

FORCES FORMING AIR MOVEMENT IN OPEN-PIT MINES

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Annotation: This paper discusses the movement and exchange of air in open-pit mines under the influence of natural and artificial factors. It highlights how wind energy, thermal forces, static pressure variations, and technological parameters affect air circulation. The main ventilation schemes, including direct-flow, recirculation, convective, and inversion systems, are described in detail. Additionally, the paper explains the use of local ventilation fans (LVF) to ensure effective air movement in deep or poorly ventilated zones of open pits. The efficiency of each method is compared, emphasizing the importance of proper air management for maintaining safe and productive working conditions.

Keywords: open pit mine, natural ventilation, wind energy, recirculation, inversion scheme, air exchange, local ventilation fan, convective flow

Introduction: Efficient air circulation in open-pit mines is essential for maintaining safe working conditions and ensuring effective removal of dust, gases, and heat from the working zones. The movement of air in open pits can occur naturally due to wind energy, thermal gradients, and changes in static pressure, or it can be enhanced through artificial ventilation systems.

Natural ventilation in open pits usually depends on wind direction, pit geometry, slope angle, and depth. Direct-flow and recirculation schemes are primarily influenced by these factors. During the daytime, convective air movements dominate due to the heating of air masses, while at night, inversion flows become more common as the air outside the pit cools faster than the air inside.

However, in deep pits or during calm weather, natural ventilation may be insufficient. In such cases, artificial ventilation using local fans becomes necessary. These systems significantly improve air exchange, making operations safer and more efficient. This paper explores these natural and artificial ventilation mechanisms, their operating principles, and their relative effectiveness in maintaining optimal air quality within open-pit environments.

Air movement in open pits can occur due to wind energy, thermal forces, changes in static pressure, and certain technological factors. In open pits, natural air exchange takes place throughout the year since calm, windless (still) days are rare (10–15%), and effective air currents are usually caused by the presence of wind. The average annual wind speed is 3–4 m/s. The efficiency of ventilation depends on the pit depth, the slope angle of the walls, technological factors, and wind direction. Ventilation of open pits using wind energy is carried out according to the following schemes.

Direct-flow scheme. This scheme is used for pits with wall slope angles less than 15°. In this scheme, the surface wind flow moves directly toward the pit benches (with slight turbulence). The efficiency of the direct-flow scheme is 2–3 times higher than that of the recirculation scheme.

Recirculation scheme. This scheme is used for pits with wall slope angles greater than 15° (Figure 9.1). In this case, straight-line wind flows are observed in the upper layers of the pit atmosphere, while in the lower layers, reverse or recirculating flows move along the benches.

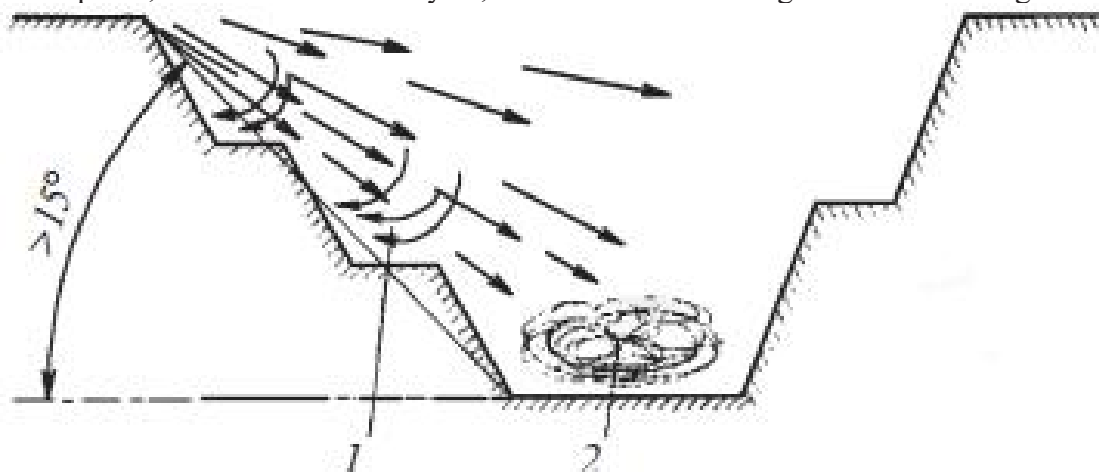


Figure 1. Recirculation of air in the pit using wind energy: 1 – recirculation of air in the working zone; 2 – non-ventilated zone.

Under the influence of recirculating flows, turbulent air motion occurs along the benches. In this scheme, the process of removing gases from the pit is significantly slower than in the direct-flow scheme, because the wind velocity in the upper atmospheric layers of the recirculation zones counteracts the upward movement of gases. Since the slope angles of most pit walls exceed 15° , non-ventilated zones are formed at the bottom of deep pits. The volume of such zones can reach up to 50% of the total pit volume. During natural draft ventilation of pits, the following schemes are used:

Convective scheme. This type of air movement mainly occurs during the daytime. In this case, the air inside the pit heats up faster than the external air, rises along the pit walls toward the cooler air masses, and ensures air exchange.

Inversion scheme. This scheme operates at night because the outside air cools faster than the air inside the pit and flows down along the walls into the pit, displacing the warm air upward and out of the pit (Figure 2). As the warm air rises through the center of the pit, the temperature increases, forming an air inversion. During inversion-mode ventilation, gases in the air descending from above may accumulate at the bottom of the pit.

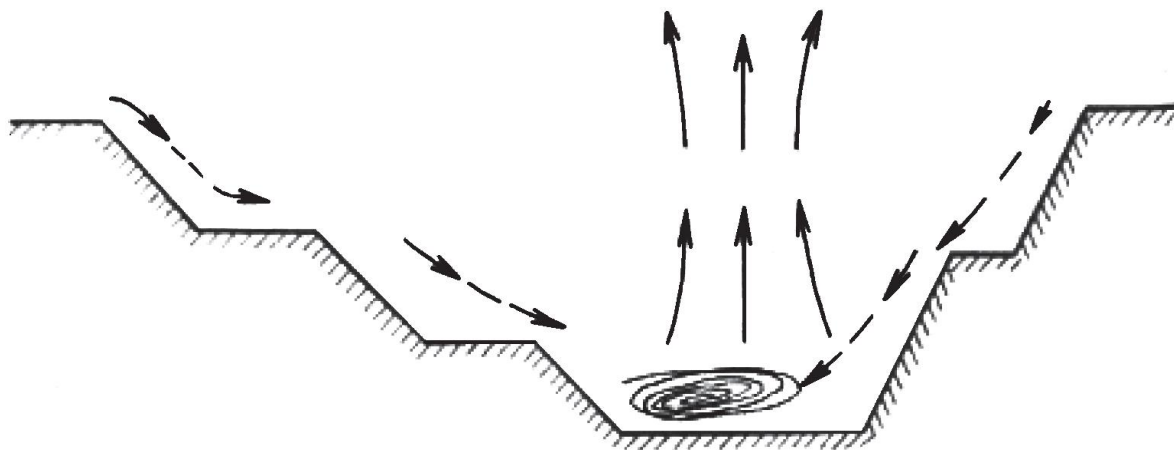
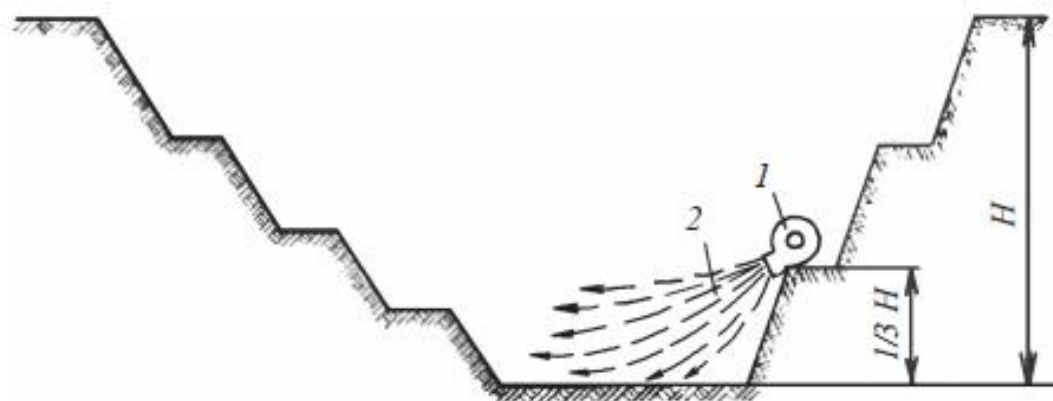


Figure 2. Inversion scheme of pit ventilation using natural draft.

If natural air exchange in the pit is insufficient, artificial ventilation using fans is applied to ventilate working areas. Local ventilation fans (LVF) must have high pressure capability. Air is supplied to the working zone through free jets (Figure



3).

Figure 3. Arrangement of a local ventilation fan on the inactive side of the pit: 1 – fan; 2 – free jet.

Using this method, the efficiency of ventilation can be 10–12 times higher compared to the blowing method and 20–25 times higher compared to the suction method.

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