CAPTURING AND SUPPRESSION OF DUST FROM THE CRUSHING-RELOADING (DPP) POINT AT THE "MURUNTOG" MINE

Kamolov N.B,
Shomurodov B.H.

Abstract. *Detailing and suppression (aspiration) of dust from the crushing and reloading (DPP) point, design features, and promising developments are presented. Bunkers, feeders, and crushers are the most important parts of the crushing and reloading point. The amount of dust, dust size, and dust velocity in the crushing and reloading point bunker are directly related to the state of the environment. When dump trucks empty the bunker rock, dust is released and damages the environment, taking this into account, dust suppression pipes are installed along the bunker and feeder, water nozzles are installed in the pipes, and options for covering the bunker and feeder are provided. Options for determining the amount of dust on the bunker and feeder by weight, as well as the installation of closed spraying equipment in the dust formation zone, are presented.*

Keywords: *hopper, feeder, pipe, water, nozzle, technology, dust, dust quantity, dump truck, crushing point, aspirator, filter.*

Currently, one of the main problems arising in the world of open-pit mining is the excessive amount of dust, which causes serious damage to the environment, people, working elements of quarry equipment, and other equipment. Dust, carbon and nitrogen oxides, sulfur dioxide, hydrogen sulfide,

and other chemical compounds are released into the air of regions with a developed mining industry (Fig. 1).



Figure 1. Muruntau quarry

In the case of dust pollution of the environment, the process of loading rocks transported by road transport into the bunker is of great importance. The conducted studies showed that on average, every 3-5 minutes, cargo is dumped into the conveyor bunker installed in the Muruntau quarry by dump trucks, creating a dusty environment (Fig. 2).

a.  **b.**  **v.** 

Figure 2. View of dust particles generated during dump truck unloading

When monitoring the level of atmospheric pollution, the following sampling procedures can be used: single, lasting 20-30 minutes; discrete, where several samples (from 3 to 8) are taken into one aspiration device or filter at equal intervals throughout the day and daily, where the aspiration device or filter is carried out continuously throughout the day. Determination of air dust content using the direct weight method with dust filtration using an electric aspirator (weight method for determining the composition of air dust). Figure

3 shows the appearance of the PU-2P type aspirator. The PU-2P aspirator is designed for automatic sampling of air and aerosols (in the workplace, atmospheric and industrial waste) during sanitary and environmental control. The PU-2P aspirator provides sampling with a certain volume of flow through two parallel channels (0.5-5 l/min, 2-20 l/min - serial version) through absorbers of any type. Table 1 shows the meteorological parameters of the PU-2P type aspirator at crushing and reloading point No. 10 of the Muruntau quarry. The PU-2P type aspirator absorbed 20.0 l/min of dusty air for 3 minutes and collected dust in the filter, at which the air temperature on the device screen was 37.90C, the barometric pressure was 731 mmHg, and the air humidity was 29%.

DETERMINING THE DUST CONTENT IN THE AIR

The volume of the analyzed sample is determined by the formula:

$$V_t = \frac{q \cdot t}{100} = \frac{20 \cdot 3}{100} = 0{,}6\,litr = 0.0006\,м^3$$

where: q - air velocity at sampling time, l/min;

t - time spent on sampling, min;

The volume of the air sample taken for analysis is brought to a normal state at a temperature of 20°C and an atmospheric pressure of 760 mm Hg. For this, the following formula is used:

V_0 – volume of air that has passed through the filter, brought to a normal, m^3;

$$V_0 = \frac{V_t \cdot 273 \cdot P}{(273+T) \cdot 760} = \frac{0.0006 \cdot 273 \cdot 731}{(273+37.9) \cdot 760} = \frac{119.74}{236284} = 0.000506\,м^3$$

Determining the mass quantity of dust in the air is based on the fact that the volume of air (V_o) passes through the filter paper and the mass of this filter is determined before (m_1) and after (m_2). Dust concentration C (mg/m^3) is determined by the formula:

$$C = \frac{(m_2 - m_1)}{V_0} = \frac{(1.7300 - 0.5500)}{0.000506} = \frac{1.18}{0.000506} = 2332.01 mg/m^3$$

where: m_1 – initial filter mass mg;

m_2 – fresh mass of the filter from the allonge, mg;

All metrological conditions and experimental measurement results are recorded in Table 2. When measuring the mass concentration of specified substances in atmospheric air, the relative total error according to standards should not exceed ±25%.

The results of these experimental tests were obtained 6 times, and it was established that during the unloading process of the dump truck, the dust emission was from 2332.01x (500-650) m^3= (1166005-1515806) mg=1.166-1.515 kg to 3097.82x (500-650) m^3= (1548910-2013583) mg=1.55 - 2.01 kg. If a dump truck unloads these dust particles no more than 15 times per hour, then up to 15x (1.55-2.01) kg=23.25-30.15 kg of dust can appear. In the shift, the amount of dust appeared up to 11.2x (23.25-30.15) = (260.4-337.68).

A feeder is used to deliver the dump truck to the bunker at the Muruntau quarry to the loading point and rock crushing points. This hopper is supplied with water through all-way water pipes. Due to the scientifically unjustified use of spraying, dust suppression was not carried out in full. When spraying water, the size of dust particles, the diameter and parameters of the spray nozzles, and the installation location relative to the dust zone must be taken.

Nozzles are special tubes used for spraying liquids, i.e., for breaking down the liquid stream into small particles as it flows into the atmosphere (or into a gas-filled phase at high pressure). Their operating principle is as follows: first, a vortex motion of the liquid is created, and then the resulting flow is narrowed.

As a result of the introduction of liquid into the injector along the tangent, its angular momentum practically does not change, but as a result of the

narrowing of the flow, the rotational velocity increases, causing an increase in the shear force. This force presses the liquid against the wall at the outlet so that a thin layer of it forms, which at the outlet of the nozzle turns into small droplets. During this movement, an air (gas) vortex with a surface pressure of one atmosphere is created along the injector's axis. The formula for the liquid flow rate in the injector is written as follows.

$$Q = m \cdot S_0 \sqrt{\frac{2g\frac{p}{\gamma}}{1-\left(\frac{d_f}{d_q}\right)^2}} = m \cdot \frac{\pi d^2}{4} \sqrt{\frac{2g\frac{p}{\rho g}}{1-\left(\frac{d_f}{d_q}\right)^2}} = 0.62 \cdot \frac{3.14 \cdot 0.003^2}{4} \sqrt{\frac{2 \cdot 9.81 \cdot \frac{6 \cdot 10^4}{1000 \cdot 9.81}}{1-\left(\frac{0.003}{0.058}\right)^2}} = 4.38 \cdot 10^{-6} \cdot 10.970 = 0.000048 \frac{м^3}{see} = 0.048 \frac{l}{see} = 2.88 \frac{l}{\min}$$

where: p - pressure of the liquid inside the nozzle; $p = 6 \cdot 10^4 \, кg/м^2$

m - consumption coefficient; m=0.62

S_0 - cross-sectional area at the injector outlet.

d_f - surface from which water flows from the nozzle; $d_f = 3 мм$

d_q - inner surface of the pipe; $d_q = 58 мм$

One of the main tasks of the research work is the correct choice of the diameter of the nozzle, which releases a large amount of water droplets capable of suppressing dust particles. Depending on the parameters of the dust field, it was determined that there are 22 injectors, and the outlet diameter of the injector was chosen to be 3 mm.

Table 3 below shows the dependence of the injector's productivity, injector diameter, and water pressure.

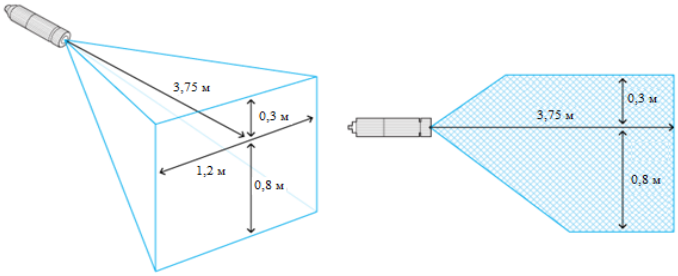


Figure 3. Injector diameter

In Fig. 3, at a nozzle outlet diameter of 3 mm and a pressure of 6-7 bar, the spraying distance of the nozzle was 3.75 meters, the width of the water range was 1.2 meters, and the height was 1.2 meters.

The dependence of the injector diameter and pressure on the spraying distance, width, and height is presented. For suppressing dust in the hopper and feeder at the crushing and reloading point of the Muruntau quarry with a nozzle diameter of 3 mm and a water pressure from the pump of 6-7 bar, the water flow rate is 2.88-3.11 l/min, based on which it is necessary to choose the type of pump.

1. Determining pump capacity.

$$Q = q \cdot n_{son} \cdot n_{avto} = 2{,}88 \cdot 22 \cdot 15 = 950{,}4 \frac{l}{\min} = 57024 \frac{l}{soat} = 57{,}024 \frac{m^3}{soat}$$

where, $q = 6bar$ and the productivity of 1 injector with a $d = 3mm$ nozzle diameter.

n_{son} - number of nozzles

n_{avto} - number of dump trucks

2. Determination of pump load.

$$H = H_h + iL = 10 + 0{,}05 \cdot 70 = 13{,}5m$$

where, H_h - water discharge height, m

i - coefficient of hydraulic losses, 0.025-0.05

L - total length of pipes, meters

Pump Night Load Pump Unipump ETSV 5-20-60 (other types of pumps can be selected in accordance with this parameter).

3. Determination of pipe diameters.

Determining the diameter of the water supply pipe.

$$d_{hay} = \sqrt{\frac{4 \cdot Q}{\pi \cdot \vartheta_{hay} \cdot 3600}} = \sqrt{\frac{4 \cdot 60}{3{,}14 \cdot 2 \cdot 3600}} = \sqrt{\frac{240}{22608}} = \sqrt{0{,}01061} = 0{,}103m = 103mm$$

$$d_{sur} = \sqrt{\frac{4 \cdot Q}{\pi \cdot \vartheta_{sur} \cdot 3600}} = \sqrt{\frac{4 \cdot 60}{3{,}14 \cdot 1{,}2 \cdot 3600}} = \sqrt{\frac{240}{13564{,}8}} = \sqrt{0{,}0177} = 0{,}133m = 133mm$$

where:

Q - pump capacity, $m^3 / soat$.

ϑ_{hay} - economical velocity of water flow in the water pumping pipe. 1,8 ÷2,5 m / sek

ϑ_{sur} - the economical flow rate of water in the drain pipe. 1÷1,5 m / sek

Using the above expressions, tables, and calculations, we can determine and select the diameter of the nozzle designed to suppress dust particles.

Based on the above calculations, it was determined that 2.88 liters of water pass through 1 nozzle per minute. Consequently, 2.88x22=63.36 liters per minute are sprayed from 22 installed nozzles. This dust can be suppressed in 30 seconds. Therefore, the suppression of dust released during the unloading of 1 dump truck can be calculated as follows. 63.36 l/min x 0.5 = 31.68 l/min. It is possible to unload 12-15 dump trucks per hour. Then 15x31.68 l= 475.2 l/hour. If we multiply by 11.2 hours to suppress the amount of dust in one shift, we get the following expression 475.2l/hour x 11.2 hours= 5322.24 liters, that is, 5322.24 liters of water can suppress dust during the shift.

Dust suppression can lead to a healthy lifestyle for many people, prevent technical malfunctions of conveyor reducers, drums, rollers, and lead to long-term operation of people and equipment in the quarry and quarry area.

In the dust formation zone, 60-70% of the dust is suppressed by spraying water using the open method.

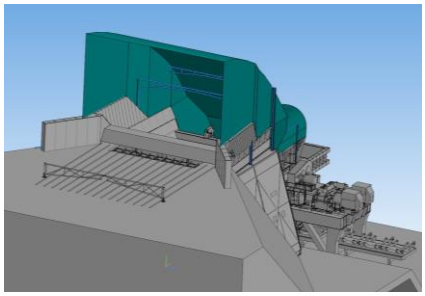


Figure 4. Diagram of the installation of closed spraying equipment in the dust formation zone (top spraying).

Dust formation is shown in Figure 5, the calculations are performed as in the open method, only to suppress the dust velocity, the surroundings are covered in the form shown in this figure. Then the velocity of the dust particles will reach 1 m/s, and the water particles sprayed from the nozzles will compress the dust particles, causing them to settle. This is the reason for choosing a 3-mm nozzle in this case. That is, the diameter of the smallest droplet exiting the nozzle must be larger than the diameter of the dust particles. As can be seen from Table 3, the diameter of the droplet exiting the nozzle with a diameter of 1 mm coincided with the diameter of the largest dust particle. It is also possible to work with a 1 mm nozzle, but during the unloading process of the dump truck, the speed of dust particles increases, and in this case, it is advisable to use a nozzle with a diameter of 3 mm. Thus, in the dust formation zone, it is possible to suppress up to 95-98% of dust by spraying water using a closed method.

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