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Optimization of the G Production Workshop Layout in T Company

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Abstract

Based on an on-site investigation of the existing layout and production logistics of the G production workshop in T Company, this study identifies several problems, including disorganized material distribution and unreasonable process layout. To address these issues, the workshop layout is analyzed and optimized using the SLP (Systematic Layout Planning) method. The logistics and non-logistics relationships among different operating units are systematically analyzed, and a comprehensive relationship diagram and activity relationship diagram are developed accordingly. Finally, considering the actual physical space constraints of the workshop, an optimized layout scheme is proposed. The results show that the proposed layout effectively streamlines material handling routes and reduces material accumulation and stagnation between processes, thereby improving the rationality and efficiency of the workshop layout.

Keywords

Facility Layout Optimization; SLP; Logistics Analysis; Production Workshop.

1. Introduction

With the gradual transformation of global manufacturing and the upgrading of China's industrial structure, manufacturing remains an important pillar of the national economy. The digital transformation of manufacturing has become an important means of promoting new industrialization and building a modern industrial system. As an important component of manufacturing enterprises, the rationality of production workshop layout directly affects production efficiency and logistics costs. At present, China's manufacturing industry is shifting from high-speed growth toward high-quality development, requiring enterprises to continuously improve their production systems and adapt to changing market demands.

In terms of workshop layout optimization, existing methods have certain limitations. The traditional Systematic Layout Planning (SLP) method relies relatively heavily on expert experience in qualitative analysis. Although it is effective for relatively simple production scenarios, its performance is limited in multi-objective optimization and dynamic adaptation. Workshop layout optimization is essentially a combinatorial optimization problem. As the number of facilities increases, material transportation routes become increasingly complex. Therefore, researchers have conducted extensive studies on workshop layout optimization. Suhardini et al., for example, applied the SLP method to PT. Gunaprima Budiwijaya and designed a new layout to address cross-traffic problems, improve production capacity, and reduce material handling costs [1].

This study takes the G production workshop of T Company as the research object. Based on the traditional SLP method, the logistics and non-logistics relationships among operating units are analyzed comprehensively. By considering the actual production conditions and physical space constraints of the workshop, an optimized layout scheme is developed to improve material flow and space utilization.

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2. Analysis of the Existing Workshop Layout

2.1. Division of Workshop Operating Units

T Company is a technology-oriented small and medium-sized enterprise specializing in precision supporting components for automotive turbochargers. The G workshop is a core production workshop, mainly manufacturing high-precision sheet-metal stamping components such as heat shields. Its production is characterized by high-precision sealing requirements and short delivery cycles. Based on the production process characteristics of the heat-shield products, the processing process consists of multiple physical forming and surface-treatment operations. Accordingly, the G workshop is divided into 13 operating areas covering the entire process from raw material input, multi-stage cold stamping, and surface treatment to finished-product storage and shipment. The existing workshop layout is shown in Figure 1.

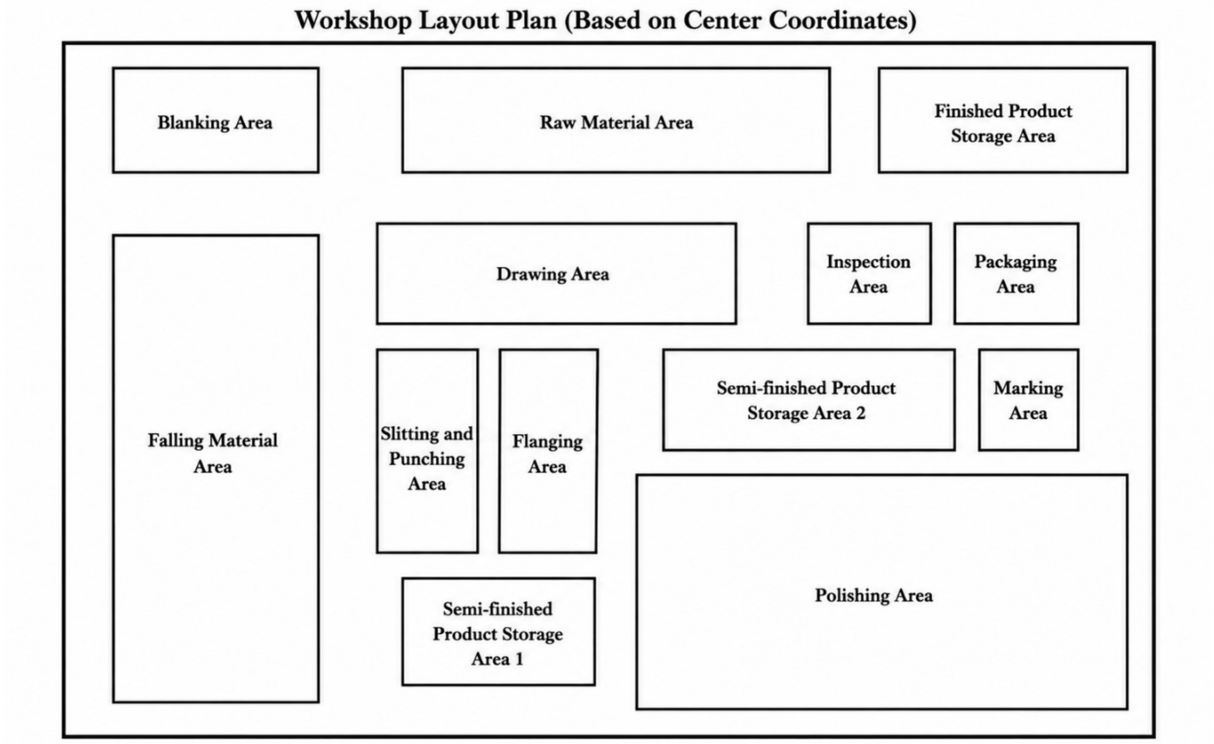

Fig 1. Original Layout of the G Production Workshop

2.2. Problems in the Existing Workshop Layout

Through on-site investigation of the G workshop and quantitative evaluation of material handling distance and volume using the F-D analysis method, three major problems were identified. First, logistics handling efficiency is low. The arbitrary arrangement of equipment results in unreasonable logistics routes between operating units, while the extensive reliance on manual handling increases handling time and the risk of product collision and damage. Second, the facility layout lacks systematic planning, and some high-flow operations are not physically adjacent. Third, space is not fully utilized. Excessive aisle space and insufficient area in key production zones, such as the polishing area, result in drying equipment being placed close to temporary storage areas, increasing the risk of dust contamination.

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3. Workshop Layout Design Based on the SLP Method

3.1. Logistics and Non-logistics Analysis

3.1.1. Logistics Intensity Levels

Based on the average daily output of heat-shield products, the material handling volume between operating units was statistically analyzed. According to the principles of logistics intensity classification, the logistics intensity between operating-unit pairs was divided into five levels: A, E, I, O, and U. The results show that the logistics intensity between the raw material area and the blanking area, as well as between the blanking area and the falling-material area, is the highest and is classified as Level A.

3.1.2. Logistics Relationship Diagram

Based on the logistics intensity analysis, a logistics relationship diagram of the operating units was developed, as shown in Fig. 3. All operating-unit pairs were considered. Combinations without direct material handling relationships were classified as Level U, representing the lowest logistics intensity.

3.1.3. Non-logistics Relationship Analysis

In addition to logistics factors, non-logistics factors should also be considered in workshop layout optimization, as they have an important influence on the arrangement of operating units. According to the actual production characteristics and product requirements of the G production workshop in T Company, six major factors affecting non-logistics relationships were identified: process continuity, ease of material handling, collision and damage costs, management convenience, noise and dust, and personnel contact. The specific factors are presented in Table 1.

Table 1. Table of Factors Influencing Non Logistics Relationships

Number	Influencing Factors
1	Process Continuity
2	Ease of Material Handling
3	Collision and Damage Costs
4	Management Convenience
5	Noise and Dust
6	Personnel Contact

Based on the above non-logistics factors, the closeness relationships between operating units were evaluated using a classification method similar to that used for logistics intensity. The non-logistics relationships were divided into six levels: A, E, I, O, U, and X. The corresponding meanings, scores, and recommended proportions of the different closeness levels are presented in Table 2. Among them, A indicates an absolutely important relationship, E indicates a particularly important relationship, I indicates an important relationship, O indicates an ordinary relationship, U indicates an unimportant relationship, and X indicates that the corresponding operating units should not be located close to each other.

Based on the above evaluation criteria, the non-logistics relationships among the operating units in the G production workshop were determined, and the corresponding non-logistics relationship diagram was developed, as shown in Fig. 2.

Table 2. Table of Proportion of Non Logistics Relationship Levels

Closeness Level	Meaning	Score	Proportion (%)
A	Absolutely Important	4	1-4
E	Especially Important	3	3-8
I	Important	2	5-15
O	Ordinary	1	10-25
U	Unimportant	0	20-85
X	Undesirable to be Adjacent	-1	As Appropriate

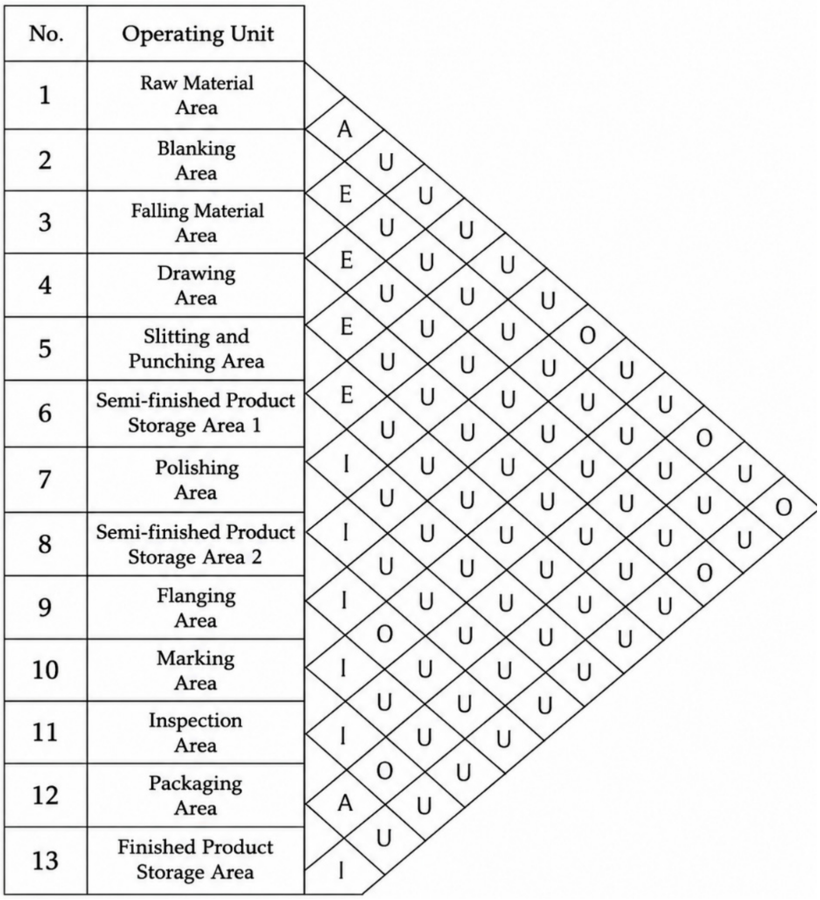

Fig 2. Non Logistics Related Diagram

3.2. Comprehensive Relationship Analysis of Operating Units

To comprehensively quantify the closeness between different operating areas, the logistics and non-logistics relationships were systematically combined. Considering the actual process requirements of heat-shield production, particularly the need to avoid product collision and prevent dust contamination, logistics efficiency was given a dominant role while the influence of safety and environmental factors was moderately increased. The weighting ratio of logistics relationships to non-logistics relationships was set at 3:2. After comprehensive calculation and normalization, the overall relationship between operating units was obtained, as shown in Fig. 3.

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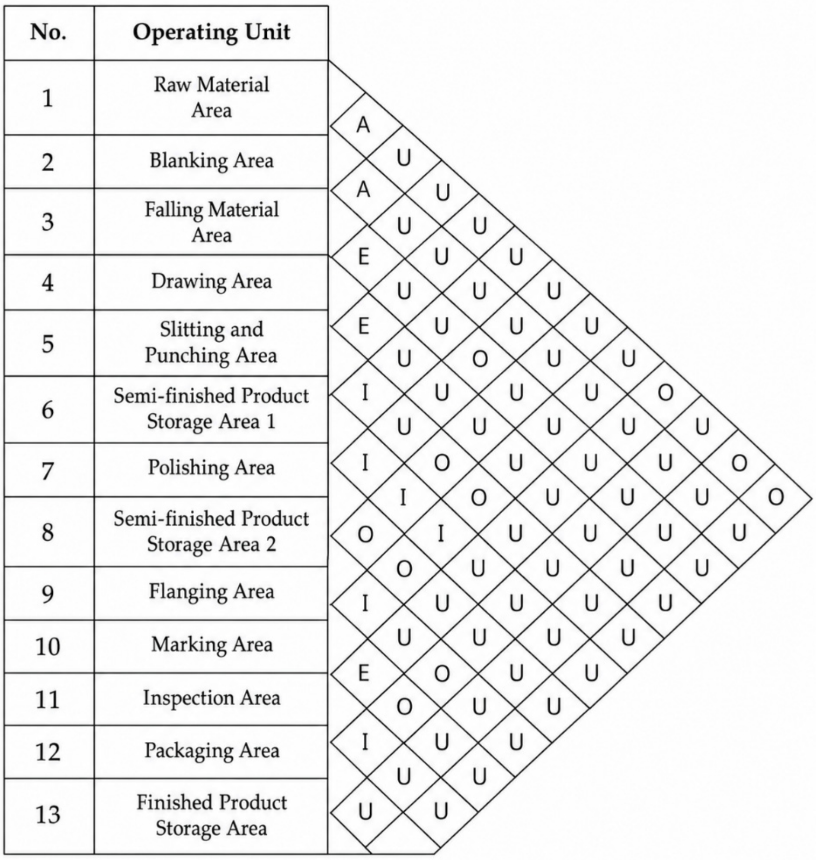

Fig 3. Comprehensive correlation diagram

3.3. Position Relationship Diagram of Operating Units

To determine the sequence of spatial arrangement in the workshop, the comprehensive closeness relationship between operating units was used as the main criterion. The comprehensive relationship scores and corresponding levels of operating-unit pairs were ranked in descending order. These quantitative results were then mapped to spatial adjacency requirements to establish the layout priority sequence. The resulting position relationship diagram is shown in Table 3.

4. Design and Analysis of the Optimized Workshop Layout

4.1. SLP-based Workshop Layout Optimization

Based on the comprehensive evaluation of logistics and non-logistics relationships, the functional areas were arranged according to their degree of closeness, with operating units having higher logistics intensity placed as close to each other as possible. At the same time, considering the physical space constraints and actual production requirements, the raw material area, processing area, semi-finished product storage area, and finished-product storage area were reorganized to form the initial optimized workshop layout, as shown in Fig. 5.

4.2. Effect Analysis of the Optimized Layout

(1) Improvement of logistics routes. Before optimization, the arrangement of some operating units did not fully consider the product process flow and logistics relationships. Certain distances existed between the raw material area, processing area, and semi-finished product storage area, resulting in repeated long-distance material handling. Some logistics routes also contained intersections and detours, increasing transportation time and manual handling costs. After optimization based on the SLP method, areas with close logistics relationships were

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arranged adjacently according to their comprehensive closeness relationships. The material transportation routes therefore better match the product processing sequence, reducing unnecessary handling and return transportation and improving logistics continuity.

Table 3. Summary of comprehensive relationships

Number	From-To	Logistics Relationship		Non-logistics Relationship		Comprehensive Relationship	
		Level	Score	Level	Score	Score	Level
1	1-2	A	4	A	4	20	A
2	11-12	O	1	A	4	11	E
3	2-3	A	4	E	3	18	A
4	3-4	E	3	E	3	15	E
5	4-5	I	2	E	3	12	E
6	5-6	I	2	E	3	12	E
7	6-7	E	3	E	3	15	E
8	8-9	I	2	I	2	10	I
9	8-10	O	1	I	2	7	I
10	10-11	O	1	I	2	7	I
11	12-13	O	1	I	2	7	I
12	7-8	I	2	I	2	10	I
13	7-9	U	0	I	2	4	O
14	9-10	U	0	I	2	4	O
15	8-11	O	1	O	1	5	I
16	7-11	U	0	O	1	2	O
17	2-8	U	0	O	1	2	O
18	3-8	U	0	O	1	2	O
19	1-13	U	0	O	1	2	O
20	2-13	U	0	O	1	2	O
21	10-13	U	0	O	1	2	O

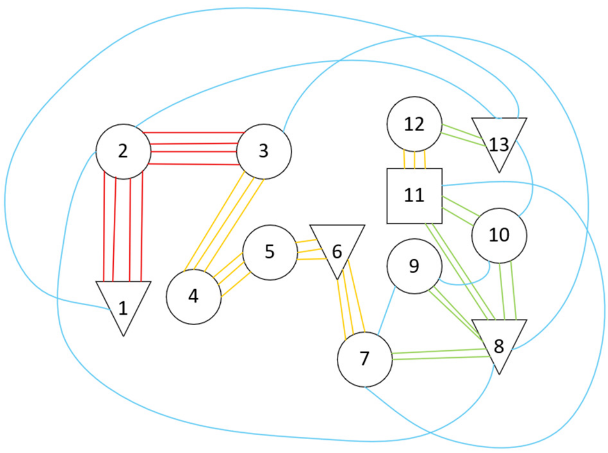

Fig 4. Position correlation diagram

(2) Improvement of comprehensive relationships among operating units. The SLP method considers not only logistics relationships but also non-logistics factors such as equipment management, production coordination, safety, and environmental conditions. Within the actual spatial constraints of the workshop, the optimized layout gives priority to the adjacent arrangement of operating units with high-level comprehensive relationships, such as Levels A and E. This makes the connections between functional areas more reasonable, reduces

interference between different operating areas while shortening logistics distances, and improves the coordination of production organization.

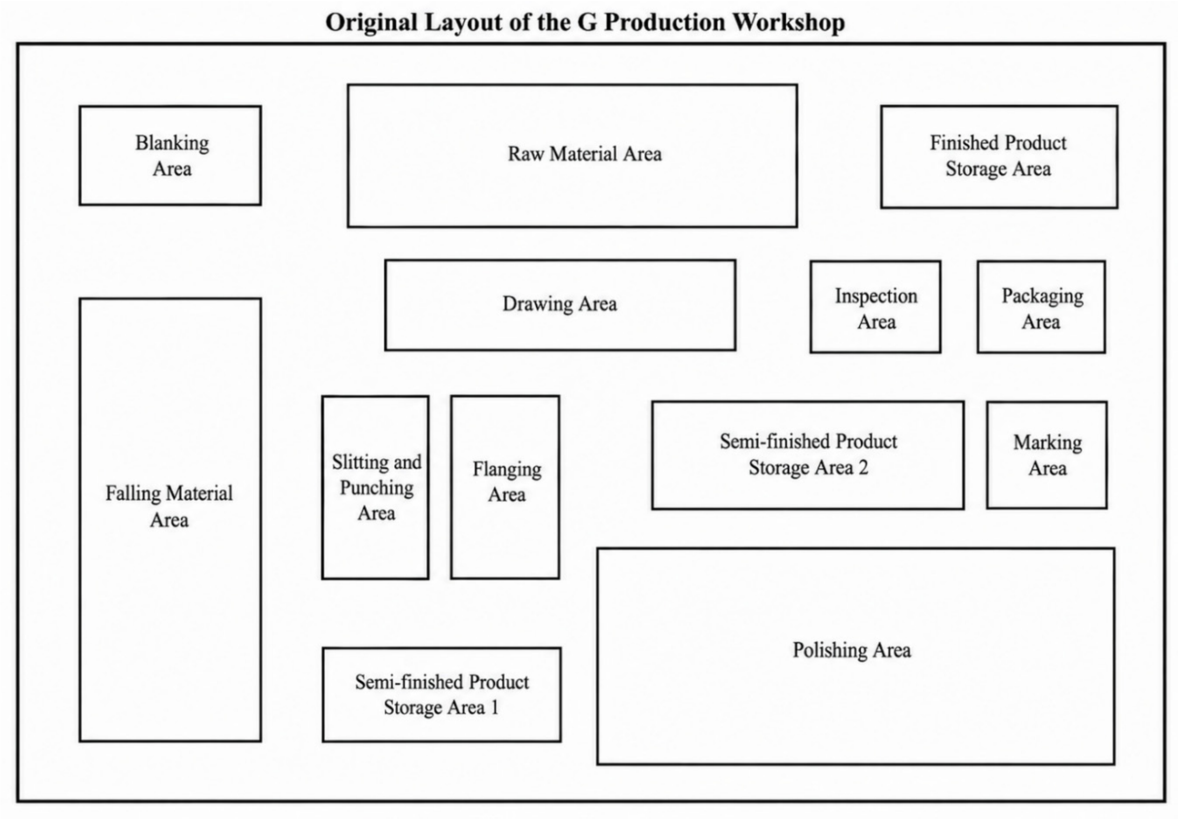

Fig 5. Optimized Layout of the G Production Workshop

(3) Improvement of space utilization and on-site management. In the original layout, unclear functional zoning led to temporary storage of some tooling, fixtures, and semi-finished products, occupying operating space and affecting personnel movement and material handling. The optimized layout reorganizes the locations and required areas of the operating units, making functional zoning clearer and logistics aisles smoother. This helps reduce disorder in the production site and improves overall workshop management.

5. Conclusion

This study addresses the problems of unreasonable equipment layout, long logistics routes, and insufficient space utilization in the G production workshop of T Company. The SLP method was applied to optimize the workshop layout. By comprehensively analyzing the logistics and non-logistics relationships among operating units, a comprehensive relationship diagram was established, and the original layout was adjusted according to the actual production conditions of the workshop to obtain an optimized layout scheme.

The results show that the SLP-based layout can effectively improve the spatial relationships among operating units, make logistics routes more continuous, reduce detours and intersections during material handling, and improve the rationality of workshop space utilization and the production environment. The study demonstrates the applicability of the SLP method to workshop layout optimization in small and medium-sized machinery manufacturing enterprises and provides a practical reference for similar enterprises seeking to improve their production layouts. Due to the influence of order changes, equipment adjustments, and fluctuations in production takt, future studies may further combine intelligent

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optimization algorithms and dynamic simulation techniques to conduct multi-objective optimization and dynamic validation, thereby improving the adaptability and practical value of the proposed layout.

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