

## OPTIMIZATION OF VIBRATING SCREEN SURFACE DESIGN FOR THE SEPARATION OF FINE AND LARGER IMPURITIES IN COTTON CLEANING AGGREGATES

<https://doi.org/10.2961/zenodo.1567753>

**Ibrohimjon Muhsinov**

*<sup>1</sup>Independent researcher, Namangan State Technical University, Namangan, Uzbekistan. E-mail: ibroximmuxsinov@gmail.com.*

### **Annotation**

This study focuses on optimizing the design and operating parameters of a vibrating screen surface used in cotton cleaning units. Experimental and theoretical analyses were conducted to assess the effects of peg drum speed, vibration frequency, and amplitude on cleaning efficiency and mechanical damage to cotton seeds. A regression-based model was developed to identify optimal parameter ranges that ensure high impurity removal efficiency while minimizing seed damage. The results provide practical guidelines for improving the performance of cotton cleaning machinery.

### **Keywords**

cotton cleaning, peg drum, vibrating screen surface, fine impurities, vibration frequency, vibration amplitude.

**Introduction.** Efficient removal of fine impurities during the primary processing of cotton is a critical factor in improving product quality and increasing production efficiency. The key performance indicators of cotton cleaning machines, including throughput capacity, cleaning efficiency, and the degree of mechanical damage to cotton seeds, are directly dependent on the design and operating parameters of the machine. Therefore, the determination of optimal operating regimes for cotton cleaners equipped with vibrating screen surfaces represents an important scientific and practical task aimed at enhancing the effectiveness and reliability of cotton processing equipment.

The above-mentioned indicators directly and significantly influence the technological parameters of the cotton cleaner. To investigate the effect of variations in the operating capacity of the proposed vibrating screen cleaner on cleaning efficiency, a series of experimental studies was conducted. As a result of experimental and theoretical investigations, the following key factors were identified: the rotational speed of the drum (rpm), the vibration frequency of the screen surface (Hz), and the vibration amplitude of the screen surface (mm).

To determine the optimal parameters, the experiments were planned as multifactorial studies and conducted in accordance with established standards. After selecting the main factors and their corresponding levels, it became possible to optimize the technological and design parameters of the peg drum and the vibrating screen surface of the cotton cleaner. In addition, the conducted analysis allowed conclusions to be drawn regarding the overall performance of the cleaner and the relative significance of the influencing parameters.

In accordance with the research objectives, it was necessary to evaluate the influence of three independent input factors – the rotational speed of the drum, the vibration frequency of the screen surface, and the vibration amplitude of the screen surface – on the output parameters, namely cotton seed damage and the cleaning efficiency of the cotton cleaner, while accounting for experimental error.

To carry out the optimization process, appropriate input and output variables were selected.

**The following parameters were selected as input factors:**

- X<sub>1</sub> – rotational speed of the peg drum, rpm
- X<sub>2</sub> – screen surface vibration frequency, Hz
- X<sub>3</sub> – screen surface vibration amplitude, mm

**The following parameters were selected as output variables:**

- Y<sub>1</sub> – mechanical damage to cotton seeds in the cleaning machine, %
- Y<sub>2</sub> – cleaning efficiency of the cleaning machine, %

The variation ranges of the input factors are presented in Table 1.

**Table 1.**  
**Ranges of variation of the input factors**

Factor name and designation	Variation ranges			Interval of variation
	-1	0	1	
x <sub>1</sub> – Rotational speed of the peg drum, rpm	350	400	450	50
x <sub>2</sub> – Screen surface vibration frequency, Hz	20	40	60	20
x <sub>3</sub> – Screen surface vibration amplitude, mm	4	6	8	2

The experimental procedure and the corresponding indicator values were continuously recorded using a high-resolution photo and video system. To ensure the required accuracy, each experimental series was repeated at least three times. Experiments showing significant deviations from the average values were repeated. The experimental data obtained were processed using computer-based software, and regression equations were derived. The statistical significance of the

regression coefficients was evaluated using Student’s t-test, while the adequacy of the obtained models was verified using Fisher’s F-test. (Table 2.)

**Table 2.**

Central composite experimental matrix

No	Factors			$x_2$	$x_3$	$x_3$	$x_1^2$	$x_2^2$	$x_3^2$	$Y_1$	$Y_2$	$S_u^2(Y_1)$	$S_u^2(Y_2)$
	$x_1$	$x_2$	$x_3$										
1	+	+	0	+	0	0	+	+	0	4	68	4,1	15,0
2	+	-	0	-	0	0	+	+	0	2,5	45	3,5	20,0
3	-	+	0	-	0	0	+	+	0	2,6	39	2,8	42,0
4	-	-	0	+	0	0	+	+	0	2,4	34	2,4	38,0
5	+	0	+	0	+	0	+	0	+	3,1	54	2,1	52,0
6	+	0	-	0	-	0	+	0	+	2,4	48	2,7	50,0
7	-	0	+	0	-	0	+	0	+	2,3	42	3	45,0
8	-	0	-	0	+	0	+	0	+	2,2	40	2,4	47,0
9	0	+	+	0	0	+	0	+	+	2,9	57	1,9	52,0
10	0	+	-	0	0	-	0	+	+	2,8	43	2,4	45,0
11	0	-	+	0	0	-	0	+	+	2,3	41	2,1	52,0
12	0	-	-	0	0	+	0	+	+	2,4	30	0,008	1,0
13	0	0	0	0	0	0	0	0	0	4,5	79	0,001	15,0
14	0	0	0	0	0	0	0	0	0	4	80	0,0018	0,8
15	0	0	0	0	0	0	0	0	0	4,2	75	0,009	5,0
The matrix should employ the coded values (+), (-), and 0.													

Using the obtained mathematical models, two regression equations were derived. Since the optimization involved four factors, the influence of the factors was analyzed in pairs, resulting in six response surface plots representing the general form of the interaction effects. Among these, the plots illustrating the effects of three paired factors are presented above.

The obtained equations for  $Y_1$  – mechanical damage to cotton seeds (%) and  $Y_2$  – cleaning efficiency (%) were tested for adequacy. The adequacy check was performed using Fisher’s F-test, and the calculated value of the Fisher criterion was determined. The calculated value of the optimized response was obtained by substituting the coded values (-1, 0, and +1) of all columns of the experimental matrix from Equation  $Y_1$  (Table 3).

$$F_{R1} = \frac{S_{naa}^2\{Y\}}{S^2\{\bar{Y}\}} = \frac{0,07}{0,0059} = 11,86$$

$$F_{R2} = \frac{S_{naa}^2\{Y\}}{S^2\{\bar{Y}\}} = \frac{28,39}{10,4} = 2,73$$

$$F_j [P_D = 0,95; f\{S_{naa}^2\{Y\}\} = 15 - 7 - (3 - 1) = 6; f\{S_u^2\} = 3 - 1 = 2] = 4,74$$

$$F_{R1} = 11,86 < 19,25 = F_j$$

$$F_{R2} = 2,73 < 19,25 = F_j$$

Table 3

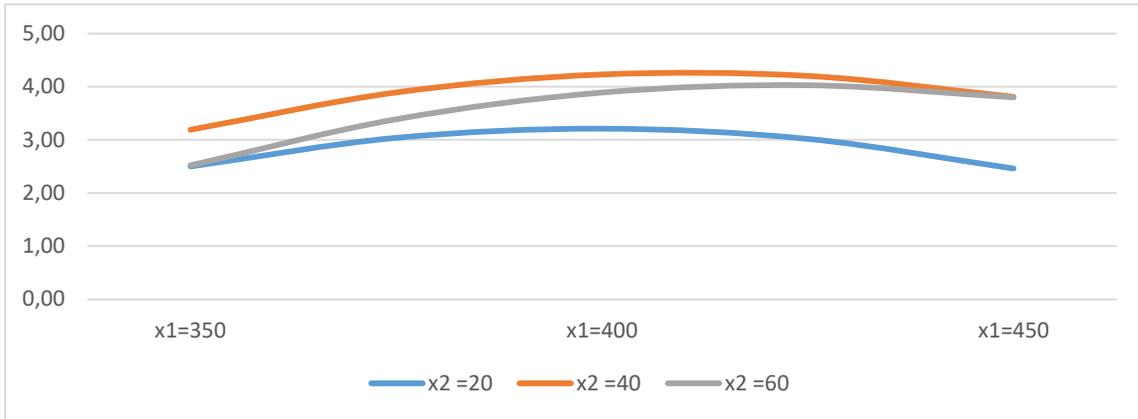
**Calculated Results of the Coded Values for the Adequacy Variance**

**Equation**

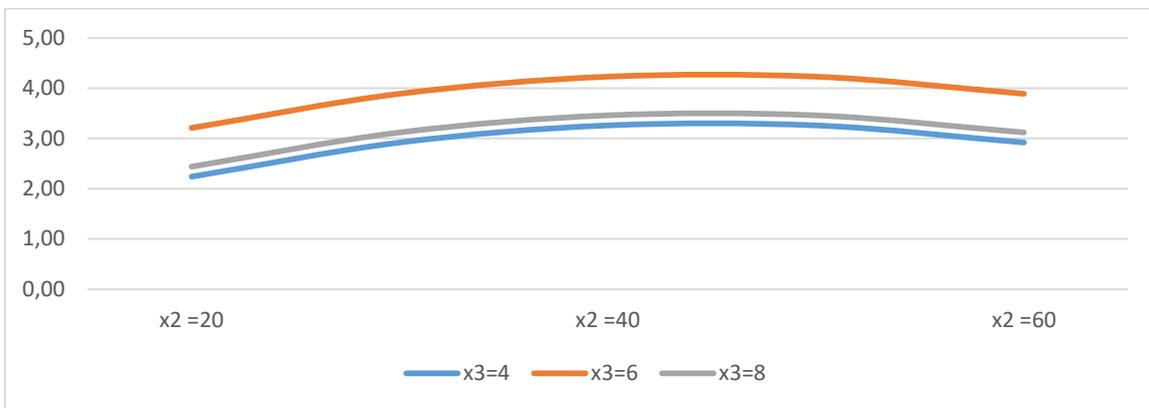
№	Y <sub>1</sub> - mechanical damage to cotton (%)				Y <sub>2</sub> - cleaning efficiency of the cleaning line, %			
	$x_{1i}$	$x_{2i}$	$Y_{1i} - Y_{R1i}$	$(Y_{1i} - Y_{R1i})^2$	$x_{2i}$	$x_{1i}$	$Y_{2i} - Y_{R2i}$	$(Y_{2i} - Y_{R2i})^2$
1	4	3,8	-0,20	0,04	68	65,95	-2,05	4,20
2	2,5	2,46	-0,04	0,00	45	42,69	-2,31	5,34
3	2,6	2,52	-0,08	0,01	39	41,95	2,95	8,70
4	2,4	2,5	0,10	0,01	34	36,69	2,69	7,24
5	3,1	3,19	0,09	0,01	54	58,2	4,20	17,64
6	2,4	2,69	0,29	0,08	48	49,94	1,94	3,76
7	2,3	2,27	-0,03	0,00	42	43,2	1,20	1,44
8	2,2	2,37	0,17	0,03	40	34,94	-5,06	25,60
9	2,9	3,12	0,22	0,05	57	56,21	-0,79	0,62
10	2,8	2,92	0,12	0,01	43	47,95	4,95	24,50
11	2,3	2,44	0,14	0,02	41	41,95	0,95	0,90
12	2,4	2,24	-0,16	0,03	30	33,69	3,69	13,62

The statistical processing of the experimental results for cotton seed mechanical damage and cleaning efficiency was performed using Microsoft Excel at a specified confidence level.

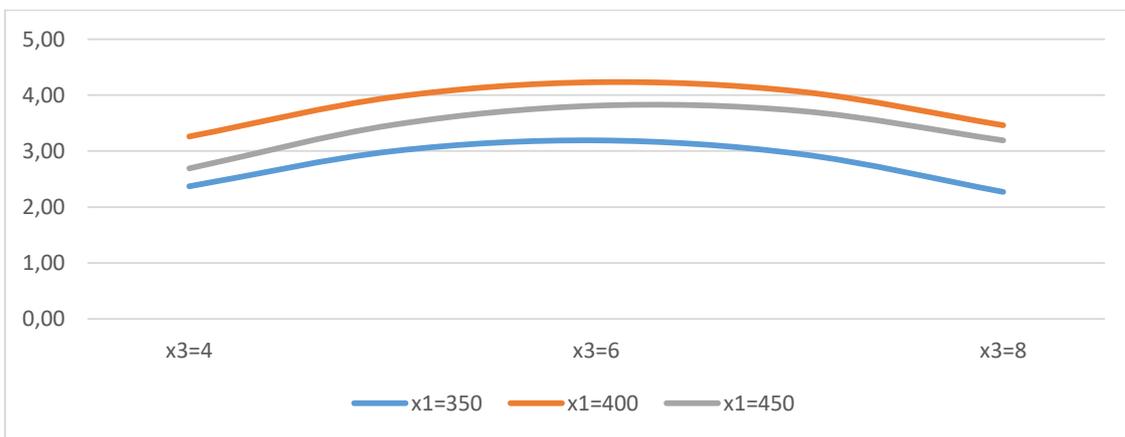
$$Y_1 = 4,23 + 0,31x_1 + 0,34x_2 + 0,1x_3 - 0,34x_1x_2 - 0,15x_1x_3 - 0,73x_1^1 - 0,68x_2^2 - 0,87x_3^3$$



a)



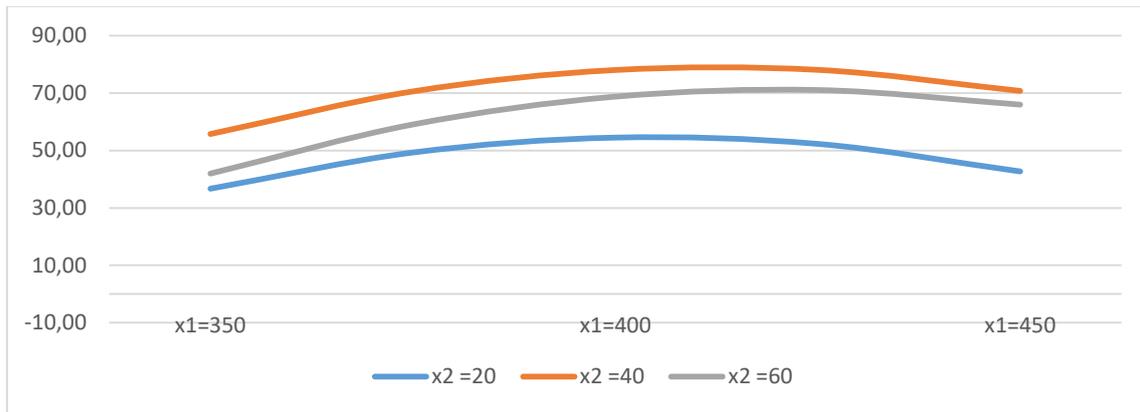
b)



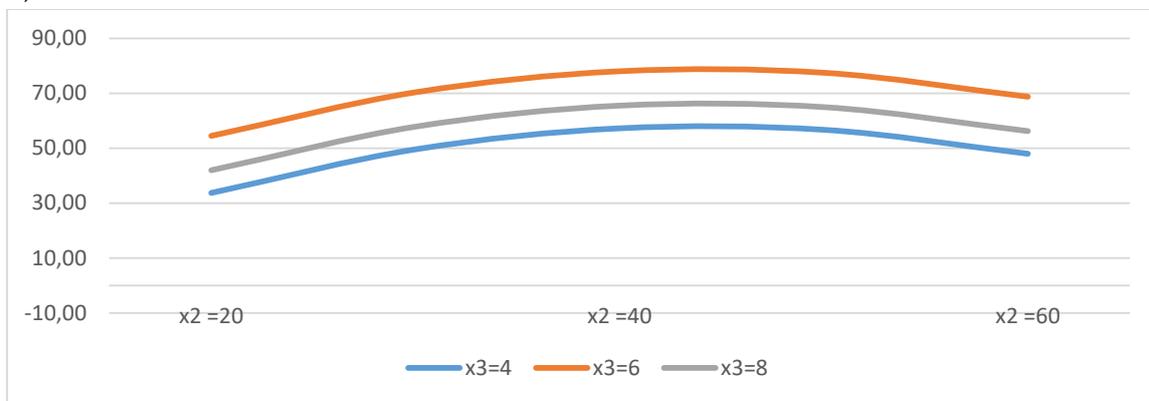
c)

**Fig. 1. Model graph for the optimization of cotton seed mechanical damage**

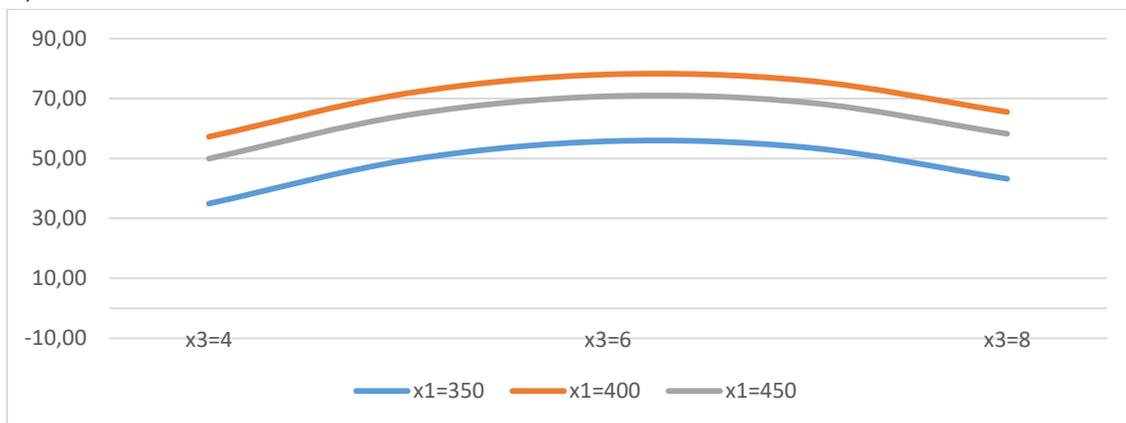
$$Y_2 = 78 + 7,5x_1 + 7,13x_2 + 4,13x_3 + 4,5x_1x_2 - 14,78x_1^2 - 16,4x_2^2 + 16,65x_3^2$$



a)



b)



c)

**Fig. 2. Model graph for the optimization of cleaning efficiency**

The results obtained from the multifactorial experimental design demonstrate a clear relationship between the operating parameters of the cotton cleaner and its performance indicators. Regression analysis revealed that the rotational speed of the peg drum, the vibration frequency of the screen surface, and the vibration amplitude significantly influence both cotton seed mechanical damage and cleaning efficiency.

The response surface analysis showed that an increase in vibration frequency and amplitude intensifies the separation of fine impurities due to enhanced dynamic interaction between the cotton mass and the vibrating screen surface. However, excessive vibration levels lead to a noticeable increase in mechanical damage to cotton seeds, indicating the presence of an optimal operating region rather than a monotonic improvement. This confirms that cleaning efficiency and seed damage exhibit opposing trends when vibration parameters exceed their optimal limits.

The adequacy of the developed regression models was verified using Student's *t*-test and Fisher's *F*-test, confirming the statistical significance of the model coefficients and the reliability of the obtained equations. The calculated values of the Fisher criterion did not exceed the critical values at the selected confidence level, indicating that the models adequately describe the experimental data.

Two-dimensional response surface plots constructed at the central level of one input factor ( $X_i = 0$ ) allowed a detailed visualization of pairwise interactions between the operating parameters. These plots clearly illustrate that the optimal combination of drum speed, vibration frequency, and amplitude minimizes cotton seed damage while maximizing cleaning efficiency. The results confirm that correct selection of technological parameters enables a significant improvement in the performance of cotton cleaning aggregates without compromising product quality.

The analysis revealed the influence of the input parameters on the output performance indicators. In particular, an increase in the peg drum rotational speed improves cleaning efficiency; however, it also intensifies mechanical damage to cotton seeds. In contrast, the appropriate selection of vibration frequency and vibration amplitude ensures a balance between these two conflicting indicators.

Optimal performance was achieved at the following parameter values: peg drum rotational speed of 400 rpm, vibration frequency of 40 Hz, and vibration amplitude of 6 mm. The regression equations developed based on these parameter values were found to be adequate and capable of describing the process with sufficient accuracy, as confirmed by statistical validation.

**Conclusion.** The results of this study provide practical guidance for the optimization and control of vibrating screen surface parameters in industrial cotton cleaning units. The identified optimal values of peg drum rotational speed, vibration frequency, and vibration amplitude enable a reduction in cotton seed mechanical damage while maintaining high cleaning efficiency. The developed regression-based models were statistically validated and can be applied for setting and adjusting operating regimes of cotton cleaning machines in industrial

conditions. Implementation of the proposed parameters contributes to improved product quality, enhanced process stability, and increased energy efficiency of cotton processing equipment.

### REFERENCES:

[1] U. Meliboyev. To'qimachilik sanoati texnologik jarayonlarini modellashtirish asoslari. O'quv qo'llanma. Namangan - 2020 yil.

[2] I.I.Mukhsinov, Sultanov.Oh, Oripov.H, Theoretical Analysis Of The Movement Of Raw Cotton With A Uniform Feeder Feed In A Cotton Gin. Scientific-technical journal (STJ FerPI, 2020)

[3] I.I.Muxsinov, Isaev Sh, Yo'ldashev X "Theoretical analysis of the motion of raw cotton with uniform feeder in a cotton cleaner". The American Journal of Engineering and Technology (ISSN - 2689-0984) Published: Doi: <https://doi.org/10.37547/tajet/Volume03 Issue01>

[4] Sarimsaqov, B Obilov, S Isayev, I Muhsinov, S Muhiddinov, M Inamova "Theoretical study of the process of contaminants from raw cotton moving on the surface of the grate" AIP Conference Proceedings

[5] Shaxboz Isaev, Maftuna Inamova, Ibroxim Muxsinov "Paxta chigitini laboratoriya sharoitida analizlar taxlili" Talqin va tadqiqotlar ilmiy-uslubiy jurnali UIF-2023: 8.2 | 2181-3035 | № 21

[6] Sarimsakov , I Muhsinov "Theoretical Study of the Movement of a Piece of Cotton on the Surface of the Grid in the Process of Separating Large Impurities from Raw Cotton" International Journal of Innovative Research in Sciences and Engineering Studies (IJIRSES) www.ijirses.com ISSN: 2583-1658 | Volume: 2 Issue: 3 | 2022