

VENTILATION OF AN OPEN-PIT MINE THROUGH PIPELINES AND
UNDERGROUND MINE WORKINGS

F. R. Usmonov

Asia International University

Lecturer of the "General Technical Sciences" Department

Annotation

This article analyzes artificial ventilation methods in open-pit mines, particularly using pipelines and underground mine workings. The principles, advantages, and disadvantages of blowing and exhaust ventilation methods are discussed. Additionally, ventilation systems based on fans, aviation technology, and thermal devices are examined. Special attention is given to the effectiveness of aviation-based systems, especially the UMP-1 unit. The results show that these methods are most effective for local ventilation of small polluted zones.

Keywords

Open-pit mine, artificial ventilation, blowing method, exhaust method, fan, mine workings, pipeline system, airflow, polluted zone, local ventilation, aviation technology, UMP-1 unit, air-water flow, efficiency, mine atmosphere

Introduction: In artificial ventilation of an open-pit mine using pipelines and underground mine workings, pipes are laid from the surface along the sides of the pit to the required horizon or down to the pit bottom, or underground mine workings are utilized.

In artificial ventilation of the open-pit mine by the air supply method ("blowing" method), clean air from the surface or from an upper horizon is delivered into the pit through pipes or mine workings using fan units (Fig. 1), and this air spreads in the form of a free jet. In this case, the fan equipment may be installed on the surface or at any point along the pipeline (or working). When the fan operates in suction mode, it extracts polluted air from the pit and discharges it upward to the surface. This type of artificial ventilation method is called the "exhaust" (suction) method.

In the blowing ventilation method, clean air is supplied directly into the polluted air zone, resulting in a relatively higher ventilation rate of the zone.

In the exhaust (suction) ventilation method, air containing a high concentration of harmful substances is removed from the zone, and it is replaced by clean air flowing in from adjacent areas. Clean air enters the center of the polluted zone (where the source of contamination—usually operating machinery—is located) only after all harmful substances have been removed. Therefore, the duration of ventilation using the suction method is significantly longer compared to the blowing method.

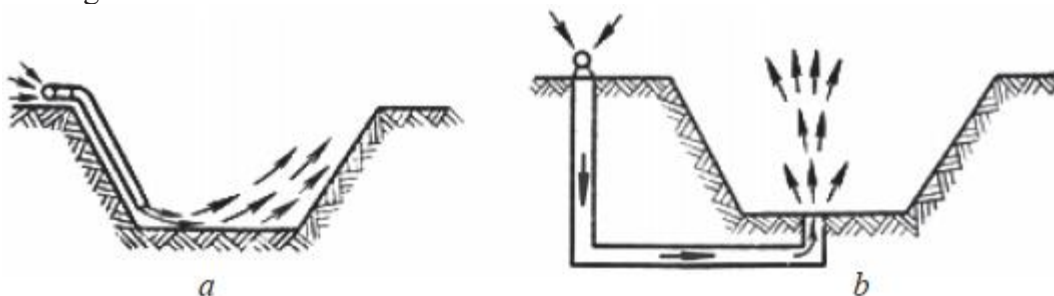


Figure 1. Scheme of open-pit mine ventilation by the blowing method:

a and b – respectively through pipelines and underground mine workings.

The removal of extracted polluted air outside the open-pit mine is considered an advantage of this method. However, in general, the efficiency of artificial ventilation methods using pipelines or underground mine workings is not very high. This is because the ability of existing ventilation systems to deliver air through pipelines or underground workings to the required ventilation zones is limited, and the associated costs are high.

The considered artificial ventilation method can be effective for ventilating small polluted zones if the pipeline or underground working is located close to the ventilation zones (workplaces). However, in open-pit mines, workplaces—and consequently ventilation zones—are frequently relocated. This, in turn, negatively affects the efficiency of artificial ventilation.

Due to the above-mentioned disadvantages, these artificial ventilation methods are not widely used in open-pit mine ventilation. Therefore, they are applied only under certain conditions, for example, when underground workings are used for other purposes (mine dewatering, transportation of rock mass, etc.), serving as an auxiliary ventilation method.

Ventilation systems using free air jets in open-pit mines can be divided into the following groups:

- I – systems based on fan units;
- II – systems based on aviation technology;
- III – thermal systems.

Fan-based systems. These ventilation systems use mine fans or special high-power stationary fans, as well as special open-pit ventilation fans of the PVU-6 type. All these systems are used for local ventilation of small polluted zones. In such cases, fans can be used with or without ducts.

Ductless fans are applied when the cross-sectional dimension of the polluted zone does not exceed the jet throw distance. This situation usually arises when local pollution is caused by the operation of machines (excavators, drilling rigs, etc.). In this case, the fan is installed within or near the polluted zone, and its air jet is directed toward the pollution source. As a result, the airflow generated by the fan disperses harmful substances away from the workplace into the open-pit atmosphere.

If the dimensions of the polluted zone exceed the jet throw distance, or if the fan cannot be installed within the polluted zone for some reason, it is placed at a certain distance from the zone, and ducted ventilation is used. Under such conditions, fans are typically installed at a distance of 100–150 m from the ventilation zone.

Systems based on aviation technology. At present, a number of ventilation systems based on aviation technology have been developed and are used in open-pit mines. These systems utilize either aviation engines or only the propellers of airplanes and helicopters.

Depending on the power of the drive units, aviation-based systems can be used for local ventilation or for ventilating the entire volume of the open-pit mine.

A unit of the UMP-1 type designed for local ventilation is based on a four-blade AV-2 aviation propeller with a diameter of 3.6 m and is mounted on the front part of a vehicle (Fig. 2).



Figure 2. UMP-1 local ventilation unit.

In addition to the propeller, the unit is equipped with a drive mechanism, a water spraying system, a pump drive, and a control system.

The control system ensures that the airflow direction can be adjusted in the horizontal plane up to 45° to either side relative to the longitudinal axis of the vehicle, and in the vertical plane up to 15° upward and downward.

When the unit operates in fan mode, the propeller generates a free air stream, and water is injected into this stream through nozzles. As a result, an air–water flow with a throwing (range) capacity of up to 350 m is formed, where the flow velocity reaches 0.25 m/s, and the air discharge amounts to $7500 \text{ m}^3/\text{s}$.

The use of this unit reduces the ventilation time of a blasted rock mass block by up to 3.5 times and ensures that the volume of air ventilated with the help of air and water flow reaches 10–12 million m^3 per hour.

Conclusion: In conclusion, artificial ventilation methods in open-pit mines have limited overall efficiency due to high costs and operational constraints. However, they can be effectively applied in specific conditions, particularly for local ventilation of polluted areas. Among the available methods, aviation-based systems demonstrate higher performance and efficiency, making them a promising solution for improving air quality and working conditions in open-pit mining operations.

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