At the present stage of development the main purpose of developers of defectoscopy systems and devices is a fully automated inspection process to eliminate the human factor and to increase efficiency. Software is being developed, whose main task is to analyze the signals received by the defect detector. However for reliable and trouble-free operation of this equipment and software it's necessary to observe a number of conditions that can be regarded as the shortcomings of the echo-method. The first condition is the need for permanent preservation of an acoustic contact between the piezoelectric converter and the tested surface. Contacting liquid used for the contact is the matching substance that keeps the focus of the ultrasonic wave during its introduction in the tested object. Accordingly, in its absence (or insufficient amount) the control can not be called qualitative. The second condition is the absence of contamination on the surface of the scan. In the presence of contaminants, as in the case of the acoustic contact, it is impossible to speak of a qualitative control.

Summarizing all the above, it is certain that a variety of methods and means of defectoscopy at this stage of development allows detecting almost all defects in tested objects. The choice of the method depends on the goals and tasks of the control. During rail defect detection the echo-method is widespread used due to its advantages. Work is under way to improve the methods and automation of defectoscopy process but complete elimination of human involvement in the process is quite problematic.

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CONTRIBUTION OF EXCESSES OF THE HIGHEST ORDER IN THE DIFFUSION BLURRING CONCENTRATION SPOTS

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The paper develops a new ideology of solving the equations of mathematical physics, describing the molecular nature of the phenomenon. Owing to the nature of the problem to be solved the quasi-stationary probability density of a random variable, associated with the desired function, is introduced. The diffusion in an endless tube is considered as an example. The asymptotic behavior of the probability density of the diffusing particles is obtained coordinates study its statistical moments. Their evolution in time is set by the diffusion equation (without solutions) and the associated initial condition. It is shown how the error is associated with the excesses of the distribution function if the exact solution is replaced by its asymptotic expression.

Diffusion plays an important role in many processes of chemical technology. For example, the penetration of impurities into the porous beads is a rate-limiting step in the problem of sorption dynamics. Usually the diffusion is modelled by the methods of mathematical physics, not taking into account the molecular nature of the phenomenon at the solution of the relevant partial differential equations. This article develops an alternative approach proposed in [1, 2] for solving the problems of sorption dynamics.

For simplicity we take one-dimensional case, and we write the diffusion equation in the form

$$\frac{\partial n(x,t)}{\partial t} = D\frac{\partial^2 n(x,t)}{\partial x^2}, \tag{1}$$

where $n(x,t)$ - volume concentration of impurities, t – time, x – coordinate, D – diffusion coefficient.

In the presence of the initial condition it has a unique solution (1) (see [3].), which allows to reliably predict the value $n(x,t)$ at any given time. However, despite this determinism, the coordinates of individual impurity molecules are random variables, the distribution law of which evolves over time. This allows you to enter the coordinates of the probability density of impurity particles

$$f(x,t) = n(x,t)S/N, \tag{2}$$

where N - the total number of molecules diffusing impurities in a horizontal tube with a cross-sectional area S.

Introduced instead of $n(x,t)$, a new unknown function $f(x,t)$ probabilistically describes the situation at time t each impurity molecule. Only their huge number (comparable with the number of Avogadro), in accordance with the law of large numbers, leads to a reliable forecast of evolution $n(x,t)$, which finds its formal expression in the theorem of existence and uniqueness of solutions of the Cauchy problem.

Substituting (2) (1), we obtain the equation for $f(x,t)$

$$\frac{\partial f(x,t)}{\partial t} = D\frac{\partial^2 f(x,t)}{\partial x^2}. \tag{3}$$

Consider the problem of the spread of uniform concentration spot width l centered at the origin. It is convenient to go to the dimensionless time τ and coordinate ξ

$$\tau = Dt/l^2, \qquad \xi = x/l. \tag{4}$$

They equation (3), and the initial condition, respectively, will take the form

$$\frac{\partial f(\xi,\tau)}{\partial \tau} = \frac{\partial^2 f(\xi,\tau)}{\partial \xi^2}, \tag{5}$$

$$f(\xi,0) = \begin{cases} 1, & \xi \in [-1/2, 1/2] \\ 0, & \xi \notin [-1/2, 1/2] \end{cases}. \tag{6}$$

Condition (6) describes the equilibrium state because the maximum entropy on the segment provides uniform distribution $f(x,t)$ [4].

According to [4] all the information about the probability density $f(\xi,\tau)$ contained in the initial moments $\nu_n(\tau)$. Because of the symmetry of the problem

$$\nu_{2n+1}(\tau) = \int_{-\infty}^{\infty} \xi^{2n+1} f(\xi,\tau) d\xi = 0 \qquad (n = 0,1,...), \tag{7}$$

i.e. for central moments $\mu_n(\tau)$ can be written

$$\mu_n(\tau) = \int_{-\infty}^{\infty} (\xi - \nu_1(\tau))^n f(\xi,\tau) d\xi = \nu_n(\tau). \tag{8}$$

For even n differentiation (8) by τ with considering (5), obtain

$$\mu_{2n}(\tau)' = \int_{-\infty}^{\infty} \xi^{2n} \frac{\partial f(\xi,\tau)}{\partial \tau} \partial\xi = \int_{-\infty}^{\infty} \xi^{2n} \frac{\partial^2 f(\xi,\tau)}{\partial \xi^2} \partial\xi. \tag{10}$$

Double integrate (10) by parts, taking into account that $f(\pm\infty,\tau) \equiv 0$

$$\mu_{2n}(\tau)' = 2n(2n-1)\mu_{2n-2}(\tau). \tag{11}$$

With the help of (11) and the normalization condition you can develop a recursive procedure consistent calculation of the moments of any even order. In particular, for $n = 1$ obtain

$$\mu_2(\tau)' = 2(2-1)\mu_0(\tau) = 2, \tag{12}$$

hence, in view of the effluent (6) - (8) of the initial conditions

$$\mu_{2n}(0) = \int_{-1/2}^{1/2} \xi^{2n} d\xi = \frac{1}{(2n+1)\,2^{2n}}, \tag{13}$$

must be

$$\mu_2(\tau) = 2\tau + 1/12 = \sigma^2(\tau), \tag{14}$$

where $\sigma^2(\tau)$ - dispersion ξ. Similarly, for $n = 2$ from (12) - (14) obtain

$$\mu_4(\tau) = 12\tau^2 + \tau + 1/80. \tag{15}$$

To determine the asymptotic behavior $f(\xi,\tau)$ at higher τ calculate the kurtosis

$$E_4(\tau) = \frac{\mu_4(\tau)}{\sigma^4(\tau)} - 3 = \frac{12\tau^2 + \tau + 1/80}{(2\tau + 1/12)^2} - 3 = -\frac{1}{120\,\sigma^4(\tau)} \underset{\tau\to\infty}{\to} 0. \tag{16}$$

Its absence at large times means that, as a result of the diffusion mixing, impurity particles are farther beyond segment $[-1/2, 1/2]$ and the initial distribution (6) evolves into a normal, providing maximum entropy on the whole axis [4]

$$f(\xi,\tau) \underset{\tau\to\infty}{\to} \frac{1}{\sqrt{2\pi}\sigma(\tau)} \exp\left(-\xi^2/2\sigma(\tau)^2\right) \equiv f_0(\xi,\tau). \tag{17}$$

For finite τ replacement $f(\xi,\tau)$ expression (17) leads to an error

$$\Delta(\xi,\tau) = f(\xi,\tau) - f_0(\xi,\tau) \tag{18}$$

In accordance with the foregoing (see. (16), (18)), the main part $\Delta(\xi,\tau)$ order $\sigma(\tau)^{-4} f_0(\xi,\tau)$. Accounting for the excesses of higher order

$$E_{2k}(\tau) = \frac{\mu_{2k}(\tau)}{\sigma(\tau)^{2k}} - \omega(k), \qquad (k = 2, 3, 4, \ldots) \tag{19}$$

$$\omega(k) = \int_{-\infty}^{\infty} \zeta^{2k} \frac{1}{\sqrt{2\pi}} e^{-\frac{\zeta^2}{2}} d\zeta = 1\cdot 3 \cdot \ldots \cdot (2k-1) \tag{20}$$

leads to deposits $\Delta(\xi,\tau)$ higher-order powers $\sigma(\tau)^{-2}$

$$\Delta(\xi,\tau) = f_0(\xi,\tau) \sum_{k=2}^{\infty} \frac{\varphi_{2k}(\zeta(\xi,\tau))}{\sigma(\tau)^{2k}} = \sum_{k=1}^{\infty} f_k(\xi,\tau), \tag{21}$$

where $f_k(\xi,\tau)$ - amendment of the order $\sigma(\tau)^{-2k}$ to the asymptotic (17), and

$$\zeta(\xi,\tau) = \xi/\sigma(\tau) \tag{22}$$

given coordinate, taking into account the evolution of the current range ξ.

Polynomials $\varphi_{2k}(\zeta)$, due to the symmetry of the problem, laid out in even powers ζ. Highest degree equal to the order accounted kurtosis:

$$\varphi_{2k}(\zeta) = \sum_{i=0}^{k} C_{2k\ 2i} \zeta^{2i}, \tag{23}$$

For the selection of the coefficients $C_{2k\ 2i}$, it is necessary to achieve a desired relationship between τ reporting incidents and previous orders:

$$E_{2n}(\tau) = \int_{-\infty}^{\infty} \zeta^{2n} \cdot \frac{1}{\sqrt{2\pi}} e^{-\frac{\zeta^2}{2}} \sum_{k=2}^{\infty} \frac{\varphi_{2k}(\zeta)}{\sigma^{2k}(\tau)} d\zeta, \tag{24}$$

where, according to (19), $E_2(\tau) = 0$ for all $f(\xi,\tau)$, a $E_0(\tau) = 0$ (m. k. by the normalization condition (see. (20))).

Assuming in (24) $n = 0, 1, \ldots, k$ and equating coefficients at σ^{-2k}, taking into account (20), (23) after integration of ζ, obtain coefficients $C_{2k\ 2i}$ ($i = 0, 1, \ldots, k.$), as the solution of a system of linear algebraic equations:

$$\begin{pmatrix} C_{2k\,0} \\ \vdots \\ C_{2k\,2k-2} \\ C_{2k\,2k} \end{pmatrix} = \begin{pmatrix} \omega(0) & \ldots & \omega(k-1) & \omega(k) \\ \vdots & \vdots\vdots\vdots & \vdots & \vdots \\ \omega(k-1) & \ldots & \omega(2k-2) & \omega(2k-1) \\ \omega(k) & \ldots & \omega(2k-1) & \omega(2k) \end{pmatrix}^{-1} \cdot \begin{pmatrix} 0 \\ \vdots \\ 0 \\ b(k) \end{pmatrix}. \tag{25}$$

where $b(k)$ - constant in expansion $\mu_{2k}(\tau)$ powers $\mu_2(\tau)$. It can be got directly (using a recursive procedure (11), (13)). It should be noted, however, that the calculation of points $\mu_{2n}(\tau)$ higher-order found in the previous steps $\varphi_{2k}(\zeta)$ ($k = 2, 3, \ldots, n-1$), after substituting (18) (21) (8), and integration with regard to (22), (20) should give the correct part of the expansion $\mu_{2n}(\tau)$ powers $\mu_2(\tau)$, i.e.

$$b(n) = \mu_{2n}(0) - \omega(n)\mu_2(0)^n - \sum_{k=2}^{n-1} \mu_2(0)^{n-k} \sum_{i=0}^{k} \omega(n+i) C_{2k\ 2i} \qquad (n = 2,3....)\ . \tag{26}$$

The absence (26) correctly (containing negative powers $\mu_2(\tau)$) is often provided by zeroes in the column of free terms in (25).

The recurrent procedure (25), (26) allows to avoid the integration of (11), and fully formalize the obtaining of amendments $f_n(\xi,\tau)$ to the asymptotic expression $f_0(\xi,\tau)$. Its start is reception (26)

$$b(2)=\mu_4(0)-\omega(2)\mu_2(0)^2=-1/120.$$

We present the results in (25), define $C_{4\,2i}$:

$$\begin{pmatrix} C_{40} \\ C_{42} \\ C_{44} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 3 \\ 1 & 3 & 15 \\ 3 & 15 & 105 \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ 0 \\ -1/120 \end{pmatrix} = \frac{1}{960} \begin{pmatrix} -1 \\ 2 \\ -1/3 \end{pmatrix}. \tag{27}$$

Return (27) to the right side (26), for $n=3$ obtain

$$b(3)=\mu_6(0)-\omega(3)\mu_2(0)^3-\mu_2(0)\sum_{i=0}^{2}\omega(3+i)C_{4\,2i}=1/252,$$

what, after substituting in (25) gives

$$\begin{pmatrix} C_{60} \\ C_{62} \\ C_{64} \\ C_{66} \end{pmatrix} = \begin{pmatrix} 1 & 1 & 3 & 15 \\ 1 & 3 & 15 & 105 \\ 3 & 15 & 105 & 945 \\ 15 & 105 & 945 & 10395 \end{pmatrix}^{-1} \begin{pmatrix} 0 \\ 0 \\ 0 \\ 1/252 \end{pmatrix} = \frac{1}{96\cdot 126} \begin{pmatrix} -1 \\ 3 \\ -3/3 \\ 1/15 \end{pmatrix}. \tag{28}$$

The results obtained (see para. (27) - (28)) let us to see a simple (binomial) pattern and to express the coefficients $C_{2k\,2i}$ of polynomials $\varphi_{2k}(\zeta)$ (see (23)) through a number of combinations C_k^i

$$C_{2k\,2i}=\frac{b(k)(-1)^{k+i}C_k^i}{\rho(k)\omega(i)}, \qquad \begin{pmatrix} k=2,4,\ldots \\ i=0,1,\ldots,k \end{pmatrix} \tag{29}$$

где
$$\rho(k)=2\cdot 4\cdot\ldots\cdot 2k \tag{30}$$

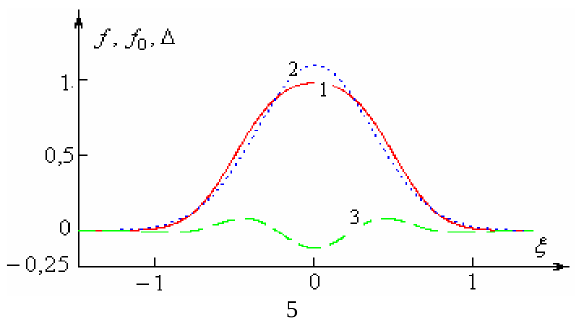
The validity of (29) can be verified directly. In particular

$$C_{40}=\frac{b(2)(-1)^{2+0}C_2^0}{\rho(2)\omega(0)}=\frac{1}{-120}\cdot\frac{1}{2\cdot 4}\cdot\frac{1}{1}=\frac{-1}{96\cdot 10},$$

$$C_{6\,6}=\frac{b(3)(-1)^{3+3}C_6^6}{\rho(3)\omega(3)}=\frac{1}{252}\cdot\frac{1}{2\cdot 4\cdot 6}\cdot\frac{1}{15}=\frac{1}{96\cdot 126\cdot 15},$$

as it should be (see (27), (28)).

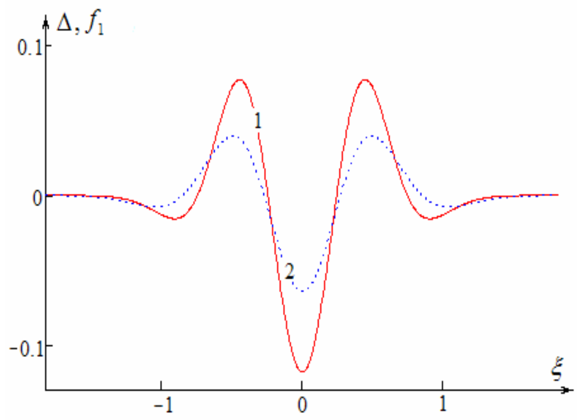
The solution (29) allows to eliminate from the recursive procedure described above (25), (26), the system (25). Substituting (29) into (26) we obtain the recurrence relation for determining figure in (29) numbers $b(k)$



Fir. 1. The probability density f, its asymptotic behavior f_0,
and the deviation Δ (curves 1, 2, 3) as a function of the coordinates ξ at time τ = 0,02

$$b(n)=\mu_{2n}(0)-\omega(n)\mu_2(0)^n-\sum_{k=2}^{n-1}\mu_2(0)^{n-k}\frac{(-1)^k b(k)}{\rho(k)}\sum_{i=0}^{k}\omega(n+i)\frac{(-1)^i C_k^i}{\omega(i)}. \tag{31}$$

Start to procedure (31) is given by $n=2$. Continuing by equation (31) calculating the recurrence any number of series of numbers $b(n)$ can be found (in particular, $b(4)=-1/576$, and $b(5)=1/1584$) and using (29), (21) - (23), (18) and (17) $f(\xi,\tau)$ can be constructed with the required accuracy (Fig. 1).



Fir. 2. Deviation $f(\xi,\tau)$ of its asymptotic expression (curve 1)
and the amendment of the order σ^{-4} (curve 2) for $\tau = 0.025$

Finally, we discuss the convergence of the series (21) and find out what times can be considered large. We restrict $\xi = 0$, where the module $\Delta(\xi,\tau)$ is maximal (Fig. 1). For the convergence it is sufficient that inequality $\lim\limits_{n\to\infty} f_{n+1}(0,\tau)/f_n(0,\tau) < 1$. According to (14), (21) - (23), (27), (28)

$$\frac{f_2(0,\tau)}{f_1(0,\tau)} = \frac{C_{60}}{\sigma(\tau)^2 C_{40}} = \frac{10}{\sigma(\tau)^2 \cdot 126} = \frac{10\cdot 12}{(24\tau+1)\cdot 126} \le 0{,}952 .$$

Similarly, $\dfrac{f_3(0,\tau)}{f_2(0,\tau)} = \dfrac{C_{80}}{\sigma(\tau)^2 C_{60}}$, $\dfrac{f_4(0,\tau)}{f_3(0,\tau)} = \dfrac{C_{10\,0}}{\sigma(\tau)^2 C_{80}}$,

Where, according to (29), (30) $C_{8\,0} = \dfrac{b(4)(-1)^{4+0} C_4^0}{\rho(4)\omega(0)} = \dfrac{-1}{96\cdot 2304}$, $C_{10\,0} = \dfrac{b(5)(-1)^{5+0} C_5^0}{\rho(5)\omega(0)} = \dfrac{-1}{96\cdot 63360}$.

Therefore $\dfrac{f_3(0,\tau)}{f_2(0,\tau)} = \dfrac{126\cdot 12}{(24\tau+1)\cdot 2304} \le 0{,}656$, $\dfrac{f_4(0,\tau)}{f_3(0,\tau)} = \dfrac{2304\cdot 12}{(24\tau+1)\cdot 63360} \le 0{,}436$, t hat is appearing in the sufficient condition for the ratio being for all $\tau \ge 0$ less than one, with increasing n decreases monotonically. This suggests that $\xi = 0$ series (21) converges even when $\tau = 0$.

Similarly, $|f_1(0,\tau)| / f_0(0,\tau) << 1$, when (see (17), (21), (27)) $\sigma(\tau)^4 > 1/96$, those. large (see (14)) can be considered times $\tau > 0.01$. For them, the schedule $f_1(\xi,\tau)$ It fits well with the dependence $\Delta(\xi,\tau)$ of coordinates (fig. 2). This account already $f_2(\xi,\tau)$ provides construction $f(\xi,\tau)$ to date range ξ with a relative error of about 1% (Fig. 3).

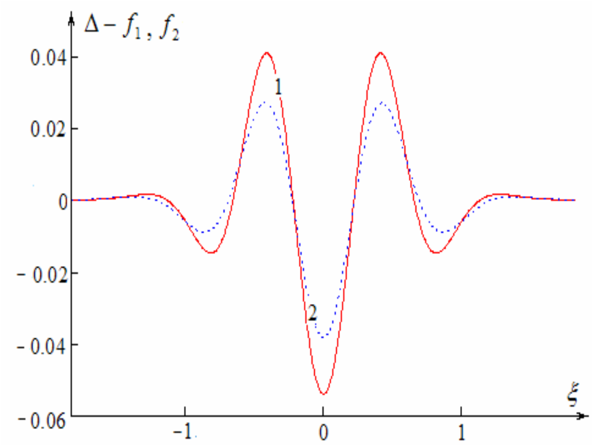


Fig. 3. The deviation correction procedure σ^{-6} (curve 2) of the first approximation
for the error for $\tau = 0.025$

Thus, the article develops the ideology of solving the equations of mathematical physics, describing the transport phenomena. The diffusion sprawling of homogeneous concentration spots in an infinite horizontal tube has been considered. The probability density of the coordinates of the diffusing molecule has been put. The recursion relation for defining the statistical moments of the random variables with the help of diffusion equation has been obtained. It is shown that over time a normal distribution location is formed. Error at the replacement of the exact solution by its asymptotic expression is represented as the sum of polynomial amendments related to excesses given appropriate orders. The task of mathematical physics is reduced to a system of linear algebraic equations for the coefficients of the above mentioned polynomials. The structure of their solution is defined, according to which the coefficients are proportional to the number of their combinations, divided by the product of odd numbers, where the number of factors is determined by the degree of given coordinates. The coefficients of the proportionality of the following polynomial coefficients are connected with the previous ones by recurrence relation. Its consistent solution allows taking into account the diffusion contribution to the spread of the concentration spots of excesses of arbitrary order and with any accuracy required to construct a solution of the diffusion equation.

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UDC 005

VAGRANT AND ANSIBLE. DEVOPS METHODOLOGY IMPLEMENTATION

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DevOps methodology requires the abolition of borders between developers and operating sector employers, which requires an implementation of specific techniques. One of them is an environment virtualization. In our company, we use Vagrant and Ansible tools for the virtualization.

The term "DevOps" is commonly used to describe a professional movement, which is in favour of a joint working relationship between developers and operating sector employers for a more rapid implementation of planned activities with increasing reliability, stability, sustainability and security of production-environment [1]. DevOps naturally inherits principles of flexible methodologies for the abolition of borders between developers, testers, administrators, quality specialists and other representatives of the operating sector, as well as for motivation to implement bold and risky cases with the fastest possible user's feedback.

Achievement of such goals requires the maximum automation of a working process: testing, continuous integration, continuous delivery, code quality check, creation of production-environments, monitoring. For realization of all these processes, there are many different solutions, each of them has its own pluses and minuses. According to the concept of DevOps, responsibility zones between various departments of technical sector of the company are washed away, that brings criterion of simplicity to the same level as functionality. The DevOps-professional must have an opportunity to write a code, write tests to it, create an environment similar to the one that will be at the production, change settings of this environment, constantly being under supervision of automatic quality control services and test covering. Of course, preventive annual preparation in a special center for a specialist isn't provided.

The problem of various environments at a developer, a tester and at a production-stand is known for everything. Its consequences are even better known: non-reproducible mistakes, the phrase "I don't know, everything works for me", unexpected falling of production-stands at excellent viability of service under the same loadings at test platforms, etc. Creation of identical configurations on 5-20 cars, it is in our century of cloudy services even not the average quantity, without automation of process turns into work that can be done only by a cool old school administrator.