

INTELLIGENT "SMART CROSSING" VENTILATION STRUCTURE FOR UNDERGROUND MINE TUNNEL INTERSECTIONS

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Abstract

This article explores an innovative method for controlling airflow at underground mine tunnel intersections — the intelligent "Smart Crossing" ventilation structure. It analyzes the shortcomings of traditional crossings, such as air leakage and energy losses. The proposed intelligent system enables real-time control of airflow using sensors and automated dampers.

Keywords: Mine tunnels, ventilation, crossing, intelligent system, aerodynamic resistance, Smart Crossing, automation.

Introduction

In underground mining, ventilation is a key factor for safety and operational efficiency. At tunnel intersections, special structures called crossings are used to separate clean and contaminated airflows without mixing. However, conventional crossings suffer from significant air losses (up to 20–30%) and high aerodynamic resistance, which increases the energy consumption of ventilation fans.

Analysis of Existing Problems. Current crossings are static structures that cannot adapt to changing underground conditions:

Air leakage: Clean air escapes through the edges of the structure into contaminated channels.

- **Energy inefficiency:** Uncontrolled airflow dynamics cause the ventilation system to operate under excessive load.
- **Lack of monitoring:** When gas composition (CH₄, CO₂) or air velocity changes, traditional crossings do not respond.

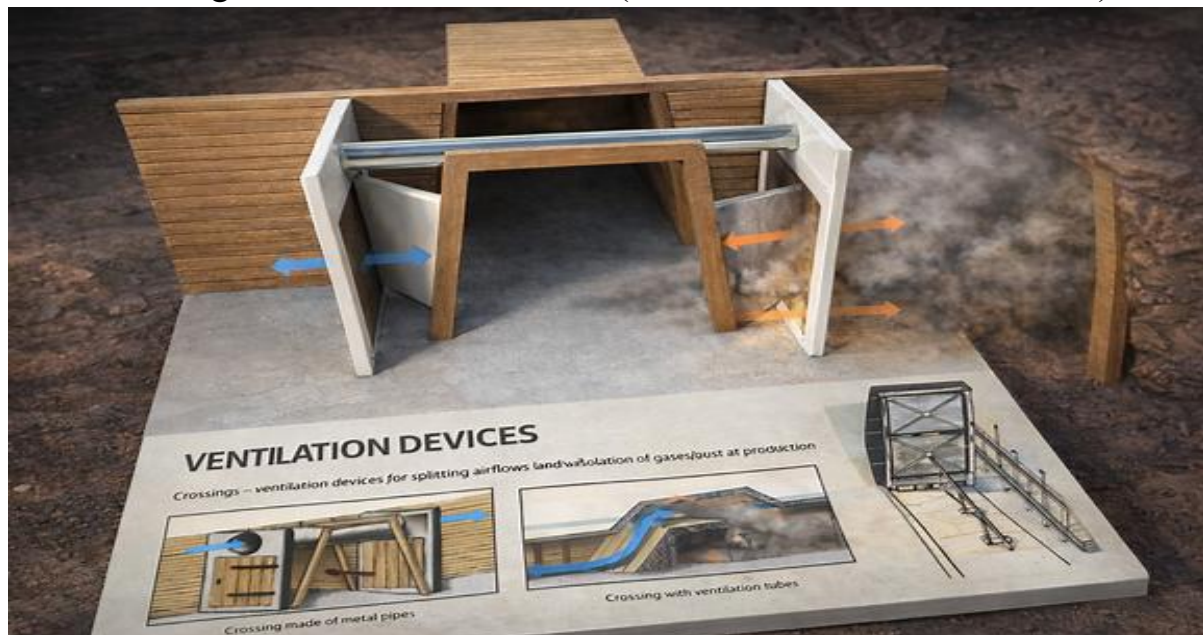
Design and Operating Principle of the "Smart Crossing"

The intelligent "Smart Crossing" system consists of the following key components:

1. **Automated Dampers:** Mechanical units that automatically adjust airflow direction and volume.
2. **Sensor Suite:** Devices that measure air velocity, temperature, humidity, and gas concentrations.
3. **Control Unit (PLC):** An intelligent system that processes sensor data and sends commands to the dampers.

Operating Mechanism

If blasting operations occur or gas levels rise in a specific block, the sensors detect it and the Smart Crossing system automatically directs more clean air to that area, while reducing airflow to inactive zones (Ventilation on Demand – VOD).



Pic.1. Crossings – ventilation devices for splitting airflows and isolation of gases/dust at production intersections

Economic and Technical Efficiency

Implementation of the Smart Crossing system yields the following benefits:

- **Energy savings:** Fan electricity consumption is reduced by 15–20%.
- **Reduced air leakage:** Use of modern sealing materials and automatic pressure regulation lowers air loss to 5–10%.
- **Safety:** In case of fire or emergency, the system allows remote closure of crossings to block smoke spread.

Conclusion

The application of the intelligent "Smart Crossing" structure at underground mine tunnel intersections is a significant step toward digitalization in mining (Industry 4.0). This system not only improves economic efficiency but also provides a high-tech solution for protecting the lives and health of underground workers.

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