DEVICES THAT PREVENT ADHESION OF MATERAL TO THE SURFACE OF LOAD-BEARING CAPACITORS

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A description of the construction of magnetic-pulse devices and their operation in preventing adhesion of materials to the working surfaces of metallic lattices, the shields of hopper units, and the mounts of bag filters is presented. A highly efficient means of combating adhesion of materials to the working surfaces is proposed.

Keywords: adhesion of material, load-bearing capacitor, hopper wall, anti-adhesion plate, vibrator, electromagnet

The outlet ports of hoppers often become clogged at business plants due to caking of pieces of material as a result of the pressure exerted by the upper layers on the ports. In winter, congealation of material occurs at negative temperatures simultaneously with the process of caking. As a result, the hoppers function with permanently caked sections of material, which may occupy up to 60% of the volume of the hopper. Complete cessation of inflow of material often occurs, as a consequence of which the production cycle is disrupted, the projected volume of output is not produced, and labor costs increase significantly. For example, in unfavorable operating periods there may be as many as 25 workers involved in servicing a single hopper. The mechanical, vibratory, and pneumatic agitators, gas-pulse devices, and even heating which are used to prevent overhang of materials on metallic lattices, the shields of hopper units, and the mounts of bag filters at enterprises in the refractory materials industry prove to be ineffective or difficult to implement.

For example, a gas-pulse cleaning system (Fig. 1) produces a burst of an air-gas mixture which in turn generates a shock wave that can cause the roof to collapse. Depending on the force and number of pulse chambers, 50 – 800 m^3/h of air and 3.5 – 80 m^3/h of gas[2] may be consumed. The plant has been installed at OAL GMK Noril(sk Nikel(for the purpose of cleaning the heat surfaces of waste-heat boilers and the hoppers of electrical filters.

Magnetic pulse devices [1 – 3] containing electromagnets that are periodically connected to a bank of capacitors charged through a power unit from a network prove to be more effective. Once the network of electromagnetic coils are connected, the energy accumulated in the capacitor bank is instantaneously transformed into the energy of a tool, thus there occurs a sudden impact, which creates a mechanical "shock wave." As a result, the material is dislodged from the walls of the capacitors (Fig. 2). An electromagnetic exciter functions reliably, though a dynamic induction exciter is more promising, since it possesses a higher efficiency and better weight and dimension indicators, and can be used to develop significantly greater forces.

The electromagnets of a dynamic induction exciter (Fig. 3) is mounted on the walls of the hopper and are periodically connected to a bank of capacitors charged through a

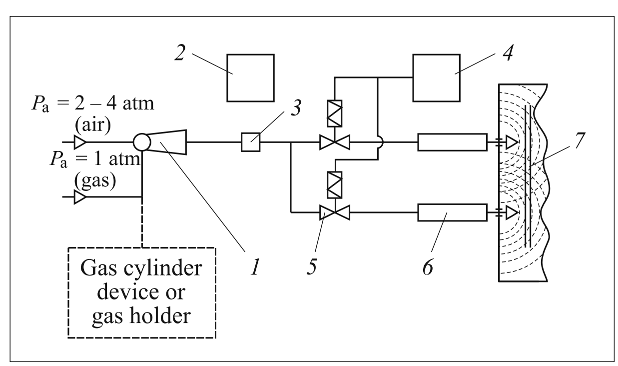

Fig. 1. Gas-pulse cleaning: *1*) mixing ejector; *2*) ignition unit; *3*) spark plug; *4*)control panel; *5*) shut-off valve; *6*) pulse chamber; *7*) cleaning subject; pressure of air and of gas P_a and P_g are indicated at positive pressure; 1 atm = 10^5 Pa.

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[2] Here and below, volumes of gas are given assuming normal conditions.

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power unit from a network. Once the network of electromagnet coils is connected, the energy accumulated in the capacitor bank instantaneously, in the course of several milliseconds, is transformed into the mechanical energy of an electromagnetic field which, once transformed into the mechanical energy of the tool, acts on the wall of the hopper, elastically deforming the latter. The "shock wave" which is thus created, once is strikes the deposits in the hopper, undergoes reflection from the hopper walls and the free surface of the layer. As a result, zones of expansion(contraction are formed in the material, which together with the elastic deformation of the walls of the hopper, causes a rupture in the relations between the particles of the material and induces defoliation of the layers of the material. The strength of the shock wave and the interval between the individual pulses of the magnetic pulse device are regulated.

A 200-μF capacitance capacitor bank permits greater discharge currents in the course of a brief time interval. The capacitor bank is charged up to 4 – 6 kV. The accumulated electrical energy ranges from 44.8 to 100.8 kJ. The technical requirements for the construction of the device (module) are as follows:

Consumption current, A	≥40
Charging voltage of storage unit, kV	0 – 3
Maximal charging energy of storage unit, kJ	≥20
Mean life of module, h	≥1000
Mean time between failures, h	≥100
Insulation resistance 380-V a.c. electrical circuits, MΩ	2
Resistance between grounding bolts and lining, Ω	≤0.1

The degree of protection of the module corresponds to the requirements of All-Russia State Standard 14254; the protection class of module, as defined by All-Russia State Standard 12.2.007.0, is equal to 1. The module must be constructed for operating conditions in compartments in which the air does not allow for the formation of dangerously explosive or inflammable mixtures. Power is delivered to the module from a three-phase network with 380 ± 22 V a.c. voltage and 50 Hz frequency. The residual charge must be automatically discharged from the storage unit whenever the module is disconnected.

In principle, the plant differs from all the different types of vibrators available, since it does not have any moving parts and strong interaction is realized in the electromagnetic field of the air gap. A similar plant has been tested over a prolonged period of time at hoppers in the form of trapezoids with width of the upper base 1.4 m, of the lower base 0.5 m, height 2.8 m, and thickness of the wall 10 mm (Fig. 4). The weight of a single electromagnet is 15 kg, pulse capacitance up to 100 kW, control is realized through thyristor control, and electric power is supplied from a network. Similar plants are functioning at the Cherepovets GRES, the cement factory of OAO GMK Noril'sk Nikel', and the OAO Central Ural Copper Smelting Factory.

In rail transport clumping of sand due to vibrations in the course of the trip is so great that a series of shocks must be delivered to the walls of the rail car upon unloading in order to completely clean the rail car. If the sand has become frozen, stronger shocks are needed. The use of magnetic pulse device makes it possible to generate shocks of given strength without causing any strain to the walls of the rail cars.

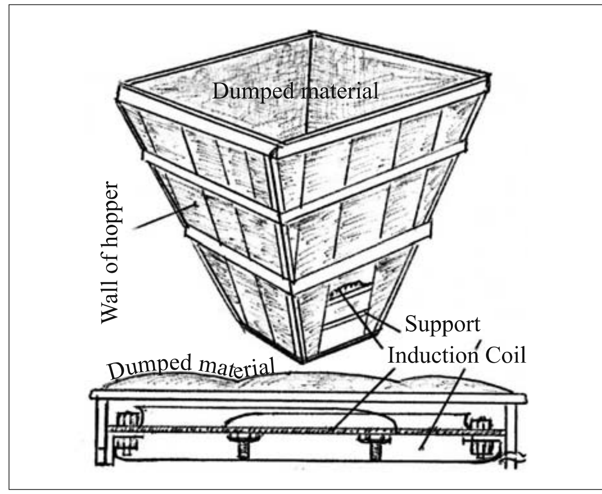

Fig. 2. Pulsed cleaning of a hopper.

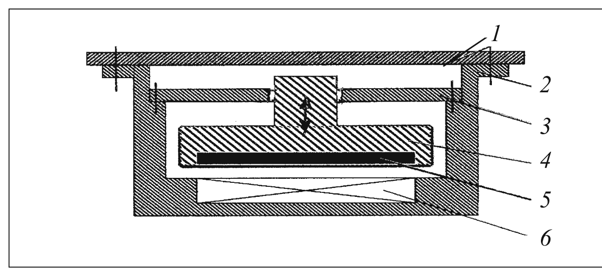

Fig. 3. Dynamic induction exciter on wall which is to be cleaned: *1*) wall to be cleaned; *2*) electromagnet case; *3*) cover; *4*) impact element; *5*) armature; *6*) induction coil.

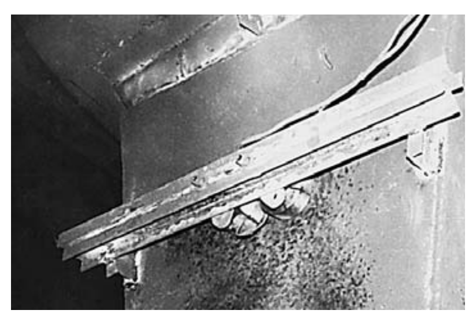

Fig. 4. Electromagnetic impact industrial plant.

Here is yet another example illustrating the use of the magnetic pulse device. In the course of cleaning the buckets from slag, the buckets are turned over and mounted on a platform (Fig. 5) with a gap between the percussive elements and the sides of the bucket. A shock wave is formed when the percussive elements come into contact with the sides of the

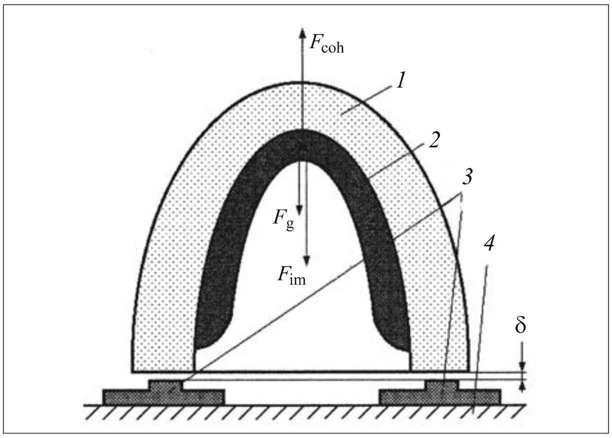

Fig. 5. Plant for cleaning buckets: F_g) gravitational force; F_{coh}) cohesive force of adhered material with walls of bucket; F_{im}) force of impact delivered to body of bucket; δ) gap between percussive elements and edges of walls of bucket; *1*) bucket; *2*) adhered material; *3*) percussive elements; *4*) platform.

bucket, under the effect of which the walls of the bucket are deformed elastically, which helps to eliminate adhesion of material. The bucket is not damaged in any way.

Polymer adhesion-preventive lined plates represent the most effective means of combating adhesion of material to a working surface. The plates are also easily mounted and replaced in the course of wear. The plates are highly hydrophobic, possess a low friction coefficient, sufficient abrasion, impact, and chemical resistance, mechanical stability, and may be used at temperatures of from –40 to +100°C. Industrial tests (more than three years) of test batches of polymer adhesion-preventive lined plates 700 × 500 × 20 mm in dimension were carried out on the cinders hoppers of of raw material mills, receiving gypsum hoopers, granule hoppers, and granulator bowls used to feed raw material to the furnace at OAO Novorostsement and the cinders hoppers of the raw materials mills at OAO Kavkaztsement.

The mixture of raw material that passes through the hopper constitutes mortar in the form of chunks up to 15 mm in dimension, moisture content 4.2%, and Mohs hardness 4. In the course of the use of production equipment that has been lined with polymer adhesion-preventive lined plates around 560,000 t of raw material mixtures passed through the equipment. The wear on the polymer adhesion-preventive lined plates amounted to about 50%. Use of polymer adhesion-preventive lined plates produced a substantial reduction in adhesion of the raw material mixture and improved the working conditions of the workers responsible for cleaning of the hoppers.

AT OAO Shchurov Tsement, limestone in the form of chunks up to 400 mm in dimension and 15% in moisture content strongly adhere to the inner surfaces of the platforms and dump trucks in the course of transportation from the mine face to the receiving hopper. This is particularly the case where the dump trucks stand for prolonged periods with unloaded stock at negative temperatures. With a projected load of the dump trucks of 75 t, it has become necessary to clean the trucks after every three trips by means of an excavator equipped with a return bucket. The length of the cleaning operation has amounted to 25 min on average. Annual use of dump trucks with platforms lined with polymer adhesion-preventive lined plates has demonstrated that a low level of adhesion (around 2%) of the volume of the material on the platform occurs only in the area between the floor and the edges, and cleaning to remove adhered limestone should be performed on a weekly basis.

Polymer adhesion-preventive lined plates 4 – 6 mm thick are successfully used at the hoppers of OAO Rybnits Cement Combine (Dniestrian Republic of Moldavia) and in the precipitation cyclone separators that produce wet-threshing flour at OAO Dolomite (Republic of Belarus). Thus, the transfer capacity of a 1200-mm cyclone separator was increased by 80%, which made it possible to reduce the use of two vibrators, which had previously been switched on every 5 – 7 min, and are now switched on only every 2 min, and to avoid the need for manual labor in the cleaning of the cyclone separators.

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