The industrial dust properties as a wear factor of pit trucks electric machines elements

Vesnin A.V.

Candidate in Technical Sciences (PhD), associate professor,
Kryvyi Rih National University

Sistuk V.O.

Candidate in Technical Sciences (PhD), assistant
Kryvyi Rih National University

Bogachevskiy A.O.

PhD student
Kryvyi Rih National University

Abstract
It has been found that for the pit tracks BelAZ-75131 there is increase of electrical machines failures number in Kryviy Rih basin pits. As the largest percentage of faults is occupied by the wear winding insulation of engines, it was suggested that the reason for this negative process is that superfine iron ore dust, which compared with coal dust has high residual magnetization and the tendency to stick, gets into the internal cavity of traction machines with the cooling air thus forming a conductive congestion.
Keywords: DUMP TRUCK, MINE, SUPERFINE COAL AND IRON DUST, INDUSTRIAL DUST, ELECTROMECHANICAL TRANSMISSION, MAGNETISM, CONDUCTIVE PROPERTIES, INSULATION

The quality of transportation process by BelAZ dump trucks with electromechanical transmission depends on the amount of down-time of this equipment. The dump trucks down-time connected with the electromechanical transmission faults are important from the financial point of view. For instance, in one of the Kryvyi Rih mines components of traction equipment failure caused down-time increase by 17 % of total time which is spent on their repairing and technical maintenance. 1578 hours have been spent on elimination of transmission components failures for a period of 6 months. It conditioned a volume decrease of mined rock by 66306 m^3. For such loss compensation it is necessary for one dump track to work 65 days non-stop. The pit dump tracks of the same model have lesser fault indicators in coal mines of Kuznetsk basin [1].

Nowadays a great attention is paid to technical condition of industrial transport, development and improvement of technological transport schemes and flow of cargo in the mines, service of pit-run dump trucks in Ukraine development, choice of change organization of new and repaired dump trucks components. Although existing researches don't reveal nature of negative factors that lead to components failures of electromechanical transmission of dump-trucks in Kryvyi Rih mines.

The aim of the research causes revealing of increased number of traction machines of dump-tracks elements failures that take place in iron ore mines and are not typically for coal mines on the base of factors analysis that influence on particular elements of traction equipment depreciation.

Most of the traction electric machines internal parts malfunctions are related to deterioration of the winding insulation [1]. It is known that the primary cause of this destructive process is a sharp decrease in their electric strength due to contamination while industrial conductive reaching the middle of the traction electric machines. Due to accumulation of a certain amount of dust winding insulation loses its mechanical strength, becomes brittle and hygroscopic [2].

The likelihood of conductive dust appearing in the inner cavity of the traction machine body depends on the purity of the cooling air in ventilation and cooling system of a mining truck, which provides the air intake of the least dusty area of the truck and forces its purification from impurities through the cyclones mounted on the power cabinet. This provides air flow in the suction duct to the inlet of the traction generator, via the discharge duct and channels in the body of the gear-wheel motor - cooling fan traction motors and the crankcase rear axle, and the output of air through the ventilation window of the rear axle [3]. The design of the filter element provides the ability to capture 95 % of the total dust with a particle size of 10 micrometers and 83 % when the particle diameter of 5 micrometers [4].

To assess the possibility of falling industrial dust in the middle of traction machines we will represent the percentage distribution of the maximum fractions of iron ore and coal dust, which are formed by drilling and blasting, excavation and transportation of rock mass (see figure 1). Considering the disperse composition of industrial dust and taking into account various factors of dust formation, it should be noted that most of the dust particles have high dispersion. There is a great discrepancy in the maximum percentage of high disperse fraction up to 5 microns depending on the type of industrial dust: this fraction takes 48 per cent in the total volume of iron ore dust and 95 % in the volume of coal. The ventilation and cooling filter allows emission of 17 % of the dust particles of the air with a diameter of 5 μm, and 5 % from 5 to 10 μm. The fractions area of high disperse dust, which are not trapped by the filter stands for particles with a size up to 10 μm, which is highlighted in a different color in figure 1. Thus, the filtering capacity of the cyclone is not enough to capture high disperse dust completely, that leads to its getting into the internal cavities of the traction of machine body.

To confirm the effects of industrial dust on the actuation elements of the traction machine, it is imperative to consider physic-mechanical, magnetic and electro conductive properties [5, 6, 7] (see table.1).

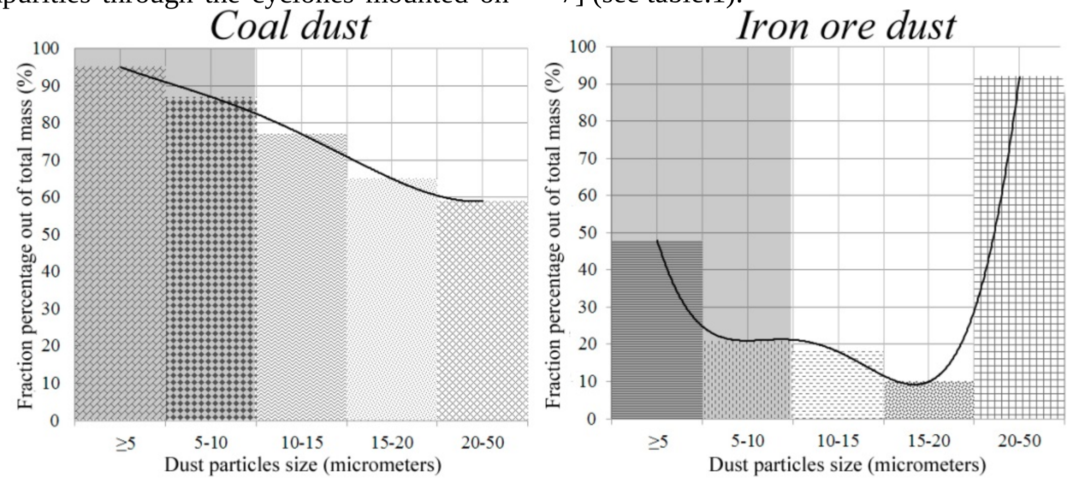

Figure 1. The iron ore and coal dust maximum fractions distribution percentage

There is a clear correlation between physical-mechanical properties of dust and solids farmed from it. One of these properties is the specific weight, i.e. the one that is freed from air and not related to water, but contains mineral impurities.

From Table 1 one can see that the iron ore dust specific weight is 1.3 g/cm^3, whilst the coal dust specific weight is within 1.3 – 1.5 g/cm^3. Due to the increase of coal impurities specific weight in the air this dust volatility is almost 2 times greater in comparison with iron ore one.

Table 1. The main physical-mechanical, magnetic and conductive properties of iron ore and coal dust

Indicator	Iron ore dust	Coal dust
Mechanical properties		
Specific gravity, g/cm^3	1,3	1,3 – 1,5
The average yield of volatile substances, %	18 – 25	33 – 39
Humidity, %	0,3 – 0,5	2,1
Magnetic properties		
Classification	ferromagnetic	paramagnetic
The average value of the Curie point, °C	850 – 900	100 – 150
Electrical properties		
Classification	strong electric conductor	semiconductor (sometimes dielectric)
The dielectric penetrability	31000–45000	16 – 25
The specific resistivity, Ohm m	$1{,}6\cdot10^4 – 3{,}9\cdot10^4$	$9\cdot10^6 – 6{,}5\cdot10^7$

On the other hand, coal dust with no inclination to magnetization and slush can easily be blown through the machine with refrigerated air and exit through its ventilation windows due to the generated internal pressure. Nevertheless, it should be noted that coal dust contains 14 – 23 % more moisture in comparison with iron ore, that is, it is somewhat more prone to hygroscopicity, that can lead to local contamination.

However, the most significant impact on the deterioration and breakdown insulation of the windings is imposed by electromagnetic properties that are quite different for iron ore and for coal dust. Primarily, this is due to the fact that iron ore dust belongs to the class of ferromagnets, the feature of which is the possibility of spontaneous magnetization due to external magnetic fields, and coal dust, is a paramagnetic material, the magnetic field of which in most cases either reach minimum values, or is even absent.

To determine dust elements transition from the ferromagnetic to the paramagnetic state, Curie point is usually used in which spontaneous magnetization almost disappears. For iron ore dust, the range of the Curie point is 850 – 900°C, and for coal – 100 – 150°C. If the operating temperature of the traction elements of the motor reaches 180°C, which exceeds the Curie point, coal dust getting inside loses the final magnetic properties. Iron ore dust, on the contrary, retains magnetic properties having large values of the Curie temperature, which cannot be achieved inside the traction machine.

Intensive interaction of the iron ore dust magnetic field with the traction electric machine magnetic field can cause contamination of the complex in their form body elements, insulation of the windings. At high humidity of surrounding air conductive clusters contribute to the emergence of a water film on the painted surfaces of the insulation. Moisture and pieces of dust can get inside the insulation via its cracks and pores that reduces its electrical resistance.

Electrical properties of iron ore and coal dust also have a significantly different character, to iron ore dust due to its elemental composition belongs to the class of highest electric conductors, and coal – to the class of semiconductors, and sometimes to the dielectrics. Basic electrical properties of industrial dust are represented by the specific resistivity and dielectric constant. The specific resistivity of coal dust with a temperature increase from 20°C to 200°C varies from 9•106 to 6.5•107 Ohm•m, and iron ore dust in the same range of thermal heating, in its turn, from 1.6•104 to 3.9•104 Ohm•m. The dielectric constant has a visual difference between iron ore and coal dust in almost 5000 times. This difference allows us to think that there are occasions when under the influence of an electrical voltage of iron ore dust particles that fall into the cracks of the lacquer coating of the windings, the latter loses its insulating properties, which ultimately leads to the insulation breakdown.

Thus, industrial dust of definite types refers to the opposite magnetic and electric classes that has a different effect on the actuation elements of the traction machine. We can confidently assume that the main factor that causes the presence of the mentioned above difference in the number of traction motors windings insulation breakdowns is iron ore dust that gets inside the electric machine with cooling air.

On the basis of iron ore and coal dust comparative analysis it has been found that one of the negative factors that causes increased traction machine elements depreciation, there are magnetic and conductive properties of iron ore dust that falls into the internal cavities of the traction motors with cooling air, namely, the possibility of spontaneous dust magnetization, a large dielectric constant (31000 – 45000), and low specific resistivity 1.6•104 - 3,9•104 Ohm•m compared with coal dust. Further studies are aimed at the proposed hypotheses testing regarding the influence of iron ore dust on the actuation components of the dump tracks electromechanical transmission.

References

1. Bogachevskiy A.O. *Porivnyalniy analiz roboti elektromehanichnoyi transmisiyi karernih samoskidiv v umovah vidkritih zalizorudnih ta vugilnih rozrobok* [Comparative analysis of pit truck electromechanical transmission operate in open iron and coal mines]. Problem solving ways for specialized vehicles facilities operation: Materials of international practical science conference. Kryvyi Rih, KNU, 2014. pp. 49–54.
2. Dero A. R. *Nepoladki v rabote asinhronnogo dvigatelya* [Problem with the asynchronous motor]. Library electrician. Release. 444 HP, Energy, 1976.
3. Karernyiy samosval BelAZ-75131 i ego modifikatsii. Rukovodstvo po remontu 7513. [Dump truck BelAZ-75131 and its modifications. Manual 7513] -3902080 RS, RUPE "BelAZ", 2007. - 208 p.
4. Cyclone. Available at: http://engineeringsystems.ru/c/ciklon.php
5. *Spravochnik (kadastr) fizicheskih svoystv gornyih porod* [Handbook (cadastre) physical properties of rocks] / Ed. by N. Century Melnikov, V. C. Rzhevsky, M. M. Protodiakonov. Moscow, Nedra, 1975.
6. Scriabina L. *Atlas promyishlennyih pyiley* [Atlas of industrial dusts]. Moscow, Synthematika, 1980.
7. NIOSH/Industry Collaborative Efforts Show Improved Mining Equipment Cab Dust Protection. Organiscak, J. A. [and others] In: Yernberg W.R, ed. Transactions of Society for Mining, Metallurgy, and Exploration, Inc. - Vol. 314. - 2003 - p. 145-152.