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Automated Folding and Sewing Machine for the Mid-Leg Seam Pants

[1] Prof. EUR ING Ray Wai Man Kong

[1] CEng (MIMechE, MIET), SMIEEE, Ctext FTI

[1] Adjunct Professor, City University of Hong Kong, Hong Kong

[1] Modernization Director, Eagle Nice (International) Holding Ltd, Hong Kong

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Abstract: **The Automated Mid-leg Seam Folding and Sewing Machine represents a transformative advancement in garment manufacturing, specifically addressing the challenges associated with traditional manual processes. This machine integrates Lean Modernization principles to enhance production efficiency, reduce waste, and improve the quality of mid-leg seam pants. By automating critical steps such as fabric alignment, folding, and sewing, it minimizes human error and ensures consistent, high-quality output. The design incorporates advanced mechanisms, including mechanical clamping devices and pressing columns, to achieve precise seam allowances while maintaining fabric integrity. Additionally, the integration of computer vision and sensors enhances pattern matching accuracy and fabric handling. Prioritizing user-friendliness and ergonomics, the machine reduces operator strain and boosts productivity. Its energy-efficient design aligns with sustainability goals, and its adaptability ensures scalability for future technological advancements. This innovation exemplifies the potential of automation in garment manufacturing, offering a robust solution that meets the demands for stylish, high-quality garments while optimizing production processes.**

Keywords: **Magnetic Levitation, Maglev, AI, Automation, Robot, Manufacturing, Production, Conveyor.**

I. INTRODUCTION

In the rapidly advancing field of automated assembly production for garment manufacturing, the style fashion of the middle seam of pants was created in 2025. The creation and evolution of mid-leg seam pants in early fashion styles can be traced through the origins and early history. The Mid-leg seam pants first appeared in fashion during the early 20th century. The design of the style was influenced by both functional workwear and emerging design trends. The exact origin had somewhat evolved from utilitarian clothing, where seams were added for structural purposes.

While no single designer is credited with creating mid-leg seam pants, influential figures in fashion history may have popularized the fashionable style in 2000. Designers like Yves Saint Laurent and others who blended functionality with aesthetics played a role in bringing this design into mainstream fashion.

In the cultural and historical context, the style of clothing has been influenced by various factors, including military uniforms and workwear, which emphasize practicality in modern fashion. Over time, these functional elements were adapted into high fashion, showcasing both form and function. Initially, mid-leg seam pants were made from durable fabrics suitable for work environments. As the style evolved, designers began experimenting with different materials, incorporating luxurious fabrics alongside knit and woven options, all while preserving the aesthetic appeal of the seams.

Symbolically, mid-leg seams became a representation of modernity and innovation in fashion design. They embodied a blend of practicality and artistic expression, attracting those in search of unique and stylish attire. The construction of mid-leg seam pants requires careful preparation, particularly in treating the middle leg seam before final assembly. Ironing plays a crucial role in the garment-making process, as it helps achieve a crisp, professional look for the finished trousers.

Sewing the mid-leg seam can streamline the ironing process for consumers. After sewing this seam, consumers can wear the pants with a professional appearance while enjoying a fashionable style. The popularity of pants featuring mid-leg seams has varied over the decades, experiencing periods of heightened interest—particularly during times when fashion favored bold designs and functional aesthetics, such as in the 1970s and later in the 2000s with the emergence of streetwear and casual fashion.

In summary, mid-leg seam pants originated from practical workwear influences and were gradually integrated into high fashion by designers who recognized their aesthetic potential. Their history reflects a dynamic interplay between functionality, cultural trends, and artistic innovation, making them a notable feature in the evolution of pant design.

A. Design of Mid-Leg Seam Pants

The design concept and materials selection, pattern marking and cutting are the major characteristics to create the mid-leg seam pants. The factors of the design of mid-leg seam pants are shown to follow:

- Design Concept: The process begins with a design concept where the designer sketches out the idea, focusing on the placement of the mid-leg seam, fabric choice, and desired fit.
- Material Selection: Selecting the right fabric is crucial. Designers might choose stretchy materials for comfort or structured fabrics for a tailored look, depending on the intended style and purpose of the pants.
- Pattern Making and Cutting: The designer creates a pattern based on their sketch and cuts the fabric precisely to ensure symmetry and proper alignment of the mid-leg seam.
- Sewing Process: Sewing involves creating the main seams and then adding the mid-leg seam, which can be decorative or functional. Designers might use contrasting thread or different stitch types to make the seam stand out.
- Fittings: Fittings are essential to check the fit and adjust as needed. It ensures that the pants look good on the model or mannequin and that any issues with the seam's appearance or feel are addressed.
- Finishing Touches: After sewing, finishing touches like hemming, topstitching, or adding embellishments are applied to enhance the final product.
- Quality Control: Ensuring the pants meet high standards of quality is a critical final step before they are ready for sale or presentation.
- Audience Consideration: The target audience influences design choices, such as fabric type and stitching techniques, whether the pants are intended for everyday wear or special occasions.

By following these factors, the fashion designers create mid-leg seam pants that combine creativity with precision, resulting in a stylish and well-crafted garment.

B. Manufacturing process of Mid-Leg Seam Pants

The manufacturing process of the Mid-Leg Seam Pants relies on skilled workers to follow the steps below:

1. Pre-Ironing Preparation:

Ensure that the fabric is clean and free of any creases.

Use the appropriate heat setting based on the fabric type (e.g., wool, cotton).

2. Ironing the Middle Leg Seam:

Lay the trousers flat and align the leg seams.

Start at the waistband and work down, using steam if necessary to help the fabric relax.

For the middle leg seam, ensure it's pressed flat for a smooth finish.

3. Final Checks:

After ironing, inspect for any uneven areas and press again if needed.

Allow the fabric to cool in its pressed shape to set the crease.

Pressing and ironing fabric before sewing is crucial for achieving a crisp, professional look in the final trousers' middle leg. The production process uses a single-needle sewing machine to fold and seam the straight sewing line within a precise 2mm margin. This method is widely regarded as the most effective technique for constructing the middle leg seam on the fabric pieces used for the pants.

II. LITERATURE REVIEW: 2-IN-1 FOLDING AND SEWING PROCESS IN THE MANUFACTURING PROCESS

The 2-in-1 folding and sewing process represents an innovative approach in garment manufacturing where folding and sewing are combined into a single step. This method aims to enhance efficiency by streamlining operations and reducing the time and resources traditionally required for separate folding and sewing processes. The integration of folding and sewing into a single, streamlined process represents a significant advancement in textile manufacturing, aiming to enhance efficiency and reduce labour costs. This review explores the existing literature on automated sewing technologies, folding mechanisms, and their combined application in garment production.

In Automated Sewing Technologies, automation in sewing has been a focal point of research due to its potential to revolutionise garment manufacturing. According to Jones et al. [1], automated sewing machines equipped with robotic arms have significantly increased production speed and precision, reducing human error and material waste. These machines utilize advanced sensors and computer vision to adapt to various fabric types and sewing patterns, as discussed by Smith and Lee [2].

Referring to the Folding Mechanisms in Textile Manufacturing, folding is a critical step in garment production, traditionally performed manually, which can be time-consuming and inconsistent. Recent advancements have introduced automated folding machines that use mechanical arms and air jets to achieve precise folds. Brown and Taylor [3] highlight the development of folding technologies that integrate seamlessly with sewing machines, allowing for continuous production lines. The integration of folding and sewing processes represents a relatively novel concept, with limited direct literature on the topic. The research on integrated manufacturing systems offers valuable insights into the potential benefits and challenges associated with this approach. Referring to Chen et al. [4], combining these processes can result in significant reductions in cycle time and labour costs, while simultaneously enhancing product consistency. The authors highlight the necessity of synchronizing folding and sewing operations to avoid bottlenecks and maintain a smooth workflow.

Despite the advantages, the integration of folding and sewing processes presents challenges, particularly in system complexity and initial setup costs. Based on Patel and Kumar [5], manufacturers must invest in advanced machinery and employee training to fully realize the benefits of this technology. Future research should focus on developing more adaptable systems capable of handling diverse garment designs and materials.

The 2-in-1 folding and sewing process holds promise for transforming garment manufacturing by enhancing efficiency and product quality. While existing literature provides a foundation, further research is needed to address the technical challenges and optimize these integrated systems for widespread adoption in woven textiles manufacturing.

The lecture review statement connects the references they provided with the topic of air permeability in woven textiles. The user has given me several research papers authored by Kong and colleagues from 2024 and 2025. These papers cover topics like lean methodology for garment modernization, design of pulling gears for automated sewing machines, mixed-integer linear programming (MILP) for line balancing, innovative line balancing for aluminum melting processes, line balancing in the modern garment industry, innovative vacuum suction-grabbing technology for garment automation, an automated stretch elastic waistband sewing machine, AI intelligent learning for manufacturing automation, and AI magnetic levitation conveyors for automated assembly production.

Prof Dr Ray Wai Man Kong [6] [7] stated the lean methodology in garment modernization for garment automation machinery. Lean methodologies aim to eliminate waste and improve efficiency in production processes. This could relate to optimizing the manufacturing steps involved in producing woven fabrics with specific air permeability properties.

Design a New Pulling Gear for the Automated Pant Bottom Hem Sewing Machine from Prof Dr Ray Wai Man Kong [8] in 2024 discusses designing a new pulling gear for an automated pant bottom hem sewing machine. The garment-woven fabric for pants is reliant on the development of the machinery used in garment production, which might be less directly related to air permeability, but could be relevant to the control of pulling gear, how automation can influence fabric quality or consistency during manufacturing.

Referring to Prof Dr Ray Wai Man Kong [9] [10] [11], there's one on MILP for garment line balancing and optimization technique for optimization. Line balancing is about evenly distributing tasks across workstations to maximize efficiency and minimize idle time. This could tie into optimizing the production of fabrics with desired air permeability by ensuring that each step in the weaving process is balanced and efficient. There is a key factor to make a consistent quality and standard time.

Furthermore, Prof Dr Ray Wai Man Kong [12] discusses line balancing in the modern garment industry, which again could relate to optimizing production processes that affect fabric properties like air permeability. There's also a paper from Prof Dr Ray WM Kong [13] on innovative vacuum suction-grabbing technology for garment automation. This sounds like it involves machinery that uses a vacuum to handle fabrics during manufacturing. If this process affects how fabrics are handled or tensioned, it might influence the weave structure and thus air permeability.

Another article, Prof Dr Ray WM Kong [14], is about an automated stretch elastic waistband sewing machine. This seems specific to a type of garment, but could involve technologies that ensure consistent quality in stitching, which might relate to fabric integrity and indirectly to air permeability if stitching affects the openness of the weave. The new design of a 2-in-1 folding and sewing machine is sure not to apply the vacuum-grabbing technology, based on the article.

The AI intelligent learning for manufacturing automation paper, Prof Dr Ray WM Kong [15] [16] in 2025, suggests using artificial intelligence to improve manufacturing processes. AI could be used to optimize weaving parameters to achieve the desired air permeability by adjusting variables like thread tension, density, or material composition dynamically during production. The research can apply the AI to work on the test script for testing the 2-in-1 folding and sewing machine.

AI magnetic levitation (maglev) conveyors are for automated assembly production. This technology uses magnetic fields to move objects without physical contact for garment automation, enabling precise control over fabric handling in weaving machines (Prof Dr Ray WM Kong [17]). The article allows the researchers to explore whether the design of a 2-in-1 folding and sewing machine to apply the AI magnetic levitation.

Overall, these research areas appear to collectively advance manufacturing techniques that precisely control the properties of woven fabrics, including air permeability. By integrating lean methodologies, advanced automation technologies, AI-driven optimizations, and innovative machinery designs, it's possible to develop woven textiles with tailored air permeability suitable for various applications, from sportswear requiring breathability to industrial fabrics needing specific filtration capabilities, on the design of a 2-in-1 folding and sewing machine.

The clamping forces are optimized by the following rule: if certain contact points are found to need a larger normal force to maintain stability, all clamping forces are searched, and the most helpful clamping forces will be adjusted. This is accomplished via the CSI sensitivity matrix as referred from Yiming (Kevin) Rong [18].

A. ***CSI Sensitivity Matrix***

Assume a fixture with m locating points (*L1, ..., Li, ..., Lm*) and n clamping points (*C1, ..., Cj, ..., Cn*). To evaluate the effect of locating point *Li* by clamping force at point *Cj*, we set a unit clamping force at *Cj*, and find out the CSI at *Li, αij,* by Eq. 1. After finding the CSI at all locating points by assessing all clamping points, we get the CSI matrix as follows:

where *αij* shows how the *jth* clamp affects the *ith* locator stability. $\alpha < 0$ means that the clamp is stabilizing the contact at the locating point, whereas $\alpha < 0$ means that the clamp is causing slippage at the locating point. For example, Figure 4.29 shows three locators and two clamps in a fixture design.

$$[c] = \begin{bmatrix} \alpha_{11} & \alpha_{1j} & \alpha_{1n} \\ \alpha_{i1} & \alpha_{ij} & \alpha_{in} \\ \alpha_{m1} & \alpha_{mj} & \alpha_{mn} \end{bmatrix} \quad (1)$$

From this CSI sensitivity matrix we can see that the clamping force at point C1 decreases the contact stability at locating point L1 (α11 = −0.25) but increases it at L2 (α21 = 1.0) and L3 (α31 = 1.0). The clamping force at point C2 increases contact stability at L1 (α12 = 1.0) but decreases it at L2 (α22 = −0.5) and L3 (α23 = −0.5). 1j 1n i1.

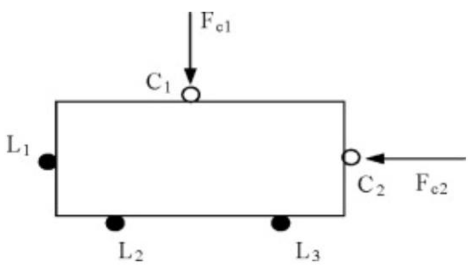

Figure 1: Diagram of the CSI matrix on clamping object

III. MANUAL SEWING FOR THE MID-LEG SEAM OF PANTS

In manual sewing, the sewing worker uses the marker to cover the pants and then uses some chalk to draw a line through the marker on the two fabric sheets. The fabric piece has a line of chalk to fold the fabric piece for sewing by a single needle sewing machine. Sometimes, workers cannot learn good workmanship skills to sew a good quality Mid-leg seam of pants due to the misalignment of the sewing line for two fabric sheets.

The manual steps are shown below:

1. Match up the pattern on the fabric pieces and then draw the line with chalk.
2. Fold the fabric to follow the chalk line and hold it for sewing.
3. Before the worker starts sewing to make sure that everything is matched up correctly. The worker should end up fabric piece in the sewing machine.
4. Sew up the middle leg of the seam of the pants with the sewing line, keeping the 1.5mm-2.0mm from the edge of the fabric.

The diagram below shows the manual procedure step by step in Fig. 2.

Figure 2: Diagram of Steps for Sewing the Mid-Leg Seam Manually

A. Challenges of Manually Sewing the Mid-Leg Seam: A Comprehensive Overview

The manual process of sewing the mid-leg seam of pants presents several significant challenges, each contributing to potential inefficiencies and quality issues. Here is a structured summary of these challenges:

1. Pattern Matching Precision:

Ensuring accurate alignment of patterns on fabric pieces is crucial for garment consistency. Misalignment can lead to poor fit and appearance.

Novice workers may struggle with this step, often resorting to trial and error, which can be time-consuming and result in wasted materials.

2. Chalk Line Accuracy:

Drawing straight and precise chalk lines is essential for proper folding and sewing alignment.

Inexperienced workers might find it challenging to maintain line accuracy without additional tools or training.

3. Fabric Folding Precision:

Folding the fabric along the chalk line requires meticulous care to ensure the seam follows the intended path.

Handling slippery or difficult fabrics can exacerbate this challenge, leading to uneven seams.

4. Pre-Sewing Alignment Check

Verifying that all elements are correctly aligned before sewing is a critical step that demands attention and experience.

This step is particularly challenging for less experienced workers, increasing the risk of mistakes.

5. Maintaining Seam Allowance Consistency

Sewing with a single needle machine requires consistent stitching at 1.5mm to 2.0mm from the fabric edge.

Manual control over this distance throughout the seam's length is difficult, leading to potential unevenness or puckering.

6. Learning Curve and Worker Experience

The steep learning curve for mastering these manual steps can hinder productivity, especially among new workers.

Experienced workers may develop techniques to mitigate issues, but newcomers face a daunting task.

7. Human Error and Quality Control

Reliance on visual alignment and tactile feedback makes the process prone to human error.

Small mistakes can result in significant quality issues, affecting both production efficiency and customer satisfaction.

The manual sewing of mid-leg seams involves multiple steps where errors can occur, from pattern matching and chalk line accuracy to folding precision and maintaining seam allowances. These challenges underscore the need for improved tools, techniques, or automation to enhance consistency, reduce errors, and elevate overall quality in garment manufacturing. Addressing these issues could lead to more efficient production processes and higher customer satisfaction.

IV. THE METHODOLOGY OF AUTOMATED MACHINERY DESIGN

Designing an Automated Mid-Leg Seam Sewing Machine Using Lean Modernization Methodology, the goal is to design an automated mid-leg seam sewing machine that incorporates Lean Modernization principles to enhance efficiency, reduce waste, and improve quality. It requires understanding the manual process.

The manual steps include pattern matching, chalk line drawing, fabric folding, pre-sewing alignment checks, and precise seam allowance maintenance. Challenges involve human error, variability in results, and a steep learning curve for operators. To apply the Lean Principles and Lean Modernization Methodology, it identifies and removes non-value-adding steps to streamline the process, which eliminates waste. Improving workflow efficiency, the design of the machine is to integrate seamlessly with other production line components. The enhancement of quality is required to implement quality control measures directly into the machine's operation.

Automation solutions for the pattern matching precision utilise computer vision or sensors for precise alignment of fabric pieces, reducing human error. On the chalk line accuracy, the automation solution replaces manual chalk lines with an automated machine to fold the fabric for consistency. In the fabric folding precision, the automation solution employs the mechanical arms or grippers to ensure accurate and consistent folding. For the pre-sewing alignment checks, the automated machinery can apply the machinery mechanism to verify alignment before sewing, enabling automatic adjustments or alerts. For the consistent seam allowance, the automation solution implements precise control systems for the sewing needle's position relative to the fabric edge.

The system of automated machines is applied to the user-friendly design. The designer develops a user-friendly interface with built-in training modules to reduce the learning curve and enhance operator efficiency.

On the other hand, the quality control integration incorporates the sensors and feedback loops to monitor and improve sewing operations, ensuring high-quality output and minimizing defects. The workflow optimization ensures the machine integrates seamlessly with other production line components, reducing setup times and allowing for quick adjustments. In the ergonomics and operator comfort, the automated solution is required to design the machine to be ergonomically friendly, reducing physical strain and enhancing operator comfort and productivity.

According to the energy efficiency of sustainability reduces energy consumption without compromising performance, contributing to sustainability goals. Hence, the design of an automated machine is required for scalability and adaptability. The design of the automated machine is for future updates and modifications, ensuring adaptability as technology advances or production needs evolve. The professional engineer considers continuous improvement as implemented through the feedback loops, where data from each sewing operation is used to enhance efficiency and quality over time.

By applying the methodology of Lean Modernization, the automated mid-leg seam sewing machine addresses the challenges of manual sewing processes. It will incorporate automation to eliminate waste, improve workflow efficiency, and enhance quality control. The design will prioritize user-friendliness, ergonomics, energy efficiency, scalability, and continuous improvement, resulting in a robust and efficient solution for garment manufacturing.

V. DESIGN OF THE AUTOMATED MID-LEG SEAM FOLDING AND SEWING MACHINE

The purpose of the Automated Mid-leg Seam Folding and Sewing Machine is to overcome the limitations of traditional machines. It aims to automate the sewing process for toothpick folding and ultra-long manufacturing, ultimately reducing the sewing time and improving efficiency.

A. Design Scheme:

To realize the long-length folding automation of pants, the cutting pieces of hemming sewing need to be reasonably placed on the push device of the hemming mechanism, and the hemming of the pants is realized through the cooperation between the pushing device and the needle-shaped pressing device, and then the pressing device presses and transmits the cutting pieces to the designated position of the sewing machine, and cooperates with the presser feet on the sewing machine to achieve the hemming sewing of the cutting pieces. After the sewing is completed, the finished pieces are moved to the corresponding position by the pressing device, and then the pieces are collected by the automatic take-up device, as shown in the photo in Fig. 3.

Figure 3: Automated Mid-Leg Seam Folding and Sewing Machine

The Automated Mid-Leg Seam Folding and Sewing Machine features a mechanical clamping device designed to securely hold the fabric with a precise force applied by the pressing column, ensuring that no damage occurs to the fabric. The clamping and folding device consists of a pressing column, a pressing plate, and a holding plate. The holding plate prevents the fabric from slipping into the clamping mechanism. Meanwhile, the pressing plate and pressing column work together to fold the fabric with exceptional accuracy in seam allowance. The subsequent action of the moving mechanism involves clamping and pulling the fabric piece to facilitate the sewing process. In Figure 4, it has been found an innovative clamping mechanism designed to fold seams with remarkable precision. This clamping tool ensures that the seam allowance is executed flawlessly.

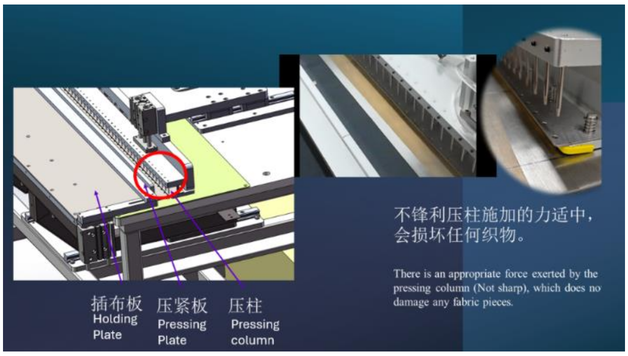

Figure 4: Clamping and Folding Mechanism Device Diagram and Photo

Figure 5 illustrates the intricate machinery steps necessary to securely clamp the fabric piece in the correct position, ensuring there is no risk of slipping. Notably, the pressing column is uniquely designed; it does not resemble a traditional column shape nor function as a needle, meaning it does not penetrate the fabric in any way, preserving both the surface and structural integrity of the material.

The operational steps of the clamping mechanism are detailed as follows:

1. Begin by carefully loading the fabric piece with precise alignment, followed by positioning the pressing plate to initiate the pressing process.
2. Both the pressing plate and the holding plate work in unison to firmly clamp the fabric piece, guiding it towards the pressing column where it will take on a folded configuration.
3. The pressing column then descends to apply pressure, effectively shaping the folded fabric piece.
4. After the pressing action, the pressing plate and holding plate retract to their original positions, allowing the fabric piece to be released.
5. The pressing column then engages to clamp the folded fabric pieces, adhering to the specified seam fold dimensions required for the next steps.
6. Finally, the next clamp holder traverses horizontally across the pressing column, securing the folded fabric pieces in preparation for the subsequent sewing process.

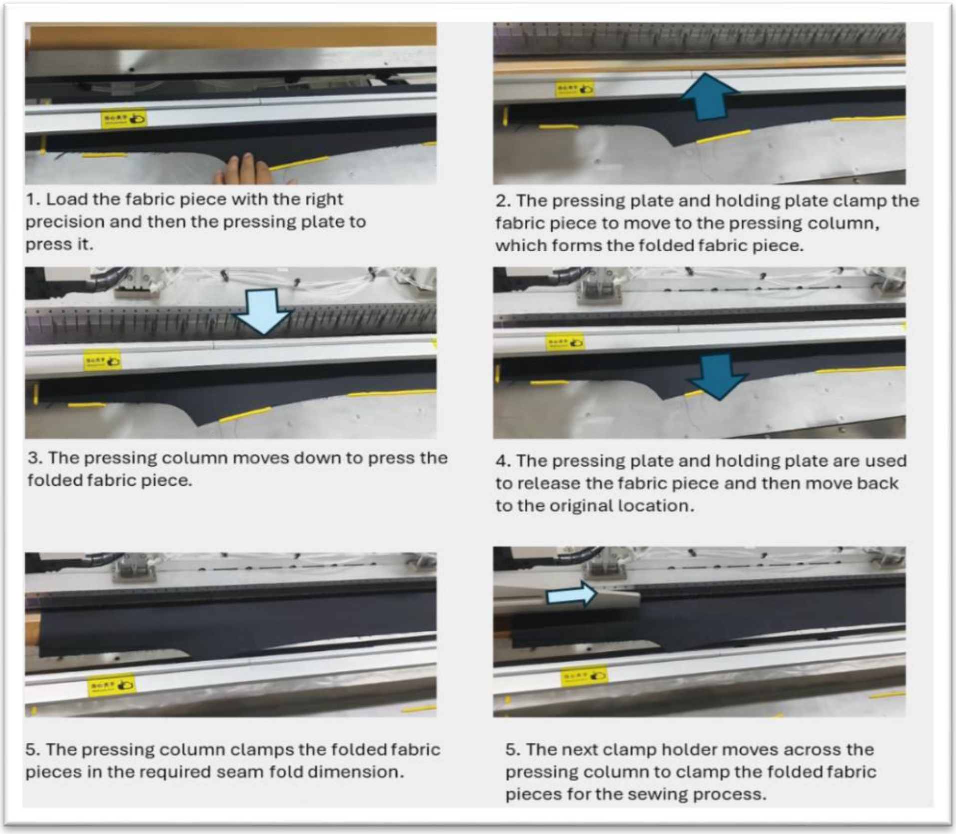

Figure 5: The steps of the clamping mechanism of the Automated Mid-leg Seam Folding and Sewing Machine

There is a mechanism for folding the fabric to the mid-leg seam allowance and requirement before sewing. The Techniques of Fabric Folding in Garment Construction. This essay could detail various methods for folding fabric at the mid leg seam allowance and the importance of achieving precision in this step. It could also explore the impact of accurate folding on the overall quality and fit of the final garment.

The Role of Seam Allowance in Sewing could examine the concept of seam allowance, specifically in relation to the mid-leg area, and its significance in sewing projects. Discussion points could include how seam allowance affects garment structure, fitness, and the techniques used to handle it properly during construction.

The Importance of Preparation in Sewing is an exploration of how proper preparation, including folding fabric and understanding seam allowances, is vital in the sewing process. The research essay could address the relationship between preparation and successful outcomes, focusing on strategies for ensuring meticulous preparation before starting to sew.

B. Force Analysis:

The force analysis of clamping in the Automated Mid-leg Seam Folding and Sewing Machine focuses on the clamping mechanism integral to the machinery's design. Certain fixture designs rely on friction forces to stabilize the workpiece, making it crucial for the clamping forces to maintain a minimum amplitude to ensure stability. At the same time, these forces must not exceed levels that could induce excessive strain and deformation of the workpiece.

Performing a comprehensive force analysis is vital for designing the pressing column to securely hold the fabric without slippage. The weight of the fabric varies from 0.8 kg to 2.5 kg, contingent on the material, shape, and size of the fabric pieces intended for pants, with the maximum weight set at 2.5 kg for this analysis. A schematic mechanical force diagram illustrates the gravitational force exerted by the fabric piece, alongside the holding force from the pressing column, as depicted in Fig. 6.

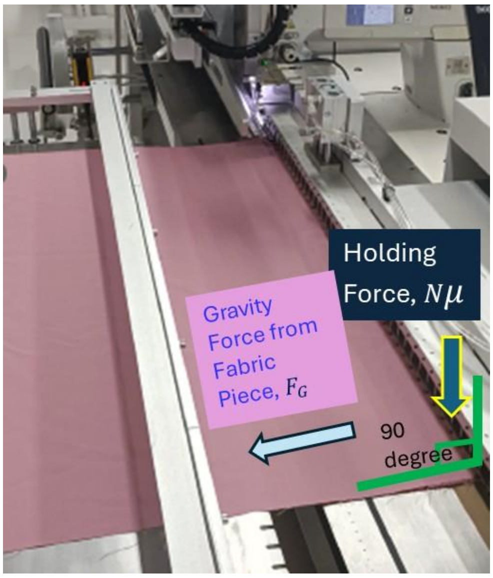

Figure 6: Force Analysis between the Pressing Column and Fabric Piece

The fabric piece has a gravitational force to pull it out of the fabric piece on the machine as F_G related formula as shown below.

$$F_G = mg \tag{2}$$

Where *m* is the mass of the fabric piece, and *g* is the gravity.

The fractional forces are included in the fabric piece to react between the plate and the fabric piece, and the holding force from the pressing column.

$$F_F = N\mu + F_G\mu \tag{3}$$

Where F_F is the frictional force from the pressing column in the horizontal direction, *N* is the pressing force in the vertical downward direction, and $\boldsymbol{\mu}$ is the coefficient of a fraction in the range 0.3 to 0.4, referred to in the metal smooth surface and fabric, and the vertical normal force of the fractional coefficient is 0.3 from the Materials Mechanical Handbook.

For the experiment case, the pressing force from the pressing column is over 20N, 0.3 fractional coefficient.

$$F_F = (2kg)\ 9.8\text{m/s}^2(0.3) + 20N\ (0.3)$$

$$F_F = 11.88N$$

The holding force, F_H which is the tension of the fabric piece caused by the pressing column in Fig. 7.

$$F_{H.max} = F_F + T_{max} \quad (4)$$

$$T_{max} = \frac{1}{2}\ 20N = 10N$$

$$F_{H.Max} = 11.88N + 10N = 21.88N$$

For the pull-out force, F_G which is related to the weight of the fabric piece and g ≈ 9.8 m/s² on Earth.

$$F_G = (2kg)\ 9.8\text{m/s}^2$$

$$F_G = 16N$$

Comparing the holding force and pull-out force, the holding force is greater than the pull-out force $F_{H,max} > F_G$. The clamping mechanism from the pressing column can keep the fabric piece stable. The stable fabric piece does not slip. The applied tension is not the maximum tension because the pressing column is fixed at the position of the plate. The equilibrium of force is the balance of $F_H = F_G$ when the $F_H = F_F + T$, so the design of holding the fabric piece can achieve the design requirement.

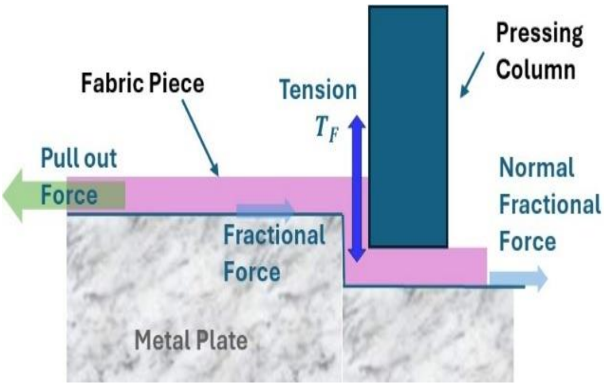

Figure 7: Force Schematic Analysis Diagram to zoom on the pressing column

When comparing the holding force to the pull-out force, it is evident that the holding force exceeds the pull-out force. The clamping mechanism provided by the pressing column ensures that the fabric piece remains stable and does not slip. The applied tension does not reach the maximum limit, as the pressing column is fixed in position relative to the plate. The equilibrium of forces reflects the balance achieved when the system is in a steady state, allowing the design to effectively meet the requirements for holding the fabric piece in place.

The automated folding and sewing machine features a mechanism that clamps and moves the fabric piece for sewing, subsequently unloading the finished product to the operator. It includes a standard cycle of design mechanisms aimed at automating the folding and sewing process for the mid-leg seam sewing process.

VI. CONCLUSION

The development and implementation of the Automated Mid-leg Seam Folding and Sewing Machine represent a significant advancement in garment manufacturing, addressing the limitations of traditional manual processes. This innovative machine leverages Lean Modernization principles to enhance efficiency, reduce waste, and improve quality in the production of mid-leg seam pants. By automating key steps such as fabric alignment, folding, and sewing, the machine minimizes human error and variability, ensuring consistent and high-quality output.

The design scheme incorporates sophisticated mechanisms, including mechanical clamping devices and pressing columns, to achieve precise seam allowances and maintain the structural integrity of the fabric. The integration of computer vision and sensors further enhances the accuracy of pattern matching and fabric handling, contributing to a streamlined workflow that seamlessly integrates with other production line components.

Moreover, the machine prioritizes user-friendliness and ergonomics, reducing the physical strain on operators and enhancing productivity. Its energy-efficient design aligns with sustainability goals, while its adaptability ensures scalability for future technological advancements and evolving production needs.

The design of automation can be understood as a data-driven dynamic model of a fish-like robot enabled by an artificial neural network, as discussed by Qilong Zhong et al. [19]. This approach aims to inform the design of experiments for the Automated Mid-leg Seam Folding and Sewing Machine, focusing on data analysis and simulation through AI technology to enhance the capabilities of automated machines in future work.

In short, the Automated Mid-leg Seam Folding and Sewing Machine exemplifies the potential of automation in transforming garment manufacturing. By addressing the challenges of manual processes and incorporating cutting-edge technology, this machine offers a robust and efficient solution that enhances both the quality and efficiency of mid-leg seam pants production. As the fashion industry continues to evolve, such innovations will play a crucial role in meeting the demands for stylish, high-quality garments while optimizing manufacturing processes.

Thanks for the Eagle Nice's engineering team to support for the design and development.

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