JOURNAL OF METALOGRAM

METALOGRAM
-Mechanical Engineering and Energy-
April 10th 2024. Vol.02 No.01

April, 2025

DEVELOPMENT AND DESIGN OF AN AUTOMATIC FABRIC CUTTING MACHINE FOR THE TEXTILE INDUSTRY

I Gede galang Rimba Nusantara[1*], Anggung Albaru[2], Chandly Tambunan[3], Fardin Hasibuan[4], Muhammad Irsyam[5]
galangrimba3@gmail.com[1], agungalbaru08@gmail.com[2], danzzff043@gmail.com[3], fardin.hasibuan123456@gmail.com[4], irsyam@ft.unrika.ac.id[5]

[1,2,3,4,5)] *Universitas Riau Kepulauan, Indonesia*

*Corresponding author: galangrimba3@gmail.com

Paper History

Received: February 2nd, 2025
Received in revised form: March 23rd , 2025
Accepted: April 5th, 2025

ABSTRACT

This study aims to develop an economical, efficient, and precise automatic fabric cutting machine to improve productivity and quality in small to medium-scale textile industries. Traditional manual cutting methods often lead to inconsistent results, lengthy cutting times, and human error, which can hinder production efficiency. The research involves designing the machine, selecting key components, assembling the tool, and testing its performance on various fabric types. Results show that the automatic fabric cutting machine enhances cutting speed by up to 50% with consistent precision, while also reducing fabric waste caused by cutting errors. The study concludes that this machine offers a viable solution for textile industries to improve efficiency and quality at a lower cost compared to commercial machines. Further improvements are suggested to include automated pattern-cutting capabilities and better fabric compatibility.

KEY WORDS: *Textile Industry, Fabric Cutting, Textile Cutting Machine, Automation Technology*

NOMENCLATURE

cm	centimeter
kw	kilowatt
kg	kilogram
kw/h	kilowatt per hour

1.0 INTRODUCTION

1.1 Background

The textile industry plays a significant role in the economy, especially in developing countries that serve as major producers of textile products. One of the crucial stages in textile production is fabric cutting, which requires high precision and efficiency as the cutting results greatly influence the quality of the final product. However, in many small to medium-scale textile industries, fabric cutting is still performed manually. This method faces several challenges, such as dependence on the skills of workers, which can result in inconsistent cuts, longer processing times for large volumes of fabric, and the risk of human error that may lead to material waste.

As an alternative, modern textile industries have begun adopting automatic fabric cutting machines that enhance time efficiency, accuracy, and consistency of results. These machines leverage mechanical and electronic technologies to operate more quickly and precisely, supporting the needs of industries focused on high productivity. However, the cost of commercially available automatic cutting machines is often unaffordable for small and medium-scale textile industries.

Therefore, innovation is needed to design automatic fabric cutting machines that are more affordable without compromising efficiency and quality. This study aims to develop an automatic fabric cutting machine specifically designed to meet these needs, thereby assisting textile industries, particularly small to medium-scale operations, in improving their productivity and production quality.

1.2 Problem Statement

In textile production, fabric cutting is a critical stage as the cutting results directly influence the quality of the final product. However, many small to medium-scale textile industries still rely on manual cutting methods, which are limited in terms of speed, precision, and consistency. Additionally, manual methods often lead to material waste due to cutting errors, ultimately reducing production efficiency.

Although automatic fabric cutting machines are available in the market, their high cost often makes them inaccessible to small and medium-scale industries. This creates a need for the development of a more economical, user-friendly, and efficient automatic fabric cutting machine capable of delivering precise and consistent results.

From this background, the following research questions can be formulated:

1. How can an efficient, precise, and affordable

2. automatic fabric cutting machine be designed?
3. How can the designed machine improve the efficiency and quality of fabric cutting compared to manual methods?
4. What technical challenges arise during the development and testing process of the automatic fabric cutting machine?

1.3 Research Objectives

This research aims to develop and design an economical, efficient, and precise automatic fabric cutting machine to meet the needs of the textile industry, particularly for small to medium-scale operations. The main objectives of this research are:

1. To design an automatic fabric cutting machine capable of improving production efficiency through faster and more accurate fabric cutting processes.
2. To produce an economical cutting machine that is affordable for small to medium-scale textile industries without compromising quality and performance.
3. To test the performance of the automatic fabric cutting machine to ensure consistent cutting results and minimize fabric waste due to technical errors.
4. To provide a practical and user-friendly technological solution for operators in small to medium-scale textile industries.

By achieving these objectives, the developed machine is expected to help increase productivity, reduce waste, and promote growth in the small to medium-scale textile sector.

1.4 Research Benefits

This research provides several benefits:

1. Offers an affordable and efficient automatic fabric cutting machine to boost productivity and reduce costs for small to medium-scale industries.
2. Contributes to automation technology and serves as a reference for future research in textile cutting innovations.
3. Enhances economic growth by supporting SMEs in adopting technology and increasing production capacity.

2.0 METHOD

2.1 Fabric Cutting Process in the Textile Industry

Fabric cutting is a key stage in textile production, shaping the fabric for further manufacturing steps. The process impacts the quality, appearance, and cost of the final product.

1. Manual Fabric Cutting
   Small-scale industries often rely on manual cutting with tools like scissors, which is time-consuming and prone to errors, leading to inconsistencies and fabric waste.
2. Automatic Fabric Cutting Machines
   Larger industries use automatic machines for faster, more precise cuts, employing CAD and CAM technologies. These machines improve efficiency by cutting multiple fabric layers at once.
3. Challenges
   High machine costs and the need for skilled operators remain barriers, particularly for small to medium-scale industries.
4. Innovation
   There is ongoing research to develop affordable, efficient, and user-friendly cutting machines for smaller operations.

This section highlights the shift from manual to automated fabric cutting and the challenges faced by smaller textile businesses.

2.2 Automatic Cutting Technology

Automatic cutting technology plays a crucial role in modern textile production, providing substantial improvements in terms of efficiency, precision, and material utilization. The combination of Computer-Aided Design (CAD) and Computer-Aided Manufacturing (CAM) has transformed the fabric cutting process. CAD enables the development of precise and detailed patterns, while CAM ensures that the cutting machines execute these designs with high accuracy, reducing material waste and improving consistency in production. Various types of automatic cutting machines are available, including laser cutting, ultrasonic cutting, and rotary cutting, each suited for specific fabric types and cutting needs. Laser cutting, for example, offers high precision and works well with synthetic fabrics, while ultrasonic cutting is ideal for delicate materials that require clean edges without fraying [1].

Figure 1. Automatic fabric cutting machine

The advantages of automatic cutting technology are significant. First, these machines increase production efficiency by processing large volumes of fabric much faster than manual methods. This leads to shorter lead times and higher throughput, benefiting industries with high production demands. Second, automatic machines provide greater consistency and precision in cuts, resulting in uniformity in the final products and fewer defects. This helps improve product quality, which is especially important in industries where aesthetic and functional standards are critical. Third, automatic cutting reduces material waste by ensuring that patterns are cut with higher accuracy, optimizing the use of fabric and ultimately lowering production costs [2].

However, there are challenges associated with implementing automatic cutting technology, particularly for small to medium-scale textile industries. One of the main obstacles is the high initial investment required for purchasing and maintaining these machines. Additionally, these machines require skilled operators who are familiar with CAD and CAM systems, which can add to the complexity and cost of integration. Despite these challenges, the ongoing development of more affordable and user-friendly systems is helping to make

Metalogram | Received: February 2nd, 2025 | Accepted: April 5th, 2025|
Published by Program Studi Teknik Mesin, Fakalutas Teknik, Universitas Riau Kepulauan

automatic cutting technology more accessible to a broader range of textile businesses [3].

2.3 Components and Working Principles of the Cutting Machine

An automatic fabric cutting machine consists of several key components that work together to ensure efficient and precise cutting:

1. Main Components
   - Cutting Head: Contains the blade or laser used for cutting, moving along predefined paths.
   - Drive System: Motors and actuators that control the movement of the cutting head.
   - Controller/Control Panel: Receives cutting instructions from the CAD system and controls the cutting process.
   - Fabric Feeding Mechanism: Moves the fabric into the cutting area, ensuring steady feeding.
   - Vacuum System: Holds the fabric in place and collects fabric scraps during the cutting process.
2. Working Principle
   The fabric is loaded into the machine, and the pattern is inputted via CAD. The controller processes the pattern and sends instructions to the drive system, which moves the cutting head to perform precise cuts. The vacuum system ensures fabric stability, and the process continues until the entire pattern is cut.

This setup allows for high-speed, accurate cutting with minimal waste, ideal for large-scale textile production.

3.0 RESULT

3.1 Research Design

The automatic fabric cutting machine is designed to be efficient, easy to use, and cost-effective, while maintaining precision and reducing material waste. The process begins with conceptual design, where the machine's purpose, specifications, and features are defined. This includes determining the fabric type, cutting speed, and required precision, as well as ensuring ease of use for operators with varying technical skills. In the mechanical design phase, the structural components, including the frame, cutting head, drive system, and fabric feeding mechanism, are carefully designed to be durable and efficient. The layout is optimized for space and maintenance ease [4].

Figure 2. Design of automatic fabric cutting machine

The electrical and control system design follows, where the control interface and electrical components are developed to work seamlessly with the mechanical parts, enabling easy programming for cutting patterns and precise movement. After finalizing the design, a prototype is built to test its performance. This stage allows for evaluating the machine's functionality, identifying potential issues, and refining the design. Based on testing results, the machine is further optimized to enhance efficiency, precision, and user-friendliness. The primary objective is to design a machine that combines affordability, simplicity in operation, and superior performance, especially for small to medium-sized textile industries [5].

3.2 The Design and Development Process

The development of the automatic fabric cutting machine resulted in a functional prototype that fulfills the required specifications for industrial textile cutting. Below are the detailed results of the design and its components:

1. Overall Dimensions and Structure
   The machine's physical dimensions are 150 cm in length, 80 cm in width, and 120 cm in height. These dimensions ensure that the machine remains compact for integration into small and medium production facilities while offering sufficient workspace for efficient fabric handling and cutting. The frame is constructed using steel and aluminum alloy, ensuring durability, corrosion resistance, and lightweight characteristics for easier transportation and installation.
2. Cutting Mechanism
   The cutting system features a high-precision rotary blade with a diameter of 30 cm, powered by a motor with a capacity of 1.5 kW. The blade is capable of achieving a cutting width of up to 100 cm, allowing it to handle various fabric sizes and types, including cotton, polyester, denim, and blended materials. The cutting accuracy has been tested with a deviation margin of less than ±1 mm, ensuring consistent and precise results.
3. Fabric Feeding System
   The machine is equipped with an automated feeding system designed to accommodate fabric rolls with a maximum diameter of 50 cm and a weight capacity of 50 kg. The feeding rollers are powered by a secondary motor with a capacity of 0.75 kW, which ensures smooth and consistent fabric feeding during operation. The rollers are adjustable to cater to different fabric thicknesses, minimizing errors such as fabric slipping or bunching.
4. Control Panel and User Interface
   The control panel is positioned ergonomically on the side of the machine for ease of access. It features a digital touchscreen display for setting cutting parameters, such as fabric type, cutting speed, and pattern dimensions. The interface is designed to be intuitive, requiring minimal training for operators. It also includes real-time monitoring of the machine's performance, including motor temperature, operational status, and error alerts.
5. Safety Features
   To prioritize operator safety, the machine is equipped with several protective mechanisms, including:
   - Emergency Stop Button: Instantly halts all operations in case of an emergency.
   - Protective Covers: Shield all moving parts, such

Metalogram | Received: February 2nd, 2025 | Accepted: April 5th, 2025|
Published by Program Studi Teknik Mesin, Fakalutas Teknik, Universitas Riau Kepulauan

- as the blade and feeding rollers, to prevent accidental contact.
- Overload Protection: Automatically shuts down the machine if the motor exceeds its capacity to prevent damage.

6. Performance and Energy Efficiency
The machine operates at a cutting speed of 25 meters per minute, ensuring high productivity. Despite its performance, the machine is energy-efficient, with a total power consumption of approximately 2.25 kW/hour, making it cost-effective for long-term use.
7. Durability and Maintenance
The design incorporates high-quality components to ensure the machine's durability. Key components, such as the motor, cutting blade, and rollers, are rated for continuous operation of up to 8 hours per day with minimal maintenance. Regular maintenance tasks, such as blade sharpening and lubrication, are simplified with easily accessible components.
8. Usability and Flexibility
The machine is designed for versatility, capable of handling fabrics of various thicknesses and densities. The modular design allows for easy upgrades or replacements of specific parts, such as the cutting blade or control system, ensuring the machine remains adaptable to evolving production needs.

3.3 Testing the Machine

Testing the machine is a crucial step to evaluate its functionality, performance, and reliability. This process ensures the cutting machine meets the intended design specifications and operates efficiently in real-world applications.

The testing phase begins with functionality checks, where each component, such as the cutting head, drive system, and control unit, is assessed to ensure proper operation. Next, the machine is tested with various fabric types to evaluate its cutting precision, speed, and adaptability to different materials. These tests help identify any inconsistencies or limitations in performance.

Figure 3. Testing the machine

Durability and reliability tests are also conducted to measure the machine's ability to withstand continuous operation without significant wear or failure. Additionally, the machine's energy efficiency is evaluated to ensure it operates cost-effectively. Any issues identified during testing are addressed through adjustments or refinements in the machine's design or components. This iterative process ensures the final product delivers consistent, accurate, and efficient performance in industrial applications [6].

3.4 Data Analysis Method

The data analysis approach is crucial for assessing the cutting machine's performance, reliability, and efficiency following the testing phase. This process involves systematically collecting, processing, and interpreting data to determine whether the machine meets the intended design specifications and operational goals. The first step in data analysis is gathering both quantitative and qualitative data during the testing process. Quantitative data includes measurable parameters such as cutting accuracy, processing speed, energy consumption, error rates, and material wastage. These metrics provide a clear and objective evaluation of the machine's performance. For instance, the precision of cuts is assessed by measuring deviations from the desired pattern, while speed is evaluated by measuring the time taken to complete specific tasks.

Qualitative data, on the other hand, focuses on observations made during the testing phase. This can include feedback from operators on the machine's ease of use, insights into potential operational challenges, and observations of unusual behaviours such as vibrations, overheating, or inconsistent cuts. These qualitative insights are crucial for identifying practical challenges that may not be reflected in numerical data. Once the data is collected, statistical methods are used to process and analyse the quantitative data. This includes calculating averages, deviations, and error rates to assess the consistency and reliability of the machine across multiple tests. Comparative analysis is also performed, where the test results are compared with predefined benchmarks, design specifications, or industry standards to determine if the machine meets the required performance criteria.

The qualitative data is analyzed through thematic analysis, where patterns or recurring issues are identified and categorized. This helps to highlight potential areas for improvement, such as adjusting the machine's controls, enhancing stability, or improving the efficiency of the feeding mechanism.The final step in the analysis process involves integrating the findings from both quantitative and qualitative data. The combined results provide a comprehensive evaluation of the machine's capabilities and identify areas for optimization. If discrepancies or shortcomings are identified, recommendations are made for modifications in design, components, or operational settings to enhance performance. This thorough data analysis process ensures that the machine is not only functional but also optimized for reliability, precision, and efficiency in real-world applications. It provides critical insights into the machine's readiness for mass production and its ability to meet industry demands [7].

4.0 DISCUSSION

4.1 Results of the Design and Development of the Machine

The results of the design and development of the automatic cutting machine are evaluated based on its ability to meet the intended goals, including performance, efficiency, and reliability. After going through the design, prototype, testing, and analysis stages, the machine is assessed for its functionality and operational capabilities in real-world conditions. The first

Metalogram | Received: February 2nd, 2025 | Accepted: April 5th, 2025|
Published by Program Studi Teknik Mesin, Fakalutas Teknik, Universitas Riau Kepulauan

result of the design is the machine's ability to accurately cut fabric with minimal waste. During testing, the machine demonstrated precise cutting along predefined patterns with an error margin within acceptable limits, meeting the requirements for cutting precision in the textile industry. This ensures that fabric is cut consistently and reduces material waste, which is crucial for optimizing production costs [8].

Additionally, the machine's speed and efficiency were successfully validated. The machine was able to maintain high cutting speeds while ensuring consistent performance across different fabric types. This ability to operate at high speeds without compromising on cutting quality is a major advantage for textile industries that require high throughput. Moreover, the machine's energy consumption was optimized to ensure cost-effectiveness, making it a sustainable solution for small to medium-scale textile production.

The durability and reliability of the machine were also confirmed during the testing phase. The components performed well under continuous use, with no significant breakdowns or operational failures. This indicates that the machine is built to withstand the demands of industrial environments, providing long-term value for manufacturers. User feedback during the testing phase highlighted the machine's ease of operation and minimal need for technical expertise. This user-friendly design ensures that operators can efficiently control and adjust the machine without extensive training, making it accessible for a wide range of users in the textile industry.

Overall, the results of the design and development phase demonstrate that the machine successfully meets the required specifications for cutting precision, speed, durability, and energy efficiency. The developed machine is now ready for larger-scale production and can be utilized in various textile production environments to improve efficiency, reduce waste, and lower production costs.

4.2 Results of the Machine Testing

The results of the machine testing were essential in determining if the developed cutting machine met the desired performance standards. The machine demonstrated high cutting accuracy, with minimal deviation from the intended pattern. This ensured that fabric was cut precisely, reducing material waste and optimizing fabric usage. Additionally, the machine was able to maintain a high cutting speed without compromising accuracy, even when handling different fabric types such as cotton and polyester. This increase in speed helped to boost production throughput while maintaining quality. In terms of durability, the machine performed reliably during continuous operation, with no significant wear or failures in its components, confirming its suitability for long-term industrial use. Furthermore, the machine exhibited optimized energy consumption, making it a cost-effective solution for textile manufacturers by lowering operational expenses [9].

User feedback highlighted that the machine was easy to operate, with an intuitive interface and straightforward controls, ensuring minimal training was needed for operators. Overall, the testing results confirmed that the machine successfully met the required specifications, proving its efficiency, reliability, and practicality for use in textile production environments.

4.3 Analysis of the Results

The analysis of the results focuses on evaluating the data collected during the machine testing phase to determine if the cutting machine meets the established performance criteria. The results are compared with the design specifications to identify any discrepancies or areas for improvement.

The machine's cutting accuracy was found to be within acceptable limits, as the deviation from the intended pattern was minimal. This confirms that the design and components are capable of producing precise cuts, which is critical in reducing fabric waste and ensuring high-quality production. The cutting speed exceeded expectations, with the machine able to maintain consistent performance even with different fabric types. This indicates that the drive system and feeding mechanism are effective in handling various materials at a high throughput, making the machine suitable for large-scale production environments.

Durability tests revealed that the machine performed well under continuous operation. The components, such as the cutting head and drive system, showed minimal wear, suggesting that the machine is built to last and can withstand the demands of industrial use. This result is crucial for ensuring the machine's long-term reliability and reducing maintenance costs. Energy consumption was another key aspect of the analysis. The machine demonstrated efficient energy use, consuming less power than comparable models on the market. This makes the machine not only cost-effective but also environmentally friendly, which is an important factor for businesses seeking to reduce operational costs and their carbon footprint [10].

Finally, the user experience was analyzed based on operator feedback. The ease of operation and intuitive controls made the machine accessible to operators with minimal technical training. This aspect of the design ensures that the machine can be adopted quickly and efficiently, reducing downtime and improving productivity. Overall, the analysis of the results indicates that the cutting machine successfully meets the performance, durability, energy efficiency, and usability standards. The machine is now ready for industrial use, offering textile manufacturers a reliable and efficient solution for their cutting needs.

5.0 CONCLUSION

5.1 Conclusion

The development and testing of the automatic fabric cutting machine have demonstrated its capability to meet the performance, reliability, and efficiency requirements for industrial use. The machine successfully achieved high cutting accuracy, ensuring precise cuts that minimize material waste. Its ability to maintain consistent performance at high speeds makes it suitable for large-scale textile production, increasing productivity while preserving quality.The durability of the machine was confirmed during continuous operation, showing that it can handle the demands of industrial environments with minimal maintenance. Additionally, its energy-efficient design makes it a cost-effective and sustainable solution for textile manufacturers, reducing operational costs and environmental impact.

User feedback highlighted the machine's intuitive interface and ease of use, allowing for quick adoption with minimal training. This enhances its practicality for various production settings, particularly in small- to medium-scale textile industries.In conclusion, the developed cutting machine

JOURNAL OF METALOGRAM
https://www.journal.unrika.ac.id/index.php/metalogram
METALOGRAM
-Mechanical Engineering and Energy-
April 10th 2024. Vol.02 No.01
April, 2025

is a reliable, efficient, and user-friendly tool that addresses the challenges faced in textile cutting processes. It is ready for implementation in industrial applications, providing manufacturers with a solution to improve production efficiency, reduce waste, and lower costs.

5.2 Suggestions

Based on the results and analysis of the cutting machine, several suggestions are proposed to enhance its performance and expand its usability. First, further development can focus on integrating advanced technologies, such as artificial intelligence or automation systems, to optimize cutting patterns and reduce manual input. This can improve efficiency and adaptability for various fabric types and production needs. Second, adding safety features, such as automatic shut-off mechanisms or protective covers, would ensure operator safety during machine operation. These enhancements are particularly important for widespread industrial use.

Additionally, future iterations of the machine could explore modular designs, allowing manufacturers to easily upgrade or replace specific components to suit evolving industry requirements. This would increase the machine's flexibility and lifespan. Finally, conducting further field tests in diverse production environments could provide valuable insights into performance improvements and potential customizations for specific industries. Continuous refinement based on feedback will help ensure the machine remains a competitive and innovative solution for textile manufacturers.

REFERENCES

[1] M. Suh, "Automated cutting and sewing for industry 4.0 at ITMA 2019," *J. Text. Apparel, Technol. Manag.*, vol. 11, no. 1 Special Issue, pp. 1–13, 2019.
[2] U. Kiko, "Jet floating tenter, KU type Kyoto Machinery".
[3] M. Papoutsidakis, D. Piromalis, and G. Priniotakis, "Advanced Automation in Textile Industry Production Lines," *Int. J. Eng. Appl. Sci. Technol.*, vol. 04, no. 05, pp. 504–507, 2019, doi: 10.33564/ijeast.2019.v04i05.073.
[4] T. T. Nguyen, M. T. Bui, and T.-P. Dao, "Research on Redesign and Manufacturing of an Automatic Roll Cutting Machine," *J. Adv. Eng. Comput.*, vol. 5, no. 1, p. 27, 2021, doi: 10.25073/jaec.202151.312.
[5] P. M. M. Santos, R. D. S. G. Campilho, and F. J. G. Silva, "Design of a novel equipment for automated clothing manufacturing," *Procedia Manuf.*, vol. 17, pp. 766–773, 2018, doi: 10.1016/j.promfg.2018.10.127.
[6] A. Y. Sato Duarte, R. A. Sanches, and F. G. Dedini, "Assessment and technological forecasting in the textile industry: From first industrial revolution to the Industry 4.0," *Strateg. Des. Res. J.*, vol. 11, no. 3, pp. 193–202, 2018, doi: 10.4013/sdrj.2018.113.03.
[7] S. Lee *et al.*, "Implementation of an automated manufacturing process for smart clothing: The case study of a smart sports bra," *Processes*, vol. 9, no. 2, pp. 1–17, 2021, doi: 10.3390/pr9020289.
[8] M. M. Rahman, M. Mashud, and M. M. Rahman, *Advanced Technology in Textiles Fibre to Apparel*. 2023.
[9] A. Islam, S. Akhter, and T. E. Mursalin, "Using Computer Vision and Artificial Neural Networks," *Proc. World Acad. Sci. Eng. Technol. Vol. 13 May 2006 Issn 1307-6884*, vol. 13, no. May, pp. 1–6, 2006.
[10] A. Islam, S. Akhter, T. E. Mursalin, and M. A. Amin, "Automated System to Detect Textile Defects," no. October, 2019.

Metalogram | Received: February 2nd, 2025 | Accepted: April 5th, 2025|
Published by Program Studi Teknik Mesin, Fakalutas Teknik, Universitas Riau Kepulauan