3. *Nazarov NN* Dozyrovanye zhydkyh ahrohymykatov / NN Nazarov // mehanyzator village. - 2012. - № 1. - P. 10.
4. *AS* 491041 USSR, MPK5 G 01 G 13/28 of automatic dispenser fluid continuously action / VD Trachtenberg, YD Vydeneev. - № 1937947 / IS-10; appl. 02/07/1973; publ. 05.11.1975, Bull. №41.
5. *A.c.* 884648 USSR, MPK5 A 01 N 7/00. Opгыskyvatel village of automatic regulation rashoda fluid / N. Yamnykov, BF Shpylevskaya. - № 2888400 / 30-15; appl. 29.02.1980; publ. 11.30.1981, Bull. №44.
6. *AS* 906478 USSR, MPK5 A 01 N 7/00. Arrangement for regulation rashoda a working fluid / GA Dundua. - № 2995344 / 30-15; appl. 10/24/80; publ. 02.23.82, Bull. Number 7.
7. *AS* 1037901 USSR, MPK5 A 01 N 7/00. Automatic dozyruyuschee Arrangement opгыskyvateley selskohozyaystvennыh crops / VA Melnikov, E. A. Yurchenko. - № 3005381 / 30-15; appl. 08/13/80; publ. 08.30.83, Bull. Number 32.
8. *AS* 1340705 USSR, MPK5 A 01 N 7/00. Automatic dozyruyuschee Arrangement opгыskyvatelya / Poroubaymyh I. S., F. I. Zlatopolkyy. - № 4057721 / 30-15; appl. 04/17/86; publ. 09.30.87, Bull. Number 36.
9. *Stalemate*. utility model 77260 Ukraine, IPC A 01 N 7/00. Device for automatic control of working fluid / VY Smith, S. Shchukin; The applicant and patentee Lugano. nat. Agrar. Univ. - №u201208048; appl. 02.07.2012; publ. 02/11/2013; Bull. №3. - 4 p.
10. *AS* 762826 USSR, MPK5 A 01 N 7/00. Arrangement for the regulation of automatic rashoda yadohymykatov / LA Boroshok. - № 1755578 / 30-15; appl. 04/18/79; publ. 09.15.80, Bull. Number 34.
11. *Collection* Abstracts of the Second International Scientific Conference "Innovative development of the agricultural sector" (19-21 March 2015) / Research Institute of Technology, Energy and Information AIC National University of Life and Environmental Sciences of Ukraine. - K., 2015. - P. 7-9
12. *Gurevich L.* Ympulsnыe system of automatic dozyrovanyya ahressyvnыh liquids / L. Gurevich, Mikhail V. Sokolov. - M .: Energy, 1973. - 112 p.

Abstract.*STATUS sovremennoho conducted analysis and trends of development funds and control rules podderzhanyya rashoda fluid in funds for vnesenyya zhydkyh myneralnыh fertilizers.*
Keywords: zhydkye Mineralniye udobrenyya, dozyrovka, smennыe norms vnesenyya

Annotation.*The analysis of the current state and trends of controls and maintaining standards in the mass flow rate for liquid fertilizer.*
Key words: liquid fertilizers, dosing, variable application rate

UDC 674,047

DEFINITIONS thermal coefficient in heat equation SOLUTIONS FOR IDENTIFICATION OF THERMAL PROCESSES ZERNOMATERIALIV

RA Kalinichenko, PhD *

Abstract.*The method of determining thermal coefficients in solutions of the heat equation with boundary conditions of the third kind of experimental data kinetics heating weevil.*

Keywords: heat treatment of grain, thermal coefficients, approximation, temperature distribution

Formulation of the problem. In industrial processes postharvest processing of grain the leaders thermal treatment. Thermal processing grain not only to preserve the quality of harvested grain, and in the process increase its postharvest heat treatment [1]. Development, improvement and intensification of heat treatment processes

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based on the theory of heat conduction part of which is knowledge and analysis of thermal properties zernomaterialiv - as objects of heat treatment methods and to select optimal modes of the process and on this basis - to create a rational design of vehicles. That is, the rational use of analytical mathematical models of heat conduction theory into practice requires knowledge of the properties of various zernomaterialiv that undergo heat treatment, such as thermal properties and their quantitative characteristics [2].λ - Heat. Also they have a coefficient of heat transfer α. The value of the coefficient of heat transfer depends on the nature of a heating or cooling medium, temperature and circulation, temperature surface grains, so this factor is the most difficult to define. Therefore, the solutions of mathematical equations of heat conduction ratio of heat transfer coefficient replace criterial dependencies, including Bio criteria:

$$Bi = \frac{\alpha R}{\lambda}, \qquad (1)$$

where:α - Coefficient of heat transfer between the grains and the environment, λ - Thermal conductivity weevil, R - equivalent radius grains. Criterion Bio characterizing heat transfer between the grains and the environment in the convective heat transfer and can be defined criterion of empirical relationships [4].

Analysis of recent research. To determine the thermal coefficients a - thermal and λ - Thermal conductivity, there are two basic approaches. The first (traditional) - experimental determination of thermal characteristics of the known methods based on solving boundary value problems of heat conduction [5]. The second - an analytical determination of thermal characteristics on the basis of theoretical ideas about the mechanism of heat transfer in model structures characteristic of real solids and disperse systems [6].

But the existing literature [2, 7-9] data on the thermal characteristics zernomaterialiv obtained by the methods listed significantly different, and the difference in values can reach 50%.

The purpose of our research was to develop a method for determining thermal coefficients in solutions of the heat equation (in the case of convective heat transfer) at the lowest possible for this resource expenses and maximum ordinary experimental studies with sufficient accuracy to allow identification of heat treatment processes zernomaterialiv.

Results. Weevil take shape in the form of a ball (which is especially important for legumes), equivalent radius which determines how the radius of the ball that has a volume equal to the average amount (by weight) particles:

$$R_e = \frac{1}{2} \cdot \sqrt[3]{\frac{6 \cdot V}{\pi}} \quad , \tag{2}$$

where:$V = G / n \cdot \rho_m$ - The volume of a weevil; G and n - random sample weight according caryopsides and number caryopsides in navazhtsi, ρ_m- Average density caryopsides.

Heat transfer between the grains and the environment considering the law convection. Obtain the problem of heat transfer boundary conditions in the third race. We write the differential equation for heat conduction balls:

$$\frac{\partial t(R,\tau)}{\partial \tau} = a \cdot \left(\frac{\partial^2 t(r,\tau)}{\partial r^2} + \frac{2}{r} \cdot \frac{\partial t(r,\tau)}{\partial r} \right) . \tag{3}$$

The initial and boundary conditions for convective heat transfer as follows:

$$-\frac{\partial t(R,\tau)}{\partial r} + H\left[t_c - t(R,\tau)\right] = 0, \quad \frac{\partial t(0,\tau)}{\partial r} = 0, \quad t(0,\tau) \neq \infty, \quad t(r,0) = f(r) . \tag{4}$$

The task of cooling the law convection balls in the initial distribution of temperature t (r, 0) = f (r) during the third kind boundary conditions will have a decision [2]:

$$t(r,\tau) - t_c = \sum_{n=1}^{\infty} \frac{2\mu_n}{\mu_n - \sin(\mu_n)\cos(\mu_n)} \cdot \frac{\sin(\mu_n \frac{r}{R})}{r \cdot R} \int_0^R r \cdot f_1(r) \sin(\mu_n \frac{r}{R}) dr \cdot e^{-\mu_n^2 \cdot \frac{a \cdot \tau}{R^2}} , \tag{5}$$

where: f1 (r) - a function, which is determined from the ratio:

$$f_1(r) = f(r) - t_c \tag{6}$$

where: tc - temperature environment (air).

If the temperature of grains at the initial time is independent of r:

$$t(r,0)=f(r)=t_0=const \tag{7}$$

is integral in (5) can be found and it is written in the form:

$$t(r,\tau)-t_c=\left(t_0-t_c\right)\sum_{n=1}^{\infty}\frac{2\left(\sin(\mu_n)-\mu_n\cos(\mu_n)\right)}{\mu_n-\sin(\mu_n)\cos(\mu_n)}\cdot\frac{\sin(\mu_n\frac{r}{R})}{r\cdot\mu_n}e^{-\mu_n^2\cdot\frac{a\cdot\tau}{R^2}}. \tag{8}$$

In formulas (5), (8) μ_n determined by the characteristic equation:

$$ctg(\mu)=\frac{1-Bi}{\mu}\cdot \tag{9}$$

To determine the changes in average temperature weevil use zalizhnistyu:

$$\bar{t}(\tau)=\frac{3}{R^3}\int_0^R r^2 t(r,\tau)dr. \tag{10}$$

If we substitute (8) to (10) and trigonometric functions replaced by μ_n Bio criteria and in accordance with the characteristic equation (9) we get after integration [2]:

$$\bar{t}(\tau)=t_c+\left(t_0-t_c\right)\sum_{n=1}^{\infty}\frac{6Bi^2}{\mu_n{}^2\left(\mu_n^2+Bi^2-Bi\right)}e^{-\mu_n^2\cdot\frac{a\cdot\tau}{R^2}}. \tag{11}$$

The change in the average temperature of grains by time (kinetics of cooling or heating) is easy to determine experimentally. To use the experimental points determined the kinetics of cooling (heating) grains in the search for the unknown thermal coefficients (a - thermal and criterion Bio) in equation (11) by the algorithm Levenberg-Makvarda, approximate empirical dependencies solutions $\mu_1-\mu_6$ transcendental equation (9). Numerical solutions of equations (9) got into mathematical package Mathcad 14 features. 1.

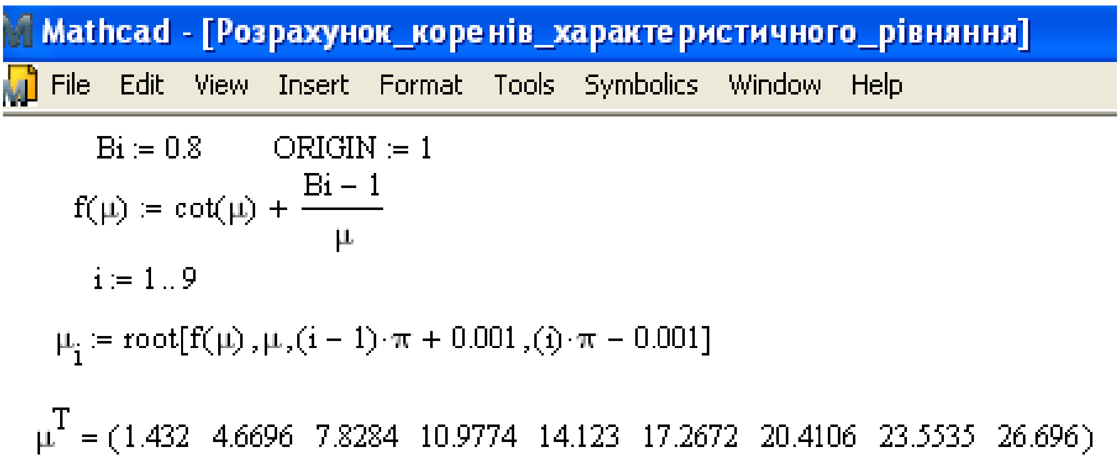

Fig. 1. Definition of the roots of the characteristic equation (9) in the mathematical package Mathcad.

For μ_1 Following the numerical experiments with different structures approximating mathematical package Statistica 10 empirical relationship is determined with the highest multiple correlation (R = 0,99981) type:

$$\mu_1 = b_0 + b_1 Bi + b_2 Bi^{b_3} \quad , \tag{12}$$

where: coefficients: b0 = -0,090821, b1 = -0,27041, b2 = -1,924477, b3 = 0,461608, Bi = 0,02÷10.5. Graphic illustration ongoing approximation shown in Fig. 2.

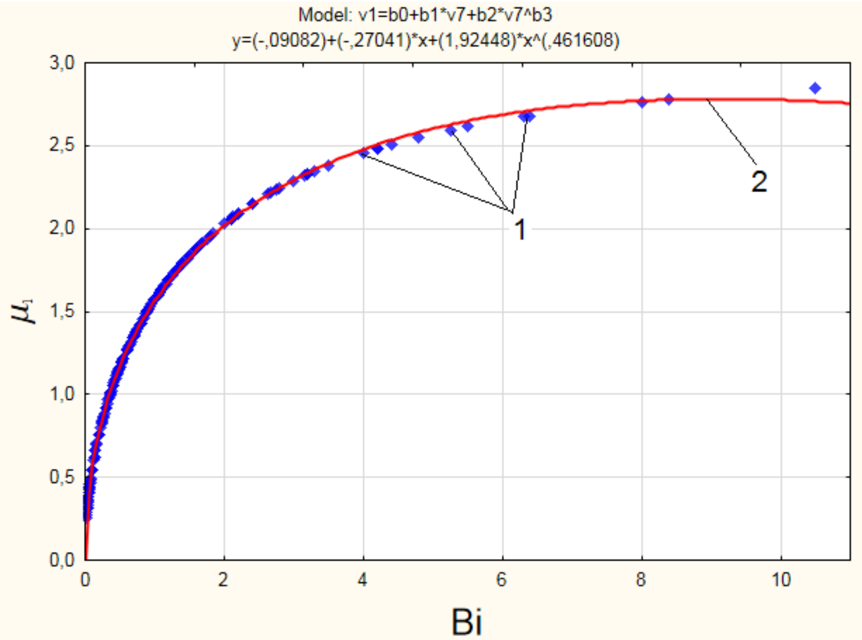

Fig. 2. Graphic illustration approximation (♦ - 1 - the point at which the value μ_1 is the numerical solution of equation (9), 2 - approximating dependence graph (12)).

For $\mu_2 - \mu_6$ approximating different points in Bio define a polynomial of the second degree:

$$\mu = b_0 + b_1 Bi + b_2 Bi^2 . \tag{13}$$

The coefficients dependence (13) defined in a package Statistica 10 and presented in Table. 1.

1.

μ	*b0*	*b1*	*b2*	R (coefficient of multiple correlation)
μ_2	4.49427	0.228132	-0.0108	.9998
μ_3	7.72303	0.136715	-0.00428	.9999
μ_4	10.90255	0.09611	-0.00206	.9999
μ_5	14.06520	0.07373	-0.00112	.9999
μ_6	17.22012	0.05973	-0.00067	.9999

depending identified $\mu_1 - \mu_6$ to substitute Vi dependent (11) and with the built-in mathematical functions genfit package Mathcad, which implements the algorithm Levenberg-Makvardta, and define the value of Bi and in which the relation (11) will most accurately describe a given set of experimental points. Initial estimates a priori and Bi set of process parameters for process heating (cooling) take the literature. Screen fragment and settlements and Bi formulas (11) - (13) in the package Mathcad shown in Fig. 3.

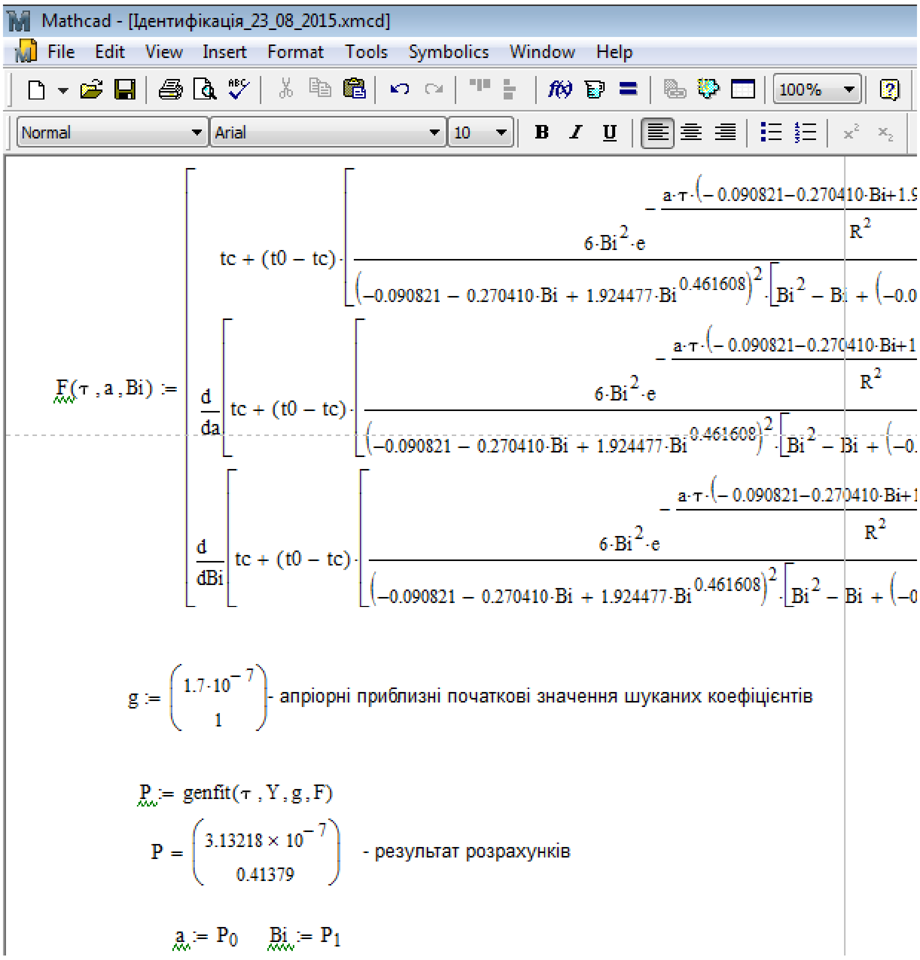

Fig. 3. Screen fragment genfit implement the function in the mathematical package Mathcad to determine the thermal diffusivity and criteria and Vi.

Substituting the values of A and Bi in the formula (11) we obtain analytical dependence of the temperature of grains and rice. 4. If the formula (11) to substitute the resulting value of the coefficient of thermal - but instead substitute Vi dependence (1) The technique then you can find rates λ - Thermal conductivity and grains α - Heat exchange between the grains and the environment, Fig. 5.

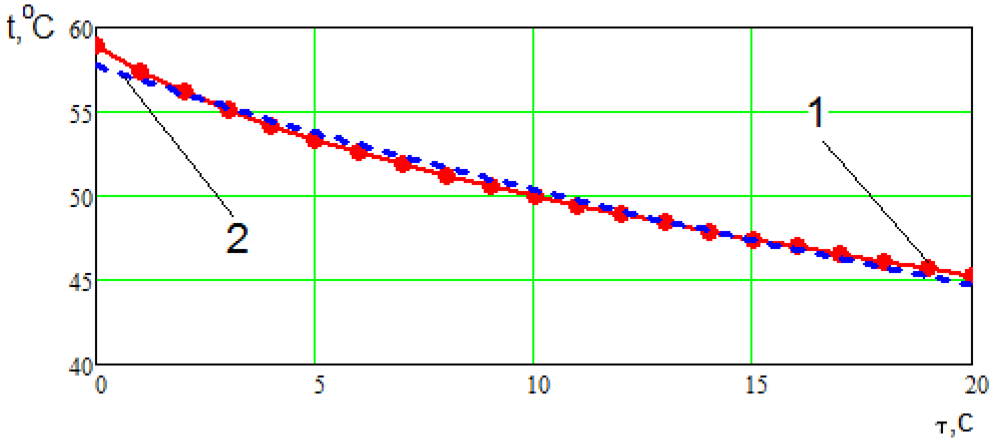

Fig. 4. Change in average temperature weevil (1 - experimental data, 2 - analytical curve obtained by the formula (11)).

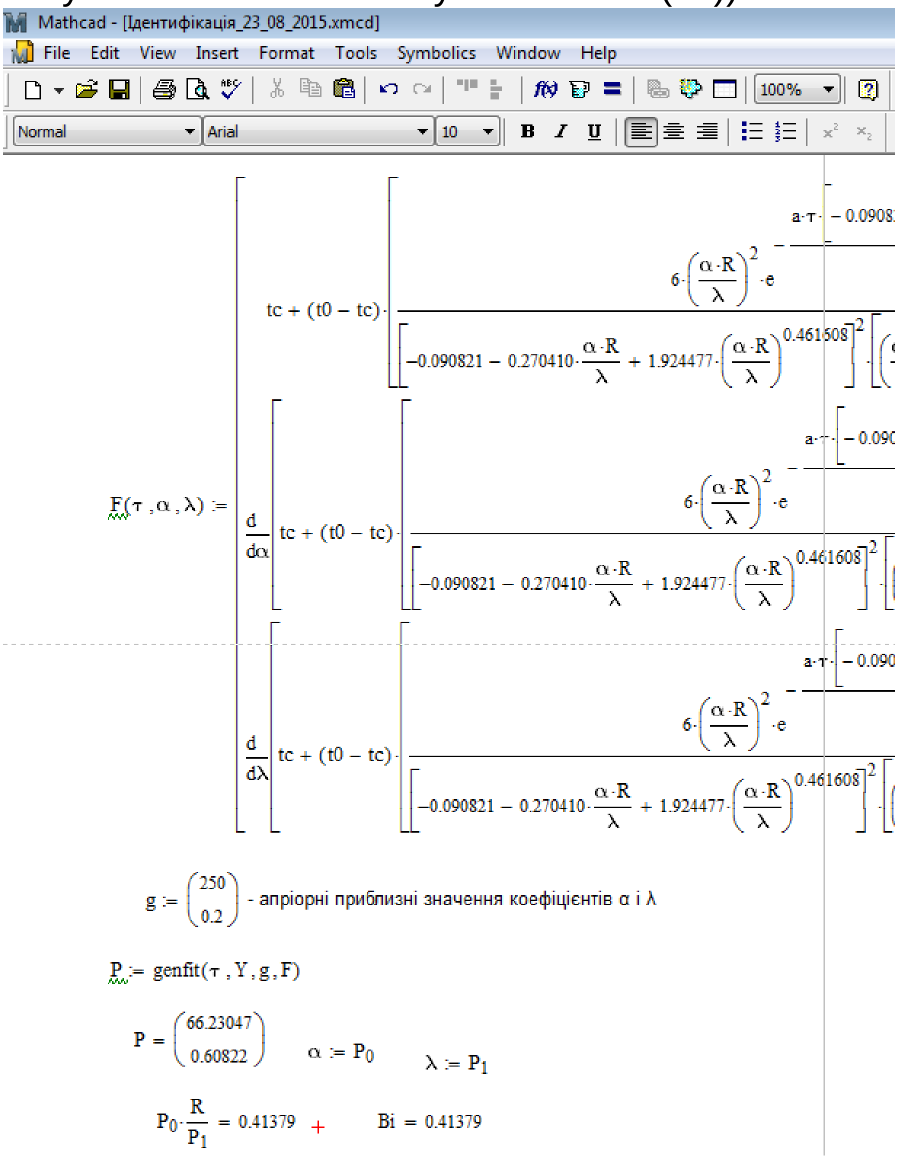

Fig. 5. Screen fragment genfit implement the function in the mathematical package Mathcad to determine the thermal conductivity -λ and heat - α.

With thermal coefficients determined by the method given temperature field find grains during cooling formulas (8) (12) (13) Fig. 6 and Fig. 7.

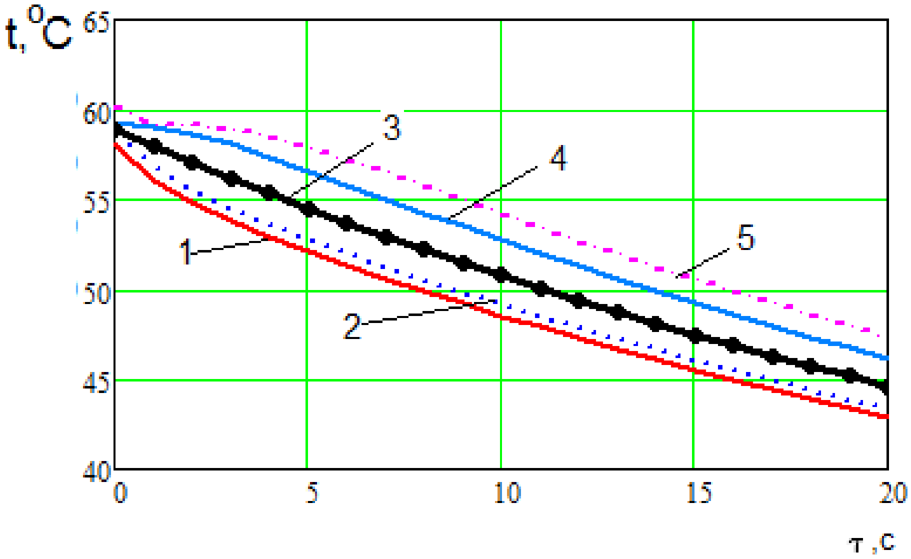

Fig. 6. Temperature distribution in zernivtsi in the cooling process (1 - R = 0.0038 m - surface grains, 2 - R = 0.0036 m 3 - the average temperature in grains, 4 - R = 0.0019 m, 5 - R = 0.0001 m - Center grains) .

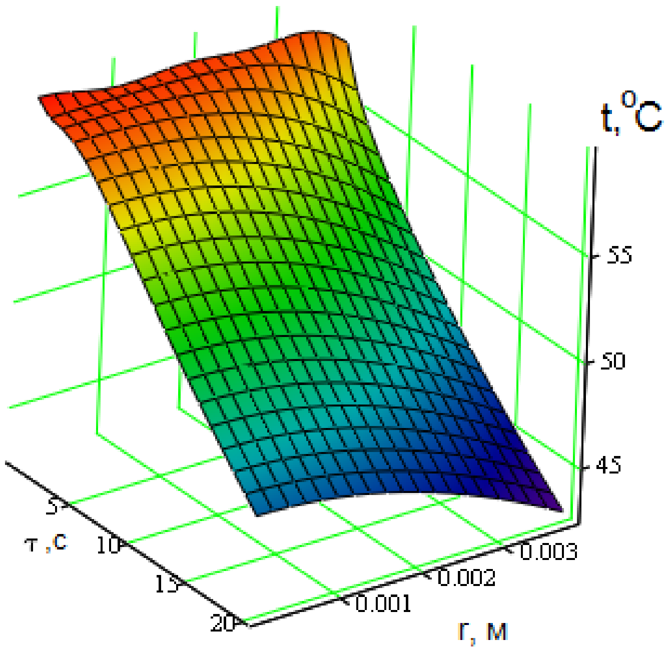

Fig. 7. The temperature field grains.

Conclusions

The resulting method of determining thermal coefficients of solutions of the equations of the theory of thermal conductivity allows the identification of experimental and analytical method of heat treatment processes zernomaterialiv with sufficient accuracy for engineering calculations.

The use of thermal processes in the calculation of analytical mathematical models can use these models for a wide range zernomaterialiv and conditions of the heat treatment.

List of references

1. *Kurdyumov VI* Teplovaya obrabotku grain facilities contact types: monograph / VI Kurdyumov, Pavlushyn AA, Karpenko, S. Sutyagin. - Ulyanovsk: UHSHA them. PA Stolыpyna, 2013. - 290 p.
2. *A. Ginsburg* Teplofyzycheskye pyschevыh characteristics of products / A. Ginzburg, MA Gromov, GI Krasovskaya. - M .: Pyschevaya Industry, 1980. - 288 p.
3. *AV Lykov* Theory teploprovodnosty / AV Lykov. - M .: Higher School, 1967. - 599 p.
4. *Mushtaev VI* Drying dyspersnыh materials / VI Mushtaev, *V. Ulyanov*. - M .: Chemistry, 1988. - 352 p.
5. *Aleksashenko AA* Sharing otsenki pohreshnostey method for determining characteristics teplofyzycheskyh IZ pryblyzhennыh solutions / AA Aleksashenko // Proceedings of VI All-Union. Conf. by teplofyz. Properties substances. - Minsk, 1978. - P. 69-70.
6. *Kolpaschykov VL* Theoretical Studies teplofyzycheskyh properties based on thermodynamic theory / VL Kolpaschykov, AI Shnip // Proceedings of VI All-Union. Conf. by teplofyz. Properties substances. - Minsk, 1978. - P. 69-70.
7. *Bobkov NA* Study teplofyzycheskyh properties of grain / NA Bobkov // Author. Thesis ... candidate. Sc. Science. - M., 1956. - 18 p.
8. *Herchesov BA* Teplofyzycheskye properties of wheat grain in dependence from humidity / BA Herchesov, TN Serыh // Izv. Universities. Pyschevaya technology. - 1977. - №1. - S. 150-151.
9. *Starovoytov VN* Study teplofyzycheskyh properties plenchatыh krupyanыh grain crops with a view to optimization hydrotermycheskoy obrabotku Krupozavod / VN Starovoytov // Author. Thesis ... candidate. Sc. Science. - M., 1978. - 27 p.

Abstract.*Method is designed for determining teplofyzycheskyh koэffytsyentov a decision equation teploprovodnosty hranychnыh terms with Rod III эksperymentalnыh zernovky the heating kinetics data.*

Keywords: termoobrabotka grain teplofy-zycheskye koэffytsyentы, approximation, ALLOCATION topics-peraturы

Annotation.*Developed method of determining the physical characteristics in the heat equation with boundary conditions of three kinds of experimental data of kinetics of heating caryopses.*

Key words: heat treatment of grain, thermal coefficients, approximation, temperature distribution

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