Journal for Technology and Science
Homepage : https://journal.antispublisher.com/index.php/IPTEKS/index
Email : admin@antispublisher.com

e-ISSN : 3047-4337
JOTECH, Vol. 3, No. 1, January 2026
Page 67-84

Assessing the Fan Cooling System for High-Speed Sewing Machine and its Acceptability

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DOI : https://doi.org/10.61796/ipteks.v3i1.446

Sections Info

Article history:
Submitted: December 15, 2025
Final Revised: December 30, 2025
Accepted: January 16, 2026
Published: January 31, 2026

Keywords:
Fan cooling system
Acceptability
Applied
Survey
CTU

ABSTRACT

Objective: *This research assessed the development and acceptability of the fan cooling system for the effective operation in the sewing process at Cebu Technological University-Tuburan Campus, Tuburan, Cebu during the academic year 2024-2025 for technology diffused adption.* ***Method:*** *This research study utilized quantitative research using applied with the use of descriptive method to assess the system acceptability of a technology infusion in the fan cooling system for the effective operation in the sewing process. The respondents of the study included the total population consisting of two types of respondents, such as experts and nonexperts inside and outside of the institution that includes instructor students and small-scale sewers.* ***Results:*** *Findings from experts and non-experts consistently indicate that the system is highly acceptable (HA) across all aspects, with an overall factor average mean of 4.75. The highest-rated aspect, perceived ease of use (4.78 HA), underscores the system's seamless integration and intuitive operation, while perceived usefulness (4.74 HA) highlights its efficiency in preventing overheating and optimizing energy consumption. Behavioral intention to use (4.73 HA) received the lowest score, though still highly acceptable, suggesting that while users recognize its benefits, external factors may influence adoption. Actual usage (4.75 HA) further supports that the system meets performance expectations, enhances reliability, and contributes to a safer working environment. The findings demonstrate that the fan cooling system is a highly effective and user-friendly enhancement for sewing machines.* ***Novelty:*** *While users acknowledge the cooling system's contribution to safety, efforts should be made to further highlight and enhance this aspect.*

INTRODUCTION

Integrating technology across various sectors enhances efficiency, productivity, and innovation by streamlining processes and enabling advanced capabilities. Technology integration allows for the automation of routine tasks, facilitates real-time data analysis, and improves communication and collaboration. This transformative approach not only optimizes operational workflows but also drives competitive advantage by leveraging modern tools and technologies to address complex challenges.

Sewing machines were lifelines for many Filipinos and essential equipment in the garment industry. Integrating technology into sewing machines fundamentally transforms the sewing process by enhancing efficiency, precision, and user experience, specifically through the implementation of alerts and a fan cooling system, offers significant enhancements in both operational effectiveness and efficiency. Traditional sewing machines, while reliable, often face challenges such as overheating, which can lead to machine wear and tear, and potential safety hazards. Incorporating a fan cooling system addresses this issue by maintaining optimal operating temperatures, thereby extending the machine's lifespan and ensuring consistent performance during prolonged use. Research has highlighted that integrating alert systems in sewing machines significantly improves operational efficiency. For instance, a study reveals that the introduction of a sensor-based machine overheat protection system has effectively minimized overheating issues by activating cooling fans when necessary. This automation leads to reduced downtime and improved production flow, which are crucial in high-demand environments like garment manufacturing [1]. Moreover, a monitoring system designed to enhance yield in sewing operations has been developed. This system utilizes visual signals to alert operators about machine status, thereby allowing for quick responses to any issues, thus maintaining the operational rhythm of production lines. Such systems provide real-time feedback that can help minimize delays caused by idle machines [2].

The assessment of fan cooling systems and their acceptability is a multifaceted endeavor that focuses on performance metrics, energy efficiency, and compliance with industry standards. By prioritizing these factors, stakeholders can ensure that cooling systems not only meet the specific demands of the application but also align with broader goals of sustainability and operational efficiency. Eventually, this assessment process helps foster an environment of informed decision-making that benefits both users and manufacturers alike while addressing the pressing challenges posed by climate change and energy consumption. In essence, proper evaluation and assessment of fan cooling systems serve as a substantial contribution to achieving optimal performance in an increasingly energy-conscious world.

In 17 Sustainable Development Goals (SDGs), Goal #12, "Responsible Consumption and Production" this research contributes responsible consumption by potentially extending the lifespan of sewing machines. Early detection and prevention of overheating can reduce motor damage and the need for frequent replacements. This aligns with minimizing waste and promoting sustainable use of resources. Building upon the findings of the DOST study, this study aimed to develop further and evaluate the effectiveness of an enhanced sewing machine equipped with fan cooling system. The successful implementation of this technology can significantly improve the safety, performance, and lifespan of sewing machines, particularly in the Philippine garment industry.

Lastly, by embedding these technological advancements, sewing machines become more reliable and efficient tools, capable of meeting the demands of modern textile production. The combination of alerts and cooling systems ensures that the machines operate smoothly, safely, and with minimal interruptions, ultimately leading to increased productivity and higher-quality outputs. This integration represents a forward-thinking approach to textile manufacturing, aligning with the industry's move towards smarter, more automated production environments.

RESEARCH METHOD

Design

This research study utilized quantitative research using applied with the use of descriptive method to assess the system acceptability of a technology infusion in the fan cooling system for the effective operation in the sewing process. A survey questionnaire was employed to generally assess the acceptability on the aspect of perceived usefulness, perceived ease of use, behavioral intention to use, and actual usage on ensuring efficient and effective operation towards the application of the fan cooling system. The gathered data was carefully analyzed to determine the level of acceptance and practical applicability of the system. The results aim to provide insights into enhancing equipment performance and guiding future innovations in sewing machine technologies.

Research Respondents

The respondents of the study included the total population consisting of two types of respondents, such as expert and non-expert inside and outside of the institution that includes instructor students and small-scale sewers. The technical expert respondents were those individuals holding National Certificate II (NC II) holder in electrical, electronics, and fashion designing/garments technology specification in material construction in related expertise and three (3) years or more of electrical, electronics and fashion designing practitioners and trainers, alongside instructors in electrical, electronical and garments technology or related fields that would provide invaluable insights rooted in the practical knowledge and professional training. The non-experts comprise the third year electrical, electronics, and garment technology students or related fields that offer a fresh lens on the study, reflecting emerging viewpoints and potential challenges faced by the future practitioners in the field. Lastly, the dressmakers and tailors of the Municipality of Tuburan were also included as non-expert respondents. Moreover, the expert respondents of the study were chosen using purposive sampling while the non-expert respondents were chosen using simple random sampling to ensure reliability of the research work.

Instrument

The research instrument for evaluating the acceptability of the technology infusion in the fan cooling system of a sewing machine was patterned from (Armstead). questionnaire that had undergone pilot testing and Cronbach alpha test run to ensure its validity and reliability. The questionnaire was thoughtfully structured into one distinct section, in serving specific purpose which was to assess the acceptability of the technology infusion in the fan cooling system in a sewing machine. A five-point Likert scale served as the primary tool to assess both expert and non-expert perceptions of the fan cooling system of a sewing machine. The respondents rated the acceptability on a scale from (Highly Unacceptable) to 5 (Highly Acceptable). The gathered responses provided quantitative data that were statistically analyzed to determine the overall level of system acceptance and effectiveness.

Data Gathering Procedures

To ensure formality, the research began with transmittal letters to the Campus Director of Cebu Technological University-Tuburan Campus and the barangay captains of Barangay 7 and 8 in the Municipality of Tuburan, Cebu Province. Following approval, data collection commenced through surveys. The researcher explained the study and addressed questions during face-to-face questionnaire distribution and collection. Finally, the results were presented in tables, facilitating further discussion and potentially enhancing response accuracy. Based on the findings, the recommended output was created after the study[3]–[5].

Statistical Treatment of Data

The study's data were carefully collected, tallied, and tabulated using appropriate statistical tools to ensure a comprehensive and accurate analysis. The weighted mean was utilized to determine the respondents' degree of acceptability regarding the technology infusion in the fan cooling system of the sewing machine. This statistical measure provided an overall average that reflected the general perception of the respondents. Meanwhile, the standard deviation was employed to measure the variability or dispersion of responses from the mean. A low standard deviation indicated that most responses were closely clustered around the mean, suggesting a high level of agreement among the respondents. In contrast, a high standard deviation signifies a wider range of opinions or perceptions, reflecting greater variability in the responses[6], [7],[8].

RESULTS AND DISCUSSION

Technical Requirements

Figure 1. Design of a fan cooling system.

Figure 2. Screw drivers.

Figure 3. Wire cutters and strippers

Figure 4. Soldering iron and solder

Figure 5. Drill and bits.

Figure 6. Multimeter

Figure 7. Hot glue gun and adhesive.

Figure 8. Dremel and cutter.

Materials

Figure 9. Fan.

Figure 10. Power supply.

CHAPT

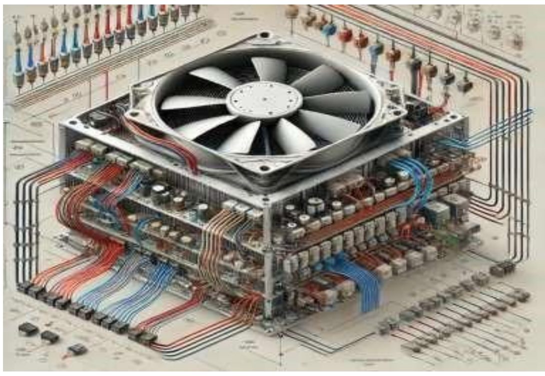

Figure 11. Wiring and connections.

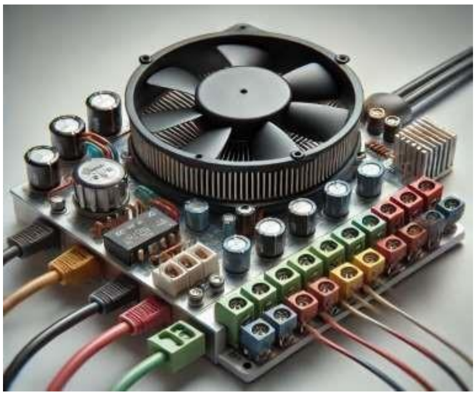

Figure 12. Speed controller.

Figure 13. Cooling ducts.

Figure 14. Heat sink.

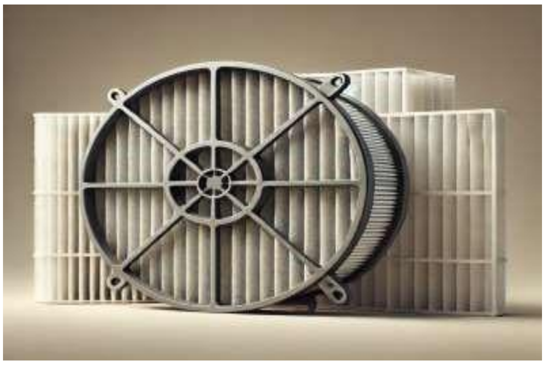

Figure 15. Filters.

Control System

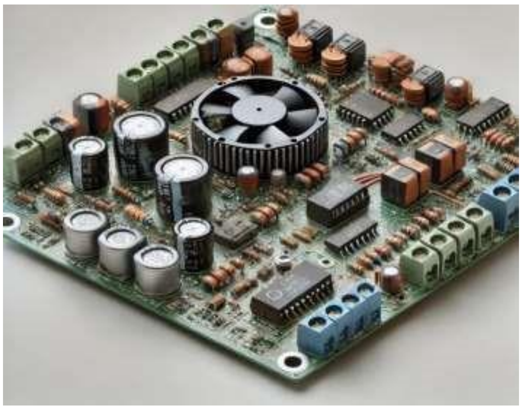

Figure 16. Microcontroller.

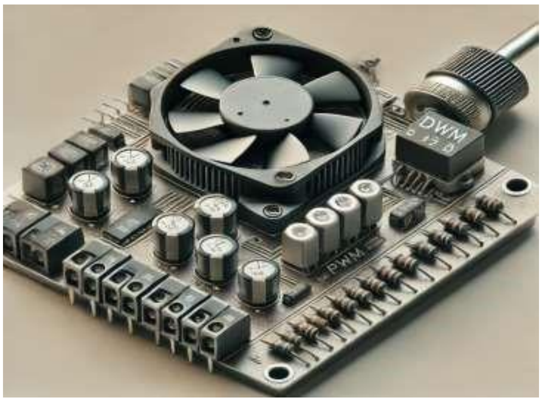

Figure 17. Temperature sensor.

Figure 18. Power supply unit.

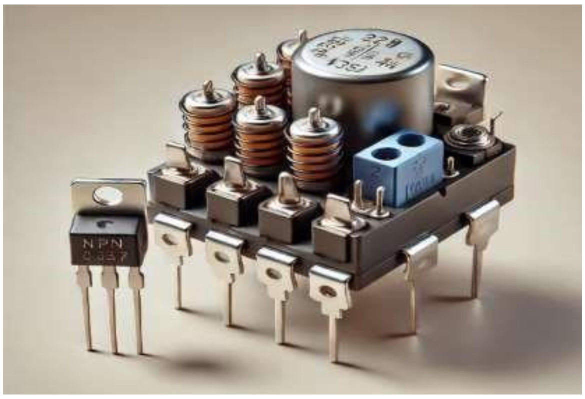

Figure 19. Relay.

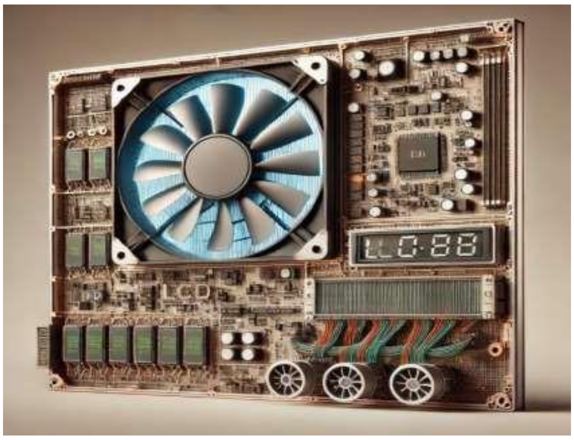

Figure 20. Display panel.

Figure 21. Control interface.

Figure 22. Wiring and connectors.

Process

Figure 23. Cooling processes.

Functions

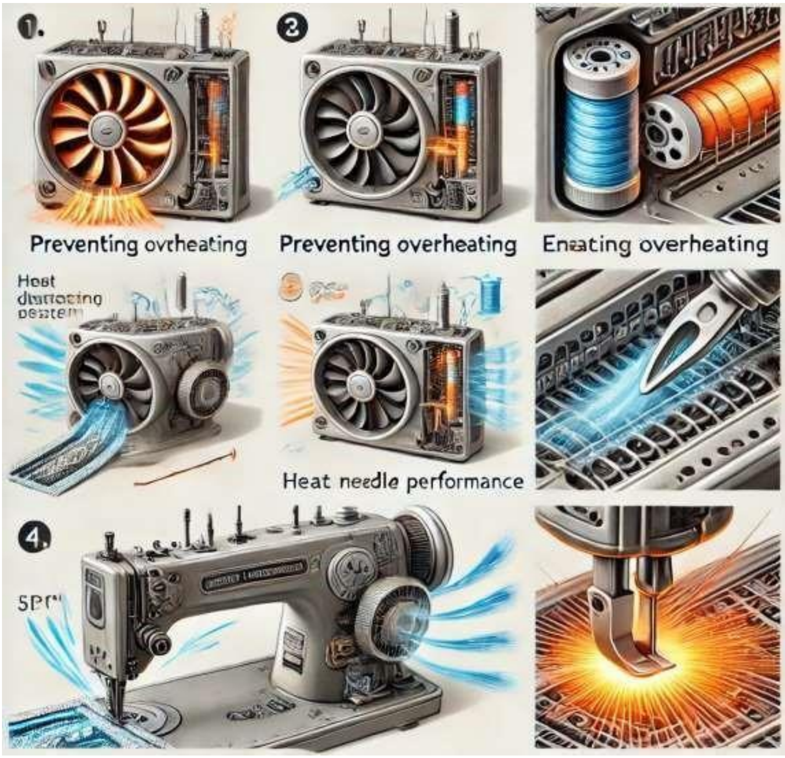

Figure 24. Fan cooling system.

Table 1. Perceived Usefulness.

Statement	Expert $\bar{x}$	VD	Non-Expert $\bar{x}$	VD	Total $\bar{x}$	VD
Perceived Usefulness						
1. The integration of a fan cooling system helps maintain optimal operating temperatures, reducing the risk of overheating during extended use and thereby ensuring consistent performance.	4.54	HA	4.80	HA	4.67	HA
2. The fan cooling system minimizes thermal stress on critical components, which users perceive as valuable in reducing maintenance needs and extending the machine's lifespan.	4.72	HA	4.90	HA	4.81	HA
3. The fan cooling system not only prevents excessive heat buildup but also optimizes energy consumption, making the sewing machine more economical to operate.	4.76	HA	4.90	HA	4.83	HA
4. The system contributes to a safer operating environment by preventing surface overheating, thereby enhancing user comfort and reducing the likelihood of heat-related hazards.	4.58	HA	4.61	HA	4.60	HA
5. The fan cooling design supports uninterrupted, high-quality stitching, which professionals view as essential for maintaining efficiency and achieving reliable results.	4.68	HA	4.90	HA	4.79	HA
Average Weighted Mean	**4.66**	**HA**	**4.82**	**HA**	**4.74**	**HA**

Legend: 5.00-4.21 – Highly Acceptable (HA); 4.20-3.76 – Acceptable (A); 3.75-2.61 -Moderately Acceptable (MA); 2.60-1.76 – Unacceptable (U); 1.75-1.00 – Highly Unacceptable (HU)

Table 2. Perceived Ease of use.

Statement	Expert $\bar{x}$	VD	Non-Expert $\bar{x}$	VD	Total $\bar{x}$	VD
Perceived Ease of Use						
1. The cooling system is engineered to operate automatically or with minimal manual intervention, ensuring that users do not have to adjust	4.82	HA	4.90	HA	4.86	HA

Statement	Expert		Non-Expert		Total	
settings frequently during sewing tasks.						
2. The fan cooling system's design is seamlessly integrated within the sewing machine's overall interface, allowing users to experience a unified system without learning additional controls or complex procedures.	4.73	HA	4.80	HA	4.77	HA
3. The components, such as the fan and filter, are designed to be easily accessible for routine cleaning or minor adjustments, thereby reducing downtime and complexity for the user.	4.68	HA	4.80	HA	4.74	HA
4. The fan cooling system is built with a compact form factor, ensuring that it does not add unnecessary bulk or interfere with the ergonomic handling of the sewing machine.	4.62	HA	4.71	HA	4.67	HA
5. The cooling system contributes to a more comfortable working environment, enabling users to focus on their tasks without distraction.	4.74	HA	4.92	HA	4.83	HA
Average Weighted Mean	**4.72**	**HA**	**4.83**	**HA**	**4.77**	**HA**

Legend: 5.00-4.21 – Highly Acceptable (HA); 4.20-3.76 – Acceptable (A); 3.75-2.61 -Moderately Acceptable (MA); 2.60-1.76 – Unacceptable (U); 1.75-1.00 – Highly Unacceptable (HU)

Table 3. Behavioral Intentions to Use.

Statement	Expert		Non-Expert		Total	
	$\bar{x}$	VD	$\bar{x}$	VD	$\bar{x}$	VD
Behavioral Intentions to Use						
1. The fan cooling system enables users to be more inclined to adopt the sewing machine when they perceive that it increases reliability and reduces the risk of thermal failure.	4.68	HA	4.92	HA	4.80	HA

Statement	Expert		Non-Expert		Total	
2. The inclusion of an advanced cooling system contributes to a positive attitude toward the machine, making users more willing to adopt and consistently use the technology in their daily operations.	4.60	HA	4.74	HA	4.67	HA
3. The fan cooling system improves operational performance and lowers maintenance needs, increasing users' intention to use the machine.	4.58	HA	4.74	HA	4.66	HA
4. A well-integrated fan cooling system builds user confidence by mitigating overheating issues, which fosters a greater willingness to rely on the machine for both personal and professional sewing tasks.	4.70	HA	4.80	HA	4.75	HA
5. The cooling system's effectiveness significantly boosts users' behavioral intention, as positive feedback and social validation reinforce its reliability and value.	4.68	HA	4.80	HA	4.74	HA
Average Weighted Mean	**4.65**	**HA**	**4.80**	**HA**	**4.73**	**HA**

Legend: 5.00-4.21 – Highly Acceptable (HA); 4.20-3.76 – Acceptable (A); 3.75-2.61 -Moderately Acceptable (MA); 2.60-1.76 – Unacceptable (U); 1.75-1.00 – Highly Unacceptable (HU)

Table 4. Actual Usage.

Statement	Expert		Non-Expert		Total	
	$\bar{x}$	VD	$\bar{x}$	VD	$\bar{x}$	VD
Actual Usage						
1. The fan cooling system consistently maintains optimal operating temperatures even during prolonged sewing sessions.	4.66	HA	4.80	HA	4.73	HA
2. The fan cooling system's robust design minimizes overheating and system failures, leading to a high level of trust in the machine's long-term reliability.	4.70	HA	4.80	HA	4.75	HA
3. The cooling system's design allows for quick and straightforward maintenance—such as cleaning or minor adjustments—enhancing user acceptance by reducing downtime and maintenance complexity during actual usage.	4.62	HA	4.78	HA	4.70	HA
4. The fan cooling system meets my expectations for improving the sewing machine's performance.	4.68	HA	4.90	HA	4.79	HA

Statement	Expert		Non-Expert		Total	
5. The fan cooling system contributes to a safer working environment, which significantly boosts user confidence and acceptability during real-world operation.	4.69	HA	4.82	HA	4.76	HA
Average Weighted Mean	**4.67**	**HA**	**4.82**	**HA**	**4.75**	**HA**

Legend: 5.00-4.21 – Highly Acceptable (HA); 4.20-3.76 – Acceptable (A); 3.75-2.61 -Moderately Acceptable (MA); 2.60-1.76 – Unacceptable (U); 1.75-1.00 – Highly Unacceptable (HU)

Discussion

Design

The cooling system design integrates an axial fan with an electronic control unit, forming a comprehensive temperature-regulated solution. The large axial fan promotes efficient air circulation, preventing overheating in heat-sensitive equipment, such as high-speed sewing machines. The control system, housed in a transparent casing, features a microcontroller, LCD display, multiple wired connections, and a red LED indicator, enabling real-time temperature monitoring and automated fan control. The organized wiring, secured with zip ties, reflects careful electrical integration, although further cable management could enhance safety and reliability. Overall, this design balances effective thermal management with structured electronic control, ensuring operational stability for sensitive machinery[1], [9],[10].

Tools

Several tools are essential for assembling and maintaining the cooling system. Screwdrivers are used for securing components, while wire cutters and strippers prepare electrical connections. A soldering iron and solder ensure electronic components are properly attached to circuit boards, and a drill with appropriate bits facilitates mounting of fans, circuit boards, or enclosures. A multimeter is crucial for testing electrical connections, voltage, and continuity, ensuring safe and accurate circuit operation. Additionally, a hot glue gun or adhesive provides minor structural support, and a Dremel or cutter allows modifications to enclosures for optimal component fit. Collectively, these tools ensure precise construction, safe operation, and flexibility in adapting the system to specific applications[11], [12].

Materials

The cooling system relies on a combination of functional and structural materials. The fan serves as the core active cooling component, ensuring efficient airflow. A power supply provides the necessary electrical energy to drive the fan and control electronics, while wiring and connectors enable proper electrical integration. Optional speed controllers allow fan performance to be adjusted based on temperature or user preference. Cooling ducts or housings direct airflow efficiently, and heat sinks dissipate heat from critical components, enhancing thermal management. Filters prevent dust accumulation, maintaining clean airflow and prolonging system efficiency. Together, these materials create a robust and reliable cooling solution tailored for high-speed machinery.

Control System

The control system manages the cooling operation, adjusting performance based on temperature conditions to ensure efficiency. A printed circuit board (PCB) forms the foundation for electrical connections, integrating control components. The microcontroller acts as the system's "brain," processing temperature data from sensors such as thermistors, LM35, or DHT11 devices, and regulating fan speed accordingly. Power is supplied via an adapter, battery, or transformer, while relays or transistors control fan activation based on predefined thresholds. A display panel, either LCD or LED, provides real-time temperature readings and system status, and control buttons or a touch interface enable user input. Wiring and connectors ensure seamless communication and power distribution among components, creating a responsive and energy-efficient cooling system.

Process

The cooling system employs a combination of methods to maintain optimal machine temperatures. It integrates traditional cooling fans, needle cooling systems, magnetic mount fans, and advanced cooling textiles to enhance heat dissipation. By combining conventional and innovative techniques, the system ensures consistent sewing performance, reduces the risk of thermal-related failures, and improves machine durability. The coordinated operation of these components allows the system to respond dynamically to heat generation, maintaining stable temperatures and supporting prolonged machine usage.

Functions

The primary functions of the fan cooling system in high-speed sewing machines include preventing overheating, enhancing needle performance, maintaining thread integrity, and extending the lifespan of components. By regulating operational temperatures, the system minimizes mechanical wear, reduces downtime, and ensures smooth, uninterrupted production. This contributes to improved user comfort, higher production efficiency, and overall machine reliability, demonstrating the crucial role of thermal management in maintaining the performance and longevity of high-speed machinery.

Perceived Usefulness

The perceived usefulness of the fan cooling system, as evaluated by both experts and non-experts, demonstrates a high level of acceptance across all assessed aspects. Experts rated the system with an average weighted mean of 4.66, while non-experts gave a slightly higher rating of 4.82, resulting in an overall acceptability of 4.74, classified as highly acceptable (HA). The most highly rated statement (4.83 HA) emphasizes the system's capacity to prevent heat buildup while optimizing energy consumption, indicating that users value both efficiency and cost-effectiveness. In addition, the reduction of thermal stress on machine components (4.81 HA) and the ability to support uninterrupted, high-quality stitching (4.79 HA) highlight its perceived reliability and long-term benefits. The lowest-rated aspect (4.60 HA) relates to safety improvements, suggesting that while users recognize its contribution to a safer working environment, safety may be secondary to performance and efficiency. Overall, these findings indicate that the fan cooling system is regarded as a valuable innovation that enhances machine longevity, efficiency, and user comfort. Its energy-saving benefits align with existing research, which suggests that advanced cooling technologies in textile manufacturing can reduce energy consumption by up to 30%, thereby lowering operational costs and promoting sustainability [13].

Perceived Ease of Use

The fan cooling system was also perceived as highly user-friendly, with experts and non-experts assigning an overall average weighted mean of 4.77 HA. The highest-rated feature (4.86 HA) pertains to its automatic operation or minimal manual intervention, underscoring the value users place on convenience and efficiency. Additionally, the system contributes to a comfortable working environment (4.83 HA), allowing operators to focus without distraction from heat. Seamless integration with the sewing machine interface (4.77 HA) and the easy accessibility of components for maintenance (4.74 HA) further demonstrate the design's user-centered approach. The compact form factor received the lowest rating (4.67 HA), indicating minor concerns regarding physical integration, though it remains highly acceptable. Collectively, these results suggest that the system is intuitive, nonintrusive, and enhances the overall sewing experience. Automation in such systems not only reduces repetitive labor but also improves productivity and job satisfaction by allowing operators to concentrate on high-value tasks [14].

Behavioral Intentions to Use

The behavioral intentions of users toward the fan cooling system were similarly high, with an overall average weighted mean of 4.73 HA. The highest-rated statement (4.80 HA) reflects users' greater inclination to adopt a sewing machine equipped with the cooling system when it enhances reliability and reduces thermal failure, highlighting the importance of performance assurance in adoption decisions. Other highly rated aspects include the system's ability to build user confidence (4.75 HA) and its reinforcement through social validation (4.74 HA), suggesting that trust and perceived necessity strongly influence usage intentions. The lowest-rated statement (4.66 HA) concerns improved operational performance and reduced maintenance needs, indicating that while users appreciate these benefits, expectations for further long-term improvements remain. Overall, the findings show that the fan cooling system positively influences adoption, consistent use, and reliance, demonstrating its critical role in enhancing reliability, efficiency, and user confidence in sewing operations. Research supports that effective thermal management in high-speed sewing significantly reduces machine malfunctions, improves stitch quality, and minimizes downtime [15].

Actual Usage

Actual usage of the fan cooling system also received high acceptability ratings, with an overall average weighted mean of 4.75 HA. The highest-rated aspect (4.79 HA) indicates that the system meets user expectations in improving sewing machine performance, reinforcing its effectiveness in practical applications. Users additionally valued its contribution to long-term reliability (4.75 HA) and the creation of a safer working environment (4.76 HA), enhancing confidence during extended use. Quick and straightforward maintenance (4.70 HA) was slightly lower but still highly acceptable, suggesting that while users appreciate its ease of upkeep, minor refinements could further improve usability. These results confirm that the fan cooling system is an effective, well-integrated feature that enhances reliability, performance, and overall user confidence. Empirical studies in textile engineering highlight that overheating in high-speed sewing operations can compromise stitch quality and operational efficiency, and the incorporation of effective cooling systems has been shown to improve stitching quality by approximately 20%, directly validating the perceived benefits noted by users [16].

CONCLUSION

Fundamental Finding : The findings demonstrate that the fan cooling system is a highly effective and user-friendly enhancement for sewing machines. **Implication :** Its perceived usefulness, particularly in optimizing energy consumption and reducing thermal stress, indicates that users find it beneficial for machine longevity and performance. **Limitation :** This study is limited by its reliance on a descriptive quantitative design and a specific institutional context, which may restrict the generalizability of the findings to other sewing environments, machine types, or operational settings. **Future Research :** Overall, the fan cooling system proves to be a valuable innovation that enhances efficiency, user comfort, and long-term machine reliability.

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