Journal of Design Intelligence
https://www.ffspub.com/index.php/jdi
ISSN 3104-9001 (print)
E-mail: jdi.office@ffspub.com

Article

Research on Quality Control and Standard Optimization in Jeans Sewing Processes under the Industrial 5.0 Paradigm

Yarui Huo[1,†], Hongge Wang[1], Qiaoling Zhang[1], Yan Zhou[2]
[1] *School of fashion, Henan University of Engineering, Zhengzhou 451191, China*
[2] *Zhongfu Chainge Artificial Intelligence Technology (Hangzhou) Co., Ltd., Hangzhou 311199, China*
[†]*E-mail: 136786107@qq.com*

Received: March 12, 2026/ Revised: May 2, 2026/ Accepted: May 20, 2026/ Published online: June 10, 2026

Abstract: Industry 5.0 advocates a human-centered, intelligent manufacturing paradigm that places heightened demands on garment sewing quality. As a category of apparel ubiquitous worldwide, jeans derive their product competitiveness directly from sewing quality. Drawing on enterprise-based field research, this paper systematically analyzes quality control and standard optimization in the sewing process. The study identifies five categories of sewing defects: fabric surface flaws, seam construction errors, stitching irregularities, component misalignment, and sewing workflow deficiencies. Frequent problems, including soiling, needle holes, slipped stitches, uneven fabric feed, and misaligned cross-seams, stem from multidimensional factors involving equipment, personnel, techniques, and materials. To address these issues, the paper establishes enterprise-level inspection standards comprising 18 key indicators, specifies defect classification criteria, and proposes systematic countermeasures spanning ironing specifications, sewing speed control, and alignment operations. The findings demonstrate that shifting quality control toward in-process management and advancing standards toward greater granularity and quantifiability are critical pathways to improving sewing quality and strengthening corporate competitiveness. This paper provides empirical evidence and practical references for the apparel industry to realize human-centric intelligent manufacturing and sustainable production within the Industry 5.0 framework.

Keywords: Industry 5.0; Jeans; Sewing Process; Quality Control; Standard Optimization
https://doi.org/10.64509/jdi.12.89

1 Introduction

The rise of Industry 5.0 has paved the way for human-machine collaborative manufacturing, presenting a critical challenge for quality control in sewing operations as they transition from automation to intelligence [1]. As one of the most globally prevalent apparel categories, the sewing quality of jeans directly determines the product's durability, comfort, and aesthetic value. It underpins consumers' fundamental trust in the brand and its market competitiveness [2]. However, current quality control is heavily influenced by subjective factors, resulting in low efficiency that fails to align with Industry 5.0's principles of human-machine collaboration and data-driven decision-making [3]. Rahaman, Md *et al.* (2025) emphasise that Industry 5.0 aims to elevate human-machine collaboration in the apparel industry by integrating human intelligence with advanced technologies [4]. Gelayol Safavi Jahromi and Sepehr Ghazinoory (2025) identified three key values brought by Industry 5.0: reintegrating humans into industrial domains, enhancing corporate resilience, and reducing environmental harm [5]. Simona Škėrė *et al.* (2025) noted that Industry 5.0 introduces a transformative vision for manufacturing by emphasising human-centred approaches, increasing human involvement, and leveraging advanced technologies [6]. He *et al.* (2025) highlighted macro-level challenges in the textile and apparel industry's digital upgrade, including insufficient corporate motivation for transformation and room for improvement in technology application, revealing the practical difficulties in the digital transformation of quality control [7]. Li (2025) systematically analysed the impact of five factors—equipment, personnel, materials, processes, and environment—on sewing quality, emphasising the need to shift sewing quality control from post-production sampling to real-time early warning systems [3]. As a critical node in generating high-quality

[†] Corresponding Author: Yarui Huo
[*] Academic Editor: Zhaohui Wang

data, the standardisation of sewing processes directly determines whether enterprises can overcome international trade's "green barriers". Under the strategic guidance of Industry 5.0, sewing quality has transcended mere technical difficulties; it has become a strategic concern affecting the industry's global competitiveness and sustainable development capabilities.

Existing research has yielded substantial achievements across three dimensions: defect diagnosis, process optimization, and the application of intelligent technologies. Regarding defect diagnosis, Sayantan Raha and Priyabrata Mondal (2025) significantly reduced sewing defects by applying the DMAIC methodology [8]. In the area of robotic apparel manufacturing, Ajith *et al.* (2025) demonstrated that integrating temporary fabric stiffening with a closed-loop visual servoing pipeline effectively eliminates the need for explicit fabric modeling, which is crucial for enabling versatile and reliable automated fabric handling and sewing across different materials [9]. In the realm of machine vision-based intelligent sewing, Marzouk *et al.* (2024) proposed a video-based spatio-temporal approach that fuses worker pose and action sequences to robustly recognize value-added tasks, thereby enhancing the real-time monitoring capability of intelligent sewing production systems [10], while Tang *et al.* (2025) proposed a process-decomposition-based fixture-free automated sewing system that integrates a dual-arm manipulator with high-speed fabric edge detection to handle edge-aligned sewing tasks across diverse fabric shapes and materials [11]. Dolberg's (2024) analysis emphasized that achieving near-zero defect detection error rates in AI visual inspection hinges critically on maintaining high image quality amidst production environment variability [12]. However, existing research exhibits notable shortcomings: First, studies predominantly focus on generalized apparel categories, with limited systematic research addressing the specialized sewing techniques of jeans. Second, standards primarily focus on outcome metrics, such as stitch density, and rarely address dynamic quality-control specifications for the sewing process. Third, intelligent technology research often centers on isolated breakthroughs, lacking integrated solutions for standard optimization. Addressing these gaps, this paper focuses on the jeans-sewing process. Against the backdrop of Industry 5.0, it systematically investigates quality control mechanisms and standardization pathways, aiming to provide theoretical support and practical guidance for the digital transformation and sustainable development of the apparel industry.

2 Literature Review

Within the framework of Industry 5.0, quality control and standard optimization in the jeans sewing process have become a focal point for both academia and industry. Existing research primarily revolves around three dimensions. The first concerns the diagnosis and control of sewing quality defects.

Kincade *et al.* (2010) demonstrated that denim jeans, as a distinct and influential apparel category, uniquely shape consumer shopping behavior, with those prioritizing the fit, color, and styling of blue jeans exhibiting a significantly greater willingness to wait for products [13]. Zulkarnain *et al.* (2026) applied the Seven Quality Control Tools to crinkle culotte pants production further validates the quality–efficiency nexus, showing that systematically reducing dominant sewing defects such as asymmetrical stitching directly minimizes rework and raises effective production capacity [14]. Germanov and Lapin (2023) emphasize from an organizational trust perspective that cultivating trusting relationships between management and frontline employees is crucial for mobilizing their initiative and pro-organizational behavior, thereby enabling effective responses to quality and production challenges in industrial processing environments [15]. Permana *et al.* (2025) focus on pants production quality control using Statistical Quality Control (SQC) and Failure Mode and Effects Analysis (FMEA). Their methodology for classifying sewing defects and analyzing root causes of appearance-quality issues holds reference value for denim sewing quality research [16]. Jin *et al.* (2022) likewise note that current quality management suffers from time lags and a lack of feedback mechanisms, and propose a digital twin-based product quality management model that integrates grey prediction and case-based reasoning to enable real-time quality prediction and diagnosis [17]. Lestari *et al.* (2025) contend that quality improvement through the Six Sigma DMAIC methodology enables garment manufacturers to build on existing controls, systematically eliminate root causes of defects such as stitching and button errors, and thereby elevate product quality to new levels [18]. Ugwu (2023) maintains that continuous improvement, when aligned with total quality management, constitutes both the focus of process performance and the wellspring of quality enhancement [19]. Goys *et al.* (2025) observe that when product quality assessment indicators are updated through a normative framework that integrates ordinal and absolute scales, all aspects of knitted garment production can be reasonably optimized and directed toward achieving excellent quality [20]. Kozak *et al.* (2025) likewise stress that quality management, as a core component of enterprise competitiveness, is the key to stable and sustainable development and must be integrated into practice [21]. Siregar and Sumiati (2025) indicate that quality improvement measures for garment production should be derived from process analysis, manufacturing procedures, supervision, and inspection, as demonstrated through Six Sigma DMAIC implementation [22]. Kournikova *et al.* (2025) likewise note that quality is the lifeline of a garment enterprise, and their case study reveals that inadequate training and the absence of structured quality planning render the total quality management system insufficiently effective and adequate, thereby undermining product quality improvement [23].

The second dimension concerns the exploration of technical pathways for process parameter optimization. Fatkhurrokhman *et al.* (2025) likewise emphasize the standardization of process execution, noting that implementing Standard Operating Procedures (SOPs) and training key personnel effectively reduce production errors and enhance product quality consistency [24]. Pitchandi and Boominathan (2025) comprehensively synthesized the influence of sewing parameters and fabric properties on seam performance, and their integration of predictive modeling with statistical experimental design offers methodological insights for refining sewing process parameters to improve quality [25].

The third dimension involves the application and standardization of intelligent quality control technologies. Fu *et al*. (2025) elucidate the optimization strategies of deep learning-driven computer vision that enable automated defect identification and enhance robustness under complex environmental conditions [26]. Ku *et al*. (2023) expand upon automated sewing research by developing a machine vision-enabled sewing system that automatically detects narrow seam lines and generates precise stitching paths, achieving human-free autonomous sewing for smart garment manufacturing [27]. Huang *et al*. (2023) emphasize the role of industrial robots as a core digital condition driving enterprise innovation and transformation through a human-capital-empowered pathway [28]. Zheng *et al*. (2023) explore the deep integration of intelligent information technologies—including IoT, machine vision, and digital twins—with textile manufacturing, achieving comprehensive data collection and in-depth data correlation analysis across the entire production chain [29].

Li *et al*. (2025) examine recycling technologies for discarded denim garments from a sustainability perspective, noting that a stepwise strategy integrating clean decolourisation, mechanical opening, and chemical degradation enables full-component recycling and circular regeneration, thereby extending quality control considerations across the full life-cycle of jeans [30]. Naeem *et al*. (2025) address the scarcity of denim defect image data by proposing a synthetic image generation method based on deep convolutional generative adversarial networks, providing a data augmentation solution for training intelligent detection algorithms [31]. Arsoy and Aslan (2026) mathematically model bias tape production from a software-optimization perspective, achieving fabric savings and offering novel insights for optimizing material consumption in sewing processes [32]. Additionally, Kirin *et al*. (2024) develops a method time measurement calculator, providing a standardized tool for determining time norms for technical sewing operations [33]. Gupta and Maniar (2025) advocate, from a macro-strategic perspective, that seizing AI-driven trends and pursuing innovative corrective, adaptive, and transformative solutions are essential to achieving resilient and scalable agile transformation [34]. Shen and Zhang (2023) highlight the importance of advancing intelligent manufacturing to enhance green technological innovation capabilities and improve environmental quality as key pathway choices for green and low-carbon development [35].

Regarding standardization research, Zhao (2024) likewise observes that current standardization management still suffers from a disconnect between requirements and actual implementation along with imperfect assessment, and proposes a process analysis-based method for constructing and optimizing enterprise standard systems [36]. Song and Park (2024) contend that leveraging standardized cybersecurity frameworks is essential for designing effective enterprise support policies, and such standardization holds far-reaching significance for strengthening SMEs' resilience and growth [37]. Sun and Gu (2025) argue that achieving high-quality development in international silk trade requires constructing a systematic, standards-based indicator framework to deliver high-quality standardization outcomes [38]. Zhou *et al*. (2025) note that enterprise technical standards alliances serve as an advanced standardization mechanism, and that context-driven mode selection is crucial for generating high-quality standardization outcomes and sustaining competitive advantage [39]. Choi *et al*. (2026) point out that enterprise systems standardization, when complemented by substantial IT investments, provides a framework for achieving high-quality standardization outcomes and realizing corporate strategies through enhanced information processing capabilities [40]. Bag *et al*. (2026) maintains that standardizing social sustainability practices via digital technologies constitutes a foundational means for modernizing MSME management, and that integrating sustainability innovation to reconcile global standards with local needs is essential to attaining high-quality standardization outcomes and industry benchmark status [41]. Purba *et al*. (2025) observe that in enterprise-driven sustainable product development, standard procedural stages constitute the core technical indicators for achieving high-quality standardization outcomes [42]. Siddiqui *et al*. (2023) contend that an ERP-driven standardization strategy, when supported by digital maturity and effective change management, serves as an effective means for garment enterprises to accelerate operational transformation, improve core competitiveness, and embed high-quality standardized processes throughout the entire production chain [43]. Wang *et al*. (2025) note that intelligent construction standardization and enterprise development are mutually reinforcing, and that achieving high-quality standardization outcomes through precise technology–business alignment forms an integral part of the digital transformation strategy [44].

A critical synthesis of the existing literature reveals a significant disconnect between the strategic rhetoric of quality management and the operational reality of shop-floor control, a gap that is particularly pronounced in the idiosyncratic sewing process of jeans. Our analysis identifies three key limitations that this study directly addresses. First, the literature lacks operational specificity. While a substantial body of work extols the strategic importance of standardization and quality systems [36, 40, 41], it remains largely prescriptive, failing to translate these high-level principles into actionable, process-specific control parameters. For instance, although [22] proposes quality improvement from a process perspective using Six Sigma methodology, no investigation examines which specific sewing parameters, such as needle tension, stitch density, or seam allowance alignment, must be controlled for a heavy, multi-panel fabric like denim to achieve the desired aesthetic and structural integrity. This creates a critical knowledge void: how do we move from the abstract concept of "quality as a lifeline" [23] to a concrete, measurable standard operating procedure for defect prevention on the denim sewing line? Second, a methodological fracture exists between normative and technical research streams. The literature is polarized between qualitative, management-oriented prescriptions (e.g., [19]) and highly specific, technology-centric solutions (e.g., [9, 27]). A critical missing link is the integration of these two domains. Research on intelligent inspection [11] excels at detecting defects yet stops short of connecting detected defects back to the root-cause analysis and workflow redesign required for systemic quality improvement.

Conversely, the management literature champions continuous improvement without engaging with the potential of real-time data from intelligent systems to enable dynamic process adjustment. This lack of integration leaves a vacuum in understanding how digital intelligence can serve not merely as a detection tool, but as the central nervous system of a holistic quality optimization loop. Third, the current research paradigm fails to capture the tacit, human-centric nature of sewing quality control. While Industry 5.0 advocates human-machine collaboration, studies on automated sewing (e.g., [27]) and AI-powered systems [28] largely treat the human operator as a source of error to be eliminated. This perspective entirely overlooks the rich, situated knowledge of experienced sewing workers, their ability to diagnose subtle fabric behaviors, adjust hand movements (a key finding in our on-site investigations), and make split-second decisions that remain beyond the capability of any algorithm. The challenge, absent from the literature, is not merely to automate, but to cultivate a socio-technical system in which worker expertise is formalized, amplified, and integrated with intelligent tools, transforming individual tacit skills into a shared, verifiable, and continuously optimizable standard.

In summary, while prior work provides valuable foundational insights, it is fragmented and insufficient to address the practical complexity of quality control in jeans manufacturing. A significant theoretical and methodological gap exists for a study that does not merely apply existing knowledge, but synthesizes and bridges these disparate streams by systematically converting accumulated field experience into a structured, operationally specific, and human-centric quality optimization system. This study is specifically positioned to fill that gap.

3 Research Methodology

This study employs an on-site enterprise investigation methodology to conduct systematic empirical research across various denim jeans manufacturers. Common quality issues in the sewing process are identified through field data tracking and analysis, with multiple production lines at a large-scale denim jeans manufacturer serving as the pilot study site. The enterprise operates 39 modern production lines and primarily exports to European, American, and Southeast Asian markets. Its stringent quality control requirements offer strong industry representativeness. The research cycle spanned six months, covering both the spring/summer and autumn/winter production peaks. The research process was divided into three phases. Phase One focuses on problem Identification and Data Collection. The research team conducted participatory observation in production workshops, tracking the complete sewing process from cut pieces to finished jeans. Quality issues were systematically documented at critical stages, including front-pocket stitching, side-seam assembly, waistband installation, and fly zipper assembly. Observations spanned 12 production lines and 36 batches, yielding over 500 photographic records of quality defects. Simultaneously, the team retrieved the company's finished-product inspection records and rework logs from the preceding two years, compiling over 2,800 quality issue entries to support problem classification and frequency analysis. Phase Two concentrates on strategy Validation and Standard Refinement. For the five identified quality issue categories, fabric surface, seam construction, stitching, component alignment, and sewing process, specific improvement measures were proposed. These underwent two months of small-scale validation across three pilot production lines, with daily tracking of issue occurrence rates and rework rates to enable dynamic adjustment of strategy details. Ultimately, by integrating brand-client quality requirements, international standards (ISO, AATCC), and national standards (GB/T), the project team collaborated with the enterprise's quality department to refine a sewing inspection standard encompassing 18 key indicators. This standard clearly defines criteria for distinguishing between severe and minor defects for each indicator, thereby establishing quantifiable and actionable enterprise-level quality specifications. The entire research process adhered to a problem-oriented and data-driven approach, ensuring both the scientific validity and practical applicability of the findings.

Although the empirical field-research method adopted in this study provides a solid foundation for addressing practical problems, a critical methodological reflection reveals certain limitations and considerable potential for further expansion. This study takes participatory observation and frequency analysis as its core methods, which perform well in identifying and categorizing quality defects. However, it has yet to incorporate the cutting-edge analytical frameworks of modern quality science. To elevate this research from a rigorous case analysis to a replicable scientific model, future studies will take the five classified defect types as dependent variables, and select fabric category, operator skill level, equipment parameter settings, and workstation production conditions as independent variables. On this basis, machine-learning classification models—such as multinomial logistic regression and Random Forest—will be constructed to predict the occurrence probability of each type of quality defect.

4 Research Findings

4.1 Common quality problems of sewing link

4.1.1 Fabric Surface Defects

(1) Soiling

Common stains include machine oil, food residue, rust, and marking crayon. As shown in Figure 1, staining renders cut pieces, semi-finished products, and finished products substandard and unsalable. Once soiling occurs, specialized cleaning equipment such as air guns and detergents should be used for treatment. Items that cannot be thoroughly cleaned must be labeled as defective and placed directly in the designated defective-product area. Defective products are then to be displayed at production department meetings, where root-cause analysis is conducted to implement source-level control.

Figure 1: Dirt

(2) Yarn-Break Needle Holes

A mismatch between coarse needles and fine threads, improper thread removal, or excessive reworking can cause yarn-break needle holes. As shown in Figure 2, such needle holes are irreparable; the only remedies are replacing the cut piece or classifying the item as defective. Once a yarn-break needle hole has occurred, the affected cut piece must be replaced, and the source operation must be identified for root-cause control.

Figure 2: Yarn break type needle hole

Countermeasures for soiling include the following: regularly cleaning oil and dirt from around machines; strictly prohibiting food, colored beverages, and rusty tools from being brought into the workshop; and refraining from using non-washable colored marking pens. As shown in Table 1, countermeasures for needle holes include using a seam ripper or scissors to remove stitches, assigning highly skilled sewing operators to fabrics and accessories prone to needle holes, and minimizing the number of reworks.

4.1.2 Seam Construction Defects

(1) Uneven Topstitching at the Seam

Inadequate ironing, low operator skill levels, or excessive sewing speed can cause uneven topstitching at the seam. As shown in Figure 3, variable stitch width compromises the appearance and quality of the finished product. If unevenness has occurred, the stitches must be removed and the seam resewn. Should obvious needle holes result, the cut piece must be replaced.

Figure 3: The bright line at the seam is not straight.

(2) Inner Layer Exposure in Double-Ply Seams

Improper hand movements or ironing errors by sewing operators can cause the inner layer of the fabric to become exposed. As shown in Figure 4, exposed lining material mars the product's appearance and renders it substandard. If exposure has already occurred, the seam must be unpicked and resewn, with hand movements adjusted according to the quality standard during re-sewing.

Figure 4: Double stitching material with exposed lining.

(3) Uneven Fabric Feed

Failure to sew in alignment with reference points or sewing at excessively high speed can cause uneven fabric feed. As shown in Figure 5, uneven fabric feed impairs both the appearance and quality of the finished product. Should this defect occur, the affected stitches must be removed and

Table 1: Common quality problems and countermeasures on the surface of the seam material

Quality Problem Points	Cause Analysis	Solution
Dirt	Machine oil stains on the sewing material	Place presser pads under the presser foot after work, and wipe the oil around the machine after repairing it.
	Food stains on the sewing material	Food and colored beverages are not allowed to be brought into the workshop.
	Rust stains on the sewing material	Rusty tools are not allowed to be brought into the workshop.
	Color pen stains on the sewing material	Colored pens should be tested and washed before use. If not washed off are not allowed to use
Needle hole	Improper way of removing stitches	Avoid pulling and pulling when removing the threads. Use a thread remover or scissors to remove the threads.
	Low skill level of employees but easy to operate needle hole fabric	Highly skilled sewing workers should be arranged for easy-to-needle hole fabric and accessories
	The high number of rework	Minimize the number of rework

the seam re-sewn, with hand movements adjusted according to the degree of unevenness during re-sewing.

Figure 5: Uneven eating potential.

(4) Pleating

Failure to sew in alignment with reference points or sewing at an excessively high speed can cause pleating. As shown in Figure 6, pleating compromises the appearance and quality of the finished product. When pleating occurs, it must be reworked immediately and must not be allowed to pass to the next workstation. If discovered only after final assembly, the item is to be handed over to the rework team for unpicking and re-sewing.

Figure 6: Pleating.

(5) Misstitching

When sewing operators fail to push aside adjacent fabric sections in a timely manner, misstitching onto unintended areas of the material can occur. As shown in Figure 7, misstitching deforms the appearance and renders the product substandard. Should misstitching occur, the seam must be unpicked and re-sewn, during which needle holes and fabric damage must be carefully checked, and the cut piece replaced if necessary.

Figure 7: Misstitching to other locations of the sewing material.

(6) Raw Edges and Seam Bursting

Failure by sewing operators to trim components before stitching or failure to follow the prescribed seam allowance can result in raw edges and seam bursting. As shown in Figure 8, these defects seriously impair quality. On garments requiring wet processing, such defects will cause seam slippage after washing, making the damage irreparable. If raw edges or seam bursting have occurred, the affected stitches must be removed and the seam re-sewn, paying close attention to the amount of trimming required.

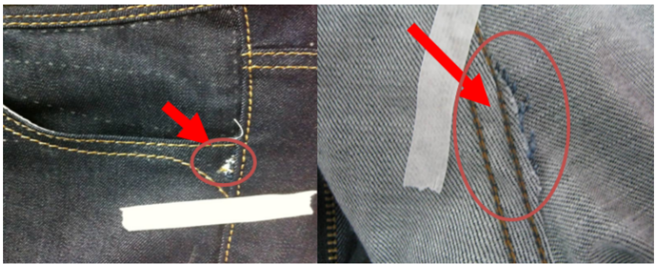

Figure 8: gross out and burst mouth.

Countermeasures for uneven topstitching at the seam include ensuring adequate ironing, controlling sewing speed, and assigning highly skilled operators to complex processes. As shown in Table 2, countermeasures for inner-layer exposure in double-ply seams include sewing with a clear understanding of the face and lining relationship and ironing properly. Countermeasures for uneven fabric feed include requiring operators to refrain from pulling the fabric forcefully, to sew strictly in alignment with reference points, and to control sewing speed. Countermeasures for pleating include operators strictly following reference points, controlling sewing speed, and pursuing quantity only after quality is assured. The countermeasure for misstitching is to cultivate the habit of pushing aside adjacent fabric pieces while sewing. Countermeasures for raw edges and seam bursting include having operators trim components as required before sewing and adhering strictly to the specified seam allowance.

4.1.3 Stitching Defects

(1) Slipped Stitches

Excessive sewing speed or improper hand movements can cause slipped stitches. As shown in Figure 9, slipped stitches not only impair the appearance of the finished product but also lead to defects after the jeans are washed, as the stitching may come undone.

Figure 9: Slip wire

(2) Floating Stitches and Skipped Stitches

Sewing directly without first testing on a trial fabric or improper machine adjustment can cause floating stitches or skipped stitches. As shown in Figure 10, these defects impair the appearance and seam strength of the finished product. If floating or skipped stitches have occurred, the affected stitching must be removed and re-sewn, and the item must not be passed to the next operation.

Table 2: Common quality problems and countermeasures in the seaming process

Quality Problem Points	Cause Analysis	Solution
The bright line at the seam is not straight	Inadequate ironing	Ironing should be in place
	The sewing speed is too fast.	The sewing speed should be controlled for this type of process.
	Low skill level of sewing employees	Arrange highly skilled turners to do such processes, and train turners' skills step by step.
Double stitching material with exposed lining	Misremembering the relationship between face and lining before sewing	When sewing, be precise about the relationship between the face and the lining, keeping in mind that the face is pressed against the lining
	Inadequate ironing	Ironing should be ironed in place to ensure that the face pressed inside
Uneven heating potential	Pulling the fabric hard when sewing	The staff should not pull the cloth hard when sewing but push the cloth smoothly to sew the stitching with the trend.
	They are not following the alignment point suture.	Strictly aligned point sutures
	Sewing too fast, only pursuing quantity	Control the speed of the car to ensure the quality of the premise of the pursuit of quantity
Pleat	No alignment when sewing	Sewing workers sew in strict accordance with the alignment point stitching.
	The sewing speed is too fast.	Control the speed of the car and the quality of the premise to ensure the pursuit of quantity
Miss stitching	Not timely to set aside the seam material	Get into the habit of plucking the sewing material with the hands of the worker when sewing.
Hair out or burst mouth	Inadequate trimming of excess seam material promptly	The process of trimming the turner trimmed and then sewn
	No stitching according to the amount of stitching	Strictly following the seam allowance

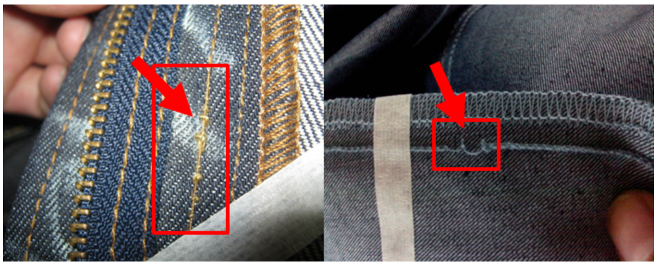

Figure 10: Floating wire and jumper

(3) Thread Breakage

Excessively tight needle or bobbin thread tension, or sewing at an overly high speed, can cause thread breakage. As shown in Figure 11, thread breakage seriously compromises quality and necessitates hand-stitching to imitate the original stitch pattern, wasting both labor and materials. If thread breakage has occurred, the ends must be joined by hand-stitching and the source operation identified for root-cause control.

Figure 11: broken wire

(4) Uneven Overlocking of Two Plies in Three-Thread Overlock Seams

Failure by sewing operators to follow the specified seam allowance, or a mismatch between sewing speed and hand movements, can cause the two plies of a three-thread overlock seam to be uneven. As shown in Figure 12, such unevenness seriously impairs quality. On garments requiring wet processing, the stitching may unravel after washing, leaving the defect irreparable. If the unevenness between plies is $\geq 1/2$, the seam must be unpicked and re-sewn; if the unevenness is $< 1/2$, a trial wash may be conducted to determine whether the product meets the required standard.

Figure 12: Two uneven pieces of the three-line overlock

(5) Decorative Stitch Deformation

Failure to use a template when sewing can easily lead to deformation of the decorative stitch. As shown in Figure 13, such deformation directly impairs the appearance of the finished garment. If deformation has occurred, the affected stitches must be removed and re-sewn, and the sewing operator performing the source operation must be instructed on the importance of using the template.

Figure 13: line with the wrong

(6) Exposed Positioning Stitches

When either a preceding or the current operation fails to follow the specified seam allowance, positioning stitches may become exposed. As shown in Figure 14, exposed positioning stitches impair the appearance and quality of the finished product. If exposure has occurred, the affected stitching must be removed and re-sewn, and the source operation responsible must be identified for root-cause control.

Figure 14: Positioning line exposed

(7) Excessive Thread Ends

Thread ends can be classified into loose ends that can be pinched off by hand and those that have not been trimmed and cannot be removed by hand. The majority of thread ends result from sewing operators cutting threads and failing to dispose of them in waste bins, causing them to adhere to garments instead. As shown in Figure 15, this detracts from the garment's appearance and necessitates subsequent trimming by the finishing department, wasting both labor and materials. It is therefore essential that every sewing operator recognizes the importance of timely thread-end removal.

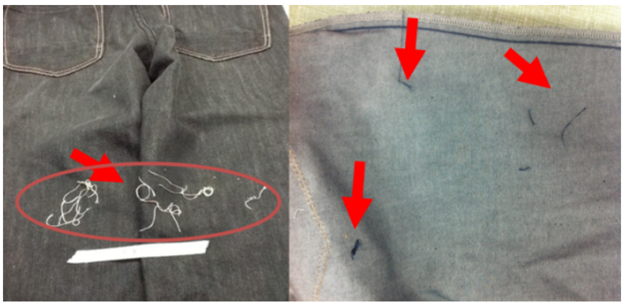

Figure 15: Sewing threads

Countermeasures for slipped stitches include the following: sewing operators performing thorough self-inspection after sewing, sewing at an appropriate speed, and feeding the fabric smoothly in a consistent direction without lateral swaying. As shown in Table 3, the countermeasure for floating stitches and skipped stitches is to test the equipment on a trial fabric before starting an order or after machine repair to confirm it is functioning normally. Countermeasures for thread breakage include adjusting the sewing speed to a moderate level, regulating needle-thread and bobbin-thread tension to ensure they work in harmony, and inspecting the machine needle and rotary hook for damage. Countermeasures for uneven overlocking of two plies include matching sewing speed with proper hand movements and sewing strictly according to the specified seam allowance. The countermeasure for incorrect decorative stitching is to use a template when sewing decorative stitches. The countermeasure for exposed positioning stitches is to sew strictly in accordance with the seam allowance specified in the process requirements. Countermeasures for thread ends include the following: sewing operators developing the habit of promptly placing cut thread ends into waste bins; affixing adhesive tape to the machine head so that cut threads can be stuck onto it as they are trimmed; and, for thread ends remaining after sewing, requiring that every sewing operation trim them promptly and dispose of them in waste bins.

4.1.4 Component Alignment Defects

(1) Severe Misalignment of Cross-Seam Intersections

Failure to match cross-seam alignment points or improper hand movements by sewing operators can cause severe misalignment at seam intersections. As shown in Figure 16, cross-seam intersections that fail to align properly impair the appearance and render the product substandard. If such misalignment has occurred, the affected seam must be unpicked and re-sewn, and the operator responsible for the source operation must be identified for root-cause control.

Figure 16: Severe misalignment of cross-alignment points

(2) Asymmetry

Not sewing in accordance with the specified seam allowance and process requirements can readily lead to asymmetry in components designed to be symmetrical. As shown in Figure 17, asymmetry detracts from the garment's appearance and renders it substandard. If asymmetry has occurred, the affected seam must be unpicked and re-sewn in accordance with the process requirements.

Figure 17: Asymmetric problem

Countermeasures for severe misalignment of cross-seam intersections include sewing operators strictly following alignment points and maintaining moderately tight, smooth stitching. As shown in Table 4, countermeasures for asymmetry include sewing in strict accordance with the process requirements and specified seam allowances, and for symmetrical components, comparing both sides after sewing to ensure symmetry.

4.1.5 Sewing Workflow Deficiencies

(1) Omitted Operations

Operator carelessness, or one operator being assigned multiple operations without following the prescribed sequence, can result in omitted operations. As shown in Figure 18, an omitted operation seriously compromises quality; for garments requiring wet processing, the defect becomes irreparable after washing.

Figure 18: Missing process

(2) Misuse of Fabric and Accessories

When changing orders, inadequate marking or an unclear changeover procedure can easily lead to the use of

Table 3: Common quality problems and countermeasures in sewing stitches

Quality Problem Points	Cause Analysis	Solution
Slip wire	No self-inspection of the processes they operate	Sewing workers do an excellent job of self-inspection after sewing; found slippery thread immediately solve
	The sewing speed is too fast, and the sewing material shakes from side to side.	Sewing workers should sew at an appropriate speed, pushing the cloth smoothly along the car line, not swinging from side to side.
Floating and patch cords	Direct sewing without a trial session	Test run before billing and after machine repair
Disconnected	The sewing speed is too fast	Sewing speed set to moderate
	The face line is too tight, or the bottom line is too tight	Tune the bottom line of the surface to make it fit well
	Damage to needle or shuttle	Check whether the needle and shuttle are in good condition
The two pieces of the three-wire wrap sewing are not flush	The sewing speed is too fast for hand gestures to be adjusted	Sewing speed and hand gestures should be well matched and smoothly pushed forward
	No sewing by the seam allowance	Strictly following the seam allowance
Decorative line deformation	No template was used, and no lines were drawn in advance	For decorative threads to be sewn using a template
Exposed positioning line	No control of the sewing portion	Sewing in strict accordance with the amount of seam allowance required by the process
Many threads	Threads are cut off and thrown away, not into the trash	Sewing workers need to develop the good habit of putting the cut threads into the waste basket in time
	The thread did not sticky tape in time.	Fixed tape on the head of the machine and cut off the thread with the sticky tape.
	Sewing workers did not cut the thread in time.	Each sewing process should be cut off for dead sewing threads and put into the waste basket in time.

Table 4: Common quality problems and countermeasures in the alignment of sewing parts

Quality Problem Points	Cause Analysis	Solution
Severe misalignment of cross-alignment sites	Not sewn according to the alignment point	Sewing workers should strictly follow the alignment point sewing.
	The sewing process is a little loose and a little tight, unstable	The stitching should be moderately tight and smooth
Asymmetrical problems	Not sewn according to the process	Strictly according to the process requirements and sewing parts
	No self-inspection after sewing is completed	For symmetrical parts, compare them after sewing to make sure they are symmetrical

incorrect fabric or accessories. As shown in Figure 19, using incorrect materials will directly cause batch defects and must be eliminated. If such misuse has occurred, the entire batch must be reworked, the root causes analyzed at a production department meeting, and the corrective solution institutionalized.

Figure 19: fabric and accessories with the wrong

Countermeasures for omitted operations include establishing a fixed sewing sequence when one operator handles multiple operations, prohibiting any unauthorized deviation from that sequence, and requiring team leaders to reinforce awareness during pre-shift meetings to draw the attention of sewing operators. As shown in Table 5, countermeasures for the misuse of fabric and accessories include clarifying the changeover procedure and implementing labeling in accordance with the 5S standard.

4.2 Specific Standard Requirements

During the jeans sewing process, as shown in Table 6, defects such as soiling, needle holes, uneven topstitching at the seam, inner-layer exposure in double-ply seams, uneven fabric feed, pleating, raw edges or seam bursting, slipped stitches, uneven overlocking of two plies in three-thread overlock seams, decorative stitch deformation, exposed positioning stitches, excessive thread ends, severe misalignment of cross-seam intersections, and asymmetry can be assessed against the corresponding standard criteria to determine whether they constitute severe or minor defects. Severe defects must be classified directly as defective products, whereas minor defects may be repaired to render the product acceptable. In addition, the presence of any of the following conditions, holes, reversed seam allowance, omitted operations, thread breakage, misstitching onto unintended areas of the material, incorrect decorative stitching, incorrect construction, incorrect directional orientation of the pile, wrong side of the fabric, or incorrect grain line direction, shall be deemed a severe defect, and the product must be classified as defective.

5 Conclusion

Through a six-month field survey spanning multiple production lines, this paper has systematically investigated quality control and standard optimization in the jeans sewing process. The study developed a five-category defect classification framework, fabric surface defects, seam construction defects, stitching defects, component alignment defects, and sewing workflow deficiencies, and established an enterprise-level quality inspection standard comprising 18 quantitative indicators. Beyond these descriptive findings, the paper yields three core conclusions of significant theoretical and practical value.

First, the findings serve as a corrective to the technocentric perspective dominating the intelligent manufacturing literature. Whereas existing research largely emphasizes computer-vision-based automated defect detection and robotic sewing, our field data reveal that high-frequency repetitive defects, such as alignment deviation, uneven seam allowance, and skipped stitches—stem not from a lack of technical equipment, but from a disconnect between standardized operating procedures and their on-site execution. This provides empirical grounding for a viewpoint frequently invoked but insufficiently substantiated in the literature: that the implementation of standardization lags behind its design. In so doing, the study bridges macro-strategic discourse and shop-floor operational reality.

Second, the two-month pilot validation yielded quantifiable quality improvements. The core mechanism of the proposed optimization scheme lies in distilling workers' tacit operational experience into verifiable and enforceable work standards. This result affirms the central value of human expertise within the human-centric paradigm of Industry 5.0 and counters the prevalent, one-sided assumption that quality can be enhanced through automation alone.

Third, the 18-indicator inspection standard constructed in this study represents a methodological advance over existing frameworks. Whereas prior work largely confines quality requirements to general, principle-based statements, this study introduces quantifiable thresholds for defect severity. For instance, it explicitly stipulates that a deviation of ≥ 0.3 cm at

Table 5: Common quality problems and countermeasures in the sewing process

Quality Problem Points	Cause Analysis	Solution
Missing process	Not sewn in the order of the choreography	When one person has more than one order, make the sewing order, do not disrupt the order.
	Inadequate communication by base managers	The team leader strengthens the class meeting to preach and clarify the seriousness of the leakage process.
Wrong fabrics and accessories	Unclear process	Clarification of the order exchange process
	Inadequate implementation of 5S before production	Marking according to 5S standard

Table 6: Sewing link jeans inspection basic standards

Serial number	Quality inspection items	The standard basis for determining severe defects (cm)	The standard basis for determining minor defects (cm)
1	Dirt	Prominent stain area greater than $0.6\,cm^2$	Not obvious
2	Needle hole	A large number of needle holes	/
3	The bright line at the seam is not straight	Significant irregularities in important parts	Minor
4	Double stitching material with exposed lining	$\geq$1	< 1
5	Uneven heating potential	Serious	Minor
6	pleat	Obvious pleating, outer width pleating	Slight pleating
7	miss stitching	The existence of such a situation is a severe defect.	/
8	Hair out or burst mouth	No. 1 part and affect the firmness	Non-1st part
9	Slip wire	① Outer width slip stitch $\geq$ 1 stitch; ② Inside width without dark thread, slip stitch $\geq$ 2 stitches; with dark thread, reverse side $\geq$ 4 stitches.	When there is no dark thread in the lining, slip stitch 1; when there is the dark thread, the reverse side $<$ 4 stitches
10	Floating and tuning lines	The existence of such a situation is a severe defect.	/
11	Disconnected	The presence of such a condition is a severe defect.	/
12	The two pieces of the three-wire wrap sewing are not flush.	① door lining, front and back wave, building seam two stop difference $\geq$ 1/2; ② profound fullness.	Door lapel, front and rear wave, building seam two stop difference $< 1/2$
13	Decorative line deformation	The presence of such a condition is a severe defect.	
14	Exposed positioning line	Important parts	Secondary parts
15	Many threads	Outside width and inside width accumulate $\geq$ 10	3 $\leq$ outside width, inside width cumulative $<$ 10
16	Severe misalignment of cross-alignment sites	① Back wave cross point $\geq$ 0.3; ② Bottom wave cross point $\geq$ 0.4.	/
17	Asymmetrical problems	①knee position and head deviation; ② foot port $\geq \pm0.2$; ③ waist alignment point $\geq$ 0.5.	0.3 $<$ waist-parity $<$ 0.5.
18	Front pocket, head height	$\geq$0.6	[0.3,0.5]
19	Missing process	The presence of such a condition is a severe defect.	/
20	Wrong fabrics and accessories	The presence of such a condition is a severe defect.	/

the back-rise cross-seam constitutes a severe alignment defect. This quantification directly addresses the subjectivity flaw long identified in standardization research, transforming traditional subjective visual inspection into verifiable, traceable metrics suitable not only for manual quality checks but also as a future basis for machine-vision-based intelligent inspection. In essence, both the five-category defect classification framework and the methodological principle of setting quantifiable thresholds are transferable across a broad range of woven and knitted apparel products.

The theoretical contribution of this paper is the construction of an empirically grounded, production-scenario-oriented quality optimization model for the jeans subcategory, a domain that has received only limited attention in general garment research. The practical implication is that, in pursuing higher quality and efficiency in jeans sewing, enterprises should prioritize systematically converting frontline workers' accumulated hands-on experience into standardized, quantifiable, and enforceable work standards; intelligent technology ought not to replace human judgment, but to serve as a tool for amplifying the effectiveness of human expertise. Future research will introduce a real-time monitoring system based on statistical process control (SPC), develop a quantitative defect prediction model, and thereby upgrade the current post-process quality control regime into an intelligent, proactive, and preventive quality assurance system.

Funding

This work is supported by the 2025 Education and Teaching Reform Research Project of Henan University of Engineering (Grant No. 2025JYZD04), titled "Research on the Optimization and Reform of the Curriculum System for Garment Engineering Major Based on Industry Demand and Engineering Certification" .

Author Contributions

Conceptualization, methodology, formal analysis, writing—original draft preparation, project administration: Huo Yarui. Data curation: Huo Yarui and Wang Hongge. Writing—review and editing: Huo Yarui and Zhang Qiaoling. Enterprise field investigation: Huo Yarui and Zhou Yan. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

All the authors declare that they have no conflict of interest.

Data Avaliable

The data and materials used in this study are available upon request from the corresponding author (Huo Yarui).

References

[1] Qiao, F., Liu, J., Wang, D., Ding, C., Shi, J., Wang, J., Ma, Y.: Human-centric Integration Technology for Production Scheduling in Industry 5.0. Journal of Mechanical Engineering, **61**(15), 40–56 (2025). https://doi.org/10.3901/JME.2025.15.040

[2] Luo, Y., Zhou, R., Li, X., Zhu, L., Wang, L., Wu, X., Ding, X.: Carbon footprint calculation and assessment of jeans products based on process modularity. Advanced Textile Technology, **30**(6), 204–210 (2022). https://doi.org/10.19398/j.att.202206030

[3] Li, M.: Analysis of the Causes of Quality Defects in Clothing Sewing and Design of Intelligent Warning Model Construction. Shoes Technology and Design, **23**, 3–5 (2025). https://doi.org/10.3969/j.issn.2096-3793.2025-23-001

[4] Rahaman, M.T., Pranta, A.D., Rahaman, M.T.: Transitioning from industry 4.0 to industry 5.0 for sustainable and additive manufacturing of clothing: framework, case studies, recent advances, and future prospects. Materials Circular Economy, **7**(1), 1–37 (2025). https://doi.org/10.1007/s42824-025-00176-7

[5] Jahromi, G.S., Ghazinoory, S.: Clothing industry in transition from industry 4.0 to industry 5.0. The Journal of The Textile Institute, **116**(3), 365–379 (2025). https://doi.org/10.1080/00405000.2024.2336438

[6] Skėrė, S., Bastida-Molina, P., Skėrys, P., Molina-Palomares, P.: Empowering industry 5.0: a multicriteria framework for energy sustainability in industrial companies. Applied Sciences, **15**(16), 9170 (2025). https://doi.org/10.3390/app15169170

[7] He, Y.T., Zhu, J.H., Yao, L.: Transformation and Upgrade of China's Textile and Garment Industry: A Supply Chain Resilience Perspective. In 18th Textile Bioengineering and Informatics Symposium Proceedings (TBIS 2025), pp. 1090–1098 (2025). https://doi.org/10.52202/081756-0123

[8] Raha, S., Mondal, P.: Implementation of lean six sigma for improving final inspection quality in an apparel manufacturing industry in india: a case study. Journal of The Institution of Engineers (India): Series C, **106**(6), 2007–2020 (2025). https://doi.org/10.1007/s40032-025-01258-w

[9] Ajith, A., Narayanan, G., Zornow, J., Calle, C., Lugo, A.H., Rincon, J.L.S., Wen, C., Solowjow, E.: Robotic Automation in Apparel Manufacturing: A Novel Approach to Fabric Handling and Sewing. In 2025 IEEE 21st International Conference on Automation Science and Engineering (CASE), pp. 3254–3260 (2025). https://doi.org/10.1109/CASE58245.2025.11163876

[10] Marzouk, M., Ashraf, M., Mohammed, A.: Enhancing Garment Sewing Employee Added Value Monitoring Using a Video-Based Spatio-Temporal Approach Through Computer Vision. In 2nd International Conference of Intelligent Methods, Systems and Applications, pp. 141–146 (2024). https://doi.org/10.1109/IMSA61967.2024.10652738

[11] Tang, K., Huang, X., Seino, A., Tokuda, F., Kobayashi, A., Tien, N.C., Kosuge, K.: Fixture-Free Automated Sewing System Using Dual-Arm Manipulator and High-Speed Fabric Edge Detection. IEEE Robotics and Automation Letters, **10**(9), 8962–8969 (2025). https://doi.org/10.1109/LRA.2025.3592145

[12] Dolberg, S.: The importance of image quality in AI visual inspection systems. PhotonicsViews, **21**(4), 32–33 (2024). https://doi.org/10.1002/phvs.202400027

[13] Kincade, D.H., Kim, J., Gibson, F.: Generational consumer segments and shopping process characteristics: Baby boomers and echo boomers with apparel product selection activities. Journal of Global Fashion Marketing, **1**(1), 19–29 (2010). https://doi.org/10.1080/20932685.2010.10593054

[14] Zulkarnain, Y., Butar, M.B., Medikano, A., Wicaksono, R.: Quality Control Analysis Using the Seven Quality Control Tools in the Production Process of Crinkle Culotte Pants at CV Damar Konveksi. Jurnal Ilmiah Teknik, **5**(1), 83–97 (2026). https://doi.org/10.56127/juit.v5i1.2451

[15] Germanov, I.A., Lapin, P.M.: The role of organizational trust in the regulation of work attitudes and labor behavior of industrial employees. Perm University Herald. Philosophy. Psychology. Sociology, **2023**(1), 131–140 (2023). https://doi.org/10.17072/2078-7898/2023-1-131-140

[16] Permana, Z.Z.A., Bachtiar, I., Rukmana, A.N.: Usulan Pengendalian Kualitas Produk Celana Menggunakan Metode (SQC) dan (FMEA) di PT. XYZ. Bandung Conference Series: Industrial Engineering Science, **5**(2), 237–248 (2025). https://doi.org/10.29313/bcsies.v5i2.20268

[17] Jin, S., Liu, X., Wu, R., Xing, R., Wang, Y.: Product quality management model based on digital twins. Gaojishu Tongxin/Chinese High Technology Letters, 32(1), 101–110 (2022). https://doi.org/10.3772/j.issn.1002-0470.2022.01.012

[18] Lestari, A., Suherman, A., Okitasari, H.: Evaluasi Tingkat Cacat Produk Menggunakan Six Sigma Pendekatan DMAIC pada UMKM Konveksi X. JURAL RISET RUMPUN ILMU TEKNIK, **4**(2), 594–610 (2025). https://doi.org/10.55606/jurritek.v4i2.6227

[19] Ugwu, K.E.: Aligning Total Quality Management, Continuous Improvement for Process Performance: A Review Approach. Journal Research of Social Science, Economics, and Management, **3**(3), 731–737 (2023). https://doi.org/10.59141/jrssem.v3i3.541

[20] Goys, T.O., Novosad, T.N., Malysheva, O.V., Gusev, B.N., Matrohin, A.Y.: DEVELOPMENT OF NORMATIVE ASSESSMENT OF KNITTED GARMENTS QUALITY. Technologies & Quality, **1**(67), 27–33 (2025). https://doi.org/10.34216/2587-6147-2025-1-67-27-33

[21] Kozak, K., Bakay, R., Buriachenko, Y.: Management of Competitiveness of Enterprise as the Basis of Become Development. Economic Herald of the Donbas, **2**(80), 99–104 (2025). https://doi.org/10.12958/1817-3772-2025-2(80)-99-104

[22] Siregar, R.R., Sumiati.: Analisis Pengendalian Kualitas Proses Bonding Garmen Menggunakan Metode Six Sigma Pada PT. PB. Jurnal Serambi Engineering, **10**(1), (2025).

[23] Kournikova, F.A., Widajanti, E., Sutarno.: Analisis Total Quality Management dalam Memperbaiki Kualitas Produk pada Perusahaan Garmen (Studi Kasus pada CV Sakti Abadi Garmindo di Wonogiri). PENG: Jurnal Ekonomi Dan Manajemen, **3**(1),1288–1305 (2025). https://doi.org/10.62710/wtejea47

[24] Fatkhurrokhman, T.F., Anggoro, W.B.A., Munandar, G.M.M., Evelyna, N.E., Khamida, R.A.K., Nareswari, H.N.: SOSIALISASI DAN PENERAPAN STANDAR OPERASIONAL PROSEDUR (SOP) DALAM PRODUKSI DAMPAKNYA MENINGKATKAN KUALITAS PRODUK (STUDI PADA SURTY COLLECTION). ADIMA Jurnal Awatara Pengabdian Kepada Masyarakat, **3**(3), 1–6 (2025). https://doi.org/10.61434/adima.v3i3.268

[25] Pitchandi, L., Boominathan, S.: Influence of Sewing Parameters and Fabric Properties on Seam Strength and Quality in Woven Garments: A Comprehensive Review. International Journal on Science and Technology, **16**(3), 1–4 (2025). https://doi.org/10.71097/ijsat.v16.i3.8492

[26] Fu, R., Huang, Z., Cao, M., Novák, D., Xie, C., Huang, J.: Optimizing deep learning-driven computer vision for civil infrastructure defect Identification: Challenges and strategies. Engineering Applications of Artificial Intelligence **158**, 111521 (2025). https://doi.org/10.1016/j.engappai.2025.111521

[27] Ku, S., Choi, H.W., Kim, H.Y., Park, Y.L.: Automated Sewing System Enabled by Machine Vision for Smart Garment Manufacturing. IEEE Robotics and Automation Letters, **8**(9), 5680–5687 (2023). https://doi.org/10.1109/LRA.2023.3300284

[28] Huang, X., Yu, L., Yuan, Y.: Industrial robots and enterprises innovation-Based on the view of human capital. Studies in Science of Science, **41**(2), 356–368 (2023).

[29] Zheng, X., Liu, Z., Chen, F., Zhang, J., Wang, J.: Current status and prospect of intelligent development in textile industry. Journal of Textile Research, **44**(8), 205–216 (2023). https://doi.org/10.13475/j.fzxb.20220305802

[30] Li, Z., Zhang, M., Li, F., Shi, S., Wang, S., Gao, C., Li, Y.: Recycling of waste denim: A stepwise utilisation strategy for clean decolourisation, opening and degradation. Waste Management, **198**, 12–20 (2025). https://doi.org/10.1016/j.wasman.2025.02.037

[31] Naeem, M., Abbas, Q., Ahmad, H., Naeem, M.S., Aldajani, M.B., Dawood, H., Hussain, M.A.: DCGAN-based synthetic image generation of denim jeans defects. PeerJ Computer Science, **11**, e3167 (2025). https://doi.org/10.7717/peerj-cs.3167

[32] Arsoy, R., Aslan, S.: Software-based optimization of bias tape production for sustainable apparel manufacturing. Sustainability, **18**(3), 1679 (2026). https://doi.org/10.3390/su18031679

[33] Kirin, S., Kralj, D., Hursa Šajatović, A.: Using the Methods-Time Measurement Calculator to Determine the Time Norms for Technological Sewing Operations in the Clothing Industry. Processes, **12**(8), 1763 (2024). https://doi.org/10.3390/pr12081763

[34] GUPTA, A., MANIAR, S.: Present-Day Trends and Complexities in Agile Frameworks: Implementing Innovative Corrective, Adaptive, and Transformative Solutions. International Journal For Multidisciplinary Research, **7**(3), 1–11 (2025). https://doi.org/10.36948/ijfmr.2025.v07i03.49112

[35] Shen, Y., Zhang, X.: Intelligent manufacturing, green technological innovation and environmental pollution. Journal of Innovation and Knowledge, **8**(3), 100384 (2023). https://doi.org/10.1016/j.jik.2023.100384

[36] Zhao, F.Y.: Research and Optimization of Enterprise Standard System Construction Method Based on Process Analysis. Accounting and Corporate Management, **6**(5), 61–66 (2024). https://doi.org/10.23977/acccm.2024.060509

[37] Song, J., Park, M.J.: A system dynamics approach for cost-benefit simulation in designing policies to enhance the cybersecurity resilience of small and medium-sized enterprises. Information Development, **42**(2), 974–990 (2024). https://doi.org/10.1177/02666669241252996

[38] Sun, Q., Gu, G.: Measurement and comparison of high-quality development level of China's international silk trade. Journal of Silk, **62**(4), 1–10 (2025). https://doi.org/10.3969/j.issn.1001-7003.2025.04.001

[39] Zhou, Q., Ye, J., Chen, P.F., Gao, Y.X.: Applicability contexts of the "Belt and Road" enterprise technical standards alliance. Studies in Science of Science, **43**(8), 1600–1609 (2025).

[40] Choi, I., Pinsonneault, A., Han, K., Animesh, A.: Enterprise systems standardization, IT investment, and firm performance: an organizational information processing theory perspective. European Journal of Information Systems, 1–19 (2026). https://doi.org/10.1080/0960085X.2026.2616041

[41] Bag, S., Routray, S., Zhang, L.L., Grebinevych, O.: Balancing global standards and local needs: Digital technologies, social sustainability, and MSMEs. Journal of Environmental Management, **397**, 128305 (2026). https://doi.org/10.1016/j.jenvman.2025.128305

[42] Purba, H.H., Hasibuan, S., Jaqin, C.: Sustainable product development for small medium enterprise. AJARCDE (Asian Journal of Applied Research for Community Development and Empowerment), **9**(2), 594–496 (2025). https://doi.org/10.29165/ajarcde.v9i2.743

[43] Siddiqui, N.A., Limon, G.Q., Hossain, M.S., Mintoo, A.A.: A SYSTEMATIC REVIEW OF ERP IMPLEMENTATION STRATEGIES IN THE RETAIL INDUSTRY: INTEGRATION CHALLENGES, SUCCESS FACTORS, AND DIGITAL MATURITY MODELS. American Journal of Scholarly Research and Innovation, **2**(2), 135–165 (2023). https://doi.org/10.63125/pfdm9g02

[44] Wang, Y., Zhao, X., Yu, X., Liu, S., Feng, M., Tao, Y., Yang, Q.: Analysis of Development Trends and Associations in Intelligent Construction of Chinese Corporations. Buildings, **15**(5), 716 (2025). https://doi.org/10.3390/buildings15050716