

Comparative Analysis of Modeling the Fields of Harmful Emissions from Vehicles Using Deterministic and Interval Approaches

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Abstract - The process of diffusion the harmful emissions from vehicles is comfortably describe by differential equation in partial derivatives. However, the measured data for these models have some measurement errors. So it is better to represent the input data in interval kind.

Keywords – Diffusion, Macro-modeling, Method of finite differences, Difference Operator.

I. RESEARCH PROBLEM STATEMENT

One of the components in environment monitoring systems is software and hardware complex that enable to get the real concentration of harmful emissions from vehicles. There the mathematical models of harmful emissions diffusion in the atmosphere, water and soil are used. These mathematical models belong to mass transfer class and based on the equations in partial derivatives. Vehicle's flow is the complex distributed object, so it is almost impossible obtain the overall situation of city's pollution using the known modeling methods. From other side measurement the actual concentrations of harmful emissions by devices of sanitary-epidemiological station makes it possible to build a macro-models as stationary and nonstationary fields of harmful pollutions. This data is useful to present in interval kind. In macro-modeling this approach requires studying the processes of mass transfer and on this basis the interval macro-model creation, computer simulation of these processes, and comparison the simulation results based on interval macro-models with results obtained by using the equations of mathematical physics that is actual research.

II. COMPUTATION SCHEME ANALYSIS IN CASE OF DETERMINISTIC APPROACH

Let's consider at the model level the application of this equation on example of the diffusion equation of parabolic type for building the field of harmful emissions:

$$\frac{\partial u}{\partial t} = a^2 \frac{\partial^2 u}{\partial x^2} + b \frac{\partial u}{\partial x} + gu, \quad 0 < x < 1, t > 0 \quad (1)$$

where a is horizontal component of the exchange coefficient; b is component of the average speed of movement the harmful pollutions in direction the x axis, accordingly; g is coefficient of change the pollutant concentration [1].

This equation can be solved by using Crank-Nicholson scheme of finite differences [2].

$$\frac{u_i^{j+1} - u_i^j}{\tau} = \frac{1}{2} \frac{u_{i+1}^{j+1} - 2u_i^{j+1} + u_{i-1}^{j+1}}{h^2} + \frac{1}{2} \frac{u_{i+1}^j - 2u_i^j + u_{i-1}^j}{h^2} \quad (2)$$

Above the foregoing shows the unsuitability of this approach for modeling concentration field emission as distributed sources of emissions because of impossibility: setting the intensity of emission sources; present data in a difficult interval setting boundary conditions; diffusion coefficients a , b and g are unknown; Crank-Nicholson scheme does not always result in convergence of task solving. So easy to solve this task using macromodeling previously conducting structural and parameter identification of the macro-model based on interval data.

III. MACRO-MODELING TASK STATEMENT AND ITS SOLVING ALGORITHM'S FEATURES

Let's describe the diffusion of harmful emissions by using differential operator as a system:

$$\begin{cases} [u_{0,0}] \subseteq [z_{0,0}], \dots; \\ z_{i,j}^- \leq f^T([u_{0,0}], \dots, [u_{0,j}], [u_{1,0}], \dots, [u_{i-1,j-1}]) \cdot \mathbf{g} \leq z_{i,j}^+; \\ [u_{i-1,j-1}] = f^T([u_{0,0}], \dots, [u_{0,j}], [u_{1,0}], \dots, [u_{i-2,j-2}]) \cdot \mathbf{g}. \end{cases}$$

Computing scheme the parameter identification of the difference operator is based on three steps: 1) setting in the interval kind the initial values of the predicted characteristics; 2) setting the initial conditions or the current estimation of parameters vector in differential operator; 3) implementation of the recurrent scheme for obtaining the interval estimates of discrete predictable characteristics.

IV. CONCLUSION

The analysis of using the differential equation in partial derivatives for modeling the fields of harmful emissions from vehicles show that it is difficult to use this equations for solving this class of tasks. The computational schemes for solving the indicated task is research. It is found that in this case macro-modeling the fields of harmful emissions is most suitable. But it is necessary previously conduct structural and parametric identification of macro-model using interval data as the results of measuring the concentration of harmful emissions.

REFERENCES

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