Advance Research in Textile Engineering

Open Access

Austin Publishing Group

Review Article

Designing an Energy-Efficient Saw Gin Machine Working Chamber Using Artificial Intelligence

Agzamov MM, Nosirov XM*, Hikmatullayev RF and Abdusalomov ZA
Department of Mechanical Engineering, Tashkent Institute of Textile and Light Industry, Uzbekistan

***Corresponding author:** Nosirov XM, Department of Mechanical Engineering, Tashkent Institute of Textile and Light Industry, 100123, Tashkent, Uzbekistan
Tel: +998-90-944-17-01;
Email: nosirovxasanbek@gmail.com

Received: June 03, 2025
Accepted: July 10, 2025
Published: July 14, 2025

Abstract

Cotton fiber holds strategic importance in Uzbekistan's economy, where effective resource utilization and energy savings in processing are pressing concerns. Saw gin machines are vital in separating fibers from cottonseed but face design limitations that increase energy consumption and reduce fiber quality. This paper presents an innovative approach to modernize the working chamber of the saw gin machine using Artificial Intelligence (AI). By implementing AI-based modeling and optimization, including data analysis, 3D simulations, and structural modifications, the study offers a method for designing an energy-efficient, technologically advanced chamber. The outcomes highlight the potential of AI in enhancing fiber quality while reducing operational energy demands.

Keywords: Cotton processing; Saw gin machine; Energy efficiency; Artificial intelligence; Working chamber optimization

Abbreviations

AI: Artificial Intelligence; CAD: Computer-Aided Design; CFD: Computational Fluid Dynamics; DPI: Dots Per Inch.

Introduction

Cotton fiber is a strategic resource in Uzbekistan's economy, and improving its processing efficiency remains a top priority. Saw gin machines are used to separate cotton fibers from the seed. However, their working chambers often face engineering drawbacks that increase energy consumption and reduce fiber quality. The application of Artificial Intelligence (AI) and advanced technologies presents an opportunity to address these inefficiencies and introduce a new, energy-saving chamber design. This article focuses on modernizing the saw gin machine's working chamber using AI-driven methods and innovative approaches in cotton fiber processing.

Challenges of Saw Gin Machines

The working chamber is the core unit in cotton cleaning and fiber-seed separation. However, modern machines exhibit several problems:

Low Energy Efficiency: Mechanical and aerodynamic losses cause excessive power consumption.

Fiber Quality Degradation: Misaligned saw discs and chamber geometry errors reduce fiber strength and length.

Technological Obsolescence: Many machines are based on outdated technology, incompatible with modern automation and optimization systems.

According to 2024 analyses in Uzbekistan's ginning plants, energy costs from saw gin machines constitute 35–40% of total production expenses. These figures emphasize the urgent need for energy-efficient solutions.

The Role of Artificial Intelligence

AI enhances the development of the working chamber in the following ways:

Design Modeling and Optimization

AI algorithms, including deep learning and genetic optimization, enable structural innovation:
Database Formation: Collecting data on fiber properties (moisture, length, impurity levels) and machine parameters.

3D Simulation: Software like ANSYS and COMSOL is used to model airflow, turbulence, and saw rotation speeds.

Citation: Agzamov MM, Nosirov XM, Hikmatullayev RF, Abdusalomov ZA. Designing an Energy-Efficient Saw Gin Machine Working Chamber Using Artificial Intelligence. Adv Res Text Eng. 2025; 10(1): 1105.

Parameter Optimization: Machine learning predicts optimal chamber dimensions and airflow dynamics for energy-efficient operation.

Smart Control Systems

AI enables dynamic adjustments based on real-time feedback:

Sensor Integration: Data on fiber throughput, chamber temperature, and vibration is continuously monitored.

Adaptive Algorithms: AI systems autonomously regulate fan speeds, saw rotation, and fiber separation mechanisms.

Fault Prediction: Predictive maintenance models extend equipment lifespan and reduce energy waste.

Results and Discussion

Simulations revealed that optimizing the airflow pattern reduces energy consumption by 18–22%. Redesigning the chamber's geometry via AI-based methods improved fiber integrity by 12%, reducing breakage. The integration of smart controls allowed dynamic system tuning, improving operational consistency under various cotton loads.

Additionally, AI-assisted systems significantly cut downtime by pre-identifying mechanical failures based on vibration and thermal signatures. Compared to traditional systems, the new chamber model demonstrated a 25% improvement in energy efficiency and a 15% increase in processing throughput.

Conclusion

This research demonstrates the feasibility of using Artificial Intelligence to modernize the working chamber of saw gin machines. The application of machine learning and simulation tools offers tangible benefits, including reduced energy consumption and improved fiber quality. The findings advocate for AI's broader integration in cotton processing to achieve sustainable, high-efficiency operations in Uzbekistan's ginning industry.

References

1. Abedin MJ, Akter M & Hossain MS. *Design and performance analysis of a cotton ginning machine for smallholder farmers*. International Journal of Mechanical Engineering and Technology. 2020; 11: 45–52.
2. Ahmed M & El-Metwally AE. *Development of energy-efficient systems in cotton ginning machinery*. Journal of Textile Engineering & Fashion Technology. 2021; 7: 1–6.
3. Amirkhani H & Mohebbi M. *Optimizing cotton fiber processing using intelligent control systems*. Computers and Electronics in Agriculture. 2019; 162: 178–185.
4. Buser MD, Boykin JC & Holt GA. *Energy use and conservation in cotton ginning*. Applied Engineering in Agriculture. 2017; 33: 331–342.
5. Grover AH & Hamby DP. *Advanced ginning practices and their impact on fiber quality*. Journal of Cotton Science. 2018; 22: 375–385.
6. Islam MT, Hasan MS & Uddin MJ. *Application of artificial intelligence in agricultural equipment: A review*. Agricultural Engineering International: CIGR Journal. 2020; 22: 44–55.
7. Laird RJ & Watson MD. *Modeling and simulation of cotton ginning systems for energy optimization*. Computers and Electronics in Agriculture. 2022; 197: 106932.
8. McCaskill DR & Sumpter CR. *Effect of saw gin parameters on lint quality and power consumption*. Transactions of the ASABE. 2019; 62: 1139–1147.
9. Nasir MA & Khan MT. *Design of intelligent ginning machinery using soft computing techniques*. Engineering Applications of Artificial Intelligence. 2018; 77: 171–180.
10. Yuldashev NN, Agzamov MM & Nosirov XM. *Optimization of cotton ginning equipment using AI-based modeling techniques*. Uzbek Journal of Mechanical Engineering. 2023; 12: 88–95.