A new method of determining the speed of gravitational settling of particles of industrial emissions

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Turbulent diffusion of industrial emissions is one of the main transport mechanisms that determine the spatial distribution of pollutants in the atmospheric surface layer. Experimental study of the spread of contaminants requires a huge number of sensors that is a very time-consuming task. Known method of studying the basic laws of the spatial distribution of the contaminant is a mathematical modeling of particles transport in the air. The diffusion-convective model of impurity transport has been widely recognized [1]. One of the main transfer parameters in this model is the gravitational sedimentation rate of dirts V_g.

The known methods for determination of this value are based on the sedimentation principle -speed and time of sedimentation of particles of different masses under the action of gravity forces or other inertial forces are not the same. In accordance with the measuring methods, the deposition of particles occurs either in a fixed dispersive medium or in the direction of moving at a high speed of stream of dust and gas that cannot properly take into account the aerodynamic properties of the particles moving in a turbulent atmosphere. In this paper, we propose to define Vg based on the measured along any direction from the source distribution function of pollutants in ambient air. Traditional methods of measuring tools of this function, especially at large distances from the source, are of little use, since to obtain reliable results a longer exposure time is required. Therefore, the research was carried out of using mosses for which the exposure time is 1-10 years. Obviously, the content of chemical elements accumulated during exposure in mosses, is in proportion to their content in the air, so the dependence of the element concentrations in mosses and concentrations of pollutants in the atmosphere has the same analytical form.

The purpose of this work is testing of a new method of determining the rate of gravitational settling of particulate emissions of the industrial enterprises (based on the measured along the chosen direction distribution functions contaminant for CHP-5 in Novosibirsk and Kandalaksha aluminum plant).

Research methods

In this paper, the definition of V_g is based on semi-empirical equation of turbulent diffusion, obtained for a point source at a degree of approximation of wind speed and vertical turbulent diffusion coefficient k_z [1]:

$$q(x) = \theta_1 x^{-\theta_2} exp\left(-\frac{\theta_3}{x}\right). \qquad (1)$$

The nature of this function is determined by the values of the parameters θ_2 and θ_3, depending on the height of the tube gas cleaning disperse composition of impurities, terrain and weather conditions. In article [1] for parameters θ_2 and θ_3 the following expressions:

$$\theta_3 = \frac{u_{\text{пр}} H^{1+n}}{(1+n)^2 k_{\text{пр}}} = \frac{u_1 \left(\frac{H}{z_1}\right)^n H}{(1+n)^2 k_{\text{пр}}}, \qquad (2)$$

$$\theta_2 = -\left[\frac{3}{2} + \frac{V_g}{k_{\text{пр}}(1+n)}\right],$$

where n – parameter characterizing the change in wind speed with height z;

H – the height of the pipe pollution source;

$u = u_1 \cdot \left(\frac{z}{z_1}\right)^n = u_{\text{пр}} \cdot (z)^n$;

u_1 – wind speed at a height z_1;

$u_{\text{пр}} = \frac{u_1}{z_1^n}$

$k_z = k_1 \frac{z}{z_1} = k_{\text{пр}} z$;

The numerical values of parameters θ_2 and θ_3 can be found by the method of least squares (OLS) for the approximation of the measured concentrations of chemical elements contained in mosses function of form (1). Then the expression (2) can be used to determine V_g:

$$V_g = -\frac{\left(\theta_2 + \frac{3}{2}\right) u_1 * \left(\frac{H}{z_1}\right)^n H}{(1+n)\theta_3}. \quad (3)$$

It is necessary to substitute the averaged over the period of exposure values of wind speed (u_1) at an altitude z_1, when using formula (3) to calculate V_g.

Experiment

In this paper, for the study of mosses was sampled *Pylaisia polyantha* (Hedw.) and *Sanionia uncinata*, which corresponded to the length of the growth period of the three-year exposure. Samples of mosses *Pylaisia polyantha* was selected in a northeasterly direction at a distance of 1-5 km from the power plants and the moss *Sanionia uncinata* - at distances of 1-7 km kilometers to the north of the aluminum plant (Figure 1).

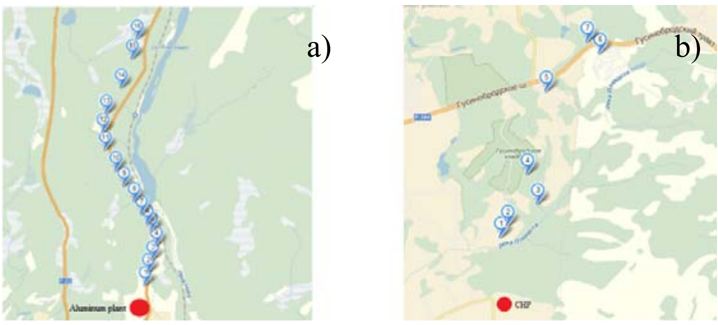

Figure 1. Map of sampling in the zone of influence of the enterprises: a) Aluminum plant; б) CHP

Sample preparation for measurement moss performed according to the procedure of [2]; the determination of chemical elements in samples of moss carried out in scientific departments of Tomsk Polytechnic University: by neutron activation method (NAA) on a research nuclear reactor IRT-T and by atomic emission spectrometry (AES) in spectrometer iCAP6300 Duo Research of Analytical Center. Analysis of the measurements showed that the concentrations of most chemical elements with increasing distance first increase, at distances of several kilometers are the maximum and then decrease. As an example, Figure

2 shows the results of measuring points concentrations of some chemical elements in mosses taken at different distances from the source.

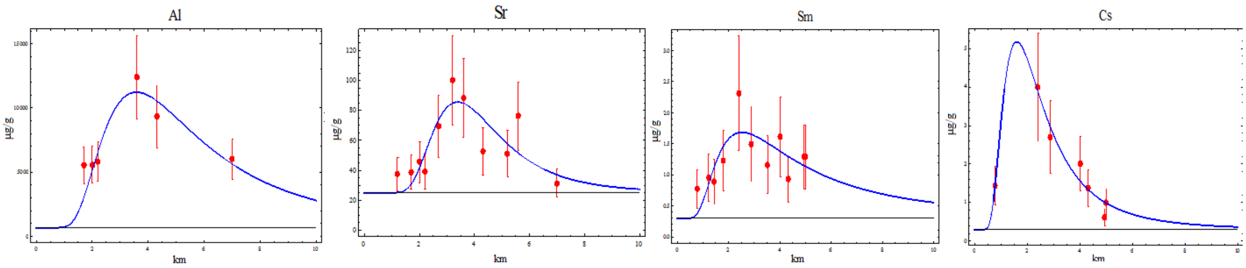

Figure 2. The concentrations of chemical elements in mosses sampled in the zone of influence:
horizontal line - background concentrations;
solid curve - the result of the approximation function of the form (1).

The results of calculation and analysis

Table 1 shows values θ_2, θ_3, V_g for CHP-5 of Novosibirsk ($\overline{u_1} = 3{,}7\frac{m}{s}$, H = 260 m) and Kandalaksha aluminum plant ($\overline{u_1} = 2{,}3\frac{m}{s}$, H = 120 m) at n = 0,2. From Table 1, it is seen that V_g of aluminum plant emissions particles is varies in the range of 13,3-20,3 cm/s; particle emissions of CHP range is 75-166 cm/s. Average values and confidence intervals of gravitational settling speed of aluminum plant and CHP emissions at a significance level of 0,05 are V_g = 15,4±1,3 cm/s, V_g = 99,2±11 cm/s respectively. Thus, the average velocity of the gravitational settling of the coal particles of CHP almost six and a half times greater than for aluminum plant emissions. These results are consistent with the reference data of the dispersed composition and particle emission rate falling off these types of productions [3].

Table 1. Values of parameters θ_2, θ_3, gravitational settling velocity V_g for CHP ($\overline{\boldsymbol{u_1}} = \boldsymbol{3,7\,m/s}$, H=260 m) and Kandalaksha aluminum plant ($\overline{\boldsymbol{u_1}} = \boldsymbol{2,3\,m/s}$, H=120 m) at n=0,2

Kandalaksha aluminum plant				CHP-5 Novosibirsk			
Element	θ_2, km	θ_3, km	V_g, cm/s	Элемент	θ_2, km	θ_3, km	V_g, cm/s
Al	4,1	14,9	14,2	Fe	5,8	15	74,9
Ba	7,5	23,7	14,4	Sm	2,7	6,9	93,6
Co	4,7	13,7	17,1	Cs	4,3	6,9	129,3
Sr	7,8	26,4	13,3	Mb	2,6	3,8	166,0
Cu	4,9	14,7	16,5	Ce	8,1	16	92,3
Li	3,1	12,1	14,4	Yb	6,1	15	77,9
Ti	8,5	28,2	13,4	Zn	2,5	7,3	84,3
V	3,5	9,3	20,3	Eu	2	4,7	114,5
Na	13,8	39,8	14,5	Sc	5	12	83,3
Mn	3,9	12,9	15,8	Ca	6,9	17	76,0

The data presented in [3] shown that for the vast number of CHP emissions particles (about 70%) and aluminum plant (about 90%) the rate of fall in the dispersing liquid (kerosene and isobutyl alcohol, respectively) does not exceed 10,6 cm/s. Such a marked difference between the gravitational settling speed of emissions particles, computed by formula (3) and the reference data on speed of fall of the particles are explained by two reasons: subsidence occurs in two different environments with very different densities; the value of the gravitational settling velocity in the air is greatly affected by turbulent flows.

Conclusions

1. There is currently no means of determining the speed of gravitational settling of particles of industrial emissions in atmospheric turbulent flows. The average velocity of gravitational settling of particulate emissions of coal thermal power station (99,6 cm/s), it is up to six times higher than that of the aluminum plant emission's particle (15 cm/s). These results are consistent with the known composition of the particulate emissions of these types of productions.
2. The rate of gravitational settling, determined by known methods, cannot be used in describing the dispersion of pollutants from a point source of pollution in the turbulent atmosphere.

References:

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Radio-chemical of fluorine-containing polymer "TEFLON-2M" for giving proton conducting properties

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Annotation. *The experimental study of the kinetics of styrene monomer accumulation in polyvinylidenefluoride films with radiation-chemical grafting of styrene monomer is presented. It is proved that the degree of grafting depends on the absorbed dose of helium ions, temperature and composition of the grafting solution.*

Introduction

Intensive research is being conducted to establish a commercially available functional proton conducting membranes. Important role in the biological processes, such as ATP synthesis, plays controllable proton transport. Proton-proton transport through the polymer membrane is also used in hydrogen fuel cells.

The objective of this study was to investigate the formation of the proton conductivity in the fluorine-containing polymer PTFE-2 M using radiation-chemical modification.

The starting material is a polymer film Teflon -2M of thickness - 20 microns. Samples of circular diameter –(80 mm) have been washed in toluene solution for 1.5 hours in the ultrasonic bath and then dried in the oven for three hours at 50^0C.