THE GAS-DYNAMIC PARAMETERS MODELLING
OF THE OPENCAST ATMOSPHERE

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Abstract. The local meteorological elements are connected with technical, economic
and social parameters of the opencast atmosphere. The goal of this paper is the
realization of methods and the development of software for the calculation and
visualization of the distribution of contaminations in the quarry atmosphere, based on
a simulation study for the dynamics of moving air masses in the opencast space. The
software system for calculation of the gas-dynamic parameters in the opencast atmo-
sphere has been developed in the Delphi environment and tested on the calculation of
natural ventilation in an open-pit mine. The developed program and methodical com-
plex allows on-line computation for hydrodynamic fields, and simulating on their
basis a change in powder-gas conditions in the opencast. The results of calculations
may be used for creation of an ecological GIS of the mining-and-processing inte-
grated works and for the design of forced ventilation for mines. The further aim of
this project is the creation of an intellectual system for decision-making in real time,
so that dangerous areas can be revealed and neutralized with respect to powder-gas at
workplaces in deep opencasts.

Keywords: Gas-dynamic parameters, opencast atmosphere, dangerous areas

1. Introduction

Nowadays at working, reconstructed and newly created mines one of the important
items is the provision of a normal atmosphere, which meets the requirements of the
public health regulations and guarantees a safe and high-efficiency operation. The
underestimation of the effect of the atmospheric conditions developing in the opencast
leads to significant economic losses and influences negatively miners’ health [1].

The major factors determining the form of pollution for the atmosphere of
opencasts are velocity fields, the evolution of the source of detrimental impurities, its
strength and the distribution of the sources on the opencast area. A design study of the
abilities for a natural ventilation includes: calculations of the velocity fields in the opencast for various wind directions, the determination of the volumes in recirculation zones, the calculation of the total intensity of the evolution of harmful conditions, as well as the calculation of the concentrations within the harmful conditions in the opencast atmosphere, and the necessity to use a method for a forced ventilation.

Taking into account the complexity to solve spatial problems of the dissipation of pollution in the opencast, due to the terrain feature and the large volume of the processed information, it is necessary to make use of GIS-technologies (Geographical Information Systems). It is also desirable to use such numerical methods, as a complex approach for solving the problems connected with the environmental monitoring of the atmosphere in the whole mining area. There arises a social order to create a software system of complexes for the calculation of the gas-dynamic parameters of the atmosphere in opencasts. This order coincides with the goals of the «Guidelines of the State Policy on Protection of the Natural Environment» [2].

The goal of this paper is the development of software for the calculation and visualization of the distribution of contaminations in the opencast atmosphere based on a simulation study for the dynamics of moving air masses in space.

2. Results and Discussion

The usage of a single vortex method allows the creation of effective design models, which possess a withstand ability of systems of the algebraic equations to define the air-stream velocity in magnitude and in direction at any point of the mine [3]. The algorithm of this method is modified for the task of the simulation study of the mine’s space [4].

Let us consider the process of transporting the pollutants in the air. In the case of a two-dimensional statement of the problem the differential equation for transport of polluting substances is as follows:

\[
\frac{\partial \varphi}{\partial t} + \frac{\partial (u \varphi)}{\partial x} + \frac{\partial (v \varphi)}{\partial y} + \sigma \varphi = 
\]

\[
= \frac{\partial}{\partial x}\left( \mu_x \frac{\partial \varphi}{\partial x} \right) + \frac{\partial}{\partial y}\left( \mu_y \frac{\partial \varphi}{\partial y} \right) + \sum_{i=1}^{N} q_i(t) \delta \left( \sqrt{(x-r_i(t))^2 + (y-r_i(t))^2} \right)
\]

Where \( \varphi \) is the concentration of a polluting substance in the unit of volume; (for gas and aerosol contaminants); \( v \) is the air velocity (a contaminant gas or aerosol); \( \sigma \) is the disintegration constant of contamination (of chemical decomposition, neutralization, washout); \( \mu_x, \mu_y \) are factors of the turbulent diffusion; \( q_i \) is the intensity of point sources of contamination, which can be a random function of time; \( r_i = (x_i, y_i) \) are the coordinates of the locations of the point sources (sources can move, and that is considered by a dependence \( r_i(t) \)); \( \delta \) is the Dirac delta function.