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Measurement of residual lint on cotton seeds, using sound vibrations

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ABSTRACT: The article presents the results of the work on application of low-frequency sound vibrations to measure the residual lint on cotton seeds by acoustic method. On the basis of earlier theoretical and applied research an acoustic measuring instrument is developed for express analysis of residual lint on seeds, using attenuation of acoustic vibrations, depending on residual lint on seeds. The block diagram of the acoustic device is presented, the results of experimental studies on the refinement of the metrological parameters of the device on various selection varieties of cotton seeds.

KEY WORDS: acoustic method, measuring instrument, measurement, residual lint on cotton seeds, testing, measurement accuracy.

I. INTRODUCTION

Cotton seeds residual lint is an important quality indicator, when supplying to oil –pressing factories, affecting the output of cotton oil - valuable food product. In the State standard of the Republic of Uzbekistan O'z DSt 596:2014 Cull cotton seeds. Technical Specifications [1] classification of cotton seeds is set in the light of residual lint. According to the standard O'z DSt 601:2008, there are two methods of detecting of seeds residual lint: - chemical-mechanical and organoleptic [2]. Chemical-mechanical method is destroying, laborious, and is associated with harmful working conditions for laboratory technicians and with using hydrochloric and sulfuric acid. Organoleptic method is based on direct comparison of seeds samples with seed samples appearance by residual lint. Method is but subjective and less accurate. Therefore, search for express non-destructive method is prompt essential.

Analysis of existing and potential methods of control of micronaire indicator has revealed that the acoustic method is the most appropriate for measuring residual lint, because measuring instruments, based on this measurement principle, have simple and compact design and is easy to operate, compared with measuring instruments, based on the method of air permeability.

There are works on the application of acoustic method in the cotton cleaning industry. In [3, 4] acoustic method and measuring instrument for determining the grade of raw cotton and cotton fibre by fibre breaking load are described. Dependence of attenuation of sound vibrations in samples of raw cotton and fibers on breaking load of fiber is used. The article [5] shows the results of studies on the use of dependence of phase difference of sound vibrations that passed through a sample of cotton fiber, on micronaire indicator, maturity factor and linear density of fibers

This research discusses acoustic method use for measuring seeds residual lint by attenuation of sound vibrations.

II. MATERIALS AND METHODS

Specialists of the Scientific Center of JSC "Paxtasanoat Ilmiy Markazi" within the framework of the innovation project developed an acoustic measuring instrument for measurement of cotton seeds residual lint. Method theory and principle of operation are published in [7, 8 and 9], in [10] the methodology and results of research on the development of the calibration dependence of the device are presented, and in papers [11, 12] the results of studies on the study of the effect of variation in the sample mass on the error of the results of measurements , as well as the metrological characteristics of the device.

According to the method theory, work principle of acoustic measurement method is based on propagation of sound vibrations in the sample of cotton seeds, placed in the measuring chamber and compacted in the form of a cylindrical plug with flat bases, besides direction of sound vibrations passage is perpendicular to the bases. Sample of seeds can be simulated by isotropic porous three-component environment (fiber, seeds, air). When flat sound wave

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passes through such environment, energy loss will occur mostly in friction against fibrous part of the seeds. Bare seeds have virtually no acoustic impedance, as specific surface of seeds is much smaller than the fibrous part of the seed, which leads to a change in sound pressure amplitude in attenuation process of acoustic waves.

Based on theoretical analysis of propagation of sound vibrations through the sample of cotton fibres, regression equation is derived, connecting rate of decay of sound vibrations with cotton seeds residual lint. The measuring instrument and operation principle of the measuring instrument that implements the acoustic method are described. The measuring instrument allows measuring seeds residual lint on attenuation of acoustic vibrations that have passed through the sample by the magnitude of the signal, measured on the measuring microphone. The microcontroller on the set program, developed on the basis of the obtained mathematical model, computes residual lint, delivering results on digital display.

Block diagram of the acoustic measuring instrument, its overview is shown in Figure 1. Sample of seeds with residual lint of specified weight is placed in the measuring chamber 3 and using a plunger, it is compressed to given density. Generator 1 and emitter 2 create sound vibrations of given frequency and amplitude. Passed through a sample of seeds, placed in chamber 3, and weakened sound vibrations are converted by microphone 4 into an electrical signal that is recorded by measuring-computing unit 5. On magnitude of the measured signal, block 5 on the specified algorithm computes value of seeds residual lint, which is displayed of indication unit on display 6.

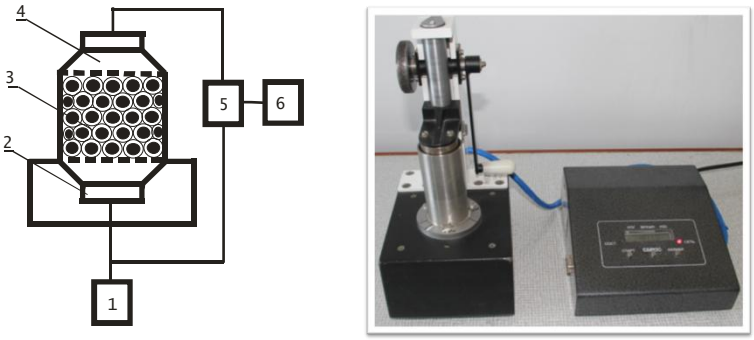

Figure 1 –Block diagram and overview of residual lint acoustic measuring instrument.

Checking of measurements range and metrological characteristics of measuring instruments was held on a set of reference materials of mass fraction of seeds residual lint with the following certified values:

- SOP 1-95 – 13,45 % ; measurement error ±0,17%
- SOP 3-95 – 4,90 % ; measurement error ±0,14% .

Climatic conditions of measurement according to GOST 10681:

а) ambient temperature (20 ± 2) °C;
б) relative air humidity (65 ± 5) %.

The tests were conducted on two prototypes of the measuring instrument of residual lint on seeds.

In order to test metrological parameters of the measuring instrument in prolonged period of operation, PAO-1 was tested on production samples of seeds of selections varieties of cotton crops of two years, selected in various regions. Seed samples were collected at the ginneries in processing raw cotton by sample takers of Regional seed laboratories of the Uzbek Centre for cotton fibre certification «Sifat». Residual lint of selected seeds in comparative trials was determined in Regional seed laboratory by chemical-mechanical method on OSH-1 seeds stripper, then, in the Science Center on acoustic measuring instrument PAO-1. Totally, 163 samples of cotton seeds were tested. Before testing, PAO-1 measuring instrument was calibrated on standard samples of mass fraction of cotton seeds residual lint. Within 5 months trial period, calibration was preserved without changes, the measuring instrument troubleshooting was not observed.

III. RESULTS OF EXPERIMENTS

The results of the laboratory tests for verification of metrological characteristics of prototypes of measuring instruments PAO-1 are presented in Table 1.

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Table 1

The results of laboratory tests for verification of meteorological parameters of prototypes of measuring instruments PAO-1

Number of measurement	Measuring instrument				Permissible measurement error values
	Measuring instrument 1		Measuring instrument 2		
	Reference material		Reference material		
	SOP 1-95	SOP 3-95	SOP 1-95	SOP 3-95	
1	13,73	4,72	13,02	4,68	
2	13,65	4,9	13,49	4,86	
3	13,52	4,72	13,31	4,93	
4	13,38	5,16	13,42	4,87	
5	13,38	4,87	13,02	4,87	
6	13,49	5,15	13,69	4,99	
7	13,43	4,87	13,78	4,93	
8	13,7	4,75	13,65	4,86	
9	13,6	5,06	13,49	5,04	
10	13,29	4,76	13,58	4,94	
Mean value of the measurement results	13,517	4,8,96	13,445	4,887	
Certified value of mass fraction of seed residual lint of reference material	13,45	4,9	13,45	4,9	
Random measurement error component (standard deviation)	0,149	0,171	0,261	0,097	0,5
Systematic measurement error component of the measuring instrument	0,067	0,004	0,005	0,011	0,25

The results of comparative tests of residual lint acoustic measuring instrument PAO-1 with the standard method on OSH-1 seeds stripped are presented in Table 2.

Table 2

The results of comparative tests of residual lint acoustic measuring instrument PAO-1 in comparison with OSH -1

Selection variety	Residual lint, %		Difference $\Delta=\Theta_1-\Theta_2$, %	Selection variety	Residual lint, %		Difference $\Delta=\Theta_1-\Theta_2$, %
	on PAO-1 Θ_1	on OSH-1 Θ_2			on PAO-1 Θ_1	on OSH-1 Θ_2	
1	2	3	4	1	2	3	4
Namangan 77	4,9	5,20	0,30	An-Bayaut -2	13	12,80	-0,20
Omad	5,15	5,62	0,47	An-Bayaut -2	12,4	12,31	-0,09
Omad	6,93	6,86	-0,07	An-Bayaut -2	11	11,48	0,48
Omad	7,16	7,6068	0,44	An-Bayaut -2	11	11,48	0,48
Omad	7,66	7,6843	0,02	An-Bayaut -2	11,6	11,18	-0,42
Omad	7,83	7,6985	-0,13	An-Bayaut -2	9,4	9,55	0,15
Omad	7,9	7,75	-0,15	An-Bayaut -2	9	9,29	0,29
Omad	9,33	8,88	-0,45	An-Bayaut -2	9,4	9,22	-0,18
Omad	9,7	9,34	-0,36	An-Bayaut -2	8	8,20	0,20
Omad	10,9	10,4	-0,5	An-Bayaut -2	7,5	7,99	0,49
Omad	11,1	10,6	-0,5	An-Bayaut -2	7,5	7,78	0,28
SOP-2	10,6	10,69	0,09	An-Bayaut -2	7,1	7,44	0,34
Omad	12,13	12,60	0,47	An-Bayaut -2	7,6	7,13	-0,47
Omad	12,93	12,84	-0,09	An-Bayaut -2	6,8	7,39	0,59
Omad	13,1	13,6	0,5	An-Bayaut -2	7	7,10	0,10
Namangan 77	13,45	13,73	0,28	An-Bayaut -2	6	6,27	0,27
S-6524	14,5	14,90	0,4	An-Bayaut -2	5,6	5,99	0,39

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S-6524	14,16	14,38	0,22	An-Bayaut -2	5,5	5,71	0,21
S-6524	13,3	12,93	-0,37	An-Bayaut -2	5	5,38	0,38
S-6524	12,2	11,89	-0,31	An-Bayaut -2	5,9	6,03	0,13
S-6524	10,2	9,74	-0,46	An-Bayaut -2	13,1	13,60	0,50
S-6524	9,0	9,0	0	An-Bayaut -2	10,4	9,90	-0,50
S-6524	6,7	7,0	0,3	An-Bayaut -2	6,7	6,2	-0,5

Continuation of table 2

1	2	3	4	1	2	3	4
S-6524	6	5,88	-0,12	An-Bayaut -2	9,4	8,90	-0,5
S-6524	6,93	6,73	-0,2	An-Bayaut -2	8,3	7,8	-0,5
S-6524	13,2	12,86	-0,34	An-Bayaut -2	7,83	7,35	-0,48
S-6524	7,5	7,45	-0,05	An-Bayaut -2	11,8	11,3	-0,5
Namangan 77	13,1	12,73	-0,37	An-Bayaut -2	8,3	8,52	0,22
Namangan 77	12,2	11,95	-0,25	An-Bayaut -2	8	7,76	-0,24
Namangan 77	11,3	11,73	0,43	An-Bayaut -2	14,27	14,77	0,5
Namangan 77	11,1	11,37	0,27	An-Bayaut -2	10,5	10,96	0,46
Namangan 77	9,9	10,20	0,30	An-Bayaut -2	6,45	6,24	-0,21
Namangan 77	9,7	10,13	0,43	An-Bayaut -2	6,93	6,92	-0,01
Namangan 77	9,6	9,87	0,27	An-Bayaut -2	7,7	7,21	-0,49
Namangan 77	8,8	9,16	0,36	An-Bayaut -2	8,63	8,16	-0,47
Namangan 77	7,7	7,65	-0,05	An-Bayaut -2	8	7,47	-0,53
Namangan 77	6,7	6,60	-0,10	An-Bayaut -2	9,41	9,36	-0,05
Namangan 77	8,35	8,24	-0,11	Andijan 35	5,6	5,67	0,07
Namangan 77	9,8	9,38	-0,42	Andijan 35	6,4	6,44	0,04
Namangan 77	9,2	8,59	-0,61	Andijan 35	6,16	5,96	-0,20
Namangan 77	11,5	11,97	0,47	Andijan 35	7,8	7,58	-0,22
Namangan 77	9,7	9,23	-0,47	Andijan 35	8,6	9,11	0,51
Namangan 77	11,9	11,91	0,01	Andijan 35	8,9	8,48	-0,42
Namangan 77	10,5	10,06	-0,44	Andijan 35	10,4	9,95	-0,45
An-Bayaut -2	9,41	9,36	-0,05	Andijan 35	11,9	11,99	0,09
An-Bayaut -2	10,15	9,79	-0,36	Andijan 35	12,6	12,22	-0,38
An-Bayaut -2	11,14	11,58	0,44	Andijan 35	14,2	13,89	-0,41
An-Bayaut -2	12,41	12,73	0,32	Andijan 35	11,3	10,97	-0,33
An-Bayaut -2	12,55	12,62	0,07	Andijan 35	9,2	9,53	0,33
An-Bayaut -2	13,5	13,71	0,21	Andijan 36	7,5	6,62	-0,88
An-Bayaut -2	5,4	5,65	0,25	Andijan 36	10,8	10,61	-0,19
Andijan 36	9,8	9,32	-0,48	Khorezm 127	8,63	7,66	0,97
Andijan 36	10,4	10,37	-0,03	Khorezm 127	10,85	10,72	0,13
Andijan 36	7,9	8,01	0,11	Khorezm 127	9,71	9,22	0,49
Andijan 36	7,6	7,93	0,33	Khorezm 127	10,81	11,29	-0,48
Andijan 36	7,3	7,75	0,45	Khorezm 127	13,2	13,64	-0,44
Andijan 36	6,4	6,58	0,18	Khorezm 127	12,5	13,01	-0,51
Andijan 36	5,4	5,66	0,26	Bukhara 6	5,7	5,40	-0,30
Andijan 36	7,4	6,93	-0,47	Bukhara 6	7,1	7,21	0,11
Andijan 36	8,5	8,21	-0,29	Bukhara 6	6,8	6,85	0,05
Andijan 36	9,1	8,78	-0,32	Bukhara 6	6,6	6,52	-0,08
Andijan 36	9,8	9,41	-0,39	Bukhara 6	6,31	6,74	0,43
Andijan 36	10,1	10,46	0,36	Bukhara 6	7,24	7,28	0,04
Andijan 36	10,8	11,13	0,33	Bukhara 6	7,76	7,40	-0,36
Andijan 36	13,5	13,70	0,20	Bukhara 6	8,66	8,99	0,33
Andijan 37	11,4	11,1	-0,31	Bukhara 6	7,66	7,98	0,32
Andijan 37	14,2	14,0	-0,20	Bukhara 6	11,85	11,44	-0,41

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Andijan 37	10,3	10,29	-0,01	Bukhara 6	12,29	12,43	0,14
Andijan 37	8,1	8,41	0,31	Bukhara 6	14,4	14,62	0,22
Andijan 37	5,2	4,91	-0,29	Bukhara 6	14,3	14,37	0,07
Khorezm 127	9,8	9,39	0,41	Mekhnat	8,2	8,47	0,27
Khorezm 127	8,2	7,77	0,43	Mekhnat	8,4	8,24	-0,16
Khorezm 127	7,1	7,51	-0,41	Mekhnat	8,6	8,56	-0,04
Khorezm 127	7,2	7,18	0,02	Mekhnat	8	8,22	0,22
Khorezm 127	6,1	6,64	-0,54	Mekhnat	9,1	8,74	-0,36
Khorezm 127	6,3	6,76	-0,46	Mekhnat	9,75	9,75	0,00
Khorezm 127	4,8	5,35	-0,55	Mekhnat	9,8	9,55	-0,25
Khorezm 127	4,6	5,03	-0,43	Mekhnat	11,6	11,53	-0,07
Khorezm 127	6,9	6,41	0,49	Mekhnat	12,3	12,54	0,24
Khorezm 127	8,15	7,68	0,47	Mekhnat	8,50	8,63	0,13

As a result of laboratory tests of the prototypes of PAO-1 measuring instrument (see table 1), it is found that their metrological characteristics meet the requirements of the technical tasck and verification techniques by features: standard deviation of measurement results (measurement results repeatability) does not exceed 0.5% and systematic component of measurement errors does not exceed 0,25 %

Analysis of obtained results of comparative tests of PAO-1 measuring instrument with OSH-1 (see table 2) indicates that interlaboratory differences (reproducibility) in 95% of the experiments did not exceed 0.5%, in 3.8% of the experiments did not exceed 0.6% and in 1.2% of experiments did not exceed 1.0%, that was within tolerance, set by standard O'z DSt 601:2008. Cull cotton seeds. Methods of definition of residual Lint.

The new measuring instrument is compact, has reliable design and convenience in operation, is a resource-saving and energy-saving one.

IV. CONCLUSION

Specialists of the Scientific Center of "Paxtasanoat Ilmiy Markazi" JSC within the framework of the innovative project developed a new acoustic measuring instrument for measurement of seeds residual lint.

Tests for verification of metrological parameters of prototypes of residual lint acoustic measuring instrument are carried out on two reference materials of mass fraction of technical seeds residual lint, covering the range of measurement. As a result of tests, it is found that across the range of measurement, limit of measurement error on the measuring instrument does not exceed 0.5%, standard deviation does not exceed 0,25 %.

As the result of comparative trials of PAO-1 measuring instrument with standard chemical-mechanical method on OSH-1 seed stripped, it is established that interlaboratory differences (reproducibility) in 95% of the experiments did not exceed 0.5%, in 3.8% of the experiments did not exceed 0.6% and in 1.2% of the experiments did not exceed 1.0%, which was within tolerance, prescribed by the standard.

When testing the prototype of PAO-1 measuring instrument under production conditions during 5 months, changes in metrological parameters and measuring instrument failures were not found.

Acoustic measuring instrument for measurement of seeds residual lint is characterized by simplicity and compactness of design; it is economical, convenient and reliable in operation.

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