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SOME TECHNICAL CHARACTERISTICS OF SHAFT HOIST MACHINES INSTALLED IN THE SHAFTS OF MACEDONIAN LEAD AND ZINC MINES

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Abstract: *The shafts hoisting plants that are installed in the shafts of Macedonian lead and zinc mines have tremendous importance for past work of the mines and represent a crucial link between underground production system and mineral processing plants. From their further operation depends on achieving the planned production capacity and profitability of the mines.*
In the Macedonian lead and zinc mines there four mine shaft hoisting plants, with whose work are achieved good production results. In this paper will first be described the shafts in Zletovo and Sasa mines, where shaft hoisting machines were mounted, and then be presented their technical characteristics, breakdowns analysis, current situation and proposed measures to improve working conditions

Key words: *shaft hoisting machines shaft, lead, zinc, underground mines.*

1 INTRODUCTION

There are four hoist plants in Macedonian mines for production of lead and zinc installed in the following shafts:

- Hoist shaft No.1 - "Zletovo" mine,
- Service - ventilation shaft No.3 - "Zletovo" mine,
- Hoist shaft"Svinjareka" - "Sasa" mine,
- Winzehoist - Service shaft "GolemaReka" –"Sasa" mine.

1.1 Purpose and description of the shafts in "Zletovo" mine

Hoist shaft No.1 is for hoisting of the ore from the horizons 450 and 350 to horizon 560, where is constructed head frame ore bin and from there, run - of - mine, with locomotive transport, through the main hoist adit, the ore is taken to the receiving bunker for flotation in the city of Probistip. Shaft is used for transporting workers and materials to the aforementioned horizons, and to supply the pit with driving, drainage and ventilation. Hoist shaft No.1 is constructed in the central part of Pit 1, in the footwall of the ore weins. The shaft is on depth of H_o = 350 [m], with circle cross - section with diameter of the light profile D_s = 3.6 [m] and on whole length is supported with concrete thick 20 [cm]. With the surface, the shaft is connected through the horizon 625 on level 648.00.

Service - ventilation shaft No.3 is intended for servicing the pit Dobrevo, supplying the materials (explosives, lumber, pile etc.), transporting workers to the horizons and inter - horizons in pit, bringing fresh air to thehorizon250 for ventilation and in case of interruption, accident or repair of hoist shaft No.1, the shaft No.3 should undertake the whole transport of ore, or should presents the hoist shaft. In that case, the ore excavated from the lower horizons (535; 450;350 and 250) will be transported to the horizon 625, and then through the ore pass gravitational will fall on the horizon 560 and from here will be transported to the ore processing plant in Probistip. Service - ventilation shaft No.3 is located in the central part of the pit Dobrevo in the footwall of the ore weins in Pit 2. The shaft is on the depth of H_o = 471.17 [m], with circle cross - section with diameter of the light profile D_s = 5 [m]. On whole length, the shaft is supported with concrete thick 30 [cm]. [1]

1.2 Purpose and description of the shafts in "Sasa" mine

Hoist shaft "Svinja Reka" in the "Sasa" mine was intended for lowering the ore from horizons 2a, 4 and 12 on horizon 14, or main hoist adit from where the ore was transported with electrical locomotives to the receiving bunker for flotation on the surface. Beside this, the hoist shaft was used for transporting workers to the horizons, supplying materials and driving energy and bringing fresh air. Today lowering of ore and service through this shaft is not done, because his life is complete. The hoist shaft is located in the floor of mineralization in dacite rock masses between the districts "Svinja Reka" and "Kozja Reka". On the surface, the shaft coming out on elevation 1582, and the shortest horizontal connection of the shaft with surface is through the adit 2a. It is with depth H_o=537 [m] ,and on entire length is coated with concrete support with thickness of 25 [cm]. It has circle cross - section with diameter of the light profile D_c = 3.6 [m].

*Winze hoist shaft "Golema Reka"*in the "Sasa" mine is intended for transport of ore from the horizon 830 to horizon 950 where is created head frame ore bin and from here, through the main hoist incline, with underground belt conveyor, the ore is directly transported to the plant for primary crashing on the surface. Also, the shaft is service for transporting workers, materials and equipment, and supplying the pit with driving energy, technical and drinking water. The shaft is located in the footwall of the mineralization in the mining district "Golema Reka". Configuration of the terrain and position of the mineralization in depth, of the existing mining objects (horizons 950, 900 and 830), of the hoist incline and the flotation conditioned the hoist skip shaft to be constructed as winze object. The shaft is made on the depth of H_o=238.8 [m], and with the surface is connected with the slope service ramp on elevation 1035 m. Cross - section of the shaft is circle with diameter of the light profile D_s=4.1 [m], and it is supported with concrete thick 30 [cm]. [2]

2 TECHNICAL CHARACTERISTICS OF THE HOIST PLANTS

Further in the text will be presented technical characteristics of the hoist plants in the Macedonian mines for lead and zinc, such as:

- type of hoist system,
- type of hoist machine,
- type of hoist cages,
- kinematics hoist and
- basic exploitation parameters.

2.1 Technical characteristics of the hoist plants in "Zletovo" mine

Hoist shaft No.1. Hoist system is with frictional Koepe hoist, with two main ropes and one balance rope, or it is word about balancing multi - rope frictional hoist system.
Hoist machine for this hoist system is produced from the Swedish company "Asea" in 1963. Driving electric engine is with power of N = 269 [kW] and works on DC using converting group type "Ward Leonard". The number of revolutions of the electric engine is n = 870 [rev/min]. For its initiation are used electric engines initiators. By clips and reducers, electric engine is connected with Koepe hoist with wheel diameter D_m = 3 [m], and mass G_m = 5100 [kg]. Hoist machine has working brake with discs and safety brake. Hoist cages of this plant are skipped - cage and counterweight. The mass of the combined hoist container is 10220 [kg], and outer dimensions are 1170 × 2300 × 11055 [mm]. Useful carrying capacity of the skip is 5 [t]. Maximum number of workers that could be transported with the cage is 30. The mass of the counterweight is 12720 [kg].
Basic exploitation parameters

- Hoist distance:
a) From horizon 560 to horizon 450: $H_1 = 110$ [m]
b) From horizon 560 to horizon 350: $H_2 = 210$ [m]
- Annual hoist capacity: $Q_g = 500\,000$ [t/g]
- Hourly hoist capacity: $Q_h = 120$ [t/h]
- Carrying capacity of hoist skip: $Q_t = 5$ [t]
- Number of trip per hour: $n_h = Q_h/Q_t = 24$
- Hoist speed: $v = 4$ [m/s]
- Acceleration (deceleration): $a_1 = a_3 = 0.8$ [m/s^2]

At this hoist facility is used trapezoidal diagram of driving with straight sides, presented on fig.1.

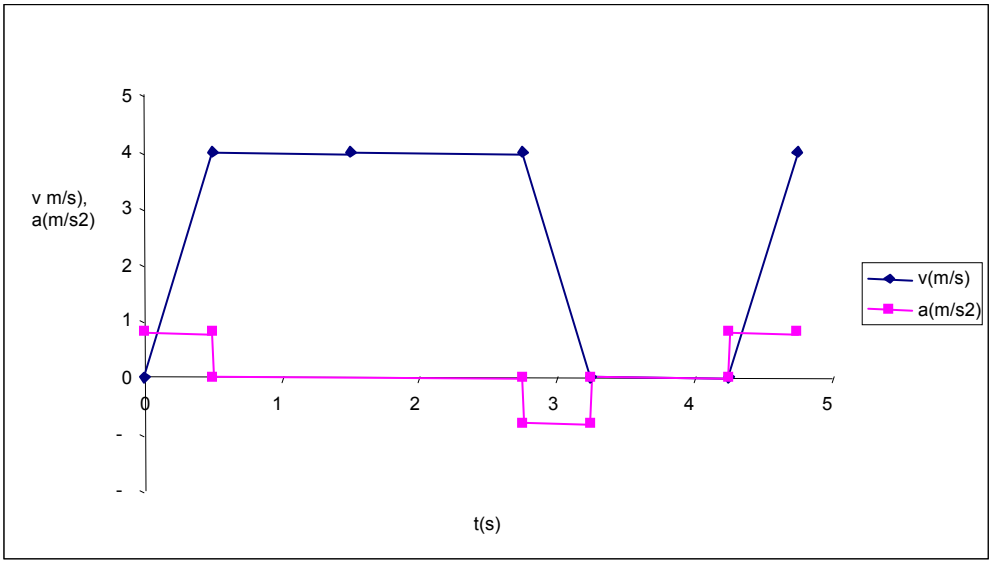

Figure 1 *Driving diagram of hoist plant in the hoist shaft No. 1*

*Service - ventilation shaft No.3*Hoist system in this shaft belongs to group of frictional multi - rope hoist systems, because it has frictional Koepe drum with four upper ropes and one balancing lower rope. The hoist machine of the service - ventilation shaft No.3 is constructed by German company "Siemag - AEG" in 1986. Driving electric engine is with installed DC power of 536 [kW] with tyristors rectifier. By reducer and clips, the engine is connected with Koepe drum for four ropes, which diameter is $D_b = 2100$ [mm]. The hoist machine has brakes with discs with electric - hydraulic propulsion.

Hoist containers on the shaft no. 3 are with double cage and counterweight. The mass of the hoist cage is 7300 [kg], and outer dimensions are 1500×4260×5400 [mm]. The area of the cage is dimensioned for two wagons per bench with volume of 1 [m^3] and for one wagon per bench with volume of 1.3 [m^3]. Maximum number of workers that could be transported with the hoist cage is 60. The mass of the counterweight is 12362 [kg]. [4]

Basic exploitation parameters

- Hoist distance:
  - a) From horizon 535 to horizon 625 $H_1 = 90$ [m]
  - b) From horizon 450 to horizon 625 $H_2 = 170$ [m]
  - c) From horizon 350 to horizon 625 $H_3 = 270$ [m]
  - d) from horizon 250 to horizon 625 $H_4 = 370$ [m]
- Annual hoist capacity: $Q_g = 320\,000$ [t/g]
- Hourly hoist capacity: $Q_h = 107$ [t/h]
- Carrying capacity of hoist skip: $Q_t = 4.42$ [t]
- Number oftripper hour: $n_h = 31$
- Hoist speed: $v = 8$ [m/s]
- Acceleration (deceleration): $a_1 = a_3 = 0.75$ [m/s^2]

This hoist system works on trapezoidal diagram of driving with straight sides, [2].

2.2 Technical characteristics of the hoist plants in "Sasa" mine

Hoist shaft "Svinja Reka". Hoist system is of type balancing multi - rope frictional system with friction Koepe drum, with two main ropes and one balancing rope. Hoist machine for this plant is produced from the Swedish company "Asea" in1963, and has the same hoist characteristics as the hoist machine in the hoist shaft no. 1 in "Zletovo" mine. Hoist containers consist of combined hoist container (skip - double cage) and counterweight. The containers have the same characteristics as the hoist containers in the hoist shaft no. 1 in mine "Zletovo".

Basic exploitation parameters

- Hoist distance:

(From horizon 12 to horizon 14) $H_2 = 180$ [m]

- Annual hoist capacity: $Q_g = 500\,000$ [t/g]
- Hourly hoist capacity: $Q_h = 225$ [t/h]
- Carrying capacity of hoist skip: $Q_t = 5$ [t]
- Hoist speed: $v = 8$ [m/s]
- Acceleration (deceleration): $a_1 = a_3 = 0.8$ [m/s^2]
- Number of trip per hour from horizon 12: $n_h = 45$
- Nominal power: $N_n = 269$ [kW].

This hoist system works on trapezoidal diagram of driving with straight sides,[2].

Winze hoist shaft "Golema Reka". Hoist system in this plant consists of frictional Koepe drum with four upper ropes and two lower balancing ropes, which means that it is word of frictional multi - rope hoist system with balancing ropes. Hoist machine of the hoist plant in this shaft is produced by the German company "Man Ghh". It consists of: [4]

- propulsion electric engine,
- reducer,

- clip,
- propulsion Koepe drum and
- brakes.

Propulsion electric power engine is produced by the company "Siemens" and has the following technical characteristics:

- nominal power 358 [kW]
- nominal voltage 400 [V]
- nominal amperage 955 [A]
- number of revolutions 1060 [rev/min]
- inertial moment 3228 [kNm]
- coefficient of efficiency 93 [%]
- type of rectifier tyristors

Diameter of the propulsion Koepe drum is D_b = 2800 [mm], the mass is G_b = 1366 [kg] and it is made with welded construction. The hoist machine has disc brakes with electric - hydraulic propulsion.

Basic exploitation parameters

- Hoist distance from horizon 830 to horizon 950: H = 201 [m]
- Annual hoist capacity: Q_g= 700 000 [t]
- Hourly hoist capacity: Q_h= 260 [t/h]
- Carrying capacity of hoist skip: Q_s = 8.8 [t]
- Hoist speed: v = 6 [m/s]
- Number of trip per hour n_h= 29
- Acceleration (deceleration): $a_1 = a_3 = 0.75$ [m/s^2]
- Nominal power N_n = 358 [kW]

Driving diagram is trapezoidal with straight sides. [4]

3 ANALYSES OF FAILURES IN OPERATION OF THE HOIST PLANTS

In the paper [1] was made analysis of failures in operation of the hoist plant in the Hoist Shaft "Svinja Reka" in "Sasa" mine. Failures are classified in six categories, and their duration and contribution in the total time of failures is presented in table 1.

Table 1 *Review of failures of the hoist plant in the shaft Svinja Reka–Sasa mine*

No.	Category of failure	Time of failure[h]	Contribution in total time of failures, [%]
1	Failures due to the removal of defects on the hoist machine and equipment	138.17	26.78
2	Failures due to defects on the equipment in head frame ore bin and dump ore bin	160.67	31.91
3	Failures due to maintenance and cleaning of the shaft	26.83	5.20
4	Failures due to the interruption of electricity and compressed air	14.33	3.0
5	Failures due to the interruption of technological systems related to the hoist system	101.25	20.01
6	Planned failures	65.5	13.08
	Total	516.00	100

In the operation of the hoist plant, most of the time is lost due to failures resulting from removing defects from the dozers in head frame ore bin and dump ore bin, removing the defects from the hoist machine and failures in operation of the horizontal transport system and processing plant. For considered period of five years operation of the hoist plant, mean time between the down (MTBD) and mean time of down (MTD) are calculated and they are: MTBD = 36.23 h; MTD = 2.49 h.
Availability of the hoist plant (A) for the reference period was 93.6%, and it is calculated according to the form:

$$A = \frac{MTBD}{MTBD+MTD} = \frac{36.23}{36.23+2.49} = 0.936 \qquad (1)$$

Disuse of the hoist plant amounted to 6.4% and it is six times greater than that given by manufacturers (1%). This increase of the disuse is because in the total duration of the failures is contained the time of failures caused by interruptions in operation of the technological systems related to the hoist system, then failures due to interruption of electricity and other failures that were listed. The period of performed observation in the hoist plant is actually part of the period of the statistically failures when the intensity of failures has a constant value.

4 CURRENT SITUATIONS OF THE HOIST PLANTS IN MACEDONIAN MINES

The hoist plants in the Macedonian mines successfully perform their function to transport the ore, transporting people and materials. Hoist plant in the Shaft No. 1 on Zletovo mine, although is almost frazzle, successfully performs its function with decreased capacity of transport. Hoist plant in the Shaft Svinja Reka in Sasa mine is out of use and its exploitation life is over. The hoist shaft in the Service - ventilation shaft No.3 in Zletovo mine is in function and successfully performs its function in transporting workers and materials. It is word of hoist plant which is in the period of effective exploitation, or in the period of utilization and it is not enough used.
The hoist shaft in the Winze - hoist shaft in the mining district Golema Reka - Sasa mine is in the period of utilization. Due to certain deformations appeared that the lining of the shaft, it is not currently operational. After reconstructing, the hoist plant will serve as the main hoist plant for the ore that will be produced from the mining district Svinja Reka, the interval between horizons 990-830. [5]

5 CONCLUSIONS

Knowing that the hoist plants installed in the hoist and the service shafts in Macedonian underground mines present key connection between the underground production system and the plants for processing the mineral raw materials, it is imposed the need of their continuous operation. From their functionality depends the achievement of the production capacities and economic of the mine working. Also, knowing that it is a word of technical systems in which large funds are invested, major requirements of the users of these facilities to increase the level of reliability or increase their working life.

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