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Determination of the Temperature of the Components of a Raw Cotton

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Abstract: *The article considers one boundary value problem for systems of parabolic type, consisting of two differential equations for determining the temperature and moisture content of a lump of raw cotton during drying in dryers. Based on the laws of thermodynamics (the laws of thermal conductivity of Fourier, Newton, conservation of energy, etc.), this problem is formulated as a system of differential equations of parabolic type An approximate solution of the problem under consideration was constructed using the variational-grid method, and a comparative analysis with experimental data was carried out. To solve this problem, was used the Galerkin variational method, i.e. introduce the basis function φi(x) satisfying the conjugacy condition φi(0)=0. A comparative analysis shows that the error in the calculated and experimental data is no more than 4-5%. And this makes it possible to analyze the heating rate in the form of a lump.*
Keywords: *dryer, temperature, humidity, mathematical model, algorithm, lump, raw cotton*

I. Introduction

A lump is called raw cotton, which has a small volume in the form of a ball. In artificial or natural drying, raw cotton usually comes in the form of a ball [1-4]. In the process of drying in a lump of wet raw cotton, a complex non-stationary heat-mass transfer process takes place, which determines the external and internal states. External processes are characterized by mass transfer from the surface of the lump to the environment and heat transfer between the fiber and the medium. Internal processes occur due to the imbalance of moisture in the volume of raw cotton clods, caused by external heat and mass transfer [5-7].

Of great importance for maintaining the quality of the fiber and seeds during drying is the rate of heat distribution in the lump of raw cotton [8-10]. In this regard, we have considered the problem of heat propagation in a lump of raw cotton.

II. Review of Literature

In connection with the given data of the introductory part, it became necessary to conduct research. The search for literature on this study was carried out in the period 2018-2020, in Internet sources (https://www.google.com, www.scopus.com, https://sciencedirect.com, https://www. webofscience.com) [1-30].

III. Research Methods

Problem statement and solution method. The problem of heat and mass transfer in a lump of raw cotton can be expressed as follows: An inhomogeneous two-component spherical body of radius R is given, which has the property of isotropy, with a known initial temperature distribution: u1(0,r)=g1(r), u2(0,r)=g2(r), - the initial temperature of seeds and fiber, located at a distance r from the center of the lump; Inside the body there is a convective heat exchange between the components (between the seed and the fiber). On the surface of contact with the medium, convective heat transfer occurs according to Newton's law, while

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the heating of the body occurs evenly over the entire surface of the body. It is required to find the radial temperature distribution of the body components at any time.

Then, relying on the laws of thermodynamics (the laws of thermal conductivity of Fourier, Newton, conservation of energy, etc.), this problem can be formulated as a system of differential equations of parabolic type [11-14]:

$$\begin{cases} \frac{\partial u_1}{\partial \tau} = a_1\left(\frac{\partial^2 u_1}{\partial r^2} + \frac{2}{r}\cdot\frac{\partial u_1}{\partial r}\right) + \frac{\alpha}{c_1\rho_1}[u_2 - u_1] + \frac{1}{c_1\rho_1} f_1(\tau) \\ \frac{\partial u_2}{\partial \tau} = a_2\left(\frac{\partial^2 u_2}{\partial r^2} + \frac{2}{r}\cdot\frac{\partial u_2}{\partial r}\right) + \frac{\alpha}{c_2\rho_2}[u_1 - u_2] + \frac{1}{c_2\rho_2} f_2(\tau) \end{cases} \quad (1)$$

with initial

$$u1(r, 0)=g1(r),\ u2(r,0)=g2(r) \quad (2)$$

and boundary conditions: at r=R

$$-\frac{\partial u_1}{\partial r} + \alpha_1[u_B - u_1] = 0$$
$$-\frac{\partial u_2}{\partial r} + \alpha_2[u_B - u_2] = 0 \quad (3)$$

Where α1 heat transfer coefficient between the seed and the heat carrier; α2- is the coefficient of heat transfer between the fiber and the heat carrier; a is the coefficient of heat transfer between seed and fiber; f1(τ), f2(τ)- given continuous functions describing the process of evaporation of moisture from the seed and from the fiber, respectively, uB- air temperature τ- drying process time; u1(r, τ), u2(r,τ)- the desired functions representing the temperature of the seed and fiber at point r at a given time τ.

At smaller R, the lump radius can be assumed that at the initial time the temperature of the raw cotton components is constant, i.e.

$$u1(r,0)=u10\ ,\quad u2(r,0)=u20$$

We integrate the last inequality over τ. Taking into account the inequality

$$\|Z_n\|_{E_n}^2 \le \frac{1}{2}\|\tilde{U} - U\|_{L_2}^2$$

we get

$$((Q_n + \Gamma_n)Z_n, Z_n)_{E_n} \le 2\varepsilon_1\int_0^\tau \|\tilde{U} - U\|_{L_2}^2 d\tau + c_1\int_0^\tau \left(\|\varepsilon_n\|^2 + \|\Phi_n(\tau)\|_{L_2}^2\right)d\tau + ((Q_n + \Gamma_n)Z_n(0), Z_n(0))_{E_n} \quad (4)$$

On the other hand, due to assumption (14), we obtain

$$((Q_n + \Gamma_n)Z_n, Z_n)_{E_n} \ge (Q_n Z_n, Z_n) - e_1 q\|Z_n\|_{E_n}^2 \ge (1 - e_1)\|\tilde{U}_n - U_n\|_{L_2}^2,$$

$$((Q_n + \Gamma_n)Z_n(0), Z_n(0))_{E_n} \le (Q_n Z_n(0), Z_n(0))_{E_n} + e_1 q\|Z_n\|_{E_n}^2 \le c_2(1 + e_1)\|\tilde{U}(r, 0) - U(r, 0)\|_{L_2(\Omega)}^2$$

$$\int_0^\tau \|\Phi_n(\tau)\|_{E_n}^2 d\tau' \le 2M\int\|\Gamma_n\|^2 d\tau' + 2K\int_0^\tau \|\Gamma_n'\|^2 d\tau' \le 2MT\|\Gamma_n\|^2 + 2KT\|\Gamma_n'\|_{E_n}^2$$

Denote

$$\int_0^\tau \|\tilde{U}_n(r, \tau) - U_n(r, \tau)\|_{L_2}^2 d\tau = y(\tau)$$

$$F_n(\tau) = c_2(1 + e_1)\|\tilde{U}_n(r, 0) - U_n(r, 0)\|_2^2 + c_1\|\varepsilon_n\|_{E_n}^2 + 2MT\|\Gamma_n\|_{E_n}^2 + 2KT\|\Gamma_n'\|_{E_n}^2$$

Then, substituting all estimates into (4), we obtain a differential inequality for yn(τ), i.e.

$$\frac{dy_n(\tau)}{d\tau} \le M \cdot y_n(\tau) + F_n(\tau)$$

from which, in turn, by virtue of the theorem on differential inequalities, the inequality follows

$$\frac{dy_n(\tau)}{d\tau} \le e^{G_1\tau} \cdot F(\tau)$$

Hence, using estimates (5) obtained for the initial conditions, we have:

$$\left\|\tilde{U}_n(r,\tau) - U_n(x,\tau)\right\|_2^2 \le p_0\|\varepsilon_0\|^2 + p_1\|\varepsilon_n\|^2 + p_2\left\|\Gamma_n^0\right\|^2 + p_3\|\Gamma_n'\|^2 + p_4\|\Gamma_n'\|^2 \quad (5)$$

where constants $p_i\left(i=\overline{0,4}\right)$ do not depend on N. Hence,

$$\left\|\tilde{G}_n(\tau) - G_n(\tau)\right\|_{E_n}^2 \le \frac{1}{q}\left\|\tilde{U}_n(r,\tau) - U_n(r,\tau)\right\|_2^2 \le \frac{1}{q}\omega^2$$

where ω2 - is the right side of the inequality (5). The last relations imply the stability of the algorithm for constructing an approximate solution and the numerical stability of the approximate solution in $L_2(\Omega)$.

Table 1 below shows the calculation results obtained for the following values of the parameters of the considered model [15-18].

For seeds: u10=100C; λ1=0.26; c1=1800; ρ1=50; R1=0.006; k1=0.005; WH1=19; α=2.30 ; ε1=0.8; r21=2082000; WP1=8; α1=2.01;
For fiber: u20=150C; λ2=0.07; c2=1600; ρ2=12; R2=0.025; k2=0.0003; WH2=9; ε2=0.8; WP2=0; α2=2.5; R=0.11.

Table 1. Calculation results obtained for the following values of the parameters of the considered model

τ \ r		0.1	0.2	0.3	0.4	0.5	0.6	0.7
		Temperature field of raw cotton components						
60	u1	28.41	27.98	22.585	19.264	17.257	16.032	15.262
	u2	48.18	46.65	37.922	31.277	26.143	22.218	19.261
120	u1	34.14	33.40	27.304	22.999	19.997	17.939	16.532
	u2	56.89	54.26	45.507	38.577	32.876	28.144	24.228
180	u1	38.36	37.25	30.884	26.086	22.521	19.893	17.98
	u2	61.95	58.49	49.815	42.891	37.082	32.127	27.883
240	u1	41.78	40.31	33.733	28.720	24.811	21.789	19.484
	u2	65.32	61.21	52.612	45.738	39.920	34.897	30.524
300	u1	44.70	42.88	36.192	31.02	26.089	23.086	20.981
	u2	67.744	63.10	54.551	47.728	41.929	36.89	32.46
360	u1	47.262	45.09	38.336	33.060	28.773	25.27	22.436
	u2	69.549	64.48	55.947	49.165	43.389	38.35	33.897

The following table 2 shows the results of the calculation regarding the radius of the raw cotton ball, at an air temperature of 1000C, with an initial temperature of 150C and with a humidity of WH1= 19%, WH2=9% of seeds and fiber, respectively. Drying time 360 seconds.

Below are the experimental and calculated data on the change in the temperature of the components of raw cotton (Table 3).

Table 2. Results of the calculation regarding the radius of the raw cotton ball.

r	0.1	0.2	0.3	0.4	0.5	0.6	0.7
u1(τ.r)	47.262	45.099	38.336	33.060	28.773	25.272	22.436
u2(τ,r)	69.549	64.478	55.947	49.165	43.389	38.348	33.897

Table 3. Experimental and calculated data on the change in the temperature of the components of raw cotton.

Lump diameter R=70 cm; air temperature 130 oC, initial moisture 17.4 %; drying time 360 sec.				
Drying time	Seed temperature		Fiber temperature	
	Experimental	Calculated	Experimental	Calculated
0	10.0	10.0	10.0	10.0
15	26.0	29.0	37.0	39.5
30	34.0	35.2	42.0	44.2
45	46.0	45.7	45.0	48.6
60	52.0	53.1	60.0	56.8
90	64.0	63.4	88.0	84.3

Analysis of the results of Table 3 shows that the diameter of the lump significantly affects the intensity of the drying process, i.e. with an increase in the diameter of the lump, the rate of heating of seeds and fibers sharply decreases. The temperature difference in seeds along the radius of the lump and the temperature difference between the fibers and seeds located at the same distance from the surface of the lump is very large, which leads to uneven drying of raw cotton components. To increase the rate of heating of seeds and achieve uniformity of drying, it is necessary to organize the drying of raw cotton in a loosened form, i.e. if possible, reduce the diameter of the lump.

IV. Results and Discussion

The article considers a boundary value problem for parabolic type systems to determine the temperature and humidity of raw cotton components during drying in dryers. An approximate solution of the problem under consideration is constructed by the variational-grid method. The stability of the approximate solution of the Galerkin method is established under the condition of strong minimality of the coordinate system. A comparative analysis with experimental data has been carried out.

V. Conclusion

Analysis of the results shows that the diameter of the lump significantly affects the intensity of the drying process, i.e. with an increase in the diameter of the lump, the rate of heating of seeds and fibers sharply decreases. The temperature difference in seeds along the radius of the lump and the temperature difference between the fibers and seeds located at the same distance from the surface of the lump is very large, which leads to uneven drying of raw cotton components. To increase the rate of heating of seeds and achieve uniformity of drying, it is necessary to organize the drying of raw cotton in a loosened form, i.e. if possible, reduce the diameter of the lump. A comparative analysis shows that the error in the calculated and experimental data is no more than 4-5%. And this makes it possible to analyze the heating rate in the form of a lump. It is shown that the proposed mathematical model and its numerical algorithm adequately describe the determination of the temperature of the fiber and seeds of the lump in the process of drying raw cotton.

References

Dai J., Dong H. Intensive cotton farming technologies in China: Achievements, challenges and countermeasures //Field Crops Research. – 2014. – vol. 155. – p. 99-110.

Mukai Y., Suh M. Design and characterization of a cotton fabric antenna for on-body thermotherapy //Journal of Industrial Textiles. – 2022. – p. 15280837221107160.

Zhou, C., Dong, J., Zhang, S., Zhang, Q., Wang, M., Zheng, L., & Jiang, W. (2022). Classification of waste cotton from different countries using the near-infrared technique. Textile Research Journal, 00405175221116059.

Dash, Ashwini Kumar, and Sanat Kumar Sahoo. "Role of Enzymes in Textile Processing." Bioprospecting of Enzymes in Industry, Healthcare and Sustainable Environment. Springer, Singapore, 2021. 395-410.

Mojsov, K., Janevski, A., Andronikov, D., Jordeva, S., Kertakova, M., Golomeova, S., & Ignjatov, I. (2019). Behaviour of biopolishing on dyeability and certain properties of cotton fabrics. Tekstilna industrija, 67(1), 20-24.

Glynis, Antonios, et al. "Regenerative endodontic procedures for the treatment of necrotic mature teeth with apical periodontitis: a systematic review and meta-analysis of randomized controlled trials." Journal of Endodontics 47.6 (2021): 873-882.

Trache, D., Tarchoun, A. F., Derradji, M., Hamidon, T. S., Masruchin, N., Brosse, N., & Hussin, M. H. (2020). Nanocellulose: from fundamentals to advanced applications. Frontiers in Chemistry, 8, 392.

Ge, S., Manigandan, S., Mathimani, T., Basha, S., Xia, C., Brindhadevi, K., & Pugazhendhi, A. (2022). An assessment of agricultural waste cellulosic biofuel for improved combustion and emission characteristics. Science of The Total Environment, 813, 152418.

Karlsson, Bo, and Monika Kurkkio. "Using calculations in the early phase of strategic capital investment projects–insights from the mining industry." Qualitative Research in Accounting & Management (2018).

Lima, M. C. R., Ramos, J. E. S., Borba, M. C., Schultz, G., & Révillion, J. P. P. (2022). A dinâmica análise das ações estratégicas empresariais no agronegócio. Revista Tecnologia e Sociedade, 18(52), 285-307.

Parpiev A.P., Kayumov A.H., Pardayev H. «Effect of temperature of steady heating components of cotton-seed at drying process», European science review, vol.7-8, pp. 205-207, 2016.

Parpiyev A.P., Kayumov A.H., «Analytical review of the applied temperature in the process of drying raw cotton», Scientific and Technical Journal of FerPI, Vol.1, pp. 29-34. 2017.

Mamatov A., Parpiyev A., Kayumov A., Analysis of Heat Heat Transmission of Cotton-Raw Components, International Journal of Advanced Research in Science, Engineering and Technology, Vol. 5, Issue 12, December 2018. P. 7534-7542

Mamatov A., Parpiyev A., Kayumov A., Mathematical models of the heat and mass exchange process during pneumo-transportation of cotton-raw// International Scientific Journal Theoretical & Applied Science , p-ISSN: 2308-4944 (print) e-ISSN: 2409-0085 (online) , Year: 2020 Issue: 11 ,Volume: 91, P. 508-513.

Mamatov, A., Parpiev, A., Shorakhmedova, M. Mathematical model for calculating the temperature field of a direct-flow drying drum//Journal of Physics: Conference

Seriesthis link is disabled, 2021, 2131(5), 052067
Mamatov, A.Z., Usmankulov, A.K., Abbazov, I.Z., Norboyev, U.A., Mukhametshina, E.T. Determination of Temperature of Components of Cotton-Raw Material in a Drum Dryer with a Constant// IOP Conference Series: Earth and Environmental Sciencethis link is disabled, 2021, 939(1), 012052
Mamatov, A.Z., Pardaev, X.N., Mardonov, J.S.H., Plekhanov, A.F. Determining of the heat-moisture stateof raw cotton in a drum dryer. Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Teknologiya Tekstil'noi Promyshlennostithis link is disabled, 2021, 391(1), p. 46-49.
Mamatov, A.Z., Zulunov R., Sodikova M. Application Of Variational Grid Method For The Solution Of The Problem On Determining Mosture Content Of Raw Cotton In A Drum Dryer// The American Journal of Engineering and Technology (ISSN – 2689-0984) Published: February 26, 2021 | Pages: 75-82
Lykov A.V. Heat and mass transfer (directory). M.: Energiya, 1978. - 480 p.
Mixlin S.G. Numerical implementation of variational methods.-M.: The science.1966, -432 p.
M.V.K.Charis, J.Salon. Numerical Methods in Electromag-netism. Variation and Galerkin methods.-2000, Pages 143-187.
Schekoldin M.N. «Heat moisture state of raw cotton», State Gizlegprom Publishing House. 74 p., 1958.
Kh. Pardaev, I. Abbazov, B. Sharopov “Pneumotransport quvurlarida vujudga keladigan karshilik kuchlar tahlili” Respublika ilmiy-amaly anjuman maqolalar to’plami Toshkent, 2021. P. 165-167.
Kh.Pardaev, I.Abbazov, B.Sharopov “Paxtani havo yordamida tashuvchi pneumotransport tizimlari tahlili” Magistr talabalarining ilmiy maqololalar tuplami Tashkent-2021, 71-74.
Agzamov, Mirsolikh & Bakhtiyarovich, Rakhmatov & Agzamov, Mirkhosil. (2019). The Results of Research to Determine the Parameters of Hardening Working Area of the Gin and Linter Grates. Journal of Mechanical Engineering Research. 2. 23-25. 10.30564/jmer.v2i2.1574.
Agzamov, M., Agzamov, M. M., & Madgidov, G. F. (2007). Ways for improvement of cotton fiber quality in process of ginning. Izvestiia-Vysshie Uchebnye Zavedeniia Tekhnologiia Tekstil'noi Promyshlennosti, 3, 34
Agzamov M.M. (2021). The influence of the rotation speed of the raw roller on fiber quality and other indicators of the generation process. Izvestiya Vysshikh Uchebnykh Zavedenii, Seriya Teknologiya Tekstil'noi Promyshlennosti, (4), pp. 88–93.
Agzamov M.M. et al. (2021). Search for ways to increase yield and improve product quality in the process of saw ginning. IOP Conf. Ser.: Earth Environ. Sci. 939 012073. https://doi.org/10.1088/1755-1315/939/1/012073.
Agzamov M.M. et al. (2021). Research of the reasons of increased drop in cotton seeds after generation with reduced density of raw roller. IOP Conf. Ser.: Earth Environ. Sci. 939 012072. https://doi.org/10.1088/1755-1315/939/1/012072.
Agzamov M.M., Yunusov S.Z., Gafurov J.K. (2017). On the technological development of cotton primary processing, using a new drying-purifying unit. IOP Conf. Ser.: Mater. Sci. Eng. 254 082017. https://doi.org/10.1088/1757-899X/254/8/082017