EXPLOSIVES BASED CLEANING OF THE SOLIDIFIED METAL SLAG AND DISMANTLING TRAPPED ELECTRODES IN FURNACE

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SUMMARY:

For the needs of the company and for reactivation in the industrial process of the not used furnace number 5, a cleaning of the cold metal slag and the trapped electrodes was requested. The entire amount of cold metal slag, from the bottom to the top of the furnace, was to be removed, as well as the electrodes and the residues on the furnace chamotte walls.The Management of company decided for explosives-based cleaning. After the appropriate tendering procedure, this order was given to other company as specialised for this kind of activities with most economical offer.

The entire operation, starting with the securing safety on site before the blasting, the transport of explosives, the blasting itself, obtaining approval from the responsible service of the police and the site and object inspection after the blasting was an obligation of Mines "Banjani" AD Skopje. During the blasting activities we had also to bear in mind the nearby high-voltage cables, pipelines for compressed air, pipelines for cold water as well as the furnace number 4 that was in full operation. All activities were conducted according the law regulations for transport, usage and protection of explosive materials.

Keywords: explosives, cold metal , blasting, safety, slag

1.0 INTRODUCTION

The furnace, subject to the drilling and blasting activities, is positioned in a former company called "Rudnici i zeleznica" Skopje- Skopje.

There are 5 furnaces in the production facilities and are used for melting Ferromanganese.

Ferronickel and in future also for Ferrosilicium. The reconstruction intended or the drilling and blasting activities will take lace in the furnace no. 5. The drilling of the mine holes will be done by trained professionals of the company Skopski Leguri Ltd. Skopje under the supervision of a team from Mines "Banjani" AD Skopje.

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2.0 DEMOLITION OF THE SEPARATE ELEMENTS

Strict attention should be given to the depth of the mine drilling and the drilling angle horizontal and vertical. The drilling of the mine holes was done with
The characteristics of the blastholes are given in Table 1, as:
a - the distance between the holes,
b - the distance between the lines,
w - the line of least resistance,
h - the depth of the mine hole,
Pe- explosive charge in the blasthole.
manual pneumatic driller type RK-21, with a diameter of a monoblock drill bit Ø32mm.

No. of Blastholes	1	2	3	4	5	6	7	8	9	10	11	12
Parameters	**Lower line**						**Upper line**					
a (m)	0,9	0,9	0,9	0,9	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8
b (m)	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8	0,8
w (m)	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4
h (m)	0,9	1	0,9	0,9	1	1	1	1	1	1	1	1
Pe (kg)	0,44	0,52	0,44	0,44	0,52	0,52	0,52	0,52	0,52	0,52	0,52	0,44

Table 1. Characteristics of the blastholes

2.1 DEMOLITION OF THE FURNACE ELECTRODES

The explosive used during the mining of the electrodes is an industrial explosive type Ammonite 6 Ø28 powder explosive and Nonel detonators. Some of the characteristics of the Ammonite 6 explosive are:

- Density … 0,9 – 1,08 g/cm^3
- Detonation velocity..... 3600m/sec.
- Content of gas ..... 890dm^3/kg
- Explosion heat ..... 4300 KJ/kg
- Explosion temperature 2400 ^{o}C

Inside the mine hole a Nonel detonator type U 475 ms and the surface connector is a Nonel detonator type SL17 ms.

For calculating of the explosive charging in the mine hole we used the following formula:

$$P = 0{,}785 \cdot d^2 \cdot g \cdot k \qquad (Kg) \qquad (1)$$

For calculating the line of least resistance (burden) we used the following formula:

$$W = 30 \cdot d \qquad (m) \qquad (2)$$

The majority of the mine holes couldn't be filled with the explosive Ammonite 6 Ø= 28 the usual way, we had to use a different approach. We developed a different method for using the

mining cartridge. The mining cartridge has diameter of Ø= 26 and length of about 90 cm (depending on the depth of the mine hole), and width of the cartridge rim 0,7 – 1 mm.

Characteristics of the cartridge as follows, (Figure 1)

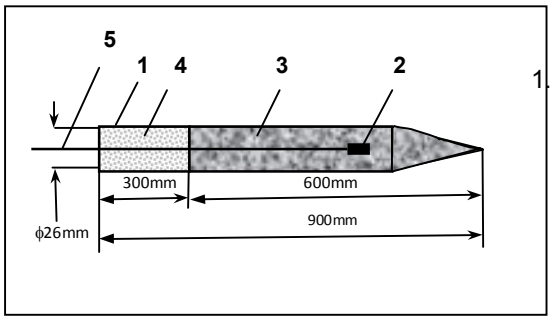


Figure 1. **Preparation of the mine cartridge**

1. Cartridge with brass casing of 0,7 – 1 mm.
2. Nonel detonator U 475 ms.
3. Explosive charging 600 mm.
4. Stemming - 300 mm.
5. Nonel fuse
6. Length of the cartrige 900 mm.
7. Diameter of the cartridge Ø26 mm

Nonel detonator U 475 was inserted in the cartridge, which afterwards was filled with Ammonite 6 explosive. Our goal was density of the explosives of about 1,o until 0,08 gr/cm^3. The cartridge was sealed with clay material.

The prepared cartridge was then placed in the mine hole and the mine hole was sealed with a mixture of clay material of about 20 until 30 cm.

The activation of the mine holes meaning the mine field was done with electric detonator DEP- C half-second no.0, with a dynamo type Schafler. During the activation of the mine holes a great care was given to the safety of the people, which are working nearby and the production facilities which were in full operation. In Figure 2 are describes the electrode with the positioning of the mineholes.

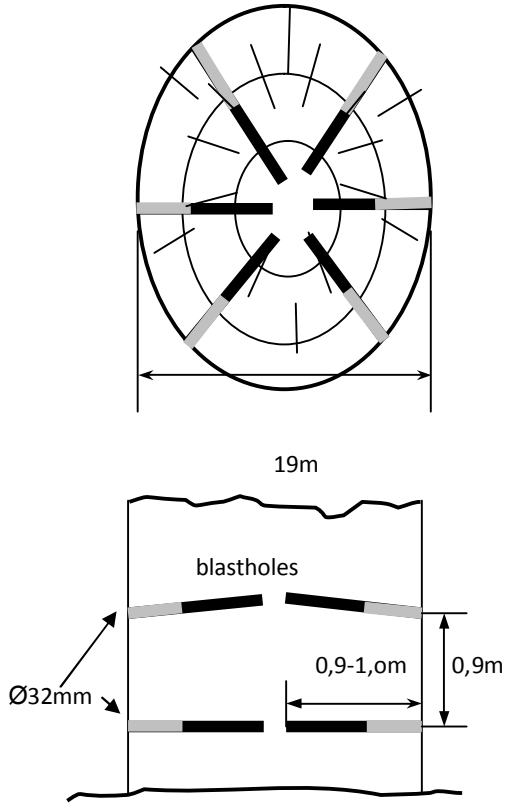


Figure 2. Position of the mine holes in the electrodes

2.2 DEMOLITION OF SOLIDIFIED METAL SLAG IN THE FURNACE

After removing the electrodes from the furnace started the second phase of preparatory activities for drilling the mine holes.

Sideways, on the furnace, where the liquid metal leaks out, in 10m length, we removed the protective brass and the internal part of the furnace, which is build of fire-resistant bricks. Afterwards we made an opening with 10m length; removed the protective brass and the internal structure of the furnace build of fire-resistant bricks. An opening with 10m length and 2-3m height was constructed in order that we drill the mine holes and the mining itself. As in the first case, we took great care during the control of the mine holes.

The drilling of the mine holes was done using pneumatic driller type RK 21 with a monoblock crown on top of its bit with a diameter Ø=32 mm.

The characteristics of the mine holes (mine field) are given in Chart in table 2, as follows:

a- the distance between the mine holes,m
b- the distance between the lines,m
w- the line of least resistance,m
h- the depth of the mine hole,m
Pe- explosive charge in the mine hole,kg

Chart - first row

No. of mine hole	1	2	3	4	5	6	7	8	9	10
a (m)	0.9	1	09	1	1	1	0.9	0.9	0.9	1
b (m)	1	1	1	1	1	1	1	1	1	1
w (m)	0.4	0.5	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.5
h (m)	0.9	1.3	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.2
Pe (kg)	0.56	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64

Chart - second row

No. of mine hole	1	2	3	4	5	6	7	8	9	10
a (m)	0.9	0,9	09	1	1	0,9	0.9	0.9	0.9	1
b (m)	1	1	1	1	1	1	1	1	1	1
w (m)	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
h (m)	1,2	1.2	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Pe (kg)	0.56	0.56	0.64	0.64	0.64	0.64	0.64	0.64	0.64	0.64

Table 2. Position of blasthole in the rows

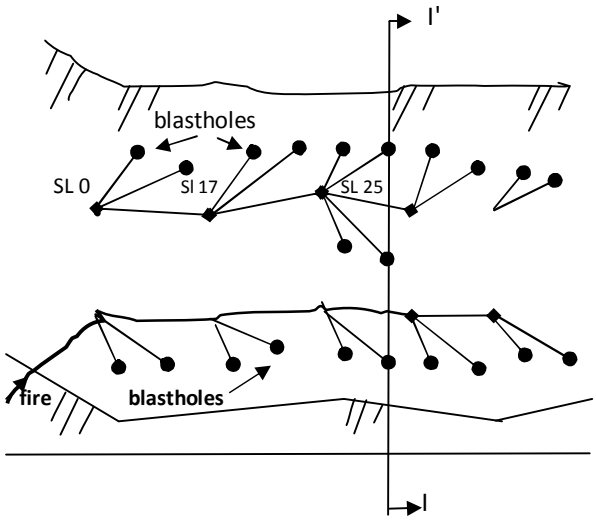
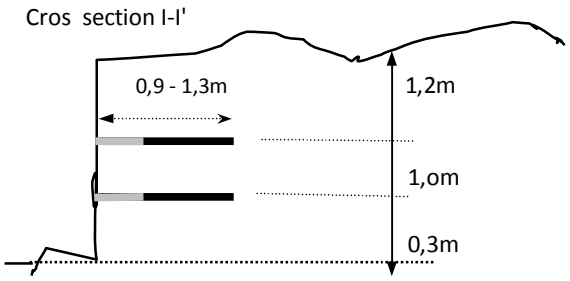


Figure 3. Scheme of blastholes at solidified metal slag



The mine field - series consisted of two lines, in each line there were 10 blastholes. For the cleaning of the solidified metal slag from the furnace we did 13-15 mining series (blasting series). Part of the mine series didn't allow a classical explosive charging to be used; therefore we had to apply the method of preparation of a mine cartridge, filed with explosives and a Nonel- detonator was used as in the first case.

Figure 4. Connecting the blastholes with Nonel system

The depth of the mine hole was limited by objective reasons. That is the surrounding facilities close by are in full operation, which contributed to the fact, that the explosive charging in the mine field should not exceed 12-15 kg.

Internal velocity delayers, Nonel detonator type U 475ms, and external velocity delayers Nonel detonator **SL 17ms** or **SL 25ms** depending on the situation on the field were installed at each blasthole.

For those reasons we calculated several parameters:

The safe distance for people was set at:

$R = 10\sqrt{Q}$, m

The danger calculation for flying debris during the mining was:

$R = \frac{2d}{\sqrt{W}}$, m

where:
d – diameter of the charging of the mine hole,m
w – the shortest distance from the charging in the mine hole to free space.

The danger perimeter for objects was:

$Ro = Kb\sqrt{Q}$, m

Kb – koefficient, *Kb* = 5
Q - total amount of explosives, kg

The delay interval at each mine hole was:

Tdl = (1,5 – 2) A W (мs)

A – Koefficient depending on the characteristics of the rock mass,
W – burden, m

Figure 5. Protection from flying debris with rubber screens

Figure 6. After the blasting

3. CONCLUSION

During the drilling and blasting activities meaning the special method of blasting, we focused especially on:

- Before the preparation activities for the filling of the mine holes meaning the blasting activities, the surrounding perimeter was cleaned of unneeded elements that may interfere with the blasting activities.
- The explosive charging as well as its placement inside of the mine hole was done with great attention;
- The amount of the total explosive charging in the mine field should not exceed the allowed limited size, not only per mine hole but also in the entire mine field,
- The connection schedule of the mine holes was conducted with previous prepared scheme,
- Before the blasting, it was obligatory to use and set the rubber screens for protection from flying debris during the blasting,
- Sound signals for the blasting, standard signalization prior and after the blasting.
- The mine holes or the mine field was inspected after each blasting and a report was prepared by the blasting crew,
- - A report was delivered to the nearest police station regarding the total explosives used,
- The remaining explosive material were returned to the warehouse of the Mine „Banjani“ AD Skopje.

The application of all legal regulations during the handling with explosive material and the compliance with the work safety processes and tools lead to a successful drilling and blasting.

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