*Materials of Conferences*

**WORK ACTIVITIES' MATHEMATICAL SIMULATION HEURISTIC ASPECTS BASED ON CONSTRUCTIVE GEOMETRY AS AUTHOR'S SPECIAL COURSE FOUNDATION**

Vertinskaya N.D.
*Irkutsk State Technical University*
*Irkutsk, Russia*

In recent years the mathematical modeling on the basis of constructive descriptive geometry was aimed at work activities, the factors, parameters and components of which can be represented in the form of many-dimensional manifolds [1, 2, 3]. Such problems arising in practice in the processes of chemical changes, physical phenomena, socioeconomic events, etc., are impossible to be solved by classic methods of mathematical simulation, as the number of variables reflecting the corresponding multidimensional functional relationships exceeds the dimensionality of the real spatial area, wherein these processes take course. Together with that, the descriptive geometry is able to consider the many-dimensional manifolds as function spaces of many variables; that allows it to present such processes visually in the form of surface equations and their geometrical models, from which it is possible to forecast quickly optimum performances and parameters of the studied processes with the help of computer equipment.

The work activities, in terms of constructive geometry, are subdivided into the processes with the chemical substances non-reacting (first method) and reacting with each other (second method). Two methods of obtaining their models in the form of equations and graphic presentation have been developed for their simulation.

Mathematical modeling on the basis of constructive geometry is heuristic, as it is based on the ability to find out functional relationships by many-dimensional test values.

The laboratory research allowing obtaining multidimensional arrays of points by experimental methods and simulating real electrochemical and bioparametrical processes on their basis are included into the special course.

The special course includes:

1. Brief mathematical introduction.
2. Introductory mathematical practical course.
3. Introductory laboratory course.
4. Laboratory research.
5. Research assignments on process optimization.

Brief mathematical introduction.

The values, which are the factors, parameters and components, can appear as variables at the mathematical modeling.

In the chemical systems, wherein the substances do not react with each other, the number of components is equal to the number of constituents (first method). In the chemical systems, wherein the substances undergo reactions, the number of components changes in the process of reaction.

To apply the first modeling method the theorem is proved:

The sum of equations of right sections of a connective gives an equation of the surface bearing these sections [4].

The second method allows modeling the processes of the substances reacting with each other described by the carcasses of the surface spanned by a sheaf of imaginary axis sections bearing one-dimensional generators, parameter bearers of 2 – surfaces, 3 – surfaces, etc.

The purpose of the introductory mathematical practical course is to study theoretical foundations of obtaining work activities' mathematical models and overlearning surface equations and their geometrical models derivation according to tabulated values of real experimental measurement parameters of multifactorial and multiparameter processes in multicomponent systems.

The core attention in the process of mastering the brief mathematical introduction should be paid to the features of obtaining models incident with sections:

1) 9 experimental points are enough for a sheaf of planes, when to construct the whole studied surface with the required accuracy it is necessary to carry out experimental study in the total space and to obtain its model [5].

2) A sheaf of planes with an imaginary axis needs to have not less than 27 experimental points available to obtain the model and arrange its equation.

In accordance with the curriculum the special course contains as few practical hours based on the results of real research as possible.

To illustrate the abovementioned let us analyse one of the numerous samples of out research. The HAR IHPP-12 sewage waters were treated with induction current. Together with that we defined optical density by the agency of a PEC, hydrogen ions' pressure (pH) by means of an ion meter in the treated water and the HAR control sewage water in fixed time periods (Table 1).

As many parameters, factors and components changed in our research, our equations are sections of a certain multidimensional hypersurface, as a matter of fact.

**Table 1.** HAR waters' induction current treatment results, I = 1; 1,5; 2,5 A

| N | T | PH | $\overline{p}H$ | $D_{start}$ | $D_{end}$ | h | PH | $\overline{p}H$ | $D_{start}$ | $D_{end.}$ | h | pH | $\overline{p}H$ | $D_{start}$ | $D_{end}$ | H |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I= 1 A | | | | | | | I=1,5 A | | | | | I=2,5 A | | | | |
| 1 | 0 | 8,6 | 8,6 | 0,085 | 0,085 | 1,5 | 8,6 | 8,6 | 0,085 | 0,085 | 1,5 | 8,6 | 8,6 | 0,085 | 0,085 | 1,5 |
| 2 | 3 | 8,6 | 8,2 | 0,085 | 0,068 | 2,5 | 8,6 | 8,2 | 0,085 | 0,065 | 2,5 | 8,6 | 8,0 | 0,085 | 0,056 | 2,5 |
| 3 | 6 | 8,2 | 7,9 | 0,068 | 0,049 | 2,5 | 8,2 | 7,8 | 0,065 | 0,036 | 3,0 | 8,0 | 7,7 | 0,056 | 0,035 | 3,5 |
| 4 | 9 | 7,9 | 7,7 | 0,049 | 0,039 | 3,0 | 7,8 | 7,6 | 0,036 | 0,032 | 3,5 | 7,7 | 7,5 | 0,035 | 0,032 | 4,0 |
| 5 | 12 | 7,7 | 7,5 | 0,039 | 0,036 | 3,5 | 7,6 | 7,5 | 0,032 | 0,032 | 3,5 | 7,5 | 7,3 | 0,032 | 0,028 | 4,0 |
| 6 | 15 | 7,5 | 7,2 | 0,036 | 0,035 | 3,5 | 7,5 | 7,1 | 0,032 | 0,032 | 3,5 | 7,3 | 7,1 | 0,028 | 0,024 | 4,0 |
| 7 | 18 | 7,2 | 7,1 | 0,035 | 0,035 | 3,5 | 7,1 | 7,0 | 0,032 | 0,032 | 3,5 | 7,1 | 7,0 | 0,024 | 0,024 | 4,0 |
| 8 | 21 | 7,1 | 7,0 | 0,035 | 0,035 | 3,5 | 7,0 | 7,0 | 0,032 | 0,032 | 4,0 | 7,0 | 7,0 | 0,024 | 0,024 | 4,0 |
| 9 | 24 | 7,0 | 7,0 | 0,035 | 0,035 | 3,5 | 7,0 | 7,0 | 0,032 | 0,032 | 4,0 | 7,0 | 7,0 | 0,024 | 0,024 | 4,0 |

According to the tabled values we obtain the studied process model

$$\Phi(D_{s.}, D_{e.}, pH_{s.}, pH', I, t, h) = 0$$

For a graphical presentation we cut it with two planes into 2 surfaces

$$D_{s.} = F(I,t) = 8{,}65\ 10^{-2} + (-4{,}43\ 10^{-3} I - 1{,}29\ 10^{-3} I^2) + (1{,}06\ 10^{-4} + 1{,}08\ 10^{-4} I - 6{,}17\ 10^{-3} I^2)t^2; \quad (1)$$

$$D_{e.} = \Delta(t,I) = (4{,}97 10^{-2} + 5{,}33 10^{-2} I - 2{,}22 10^{-2} I^2) + (1{,}99 10^{-3} - 1 10^{-2} I + 3{,}43 10^{-3} I^2) + 5{,}64 10^{-4} + 3{,}81 10^{-4} I - 1{,}24 10^{-4} I^2)t^2; \quad (2)$$

$$pH_h = \Sigma(t,I) = (8{,}52 + 5{,}49\ 10^{-1} I - 2{,}71\ 10^{-2} I^2) + (-2{,}38\ 10^{-2} - 1{,}29\ 10^{-1} I + 4{,}52\ 10^{-2} I^2)t + (-1{,}65\ 10^{-3} + 4{,}45\ 10^{-3} I^2)t^2; \quad (3)$$

$$pH' = \Psi(t,I) = (8{,}12\ 10^{-2} + 5{,}91\ 10^{-1} i - 2{,}13\ 10^{-1} I^2) + (-3{,}88\ 10^{-2} - 9{,}62\ 10^{-2} I + 2{,}96\ 10^{-3} I^2)t + (-4{,}62\ 10^{3} + 3{,}24\ 10^{-2} I - 9{,}11\ 10^{-3} I^2)t^2; \quad (4)$$

$$h = \Omega(t,I) = 1{,}51 + (-8{,}09 10^{-2} + 3{,}49 10^{-1} I - 8{,}88 10^{-2} I^2)t + (4{,}76 10^{-3} - 1{,}21 10^{-2} I + 3{,}17 10^{-1} I^2)t^2. \quad (5)$$

A combined graphical presentation of the equations (1)-(5) in the form of an extended multilevel Radishchev drawing allows depicting a hydraulic ash removal sewage treatment semi-parameter technological process under the action of induction currents in three-dimensional spatial area graphically and calculating optimal values of the parameters:

$t_{opt}$=20min, $I_{opt.}$>2,5Amper, $h_{opt.}$=4,0 mm

and formulating a conclusion about the total absence of suspended matters in the waters treated with induced currents and the pH value of 7,0; that testifies to approaching to normal properties of the treated waters and the possibility of their being reused for the ash-slag pulp transportation. On the research base an application for an invention ("Hydraulic ash removal water purification device") was filed and a patent (№ 2199491) was obtained.

The purpose of the second laboratory course is to study the operating rules and mechanism of standard industrial gauges, which allow performing effective measurements of most important physical and chemical parameters of solutions and acquiring operating skills. In accordance with the curriculum the special course contains as few laboratory hours necessary to acquire practical skills of experimental measurements using pH meter, photoelectric colorimeter and spectrophotometer as possible.

A special attention in the introductory laboratory course should be paid to hard-and-fast carrying out safety instructions stated in the devices' service manual. The carefulness in performing all the operations of preparation and carrying out experiments and proper treatment of the devices are of great significance in the obtained measurement results' objectivity.

The laboratory research purpose is to study many-dimensional manifolds in the form of function spaces obtained in the process of experimental measuring of real technological processes' parameters in multicomponent systems and the formation of skills of practical application of methods of modeling multifactorial and multiparameter technological processes in multicomponent systems.

An important fact of the present special course mastering efficiency upgrading in conditions of creative atmosphere at solving topical technological problems lying in the area of students' vocational interests should be made a point on here.

From the experience of the present special course one may conclude that graduation and term papers on real production assignments of industrial enterprises can be one of concrete forms of such academic creative tasks; for example:

1. Mathematical modeling of multicomponent mixtures of non-reacting substances.

2. Multidimensional mathematical modeling for the purpose of work activities' optimization by the example of electric coagulation in sewage waters at their being treated with induction currents.

3. Mathematical modeling of an electrodeless electrochemical process in solutions at their being treated with induction currents and the like [6].

The purpose of research tasks is to reinforce the acquired earlier knowledge on modeling many-dimensional manifolds in the form of function spaces obtained in the process of experimental measurements of real technological processes' parameters in multicomponent systems and to form creative skills of practical application of mathematical modeling methods; for example:

a) Examination and optimization of the operating regime for a pipeline inner surface electrochemical metallization and passivation plant (patents № 2241075and № 2244766).

b) Mathematical modeling of a biochemical process at electrodeless disinfection of environmental waters (patent № 2264992).

c) Mathematical modeling of the chemical coal conversion process (patent № 2272825) and others.

4. Follow-up study perspectives. The introduction into HEI specialist training of the special course on mathematical modeling of technological processes on the basis of constructive geometry is intended for the formation of an up-to-date engineer able to independent exploration, finding and solving scientific and technological problems of sophisticated technology.

The special course is scheduled for 454 hours (90 lecture-hours, 108 hours of practice, 46 hours of laboratory research, and 210 hours for term papers among them) from the second to eighth semesters.

**References:**

1. Vertinskaya N.D. Multidimensional mathematical modeling of multifactorial and multiparameter processes in multicomponent systems / N.D. Vertinskaya – Irkutsk: ISTU Publishing House – 2001 – p. 289.

2. Vertinskaya N.D. and others. Mathematical modeling of technological processes based on constructive geometry (laboratory course) - Irkutsk: ISTU Publishing House – 2007 – p. 176.

3. Vertinskaya N.D. Author's optional special course as a creative personality preparation method at higher school. Article collection of II All-Russia Congress of mathematician-women. Krasnoyarsk – 2002 – pp. 13-19.

4. Vertinskaya N.D. Simulation and construction of bearing higher plane curve carcass surfaces. Present-day problems of geometric simulation. Kharkov – 2007 – pp. 243-249.

5. Vertinskaya N.D. Mathematical modeling of substances non-reacting with each other. Issue № 22, part 1. Lutsk. 2008 – pp. 51-57.

6. Vertinskaya N.D. and others. Research and development of coal extraction electrochemical method using mathematic simulation. Ugli, № 1 – 2008 –pp. 66-67.

The work is submitted to Scientific Conference "The Problems of International Integration of Educational Standards", England (London) – France (Paris), April 20-28, 2009. Came to the Editor's Office on 25.12.2008.