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Research on Human Factor Process Improvement of Workshop Operations under Lean Production Mode

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ABSTRACT

In the promotion of lean production, workshop sites are frequently plagued by poor operation processes, prominent operator fatigue, and mismatched human-machine coordination. Taking a machinery processing and assembly workshop as the research object, this paper adopts literature review and on-site tracking investigation. Supported with human factors engineering theories including biomechanics, cognitive load and operation motion analysis, hidden human factor defects in the existing operation processes are identified and diagnosed. On this basis, process optimization schemes are designed from the perspectives of motion simplification, workstation layout adjustment, operation task redistribution and auxiliary equipment deployment. After the implementation of optimization schemes, the risk of musculoskeletal injuries is controlled, invalid motions and operation fatigue are alleviated, and operation efficiency and operating comfort are both improved.

KEYWORDS

Lean Production; Human Factors Engineering; Workshop Operation; Motion Optimization; Musculoskeletal Injury

1. INTRODUCTION

1.1. Research Background

Lean production is a mainstream production management mode in industrial engineering, with the core of eliminating waste and improving production efficiency. It has been widely applied in machinery manufacturing, automobile assembly and other industries. At present, most enterprises focus on equipment, production capacity and logistics optimization when implementing lean production, while ignoring human factors. Long-term exposure to unreasonable working postures, repetitive mechanical movements and high-intensity cognitive load makes workshop employees prone to operation fatigue, operational errors and musculoskeletal strain. These issues not only harm employees' physical and mental health, but also restrict the implementation effect of lean production and generate implicit production waste.

1.2. Problem Statement

The research object of this survey is a finished product assembly workshop of a small and medium-sized machinery processing enterprise, which has fully implemented standardized lean operations. Three typical human factor problems exist on site: First, assembly stations feature redundant motions with frequent bending and arm-lifting movements, leading to excessive biomechanical load. Second, messy material placement at workstations forces workers to turn around frequently to fetch materials, generating invalid operations. Third, unclear operation guidance signs raise cognitive load for both new and veteran workers, accompanied by occasional operational errors. Based on human factors engineering theories, this paper carries out human factor improvement on lean production operation processes of the workshop as the core research task.

1.3. Research Significance of Human Factors

Integrating human factors engineering into lean production process optimization balances production efficiency and occupational health, conforming to the people-oriented development concept of modern industrial engineering. Optimizing operation motions, spatial layout and information interaction can eliminate human factor waste in lean production, boost overall workshop capacity and operation standardization, reduce occupational health risks, and upgrade human-machine working environments. It realizes dual improvement of production benefits and human-machine safety.

2. RESEARCH METHODS AND FIELD INVESTIGATION

2.1. Literature Review

A total of 16 documents related to human factors engineering, lean production, workshop operation optimization, musculoskeletal injuries and motion analysis were retrieved from CNKI, Wanfang and foreign databases. Domestic and foreign research status is sorted out: Foreign scholars started earlier to combine human factors engineering with lean production, focusing on human-machine collaboration and operation fatigue monitoring. Domestic studies mostly target automobile and electronics manufacturing workshops, taking motion analysis and workstation layout optimization as major improvement directions. Existing research proves that human factor defects are the most easily overlooked waste in lean production sites, and motion optimization and spatial reconstruction are low-cost and high-efficiency improvement approaches.

2.2. On-site Investigation

2.2.1. Research Subjects

The finished product assembly workshop of a machinery processing enterprise owns 12 standardized assembly stations and 36 frontline operators, responsible for sorting, assembly, inspection, packaging of small mechanical parts. The workshop adopts two-shift system with daily operation time of about 8 hours.

2.2.2. Investigation Methods

On-site observation: Full-day on-site observation for 3 consecutive days to record operation motions, material circulation, working postures and operating habits at each workstation.

Interview: Interviews with 18 frontline workers and 3 workshop team leaders to collect subjective fatigue feelings, operation difficulties and inconvenient operating problems.

Data recording: Statistics of average total assembly time per product at single station, times of invalid motions, frequency of bending/turning movements and operational error frequency.

Simple biomechanical assessment: Working posture load grade evaluation based on human factors engineering posture standards.

3. CURRENT SITUATION ANALYSIS AND DIAGNOSIS OF HUMAN FACTOR PROBLEMS

3.1. Original Workshop Operation Process

The original lean assembly process is as follows: Parts collection → manual sorting → assembly splicing → function inspection → labeling and packaging → finished product transfer. The whole process is completed independently by one worker for a single product, with fixed single-person operating tables and all material boxes placed on the ground behind each workstation.

3.2. Summary of On-site Human Factor Problems

3.2.1. Excessive Biomechanical Load Causing Occupational Injuries

Workers have to bend over, lean forward and turn around continuously to pick materials, with an average of 22 bending movements in assembling one single product. Long-term repeated bending and arm-lifting movements sustain continuous stress on waist, neck, shoulder and upper limb muscles. Many employees report waist and neck soreness after work, accompanied by risks of musculoskeletal injuries. In addition, the mismatch between operating table height and workers' height exacerbates physical load: tall workers keep bowing their heads while short workers lift arms for a long time.

3.2.2. Redundant Operation Motions Generating Massive Human Factor Waste

A large number of invalid movements and turns exist on site in line with lean production motion classification. Materials are placed behind workstations, requiring workers to turn around for material fetching in every working procedure. Invalid movements including turning and walking account for 18% of single procedure duration, violating the core lean production requirement of eliminating motion waste.

3.2.3. Unreasonable Human-machine Information Interaction Leading to High Cognitive Load

Only a unified version of operation instruction is hung in the workshop with small fonts and chaotic graphic partitions, without local operation guidance at each workstation. New workers take long time to get familiar with operations, while veteran workers occasionally miss working procedures or misread parameters. High operation cognitive load indirectly reduces production efficiency.

3.2.4. Unreasonable Workstation Spatial Layout with Crowded Operation Space

No functional zoning is divided on single-person operating tables, where assembly, inspection and tool storage areas are mixed together. Crowded working space with randomly placed tools extends tool searching time, restricts workers' limb movement and forces awkward working postures.

3.3. Statistical Analysis of Survey Data

Table 1. Core Statistical Indicators of Single Station & Single Product

Serial Number	Indicator Name	Indicator Value	Explanation
1	Total assembly time	4 minutes and 12 seconds	Average total time for single station to complete full assembly of one product
2	Times of invalid bending & turning movements	31 times	Average non-essential movements of turning and bending during single product assembly
3	Time spent on searching tools & materials	38 seconds	Average total time spent searching for tools and materials for one product
4	Daily average subjective fatigue score of workers	7.6 points	Full score: 10; higher score means severer operation fatigue, average score before off-work every day
5	Weekly average operational error frequency per station	2.3 times	Average frequency of operational mistakes and missed procedures per station weekly

4. PROCESS IMPROVEMENT SCHEME BASED ON HUMAN FACTORS ENGINEERING

Combining lean production principles with core human factors engineering theories including biomechanics, working space design, cognitive human factors and motion economy principles, systematic improvement schemes are designed from five dimensions: motion optimization, workstation layout, material placement, information guidance and operation task allocation.

4.1. Operation Motion Optimization

Cut redundant motions: Combine sorting and assembly procedures to reduce repeated parts fetching movements. Limit main operations within human comfortable working zones to avoid large-scale arm-lifting and bending movements.

Optimize posture standards: Two types of operating table heights are set matching workers' height range, unified standard working postures are formulated to eliminate bad working postures.

Standardize motions: Compile Standard Operation Motion Manual to specify standard hand and limb motions for each procedure and reduce random movements.

4.2. Improvement of Workstation Space and Material Layout

Reconstruct functional zoning: Divide single-person operating tables into four fixed zones: material fetching zone, assembly zone, inspection zone and tool zone, with clear partitions to shorten operation routes.

Renovate material overhead racks: Remove ground material boxes and install layered inclined material racks on both sides of workstations. Materials are placed within comfortable standing fetching height so that workers can access materials without bending or turning around.

Positioned tool management: Install magnetic tool racks and positioning slots to fix all tools at designated positions for instant access, eliminating invalid tool searching time.

4.3. Optimization of Human-machine Information Interface (Reducing Cognitive Load)

Install mini visualized operation boards at each workstation with enlarged fonts and simplified pictures. Operation key points and parameter standards are displayed by working procedures, and boards are mounted at the optimal visual position directly in front of workers.

Add warning signs for key procedures: Attach colored warning labels on error-prone procedures such as inspection and parameter adjustment to strengthen visual reminders and lower cognitive error probability.

4.4. Optimization of Operation Process and Task Allocation

Break the original full-process independent operation mode. Based on the principle of balanced human factor load, split the whole process into sorting group, assembly group and inspection & packaging group to implement segmented pipeline operation. Each workstation has fixed operation contents with controllable repetition degree of single motion, preventing single worker from undertaking full-process high-intensity work and balancing overall human factor load.

4.5. Deployment of Auxiliary Human Factor Facilities

Anti-slip shock-absorbing foot mats are equipped for long-time standing workers to relieve lower limb fatigue. Simple rest areas are set beside workstations with short rotating rest rules to avoid continuous high-intensity operations.

5. VERIFICATION AND ANALYSIS OF IMPROVEMENT EFFECTS

5.1. Comparison of Data Before and After Optimization

Table 2. Indicator Comparison Before and After Improvement

Indicator Name	Before Improvement	After Improvement	Optimization Effect
Single product assembly duration	4 min 12 s	3 min 28 s	Shortened by 44 seconds, efficiency increased by 17.46%
Times of invalid bending & turning movements	31 times	8 times	Reduced by 23 times, motion waste decreased by 74.19%
Time spent searching tools and materials	38 s	9 s	Shortened by 29 seconds, searching time reduced by 76.32%
Daily average worker fatigue score (full score 10)	7.6 points	4.2 points	Reduced by 3.4 points, operation comfort improved by 44.74%
Weekly average operational error frequency	2.3 times	0.4 times	Reduced by 1.9 times, error rate decreased by 82.61%

5.2. Analysis of Human Factor Improvement Effects

Biomechanical level: Large-scale bending and leaning movements are eliminated, bad working postures are basically removed, and waist, neck and shoulder load are significantly reduced, effectively lowering occupational musculoskeletal injury risks.

Motion and efficiency level: Following motion economy principles shortens operation routes and drastically cuts invalid motions, perfectly matching the lean production target of waste elimination.

Cognitive human factor level: Clear visualized on-site guidance reduces workers' cognitive load and greatly cuts operational error rates.

Subjective experience level: Workers generally report smoother and less exhausting operations with improved job satisfaction.

5.3. Minor Existing Problems

Slight differences exist in operation beats of each workstation after segmented pipeline transformation, occasionally causing short material waiting. Some veteran workers need an adaptation period for new motion standards and layout.

6. CONCLUSIONS AND FUTURE OUTLOOK

6.1. Brief Conclusions

This paper takes the assembly workshop of a machinery manufacturing enterprise as research object, adopting literature review and on-site investigation to sort out human factor defects in operation motions, workstation layout, material storage, human-machine information interaction and post allocation. Supported by biomechanics, motion economy and cognitive human factors theories, systematic improvement solutions are designed and verified by three consecutive days of on-site data tracking.

The integrated application of human factors engineering and lean production can solve the traditional lean management defect of prioritizing output over workers. The proposed low-cost and easy-to-implement schemes greatly cut invalid motions, shorten assembly time and reduce error frequency to eliminate implicit production waste and standardize workshop operations. Meanwhile, optimized working postures, renovated workstation facilities and balanced labor load improve working environments and reduce musculoskeletal injuries for employees. The research proves that integrating lean production and human factors engineering can realize coordinated promotion of production efficiency, human-machine safety and employee health, providing practical references for similar machinery assembly workshops.

6.2. Brief Research Limitations

First, only one single assembly workshop is selected as research sample, limiting the universality of optimization schemes for workshops with different scales, product types and staff structures. Second, evaluation relies on manual statistics and subjective scoring without professional physiological monitoring equipment, leading to insufficient refined quantitative analysis of cognitive load and muscle fatigue. Third, the research mainly focuses on hardware and process optimization, lacking supporting long-term management and training mechanisms to sustain long-term optimization effects. Unbalanced pipeline beats have not been fully resolved as well.

6.3. Simplified Future Outlook

Subsequent research can adopt professional physiological monitoring devices to realize refined quantitative human factor measurement. Production line balance theory will be used to adjust workstation beats and eliminate material waiting. The optimization framework of "Lean + Human Factors" can be extended to other production links to form standardized universal optimization manuals. Complete training, inspection and feedback management systems will be established to maintain long-term optimization effects. In addition, the combination of intelligent auxiliary equipment and human factors engineering under intelligent manufacturing will be further explored.

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REFERENCES

[1] Qiu, A. P., & Zhang, Q. (2026). Research on application of material lifting follow-up device from the perspective of human factors engineering. Automotive Practical Technology, 51(6), 96–100, 135. (In Chinese)

[2] Ma, H. Y., Wan, Y. L., Guan, Y. H., et al. (2026). Building a solid safety barrier to escort lean production—Practice and exploration of inspection and maintenance operation safety management in FAW Toyota. Labor Protection, (7), 18–20. (In Chinese)

[3] Wang, X. P. (2026). Bid farewell to factory chaos: How lean production reshapes manufacturing industry just like tidying up rooms? China Science and Technology Information, 38(8), 135–136. (In Chinese)

[4] Li, Y. (2026). Research on operation process optimization of automobile final assembly line from the perspective of lean production. Modern Manufacturing Technology and Equipment, 62(3), 131–133, 152. (In Chinese)

[5] He, X. X. (2024). Research on operation process optimization of N metro bogie overhaul based on lean production [Master's thesis]. Central South University. (In Chinese)

[6] Hong, W. (2015). Research on cold chain home delivery process optimization of H agricultural products [Master's thesis]. Hebei University of Technology. (In Chinese)

[7] Ding, S. L. (2025). Research on production line operation optimization of C company's PCB products [Master's thesis]. Lanzhou University. (In Chinese)

[8] Hu, L., Ding, J., & Shen, X. (2026). Injury prevention in fatigue-prone nursing environments: A comprehensive review of strategies centered on work design, human factors engineering, and safety culture. Frontiers in Public Health, 14. https://doi.org/10.3389/fpubh.2026.1182456

[9] Zhang, W., Zhu, Y., Wang, J., et al. (2026). Research on the enhancement of lean production management capability in production-oriented enterprises empowered by digital informatization. Academic Journal of Business & Management, 8(5). (In Chinese)

[10] Vinodh, S. (2026). Lean manufacturing and Industry 5.0: Concepts, technologies, and methods. CRC Press.