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Shok-free Dismounting of Cathode Assembly Lining of Aluminum Cells

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The technology of dismantle of the cathodic device of electrolytic furnaces is considered. Lining destruction in the cathodic device of an electrolytic furnace is made by a special hydraulic press. In a lining material locally non-uniform loadings causing occurrence of cracks are created. The technology allows to exclude with great dispatch-vibrating influence on near electrolytic furnaces and to increase term of their operation.

Keywords: cathode, lining, dismounting, diamond tools, aluminium cell.

Introduction

In “Rusal Co Ltd” the technological cycle of the Soderberg aluminium cell operation includes a periodical stoppage (once within 5 to 7 years) of the cells for the major overhaul [1]. A total dismounting of the cathode assembly lining is carried out followed by the mounting of a new one usually in special maintenance departments. That is why there is a great need for the electrolysis workshops to be equipped with powerful portal cranes of over 100 tons hoisting capacity and a branched intraplant railway system for transporting large-size cargo. In some smelters along with this technology there also exists a historically earlier one for the major overhaul of the cells directly in electrolysis workshops (in-situ). The use of the latter is a compulsory measure forced by the impossibility (or unprofitableness) of the electrolysis workshop reconstruction for the implementation of the former.

Carrying on the lining dismounting works in-situ by means of the current shock destruction technology leads to undesirable influence on neighbouring pots. In some circumstances the lining dismounting of one pot causes degradation of operating characteristics of the neighbouring ones and leads to the necessity for their early repair [2, 3]. In our paper there are considered prospects of the use of shock-free technology of the cathode assembly lining dismounting in-situ by means of the hydro-press equipment and diamond tools. Using the technology makes it possible to eliminate the problem

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of the undesirable influence on the neighboring pots, automatize the dismounting process as well as decrease material and time costs of the cathode assembly major overhaul [4].

Features of the vibrational influence on the lining of the neighbouring pots when dismounting the cathode assembly lining in a pot

Cathode assembly lining dismounting directly in electrolysis workshops by dismounting machines equipped with pneumatic or hydro-hammer [1] is followed by the formation of the excess vibrational dynamic influence on the neighbouring pots that is **additional** to the background vibrational field. According to estimations when using the percussive destruction technology the excess vibrations in the neighbouring pots may exceed the total background vibratory load by a factor of 1.5 – 2.5 for a turnaround time of a pot operation without the additional load. As a result the lining of the neighbouring pots deteriorates. And this can finally lead to an early major overhaul of the pots.

When using the technology of the percussive destruction of the cell cathode assembly lining the occurrence of excess vibratory and dynamic loads in the neighbouring pots results in the following:

1. An intensification of cracking due to the excess vibratory influence on the lining;
2. Increasing diffusion and leakage of the aluminium melt into the lining and cathode assembly through appearing cracks;
3. Instability of the aluminium melt surface followed by the excitation of melt surface oscillations on their own natural frequencies leading to change in the cell performance.

When using the pneumo- or hydrohammer in constructions surrounding a pot being repaired a wide spectrum of vibrations is excited along with the fundamental vibration frequency that is defined by the forcing frequency F of the operating hammer being within 6÷15 Hz. The upper bound of the spectrum may be estimated by order of magnitude as follows

$$F_g = 2V/d,$$

where V is the impact velocity of the striking part of hammer; d - the striking part penetration depth into the material being destroyed. According to estimations the upper bound of the vibrations F_g excited by the hammer impact is within a range 150—300 Hz.

If the hammer strikes at the metal wall, bottom or agglomerates possessing a high strength the bandwidth of the frequencies excited may be 10 to 20 times higher. However, since high frequency vibrations dissipate quicker while propagating, low frequency ones of 150 – 300 Hz have the main influence on the neighbouring pots. This assumption has been confirmed by the experiments that show the main frequency range of vibrations in the neighbouring pots to be within the range 200—400 Hz when using the percussive destruction technology of the cathode assembly dismounting.

The dynamics of vibrations excited by the operation of the dismounting machine PM 1700M4 with the pneumo-hammer is presented in Fig. 1. The impact frequency of the hammer is within the range 4 – 4.5 impacts per second. Maximum vibrational accelerations in a neighbouring pot of a potline comprise 0.4 m/c^2 and the amplitude of vibrations being registered reaches 0.2 mm. Vertical vibrations have the greatest amplitudes, but horizontal ones are 3 to 4 times lower. The presence of fast variations means the simultaneous excitation of a particular natural frequency set of the constructions. The characteristic decay time of the excited vibrations is 0.2 s. This indicates that the pneumohammer strikes at the frequency of 5 impacts per second may lead to the resonant

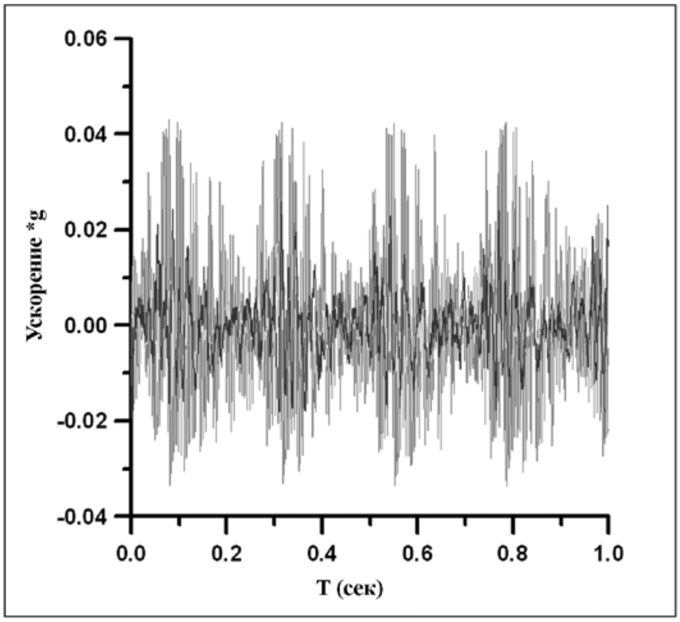

Fig. 1. Shock accelerations dynamics on a neighbouring pot during the operation of the pneumo-hammer PM 1700M4. The impact frequency of the hammer is 4.3 impacts per second. Maximum vibrational acceleration on a cathode housing in a neighbouring pot is 0.04g (0.4 m/c^2). The amplitude of the vibrations registered is 0.2 mm

amplification of vibrations. Since the hammer has maximum impact frequency of up to 7 Hz, vibrational loads may be higher than those registered in the set of the tests if the time interval between the strikes appears to be lower than the decay time of the natural frequencies of construction vibrations, that is, less than 0.2 s.

The resonant amplification effect does take place at the operation of the hydrohammer BROKK SB 450 having lower impact energy 0.85 KJ compared to that of the pneumo-hammer (1.7 KJ) but higher impact frequencies – 10 – 13 Hz. In this case there are also registered components corresponding to the natural frequencies of vibrations within the ranges 10 – 15 and 100 Hz [Fig. 2]. Maximum accelerations in the neighboring pots reach 2.75 m/c^2 and maximum vertical excursions 1.5 mm.

In comparison with the background vibrational field the operation of the dismounting machine is followed by the increase of peak vibrational loads on the neighbouring pots by a factor of 300 – 1800. Taking into account the duration of works (up to 1.5 days and nights) to wholly destruct the cathode assembly lining the excess vibrational load in neighbouring pots of the same pot line corresponds to 3.5 – 5 years (time average). For the nearest pot in a parallel line this figure exceeds 1 – 1.5 years. As a result, the excess vibrational load in a pot during its standard operation for 5 years may be 1.5 – 2 times higher than the background vibrational one for the same time period. In combination with high peak loads this means that the cathode assembly lining dismounting with percussion mechanisms in-situ is one of the factors decreasing the standard operation duration of the aluminium cells.

In spite of the fact that the problem of the cathode assembly lining dismounting directly in the electrolysis workshops is currently concerning rather old smelters with no technical means for a cell to be transported into a specialized maintenance department the development of the shock-free technologies may be of a great importance not just in this particular case. It prospectively enables to

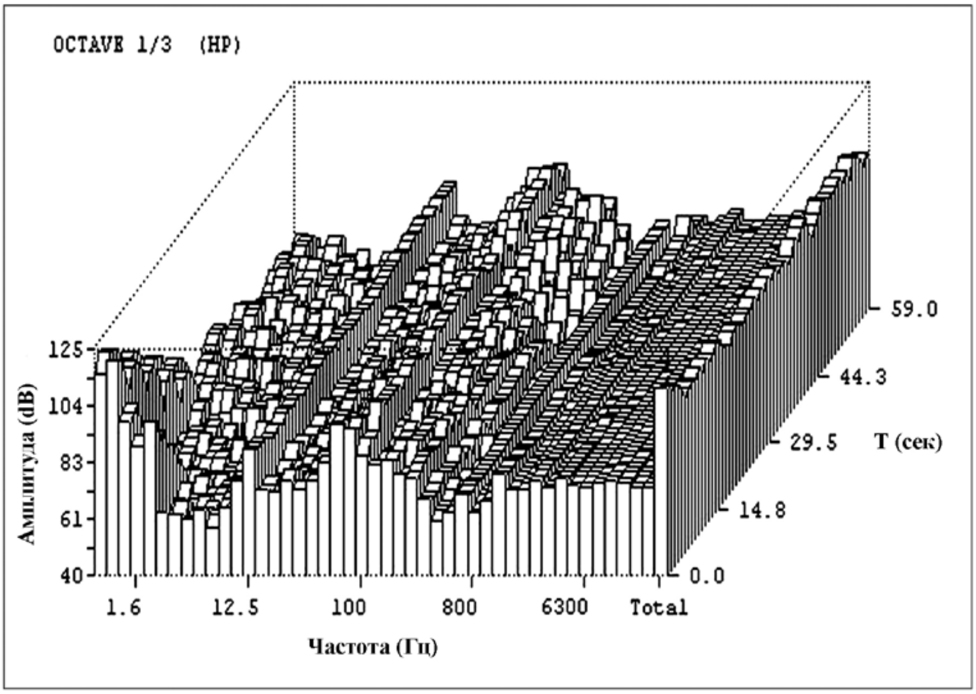

Fig. 2. Frequency distribution of accelerations on the cathode housing of a neighbouring pot at the operation of the hydrohammer BROKK SB 450

decrease significantly time and material costs for the major overhaul thanks to cancellation of some excess operations in the work schedule, different specialized equipment and workshops.

Hydro-press equipment- and diamond tool-based technology of shock-free dismounting of the cathode assembly lining of the aluminium cell

In STC “Innovation Technologies” of SFU in collaboration with “Rusengineering Co Ltd.” (Krasnoyarsk) there was worked out the technology of shock-free dismounting of the cathode assembly lining with the implementation of hydro-press equipment and diamond tools. The technology has passed tests in “Rusal Novokuznetsk Co Ltd.”

The technology is based on the hydro-press equipment generating non-uniform stresses in the cathode assembly lining bulk that exceed the material’s ultimate compressive strength. In Fig. 3 there is presented a layout of the experimental equipment for the whole cycle of the shock-free dismounting of the cathode assembly lining.

Two-layered lining of the cathode assembly is composed of the first layer consisting of graphite blocks and steel current carrying rods (blooms) embedded into the blocks and the second lower one made of refractories. The total depth of the lining is 1.2 to 1.5 m. The lining dismounting is carried on in turn. By the existing technology the upper layer is broken first with debris being separated off the blooms. The graphite debris removal is made with excavator. The steel blooms are removed with the standard cranage of the electrolysis workshop. After the debris is removed from the pot, the second refractory layer is broken followed by the preparation of the pot for mounting a new set of the cathode assembly lining.

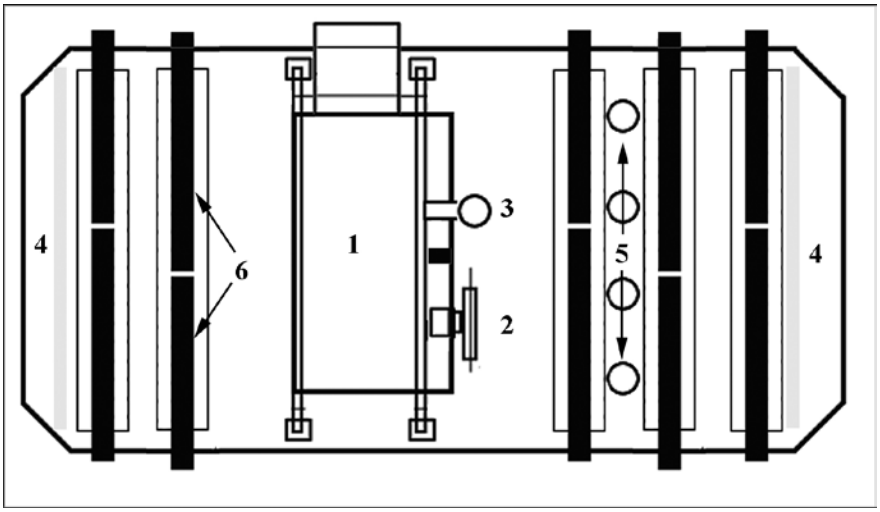

Fig. 3. The layout of the experimental equipment for the cathode assembly lining dismounting: *1* – the operating floor; *2* - the drilling installation; *3* - the diamond disk saw; *4* - bore pits for the insertion of hydraulic pressure cylinders; *5* - safety saw cuts; *6* – steel cathode rods – blooms

According to the suggested technology the following equipment package was used for the shock-free dismounting:

1. Fluid-operated disk saw with a set of diamond disks 1200 – 1600 mm in diameter;
2. Electrically driven drilling installation and a set of diamond crowns 180 mm in diameter and 600 mm in length;
3. Hydro-press equipment package – Ferro-concrete breaker SBB 2000 with pressure cylinders CEDIMA PZ-300 [5] (4 pcs.).

The package was secured on a movable operating floor travelling along the pot on slide-rails and could be adjusted by height to a level required for the operations.

First of all safety saw cuts were made with the diamond disk saw through the whole upper graphite layer along outmost blooms near the short pot's walls in order to protect the cell from being damaged. The saw is also used for cutting solidified aluminium on the lining's surface or inside of it. After that 4 bore pits were made with the drilling installation in the space between blooms. The pits were two blooms spaced and had a depth of 400—600 mm. Then the pressure cylinders were inserted into the bore pits that generated in the lining's bulk a non-uniform stress field of a total load up to 1200 tons. Destructing lining took 1.5 to 2 min after the pressure delivery into the cylinders. Graphite blocks cracked and separated from the blooms simultaneously. Then the operating floor was moved towards the opposite wall of the pot by a distance of 2 blooms and the operation cycle repeated.

The main timetable in the cycle is conditional on that of boring the pits. It takes 25 to 40 min to bore a pit. In the running test regime the complete removal of the upper graphite lining layer took 2 working shifts including blooms being taken out and the lower layer being prepared for the subsequent treatment. The refractory layer has a much lower strength compared to the upper graphite layer. Thus its destruction takes about half as much. The lining debris is removed with excavator and blooms with cranage of the electrolysis workshop according to the existing technology.

Conclusions

The experimental technology of the shock-free dismounting of the cathode assembly lining of aluminium cells in-situ worked out on the basis of the hydro-press equipment makes it possible to fulfil the pot preparation for the subsequent new cathode assembly mounting within the framework of time allotted for the standard overhaul cycle realization.

The technology enables to entirely prevent the impact action on the neighbouring pots and, correspondingly, enhance the economy of the smelter operation thanks to increasing time intervals between major overhauls of the pots. When implementing the technology in new smelters the saving rate can be acquired because of a decrease of expenditures for maintenance of the additional workshops, cranage hoisting capacity reduction and the acceleration of the technological operations of the overhaul on the whole.

In perspective the technology enables to reduce significantly time needed for the destruction operation thanks to the automatization of the operation paralleling with the use of 2 or 3 hanged modular units having various sets of tools each. A movable rack such as BROKK 330 or the like can be used for the mounting of the units.

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Демонтаж футеровки катодного устройства электролизеров для производства алюминия

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Рассматривается технология демонтажа футеровки катодного устройства при капитальном ремонте алюминиевых электролизеров непосредственно в корпусах электролиза. Для ускорения *процесса разрушения футеровки и снижения воздействия ударно-вибрационных нагрузок при выполнении демонтажных работ на соседние с ремонтируемым катодным устройством электролизеры, демонтаж выполняется с использованием гидропрессового оборудования для безударного разрушения материалов с применением инструментов алмазной резки и бурения. Ускорение процесса демонтажа достигается за счет использования гидропрессового оборудования, позволяющего создать в материале футеровки катодного устройства электролизера локально неоднородное распределение давления, обеспечивающего образование трещин, разрушающих целостность футеровки.*

Ключевые слова: катод, футеровка, демонтаж, алмазные инструменты, алюминиевый электролизер.