point (the limit sensor turns on), the two platform supports, the location of which is identified by appropriate sensors, should be extended. Once all these actions have been taken, the gate is unblocked for 10 seconds. During that time it should be opened by members of the crew – otherwise it will be blocked again. The person who operates the platform is able to unlock the gate for another 10 seconds by pressing the "shaft gate unlock" button, which is located on the upper control panel. The open gate and extended platforms block any possibility of movement. As the platform is moving down, the gate is blocked and there is no possibility to open it. When the platform reaches the bottom point (the limit sensor turns on), the gate is unlocked for another 10 seconds. During that time a member of the crew should open it – otherwise it will be locked again. The person operating the platform can unlock the gate for another 10 seconds by pressing the "shaft gate unlock" button, which is located on the lower control panel. The open gate blocks any possibility of movement.
– **Semi-automatic system:** used to transport very long materials without a transport platform (the long material is attached to the rope winch hook). In this case, the opening of the bottom gate does not initiate any movement, which means that no action can be taken when the top gate is opened using the lower control panel.

4. SUMMARY

The system for transporting loose materials (in bags) or lumber (long materials) between level III and level II lower at the Wieliczka Salt Mine has been improved in many ways. The key improvement was facilitating the transport route for materials used to secure the mining excavations, in particular the area of the Crystal Grottoes Cave (sets of Baum, Schmidt and Ferro, Ksawer, Leopold, Schwind chambers). Currently, there is no transport connection between level II lower and level II upper of the mine. However, plans have already been made to implement

a fully mechanized transport system. The facilities (ladder compartment) of the new transport fore-shaft will be made of composite materials. In the future they could become primary materials for the construction of reinforcement components and furniture of shafts and fore-shafts. Unfortunately, we have little experience in using such materials for constructing these elements of excavation furniture. In particular, there is no method for controlling the performance of reinforcements and shaft facilities made of composites.

All these actions and investments have increased the safety of mining works performed in the excavations and adjacent areas.

It was achieved by:

- eliminating the manual transport of materials through corridors and stairs form level III to level II lower,
- mechanization of works,
- steering the process of transport device (winch) automation,
- implementation of multi-level safety components and locks for transport works in the shaft.

In addition, the process of securing the Crystal Cave area will be significantly accelerated, which will help to protect this unique nature reserve on a global scale. What is more, the cost of materials transport between levels III and II lower will be reduced.

The improvements involved in the launching of an inter-level vertical transport system in the Wieliczka Salt Mine must be based on modern solutions that can be adapted to mine conditions, mostly in terms of materials and machines used. Due to the emergence of a market of composite materials, which fulfil the key criteria for mining excavations (flame retardancy, anti-static properties, non-toxicity), it is recommended that analyses be carried out so as to confirm the suitability of these materials in excavations. In comparison with traditional materials [4], composites demonstrate numerous advantages. The widespread use of composite materials can contribute to the improvement of effectiveness in the Wieliczka Salt Mine and many other mining plants in Poland.

References

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