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Cotton fibre humidification at cotton ginneries

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A novel humidifier has been designed and developed for improving the quality of cotton lint, by providing more efficient and qualitative humidification of cotton lint before pressing. Existing methods of cotton lint humidification have not been found effective enough, do not provide required increase in moisture content and have technological and structural disadvantages. The proposed humidifier ensures the gain of moisture content up to 1.6 % and its high uniformity.

Keywords: Cotton lint, Cotton bale, Ginning, Humidifier, Seed cotton

Cotton lint is one of the most important strategic commodities in the world trade[1]. According to the International Cotton Advisory Committee (ICAC), world production of cotton in 2015-2016 has reached 26.2 million tons[2].

The Republic of Uzbekistan has implemented comprehensive large-scale measures to improve efficiency of the production process of seed cotton ginning and to introduce highly effective technological process management systems that improve properties of cotton products. The works on introduction of flexible technological processes of seed cotton ginning were carried out at several ginneries. In particular, the special attention was paid on the seed cotton and cotton lint humidification technology, depending on initial characteristics of the raw material to obtain cotton products of required quality with minimal loss of raw material and low energy consumption.

During the primary processing/ginning of cotton, the moisture of lint before pressing plays important role. In accordance with Uzbek Standard O'z DSt 604:2016 (Cotton lint - Technical specifications) and (primary processing of seed cotton PDI 30-2012), cotton lint before pressing should be humidified to the level of 7.5 - 8.5 %. It provides well-known advantages in pressing and energy saving.

Existing methods of cotton lint humidification have not been found effective enough, do not provide required increase in moisture content, and have technological and structural disadvantages. As per literature survey, it showed the necessity to humidify cotton lint by 1.0-1.5 % up to recommended level of 7.5-8.5 %. The present study is therefore underlain to develop a comprehensive phased humidification technology for seed cotton before ginning and cotton lint prior the pressing.

Experimental

The device for humidification of cotton lint before pressing (UVR) have been developed on the basis of analytical and theoretical studies. The appearance and embodiment scheme of the novel device is shown in Fig.1. During the processing the fibrous material coming out from condenser **(1)** in the form of layer passes to the loosening drums **(6)**, rotating in opposite directions at the speed of 300-500 rev/min, thus dividing the material in to separate flocks. Then, these flocks having average mass of about 0.15-0.30 g each are divided into two streams and thrown along deflector plates **(2)** into humidification chamber **(3)**, where they are exposed to the humidification agent in the form of fine mist, fed from the nozzles **(11)** to the entire volume of the chamber. The suction outlet **(12)** performs the bleeding of used air outside. Ascending agent flow provides efficient and uniform humidification of the fibrous material through entire volume. Finally, the humidified fibrous material is collected again in the form of single layer by the crimping rollers **(7)** at the bottom of chamber **(3).**

For the proposed methods and devices of humidification of lint prior to pressing, the patents of the Republic of Uzbekistan were received[3-5].

A total of 220 kg of cotton lint (S 6524 of the Ikkinchi grade Yakshi class) was processed through the humidifier. The humidifier nozzle was connected

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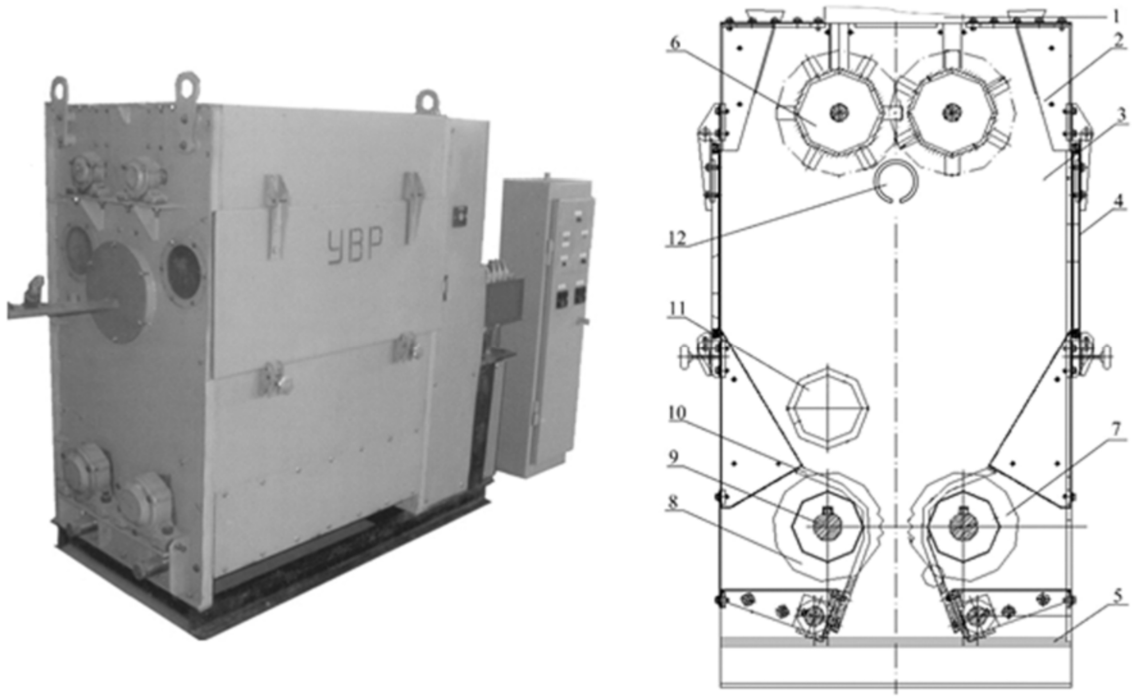

Fig.1 — Cotton lint humidifier UVR [1 – condenser, 2 – deflector plates, 3 – humidification chamber, 4 – longitudinal wall of the chamber, 5 – end wall of the chamber, 6 – loosening drums, 7 – crimping rollers, 8 – set of gear drives, 9 – shaft, 10 – grate grille, 11 – a spray and 12 – suction outlet of humidification agent]

to the water pump through a system of cranes providing an adjustable water flow. Humidification was carried out using ordinary water in two modes, namely with a water flow of 30 L/h and 45 L/h, and with lint flow rate of 4000 kg/h. Amount of lint was enough for producing 3 bales weighing about 70 kg each. The lint for the first bale was not humidified and was used as a control. Lint for the second bale was moistened with water at flow rate of 30 L/h, and for the third it was moistened at flow rate of 45 L/h. Bales were pressed on the Harris press to a volume density of about 250 kg/m^3. Upon completion of pressing, bales were packed into soft containers made of knitted fabric.

After one day, an intermediate decompression of bales was carried out to estimate the degree of moisture increase and the uniformity of moisture distribution within the bale. For these purposes, each bale was evenly divided into 9 layers of 15 cm wide each. From each lint layer, one sample was selected to evaluate its moisture content.

Upon finishing of sampling, bales were packed again, placed in the warehouse and stored for 6 months. The ambient temperature in the warehouse was varied from +11 ℃ to +30 ℃ and relative humidity from 40 % to 80 %.

Table 1 — Quality parameters of control and humidified cotton after 6 months of storage

Fibre HVI parameters	Control (8.28 % moisture)	Water rate 30 L/h (8.91 % moisture)	Water rate 45 L/h (9.38 % moisture)
Micronaire (mic), units	3.5	3.6	3.6
Strength (str), gf/tex	30.80	31.42	31.45
Upper half mean length (len), inch	1.15	1.16	1.17
Uniformity index (unf), %	82.76	82.88	83.04
Short lint index (SFI), %	5.95	5.60	5.66
Elongation (elg), %	9.36	9.96	9.58
Trash code (T), unit	4.65	3.85	4.85
Reflectance degree (Rd), %	75.05	74.11	73.11
Yellowness (+ b), %	8.83	8.82	9.07

At the end of storage period, bales were transported to the warehouse of the Central Laboratory of the Center "Sifat" and then evaluated for the quality parameters. For this purpose, each bale was evenly divided into 5 layers of 15 cm wide each. From each lint layer, four samples were selected to determine the lint quality parameters on HVI system (Table 1). The dependence of lint quality parameters from its moisture content during long-term storage was studied. To carry out research, about 5 kg of lint of the same variety was selected from the press tray at the ginnery.

In order to avoid loss of moisture (O'z DSt 614:2009 Cotton lint. Methods of Sampling), lint was placed into a plastic bag and a sealed container with a tight-fitting lid, and sent to the laboratory.

Nine samples of 100 g each were tested to determine the homogeneity of the quality parameters of initial lint, while six samples of 5 g each were taken for determining the moisture content of lint by drying in the oven. Tests on the HVI 900 SA system were carried out in accordance with Uzbek Standard (O'z RH 73-01:2001) after conditioning of samples to an equilibrium moisture content of 6.75-8.25% in the SC-100 rapid conditioning device under standard climatic conditions in accordance with the standard (GOST 10681-75). Micronaire, upper half mean length, uniformity index, strength, elongation, short fibre index, maturity, reflectance degree, yellowness, trash code and area have been determined.

Upon completion of the analyses, the remaining volume of initial lint was divided into five samples of 400 g each. Four samples (No.1 - No.4) were subsequently subjected to artificial moistening with ordinary water. Sample No.5 was retained as a control.

Artificial moistening of lint samples up to 4 moisture levels of 8.6, 10.3, 13.8 and 17.5 % was performed using the additive method. The assumed mass of the moisture agent ($\Delta m_в$), necessary for obtaining the conditional humidity (W_y) and the mass of the sample before humidification ($m_н^*$), were calculated using the following formulas:

$$\Delta m_в = \frac{(W_y - W_o) \cdot m_н}{W_y + 100} \quad \ldots (1)$$

$$m_н^* = m_н - \Delta m_в \quad \ldots (2)$$

where W_0 is the calculated humidity of the reference control sample, determined in the dryer (%); W_y, the conventionally given humidity of the sample (%); m_H, the weight of lint sample (400 g); and m_H^*, the mass of the lint sample before artificial moisturizing.

Humidification of samples was carried out by means of a uniformly distributed spray of the moisture agent by a fine sprayer. After wetting, samples were placed in a double sealed cellophane bag and a sealed plastic bag with a tight-fitting lid.

Upon completion of humidification of lint, in order to simulate the storage conditions in the cotton bales, bags with samples were placed into the packaging material, fitted to a container and pressed to a bulk density of 150 kg/m^3. Once in a month (for 3 months), a container with samples was unpacked and probes of 100 g of lint each were taken from the samples. They were then conditioned to an equilibrium moisture content of 6.75-8.25%, and tests were carried out on a HVI 900 SA system.

Results and Discussion

Humidification of cotton lint with an initial moisture content of 8.28 % has been carried out with incoming water flow sprayed at the rate of 30 and 45 L/h. Increase of the moisture in the first case amounts to 0.63 %. The average moisture content of lint is found 8.91 % (SD 0.25 %). Gain of lint moisture from the water flow rate of 45 L/h is found 1.11 %. The average value of moisture content is found 9.38 % (SD 0.19 %). Obtained results show high uniformity of lint's humidification by volume[6].

Evaluation of lint quality parameters carried out after 6 months of storage (Table 1) reveals that the parameters as micronaire, upper half mean length, strength and uniformity index do not undergo significant changes during long-term storage, and have differences within the error tolerance of the test method. However, changing of color grade parameters of lint is evident (whiteness, yellowness).

For the scientific justification of the proposed options and of the moisture range limits, experimental studies were carried out for revealing the effect of different lint moisture levels on the quality parameters during prolonged storage. Quality indices of lint samples artificially humidified at 8.6 %, 10.3 %, 13.8 %, 17.5 %, are compared with the original quality of lint having moisture content of 7.3 %.

Lint color indicators are found to change at different initial moisture contents during 3 months of storage. Figure 2 shows that the reflectance degree and yellowness of lint humidified to 10.3 %, 13.8 % and 17.5 % are significantly changed, resulting in the transfer of lint to a lower grade according to USDA classification – from initial 21 (SM white) to 31 (Middling white) at the end of storage period.

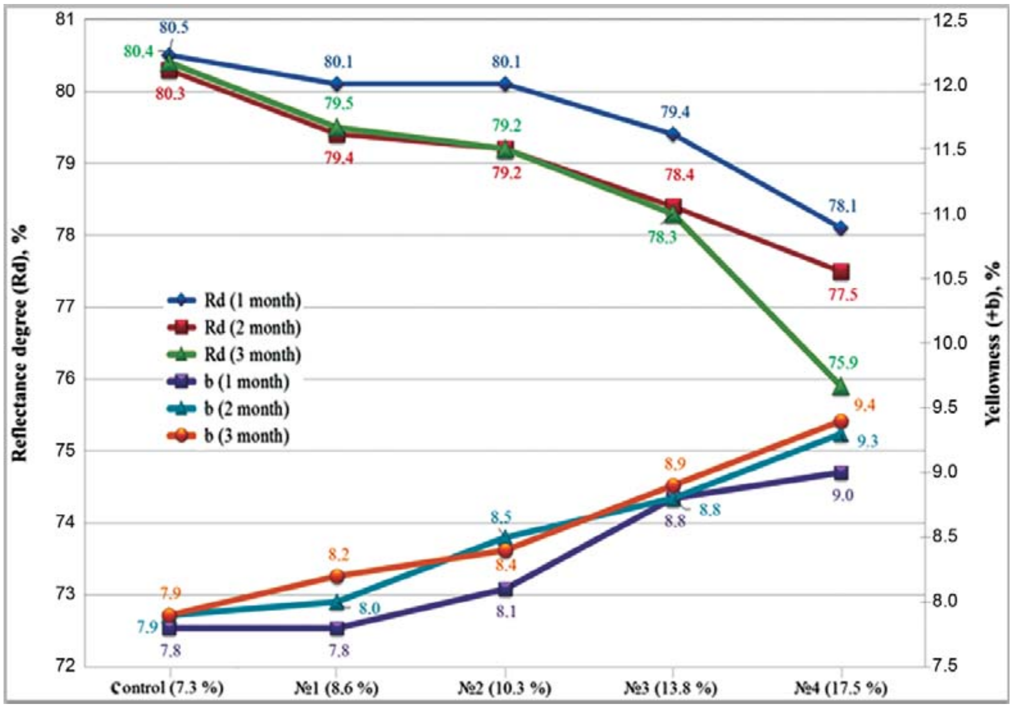

Fig. 2 — Changes in reflectance degree (Rd) and yellowness (b) of cotton lint with different initial moisture content during 3-month storage

The results of performed studies indicate that the moisture content of lint prior to pressing should not exceed 8.5 % to avoid degradation of whiteness and yellowness and relevant move of cotton to a lower grade.

In the continuation of studies, it is important to estimate the effect of various types of humidification agents on changing of lint quality parameters during prolonged storage. In particular, as an alternative, humidification agents presented by 10 % to 20 % table salt solutions, are tested. These studies show that salt solutions, by virtue of the bactericidal properties, prevent development of bacterial flora and contribute to the preservation of cotton color characteristics. Methods of humidification of fibrous material with activated and salt solutions are patented (UZ №IAP 02732, UZ №IAP 03995).

A new apparatus for humidification of cotton lint before pressing has been developed.

Humidification of seed cotton before ginning and cotton lint before pressing provides the net gain of moisture up to 1.6 % and its high uniformity. Applied humidification technology does not deteriorate the lint quality parameters, while avoiding moistening of lint to more than 8.5 %.

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