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Effects Of The Bulk Density Of Raw Cotton On The Thermal Conductivity Coefficient

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Abstract: In the article the influence of temperature and volume density of raw cotton on heat conductivity coefficient is studied.

Key words: Cotton seeds, drying parameters, humidity, thermal and hygroscopic properties, heat, electrical conductivity, resistance, meter, temperature, steam, etc.

As it is known, preservation of the quality of raw cotton and its components is one of the priority tasks facing the industry of the Republic of Uzbekistan. One of the important tasks in this direction is a rational choice of parameters for drying and storage of raw cotton and its components. This is primarily due to its primary heat treatment - heating, heating, drying, humidification, etc. All these technological operations are inextricably connected with changes in thermal and humidity parameters. For correct choice of technological parameters of drying and processing of raw cotton such thermal characteristics as thermal conductivity of raw cotton, its fibers and seeds should be known. [1]

Known scientific and applied works [1,2] do not allow to receive satisfactory enough thermal and hygroscopic parameters of raw cotton. Now in our Republic a number of original methods of research of thermal parameters, some materials and the substances allowing to solve the above-stated problems are developed and created. Therefore, there is an urgent need to develop methods to objectively assess the thermal and moisture parameters of cotton [3].

In the given work the influence of volume density of raw cotton on thermal conductivity coefficient was investigated.

Experiment methods

Set the set temperatures of the refrigerator, the system of automatic regulation of the refrigerator temperature is activated, at temperatures below 100ºC the system of water supply to the refrigerator is activated in order to ensure reliable operation of the heat flow. The main heater is supplied with power, and by its regulation the required temperature difference on the surface of heat exchangers is achieved. The systems of automatic regulation of temperature modes are switched on. After such heating, the sample to be tested is placed in the device. Location of the sample - horizontal, direction of heat flow from top to bottom.

During the test, the temperature difference between the face faces of the sample ΔT_u should not be more than 3-4 K. Every 5-10 minutes, the signals from the heat meter e_u and the temperature sensors of the sample's face faces and the power supplied to the heater of the hot plate measuring zone of the device are sensed. The heat flux through the sample under test shall be considered steady (stationary) if the thermal resistance (thermal conductivity) of the sample, calculated from the results of five successive measurements of the temperature and power sensors' signals to the main heater, differs from each other by less than 0.5%, and these values do not increase or decrease monotonously. Additionally, the uniformity of the heat flow was controlled by means of a heat meter with 128 thermocouple contacts located on it and automatic measurement. After the end of the test, the mass of the M_3 sample is determined, if the change in mass does not exceed 0.5%, the test is considered a success. If not, the system is tested for leaks with a new fresh sample and the experiment is repeated.

For deeper studying of influence of volume density on thermal conductivity corresponding experimental researches were conducted.

Pictures 1, 2, 3, 4 show the experimental data of heat conductivity, depending on the volume density of raw cotton at humidity of raw cotton W=10, 24, 36, 45%.

Pic. 1-4 shows the curves of dependence of thermal conductivity on the volume density of raw cotton obtained at drying temperature $T_1 = 40^\circ C$, $T_2 = 50^\circ C$, $T_3 = 60^\circ C$, $T_4 = 70^\circ C$ and $T_5 = 80^\circ C$.

Pic. 1 shows the dependence of thermal conductivity on the volume density obtained at the initial moisture content of raw cotton W=10%. Curves 1 - 5 in this figure correspond to the temperature $T_1 = 40^\circ C$, $T_2 = 50^\circ C$, $T_3 = 60^\circ C$, $T_4 = 70^\circ C$ и $T_5 = 80^\circ C$.

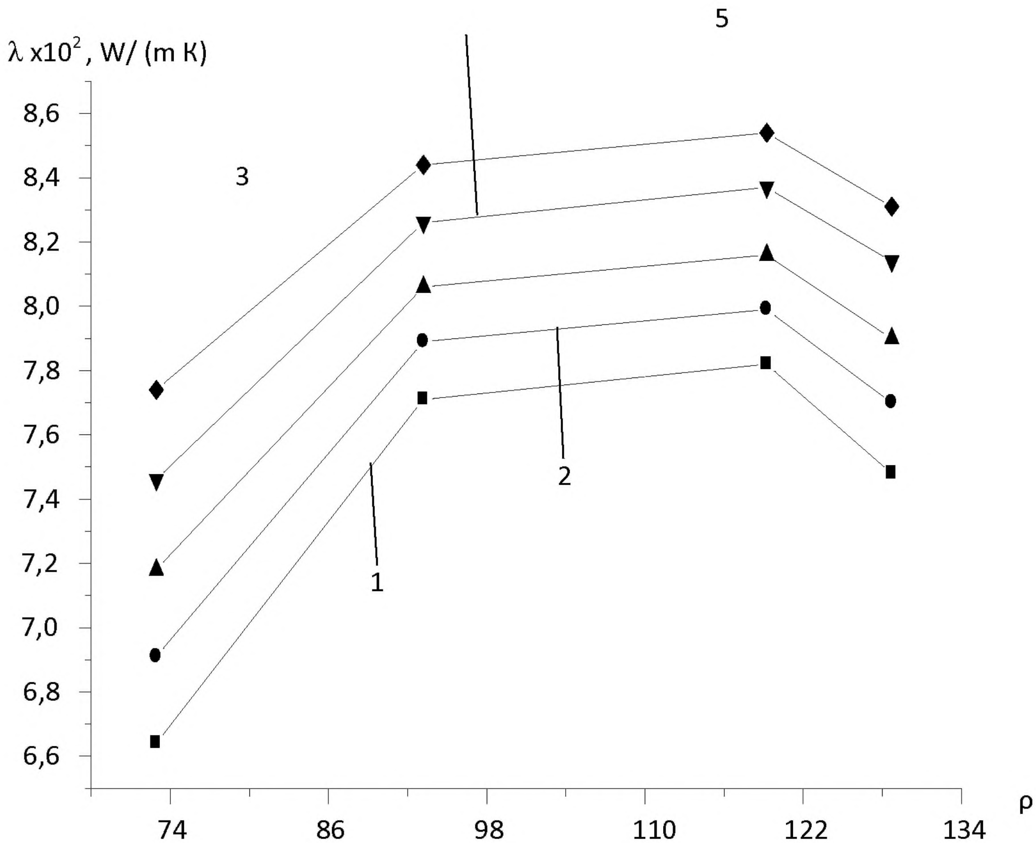


Figure 1: Dependence of the thermal conductivity coefficient of raw cotton on the density at different temperatures (raw cotton (°C); 1-40, 2-50, 3-60, 4-70, 5-80, humidity of raw cotton W=10%.

It can be seen that the quality of the law of change of heat conductivity curves at the increase of the volume density does not depend on the drying temperature. All curves in the area $74\frac{\kappa\Gamma}{м^3} < \rho < 122\frac{\kappa\Gamma}{м^3}$ increase. And in the area $74\frac{\kappa\Gamma}{м^3} < \rho < 92\frac{\kappa\Gamma}{м^3}$ it increases faster than in the area $92\frac{\kappa\Gamma}{м^3} < \rho < 122\frac{\kappa\Gamma}{м^3}$. All the curves fall in the area $\rho > 122\frac{\kappa\Gamma}{м^3}$. Points $\rho = 92\frac{\kappa\Gamma}{м^3}$ and $\rho = 122\frac{\kappa\Gamma}{м^3}$ for all curves are also transient.

Pic. 2 shows the dependence of thermal conductivity on the volumetric densities obtained at the initial moisture content of raw cotton $W = 24\,\%$. Curves 1 - 5 are obtained at drying temperature $T_1 = 40^\circ C$, $T_2 = 50^\circ C$, $T_3 = 60^\circ C$, $T_4 = 70^\circ C$ and $T_5 = 80^\circ C$ accordingly.

All curves in the area $87\,\frac{\kappa\Gamma}{м^3} < \rho < 111\,\frac{\kappa\Gamma}{м^3}$ increase, and the areas $111\,\frac{\kappa\Gamma}{м^3} < \rho < 146\,\frac{\kappa\Gamma}{м^3}$ fall. The point $\rho = 111\,\frac{\kappa\Gamma}{м^3}$ is the boundary between the areas of increasing and decreasing thermal conductivity. The boundary between the areas of increase and decrease in thermal conductivity has moved much to the right along the horizontal axis in comparison with the previous experiment (see points $\rho = 92\frac{\kappa\Gamma}{м^3}$ in Pic. 1). In this case, the first transition point corresponds to the density with the value of $\rho = 111\,\frac{\kappa\Gamma}{м^3}$.

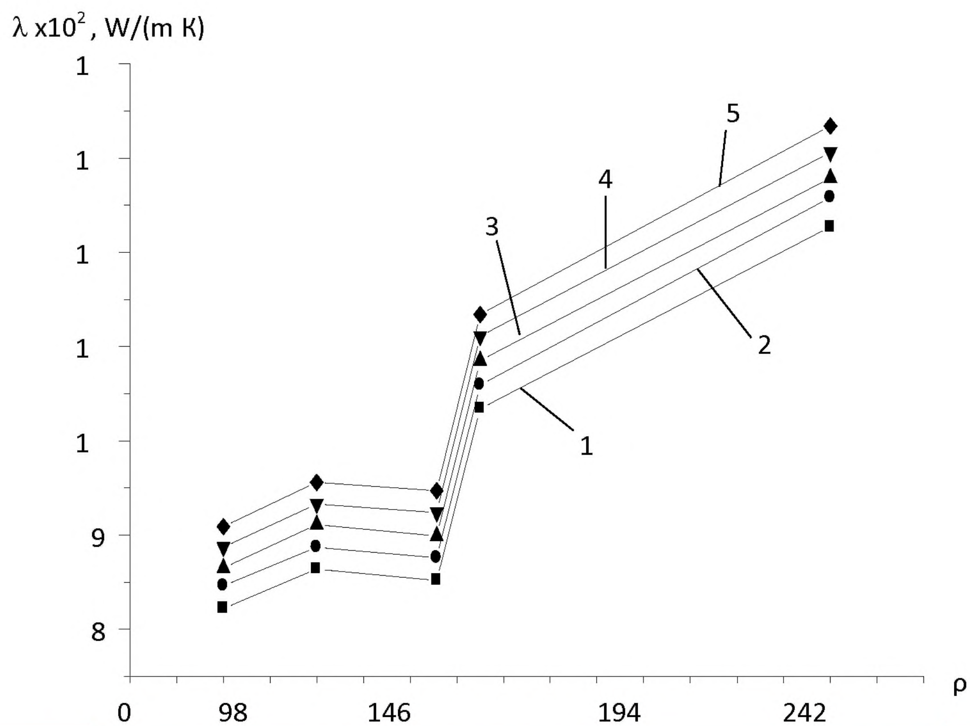


Figure 2: Dependence of the thermal conductivity coefficient of raw cotton on density at different temperatures (raw cotton temperature (ºC); 1-40, 2-50, 3-60, 4-70, 5-80, humidity of raw cotton W=24%.

Besides, in this experiment, the heat conductivity curves have at least three transition points at the transition of which the heat conductivity increases monotonically, drops and increases significantly. In the area $146\frac{\kappa\Gamma}{м^3} < \rho < 170\frac{\kappa\Gamma}{м^3}$, the value of thermal conductivity increases significantly faster than the areas $111\frac{\kappa\Gamma}{м^3} < \rho$ and $\rho > 159\frac{\kappa\Gamma}{м^3}$.

Thus, the laws of change of the heat conductivity curves obtained at the initial humidity $W = 10\,\%$ and $W = 24\,\%$ raw cotton significantly differ. For comparison and generalization of results of these researches we will continue studying of dependence of thermal conductivity on volume density of the set sample of raw cotton.

Pic. 1 shows the dependence of thermal conductivity on the volume density of a given raw cotton sample. 3 The dependences of thermal conductivity on the volume density obtained at the initial moisture content of raw cotton $W = 36\,\%$. are given.

Curves 1 - 4 correspond to the drying temperature $T_1 = 40^\circ C$, $T_2 = 50^\circ C$, $T_3 = 60^\circ C$ и $T_4 = 70^\circ C$.

The law of change of curves 1 - 5 essentially differs from laws of change of the similar curves presented in Figures 1 and 2. In this case, all curves in the area $110\frac{\kappa\Gamma}{м^3} < \rho < 146\frac{\kappa\Gamma}{м^3}$ fall, and in the areas $146\frac{\kappa\Gamma}{м^3} < \rho < 182\frac{\kappa\Gamma}{м^3}$ and $182\frac{\kappa\Gamma}{м^3} < \rho$ they increase. At the point $\rho = 182 \frac{кГ}{м^3}$ of inclination of the curves to the horizontal axis there is a gap.

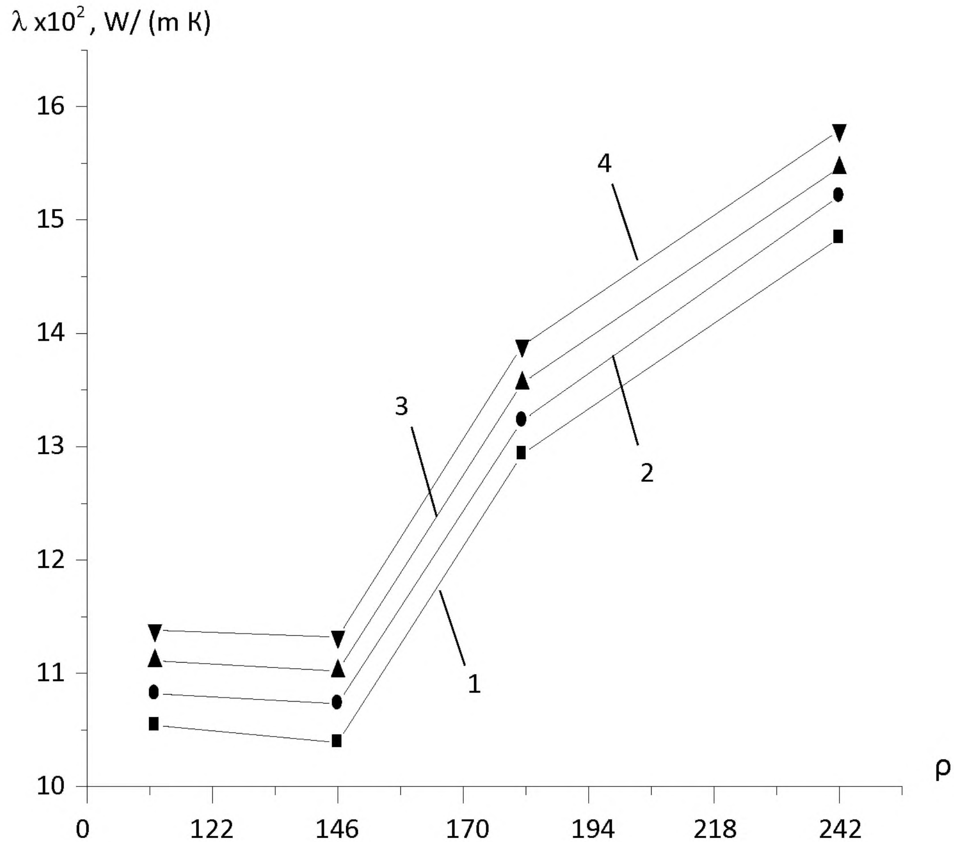
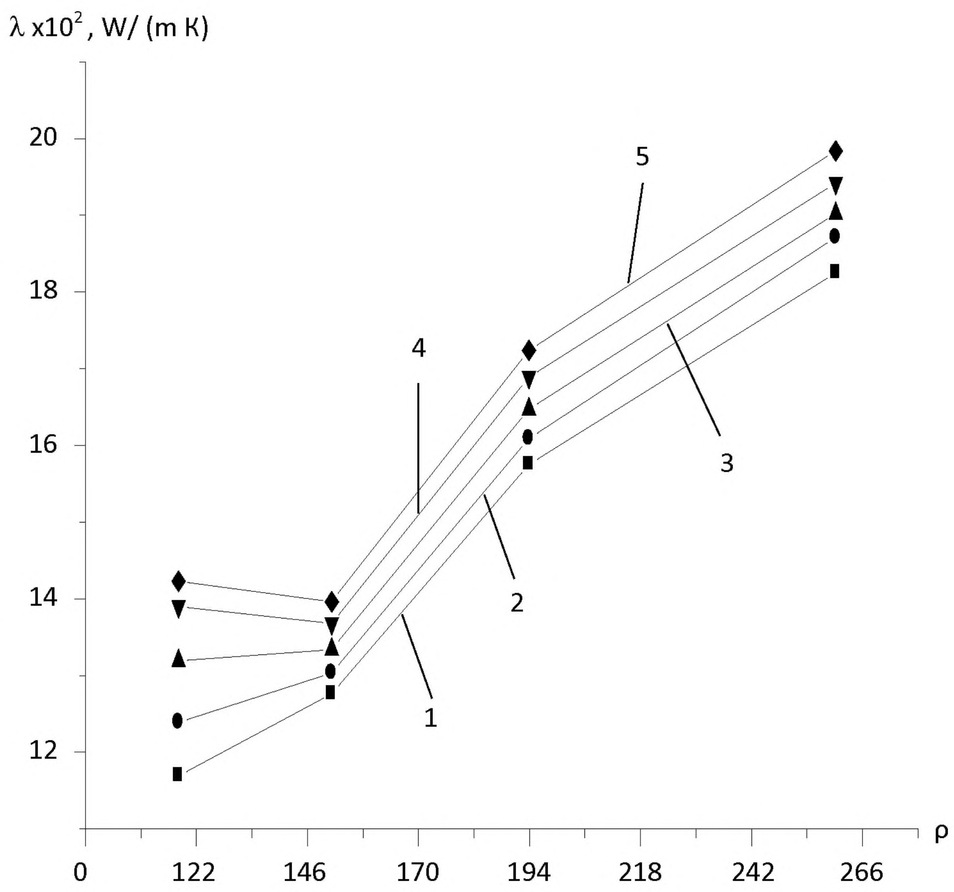


Figure 3: Dependence of the thermal conductivity coefficient of raw cotton on the density at different temperatures (raw cotton temperature (°C); 1-40, 2-50, 3-60, 4-70, humidity of raw cotton W=36%.

Picture 4 shows the dependence of thermal conductivity on the volumetric density obtained at the initial moisture content of raw cotton $W = 45\ \%$.

Curves 1 - 5 are obtained at drying temperature $T_1 = 40^\circ C$, $T_2 = 50^\circ C$, $T_3 = 60^\circ C$, $T_4 = 70^\circ C$ and $T_5 = 80^\circ C$ accordingly.

In this case, there is no area of thermal conductivity drop. In all areas, the thermal conductivity increases with different speeds. Inside the considered area curves 1 - 5 have two transition points.



Picture 4: Dependence of the thermal conductivity coefficient of raw cotton on the density at different temperatures (raw cotton (ºC); 1-40, 2-50, 3-60, 4-70, 5-80, humidity of raw cotton W=45%

Summarizing the results of the experimental studies presented in Pic. 1-4, we note the following. On all considered cases, irrespective of humidity, in the area of drying temperature $20^\circ C < T < 80^\circ C$ there are areas of fall and increase of thermal conductivity of raw cotton. From the point of view of productivity and quality of drying the areas of heat conductivity drop are not rational. For example, within the limits of considered area of drying temperature $20^\circ C < T < 80^\circ C$ for raw cotton with humidity $W = 10\%$ the most rational is the area of volume density $90\frac{кГ}{м^3} < \rho < 120\frac{кГ}{м^3}$,

for raw cotton with humidity $W = 24\%$ - area of volume density $145\frac{кГ}{м^3} < \rho < 170\frac{кГ}{м^3}$,

for raw cotton with humidity $W = 36\%$ - area of volume density $145\frac{кГ}{м^3} < \rho < 180\frac{кГ}{м^3}$,

for raw cotton with humidity $W = 45\%$- area of volume density $145\frac{кГ}{м^3} < \rho < 195\frac{кГ}{м^3}$,

for raw cotton with humidity - area of volume density.

In the area of drying temperature for raw cotton with humidity $W = 10\%$ the most ineffective are the areas of bulk density $70\frac{кГ}{м^3} < \rho < 90\frac{кГ}{м^3}$ and $\rho > 90\frac{кГ}{м^3}$.

Conclusions

The analysis of experimental researches of dependences of thermal conductivity of raw cotton on humidity, volume density and temperature is established:

-Dependences of thermal conductivity of raw cotton on volume density and temperature at different humidity are received, which allow to carry out calculations by the equation of heat and mass transfer at drying of raw cotton;

- between the thermal conductivity of raw cotton and the temperature has linear dependences at a constant density and humidity. As the temperature increases, the thermal conductivity of raw cotton increases proportionally, and for small densities the curves of the curves of dependence are close to each other, with increasing density the thermal conductivity coefficient increases sharply and then again are close to each other. The thermal conductivity curves have three areas where the thermal conductivity first increases and decreases monotonically, then increases again;

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