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Research of Dependence of Heat Conductivity of The Clap-Raw And Its Components From Temperature And Humidity

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ABSTRACT: A comparative analysis the productivity of equipment various methods of preparation the basis.

KEYWORDS: drying, clap-raw, fibers, clamping device, formulas, speed, coefficient of useful time, productivity.

I.INTRODUCTION

The rational choice of parameters of drying and storage of a clap-raw and its components first of all is connected with its primary treated steel -which - heating, warming up, drying, humidifying и.т.д. These all techno-logic of operation are indissolubly connected with change thermal and влажностных parameters. For a correct choice technological the pair-meters drying and processing of a clap-raw should be known such thermal characteristics, as heat conductivity, a thermal capacity, rate- number of conductors, thermo-moisture conductors, and also possible kinds and forms of communication of a moisture of a clap-raw, its fibers and seeds.

Clap - a raw and its components (the fiber and seeds) on the physical to properties can be carried to firm bodies of type heat-retention [1], at heating (drying) which undergo the physical and chemical transformations accompanied within the limits of certain temperatures by thermal effects of various force. Thus the fiber and seeds of a raw partially change structure, lose a significant part of the weight and get new, differing from originally at-native, physical and chemical properties.

In the given work it was investigated heat conductivities of a clap-raw, and seeds depending on temperature and humidity. Measurement of heat conductivity was made widely known methods a stationary thermal stream of the-interstate standard. A method of definition of heat conductivity and thermal resistive capacity at a stationary thermal mode of GOST 7076-99, accepted by the inter-state scientific and technical commission on standardization on November, 17th, 1994.

The standard completely corresponds STSEV 4923-84 and a method definition to heat conductivity a cylindrical probe. The essence of a method consists in creation of a stationary thermal stream (rice-1) passing through the flat sample and directed at right angle to obverse sides (to the greatest sides of the sample, measurement of density of a thermal stream, temperatures opposite obverse and thickness of the sample). To the sample the form of a square 250x 250x5-10 mm is given to the examinee. The sample is located between system of creation of a stationary thermal stream and system heat-resistance. For dense abutment the sample to these systems without air backlashes the special clamping device is provided. The sample of a bulk material should be placed in a box, the bottom and which cover are made from thin sheet material-annealed red copper. The length and width of a box should be equal to corresponding sizes of working surfaces of plates of the device, depth - to thickness of the tested sample.

Relative hemispherical radiating ability a bottom and covers of a box should be more than 0,8 at those temperatures, which these surfaces have during test. Thermal resistance RL a sheet material of which make a bottom and a cover of a box it is known. For each examinee of a material produced with identical tests on weight. Test of a bulk material divide into four equal parts which serially fill in a box, density each part so that it has borrowed a part of internal volume of a box corresponding it. A box closes a cover. A cover attached to lateral walls of a box.

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Weigh a box with the sample of a bulk material. On definitely value of weight of a box with the sample and to preliminary certain values of internal volume and weights of an empty box calculate moisture of the sample of a bulk material. The error of definition of weight and the size of samples not should be more than 0,5. Then the system is checked on tightness by manufacturing facilities a box under a vacuum cap and eviction. Thus loss of weight should not exceed accuracy of analytical weights. Power supply systems of installation and devices join, and get warm in current of 30 minutes. At work with temperatures from above 1500C it is necessary to include system in cooling of a casing of installation. Shortening an input of voltmeter V7-21 its indications on a zero are established at a limit of measurements. This item is necessary for carrying out periodically.

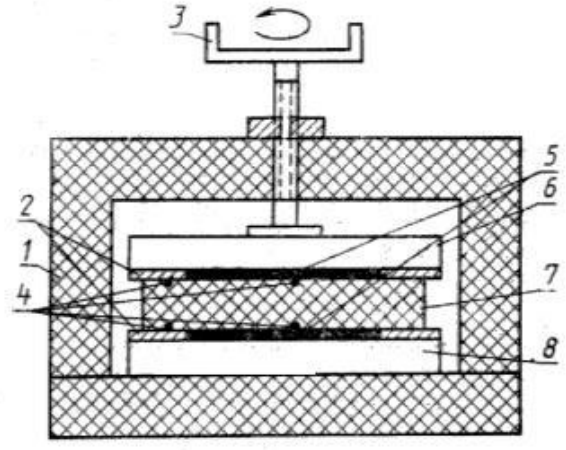

Figure 1. The scheme of the thermal block of installation
1 - heat-insulated a casing; 2 - a security zone of the converter warmly a stream; 3 clamping device; 4 - converters of temperature; 5 - converters of a thermal stream; 6, 8 - heat-insulated; 7 sample.

Establish preset values of temperatures of a refrigerator, switch on system of automatic control of temperature fridge, at temperatures below 1000C the system of water delivery on fridge with the purpose of reliable work heat-resistance joins. On the basic heater a feed moves, and its adjustment achieve a demanded difference of temperatures on a surface heat-resistance. Systems of automatic adjustment of temperature modes join. After such warming up - the sample a subject test place in the device. An arrangement of the sample - horizontal, a direction of a thermal stream from top to down.

During test the difference of temperatures of obverse sides of sample D Tu should make no more than 3-4 K. Through each 5-10 minutes dream-toil signals heat measure and gauges of temperatures of obverse sides, and the capacity submitted on a heater of a zone of measurement of a hot plate of the device. Thermal stream through tested the sample consider established (stationary) if values of thermal resistance (heat conductivity) of the sample, calculated by results of five measurements of signals of gauges of temperatures and capacities, on the basic heater, differ from each other less than on 0,5, thus these sizes do not increase and do not decrease monotonously. Up additional uniformity of a thermal stream it was supervised with with the help of heat measure with 128 contacts of thermocouples located on it and automatically measurements. After the termination of test define weight sample M3 if change of weight no more than 0,5, experience is considered is lead successfully. If the system is checked on tightness with new fresh test, and experiment again is spent.

II. EXPERIMENTAL RESULTS

In figure 2-4 curve dependences of heat conductivity of a clap-raw (p.2) fibers (p.3) and seeds (рис.4) from temperature of the humidity, received by practical consideration are presented. The received dependences show, that at humidity it is less than 20 dependence of heat conductivity of a clap of a raw and its components from temperature is close to linear, and at humidity from above 20 and above it sharply increases, that is connected with heat-changing parameters between components as clap of a raw, and its components at great values of temperature and humidity.

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Let's enter density of a clap of raw ρ_{ax} and its components (a fiber- $\rho_{a\text{в}}$, lowered seeds - ρ_{ac}) in the modular condition, defined under formulas

$\rho_{ax} = m_1\rho_1 + m_2\rho_2 + m_3\rho_3 + m_4\rho_4$, $\rho_{ax} = m_1\rho_1 + m_2\rho_2 + m_4\rho_4$, $\rho_{ax} = m_1\rho_1 + m_3\rho_3 + m_4\rho_4$ where ρ_1, ρ_2, ρ_3 and ρ_4 - true density of air, a fiber, seeds and water; m_1, m_2, m_3 and m_4 - according to their concentration in shares of unit,

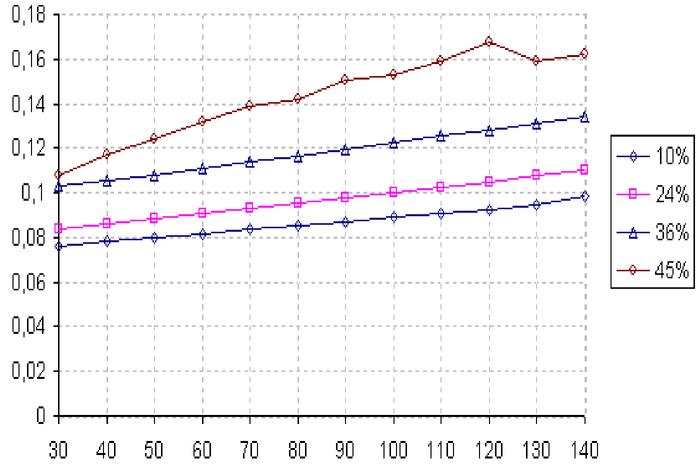

Figure 2. Dependence of heat conductivity of a clap-raw on temperature at different moisture (density of 110 kg/m^3; heat conductivity, Vt/m)

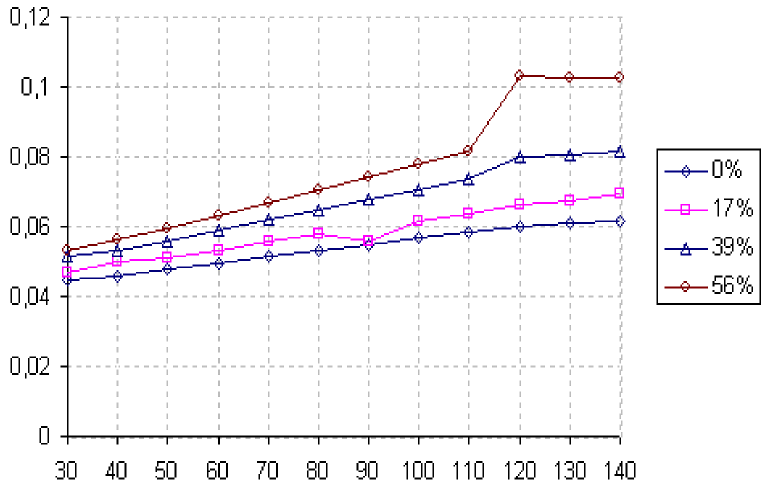

Figure 3. Dependence of heat conductivity of a cotton fiber on temperature at different moisture (density of 76 kg/m^3; heat conductivity , Vt/m)

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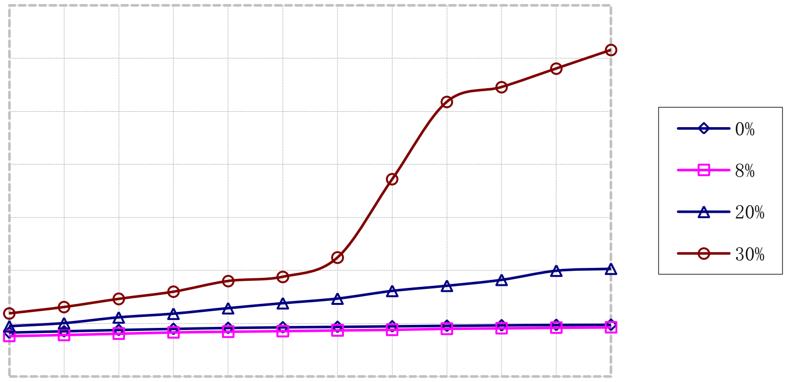

Figure 4. Dependence of heat conductivity of the lowered seeds on temperature at different moisture (humidity in %, heat conductivity λ, Vt/m) and $m_1+m_2+m_3+m_4=1$ for a raw clap, $m_1+m_2+m_4=1$ for a fiber, $m_1+m_3+m_4=1$ for seeds. At $T>100\ ^0C$ size m_4 will correspond concentration of water as a part of steam.

As experiences were spent at constant density of a clap of a raw and its components in modular condition $\rho_{ax}=110\,кг/м^3$, $\rho_{ав}=76\,кг/м^3$, $\rho_{ac}=76\,кг/м^3$ to temperature and humidity change there is under different laws a redistribution of concentration of air m_1, fibers m_2, seeds m_3 и of water m_4 as a part of a clap of a raw and its components. These can explain considerable change of behavior of curves near to point $T=100\ ^0C$ where water completely turns to steam. It is especially appreciable for curve dependences of heat conductivity of seeds on temperature at big moisture (fig. 4)

Apparently to dependence of heat conductivity on temperature practical submits linear, or it is more exact to the square-law law. Experimental curves for heat conductivity of a damp clap-raw and its components we shall present by means of the general dependence

$$\lambda = aT^2 + bT + c;$$

Where a, b и c - the constants depending on humidity u and defined from an extremefunction of a square-law deviation

$$S=\sum_{i=1}^{N}(y_i - aT_i^2 - bT_i - c)^2;$$

Where y_i - skilled values of heat conductivity at temperature T_i for the fixed humidity of a material, N - quantity of experimental points.

The relative divergence of skilled data of heat conductivity with its values calculated under the formula (1) was estimated under the formula [4]

$$\Delta_i = \frac{|y_i - aT_i^2 - bT_i - c|100\%}{y_i};$$

Practical application of the formula (1) causes inconvenience as factors a, b и c implicitly depend on humidity u. Therefore we enter the formula containing obvious dependence of heat conductivity from humidity. Dependence (1) we will present in a kind

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$$\lambda = (k_2 u^2 + k_1 u + k_0)(a_* T^2 + b_* T + c_*);$$

Where k_0, k_1, k_2 - the new constants defined by practical consideration, a_*, b_* and c_* - average values on humidity of constants a, b and c.

In tables 1-3 values of constants a, b, $c.$, a_*, b_*, c_*, k_2, k_1, k_0 and the given heat conductivity depending on the temperature, received by practical consideration and results of calculations under formulas (1) and (2) for various values of humidity are presented. From tabular data follows, (2) value of constant k_2 практически is equal in the formula to zero that will be coordinated with the formula offered in work [1]. Factors a, b, c a_*, b_* and c_* at different moisture differ from each other, that specifies in various character of course warmly and processes in the clap a raw, a fiber and seeds. Thus the picture of change of heat conductivity of a clap of a raw and its components at small measure is close to each other. Essential difference is found out at great values of humidity where at the expense of activity mass-transfer the process, connected with the evaporation phenomenon, heat conductivity of seeds undergoes considerable changes.

$$a_* = -0.872 \cdot 10^{-4}, b_* = 0.0454, c_* = 7.987, k_2 = 0.00045, k_1 = -0.014, k_0 = 0.891$$

$W = 10\%$

$a = 0.0000374, b = 0.0128, c := 7.2504$

$W = 24\%$

$a = 0.3796 \cdot 10^{-5}, b = 0.0228, c = 7.7216$

Table 1. Comparison of skilled data of change of heat conductivity of a clap - of raw $\lambda \cdot 10^2 = La$ (Vt/m.) from temperature at various values with results of calculations under formulas (5) and (6)

$T^0 C$	Experiment	Formulas(1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$	Experiment	Formulas (1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$
30	7.64	7.67	0.367	7.38	3.409	8.41	8.41	0	7.548	10.24
40	7.82	7.82	0	7.69	1.633	8.64	8.64	0	7.868	8.933
50	7.99	7.98	0.076	7.99	0.013	8.87	8.87	0	8.174	7.849
60	8.16	8.15	0.084	8.276	1.421	9.11	9.1	0.073	8.465	7.078
70	8.37	8.33	0.481	8.547	2.114	9.33	9.34	0.067	8.742	6.298
80	8.54	8.51	0.306	8.804	3.578	9.56	9.57	0.104	9.005	5.801
90	8.72	8.70	0.166	9.047	3.754	9.81	9.80	0.056	9.254	5.665
100	8.90	8.90	0	9.276	4.233	10.04	10.04	0	9.488	5.489
110	9.09	9.11	0.233	9.492	4.424	10.28	10.27	0.042	9.709	5.552
120	9.27	9.32	0.595	9.694	4.571	10.51	10.51	0	9.915	5.567
130	9.45	9.54	1.023	9.881	4.565	10.76	10.75	0.093	10.11	6.065
140	9.89	9.77	1.155	10.05	1.671	10.98	10.99	0.075	10.28	6.239

$W = 36\%$

$a = 0.167 \cdot 10^{-4}, b = 0.02554, c = 9.5167$

$W = 45\%$

$a = -0.407 \cdot 10^{-3}, b = 0.1204, c = 7.462$

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Table 2. Comparison of skilled data of change of heat conductivity of fibre $\lambda \cdot 10^2 = La$ (Vt/m.) from temperature at various values moisture with results of calculations under formulas (5) and (6)

T^0C	Experiment	Formulas(1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$	Experiment	Formulas (1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$
30	10.33	10.29	0.308	9.000	12.93	10.78	10.71	0.668	10.86	0.813
40	10.54	10.56	0.241	9.376	11.04	11.69	11.63	0.537	11.33	3.095
50	10.82	10.84	0.147	9.740	9.806	12.39	12.46	0.605	11.77	5.018
60	11.11	11.11	0	10.09	10.72	13.19	13.22	0.239	12.19	7.598
70	11.38	11.39	0.062	10.41	11.65	13.90	13.89	0.024	12.59	9.446
80	11.66	11.67	0.065	10.73	12.24	14.23	14.49	1.829	12.97	8.885
90	11.97	11.95	0.154	11.02	12.41	15.07	15.00	0.447	13.33	11.59
100	12.24	12.24	0	11.31	12.62	15.25	15.43	1.203	13.66	10.41
110	12.54	12.53	0.083	11.57	12.54	15.89	15.78	0.673	13.98	12.02
120	12.82	12.82	0	11.81	12.52	16.78	16.05	4.343	14.28	14.9
130	13.14	13.12	0.145	12.04	11.93	15.90	15.90	2.125	14,56	8.47
140	13.40	13.42	0.161	12.25	11.61	16.19	16.34	0.947	14.81	8.53

$a_* = 0.6458 \cdot 10^{-4}$, $b_* = 0.01751$, $c_* = 4.3544$, $k_2 = 0.00028$, $k_1 = 0.005$, $k_0 = 0.85$

$W = 0\%$

$a = -0.4608 \cdot 10^{-5}$, $b = 0.0157$, $c := 4.171$

$W = 17\%$

$a = 0.14 \cdot 10^{-4}$, $b = 0.01826$, $c = 4.1476$

Table 3. Comparison of skilled data of change of heat conductivity downy cotton-seed $\lambda = La$ (Vt/m.) from temperature at various values moisture with results of calculations under formulas (5) and (6)

T^0C	Experiment	Formulas(1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$	Experiment	Formulas (1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$
30	4.68	4.382	0.891	4.200	10.31	4.68	4.707	0.598	4.657	0.491
40	4.775	4.792	0.363	4.385	8.175	4.89	4.900	0.210	4.865	0.514
50	4.92	4.947	0.518	4.583	6.851	5.12	5.096	0.477	5.085	0.687
60	5.08	5.10	0.349	4.792	5.666	5.34	5.293	0.869	5.137	0.431
70	5.245	5.249	0.076	5.012	4.434	5.56	5.495	1.181	5.561	0.024
80	5.395	5.399	0.081	5.244	2.806	5.78	5.698	1.419	5.818	0.656
90	5.54	5.549	0.160	5.486	0.978	5.57	5.904	6.002	6.087	9.275
100	5.70	5.697	0.046	5.739	0.684	6.17	6.113	0.915	6.367	3.201
110	5.87	5.845	0.426	6.003	2.268	6.37	6.325	0.697	6.660	4.562
120	6.04	5.991	0.800	6.278	3.944	6.63	6.540	1.352	6.966	5.066
130	6.13	6.137	0.041	6.564	6.911	6.76	6.758	0.030	7.283	7.741
140	6.18	6.282	0.678	6.861	9.959	6.94	6.978	0.553	7.613	9.696

$W = 39\%$

$a = 0.8766 \cdot 10^{-5}$, $b = 0.02823$, $c = 4.1888$

$W = 56\%$

$a = 0.0024$, $b = 0.00784$, $c = 4.911$

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Table 4. Comparison of skilled data of change of heat conductivity downy cotton-seed $\lambda = La$ (Vt/m.) from temperature at various values moisture with results of calculations under formulas (5) and (6)

T^0C	Experiment	Formulas(1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$	Experiment	Formulas (1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$
30	5.15	5.043	1.103	5.367	5.235	5.31	5.362	0.981	6.013	13.25
40	5.34	5.332	0.145	5.606	4.990	5.64	5.608	0.557	6.282	11.38
50	5.59	5.662	0.581	5.860	4.830	5.97	5.903	1.121	6.566	9.983
60	5.87	5.914	0.757	6.127	4.388	6.32	6.245	1.177	6.865	8.636
70	6.19	6.208	0.293	6.409	3.541	6.68	6.636	0.655	7.181	7.505
80	6.48	6.503	0.365	6.705	3.470	7.05	7.075	0.352	7.512	6.562
90	6.78	6.800	0.308	7.014	3.460	7.44	7.561	1.632	7.859	5.639
100	7.06	7.100	0.564	7.338	3.941	7.79	8.096	3.929	8.222	5.549
110	7.36	7.400	0.552	7.676	4.294	8.17	8.679	6.228	8.600	5.272
120	7.98	7.703	3.469	8.028	0.599	10.3	9.309	9.615	8.994	12.67
130	8.06	8.00	0.653	8.393	4.139	10.27	10.00	2.742	9.405	8.423
140	8.14	8.313	2.130	8.773	7.783	10.24	10.71	4.640	9.830	3.998

$$a_* = -0.851 \cdot 10^{-6},\ b_* = 0.000282,\ c_* = 0.0706,\ k_2 = 0,\ k_1 = -0.01,\ k_0 = 1.05$$

$T\ ^0C$ $W = 0\%$

$a = -10^{-6}$, $b = 0.00031$, $c = 0.07426$

$W = 8\%$ $\kappa_2 = 0.001$, $k_1 = -0.008$

$a = -6.6 \cdot 10^{-7}$, $b = 0.00026$, $c = 0.0692$

Table 5. Comparison of skilled data of change of heat conductivity downy cotton-seed $\lambda = La$ (Vt/m.) from temperature at various values moisture with results of calculations under formulas (5) and (6)

T^0C	Experiment	Formulas(1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. Δ_i (%)	Experiment	Formulas (1)	Pogr. $\Delta_i(\%)$	Formulas (2)	Pogr. $\Delta_i(\%)$
30	0.0823	0.0825	0.2901	0.0822	0.1519	0.0762	0.076	0.217	0.0760	0.3753
40	0.0847	0.0849	0.2144	0.0845	0.2266	0.0782	0.078	0.353	0.0781	0.1671
50	0.0872	0.0870	0.2096	0.0866	0.6166	0.0806	0.080	0.178	0.0800	0.6706
60	0.0893	0.0889	0.3688	0.0864	0.7415	0.0830	0.082	0.837	0.0819	1.3440
70	0.0911	0.9066	0.4756	0.0904	0.7305	0.0843	0.084	0.330	0.0835	0.8965
80	0.0923	0.0922	0.1293	0.0920	0.2682	0.0854	0.085	0.241	0.0850	0.4228
90	0.0932	0.0935	0.3082	0.0935	0.3128	0.0867	0.087	0.415	0.0864	0.3824
100	0.0942	0.0946	0.4104	0.0947	0.5859	0.0879	0.088	0.549	0.0875	0.4177
110	0.0952	0.0955	0.2928	0.0958	0.6655	0.0898	0.089	0.251	0.0885	1.4120
120	0.0961	0.0962	0.0663	0.0967	0.6622	0.0906	0.090	0.	0.0893	1.3619
130	0.0968	0.0966	0.1638	0.0974	0.6824	0.0917	0.091	0.151	0.0900	1.8157
140	0.0971	0.0969	0.1938	0.0980	0.9328	0.0924	0.092	0.045	0.0906	2.0144

$T\ ^0C$ $W = 20\%$

$a = 0.217 \cdot 10^{-5}$, $b = 0.000664$, $c = 0.071387$

$a_* = 0.2045 \cdot 10^{-5}$, $b_* = 0.0009$, $c_* = 0.0734$

$W = 30\%$

$a = -0.143 \cdot 10^{-6}$, $b = 0.00146$, $c = 0.0738$,

$a_* = 0.2045 \cdot 10^{-5}$, $b_* = 0.0009$, $c_* = 0.0734$

$k_2 = 0.00312$, $k_1 = -0.1253$, $k_0 = 2.128$

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$k_2 = 0.00312,\ k_1 = -0.1253,\ k_0 = 2.128$ при $T < 90$

$a = -0.18 \cdot 10^{-3}$, $b = 0.0489$, $c = -2.725$

$a_* = -0.1428 \cdot 10^{-6}, b_* = 0.00146,\ c_* = 0.063$

$k_2 = 0,\ k_1 = -0.0005,\ k_0 = 2.06$

при $T > 90$

Table 6. Comparison of skilled data of change of heat conductivity downy cotton-seed $\lambda = La$ (Vt/m.) from temperature at various values moisture with results of calculations under formulas (5) and (6)

T^0C	Experiment	Formulas(1)	Pogr. Δ_i(%)	Formulas (2)	Pogr. Δ_i (%)	Experiment	Formulas (1)	Pogr. Δ_i(%)	Formulas (2)	Pogr. Δ_i(%)
30	0.0944	0.0933	1.2025	0.0890	5.7333	0.119	0.1176	0.9508	0.1204	1.4231
40	0.1002	0.1014	1.2256	0.0981	2.1226	0.131	0.1321	1.0667	0.1327	1.5114
50	0.1111	0.1100	0.9666	0.1075	3.2343	0.146	0.1466	0.3344	0.1454	0.4497
60	0.1181	0.1190	0.8118	0.1173	0.6774	0.159	0.1610	0.9112	0.1587	0.5689
70	0.1285	0.1285	0.0205	0.1274	0.8178	0.180	0.1755	2.3963	0.1724	4.1032
80	0.1379	0.1384	0.3837	0.1379	0.0392	0.188	0.1899	1.1182	0.1866	0.6206
90	0.1467	0.1488	1.4081	0.1488	1,4416	0.224	0.2043	8.8845	0.2013	10.201
100	0.1612	0.1595	1.031	0.1600	0.7247	0.372	0.3762	1.116	0.4266	14.660
110	0.1709	0.1707	0.0912	0.1716	0.4121	0.518	0.4869	6.029	0.4559	12.014
120	0.1821	0.1824	0.1568	0.1835	0.7868	0.546	0.5616	2.862	0.4559	11.140
130	0.1994	0.1945	2.4766	0.1958	1.7968	0.581	0.6002	3.316	0.4851	11.472
140	0.2031	0.2069	1.9067	0.2084	1.7967	0.616	0.6029	2.131	0.5435	11.776

III.CONCLUSION AND FUTURE WORK

Dependences of heat conductivity of a clap-raw and it from temperature are received at different moisture which calculations on the equation heat changing at drying a clap-raw. 2. By the analysis of experimental data it is established, at density of a clap-raw and its components, high temperature and humidity can essentially influence values of their heat conductivity and change concentration of air and a moisture in their structure. 3. It is proved uses empirical formulas for calculation of heat conductivity of a clap-raw and its components, approximating experimental dependences linear or square-law function.

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