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Improvement and Design of H Company's Production Line

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Abstract

With the rapid development of the manufacturing industry, enterprises face multiple challenges, including improving production efficiency, reducing costs, and enhancing product quality. As an advanced production management philosophy, lean production aims to achieve high efficiency and low-cost manufacturing by optimizing processes and eliminating waste. This study takes H Fertilizer Plant as the research object and addresses issues such as unreasonable facility layout, low logistics efficiency, and high product moisture content. By integrating lean production principles with industrial engineering methods, production facilities are optimized and improved. The research focuses on adjusting the natural gas storage location, optimizing the drying process, and improving the loading workflow to enhance resource utilization, shorten production cycles, reduce energy consumption, and strengthen the coordination and stability of the production system. The results show that reasonable facility layout optimization and process improvement can significantly enhance enterprise operational efficiency, providing valuable insights and references for lean production in manufacturing enterprises.

Keywords

Lean Production; Industrial Engineering; Facility Layout Optimization; Systematic Layout Planning (SLP).

1. Introduction

With the rapid advancement of technology, modern manufacturing enterprises are experiencing significant improvements in automation and informatization. Traditional management methods are no longer suitable for the needs of contemporary manufacturing enterprises[1]. The improvement and innovation of production processes play a crucial role in the long-term development of enterprises[2]. Against this backdrop, lean production[3], as an advanced production management philosophy, has attracted widespread attention in the global manufacturing industry. Its core principle is to eliminate all forms of waste in the production process, creating maximum value with minimal resource input, thereby achieving the goals of low cost, high efficiency, and high quality. The lean production system originates from the Toyota Production System (TPS) in Japan[4]. With increasingly intense competition in the global manufacturing sector, the integration of lean production principles with industrial engineering theories and methods provides strong theoretical support and practical guidance for enterprises to optimize production processes and improve operational efficiency[5].

This study takes a specific enterprise as an example, addressing issues such as unreasonable facility layout, low logistics efficiency, and high product moisture content in its production process. By applying lean production principles and industrial engineering methods, the production facilities are redesigned and optimized. Measures such as adjusting the natural gas storage location, extending the length of the drying drum, and optimizing the loading process are implemented to enhance production

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efficiency, reduce costs, and improve product quality. This research aims to provide valuable references for enterprises seeking sustainable development.

2. Research Methodology

This study focuses on H Fertilizer Plant, a typical bio-fertilizer manufacturing enterprise. Due to limited plant space, the production capacity and efficiency have reached a bottleneck despite the presence of a complete production line. As a result, the plant urgently requires industrial engineering and lean production techniques to optimize facility layout, production workflow, and equipment processes to further enhance production efficiency and scalability[6].

By applying expertise in industrial engineering and lean production, we identify layout issues in the production site and develop a facility layout plan to visualize the production workflow. The schematic diagram of the workstations and facility layout, as shown in Figure 1, illustrates the arrangement of different workstations, with arrows representing conveyor belt transport systems between them.

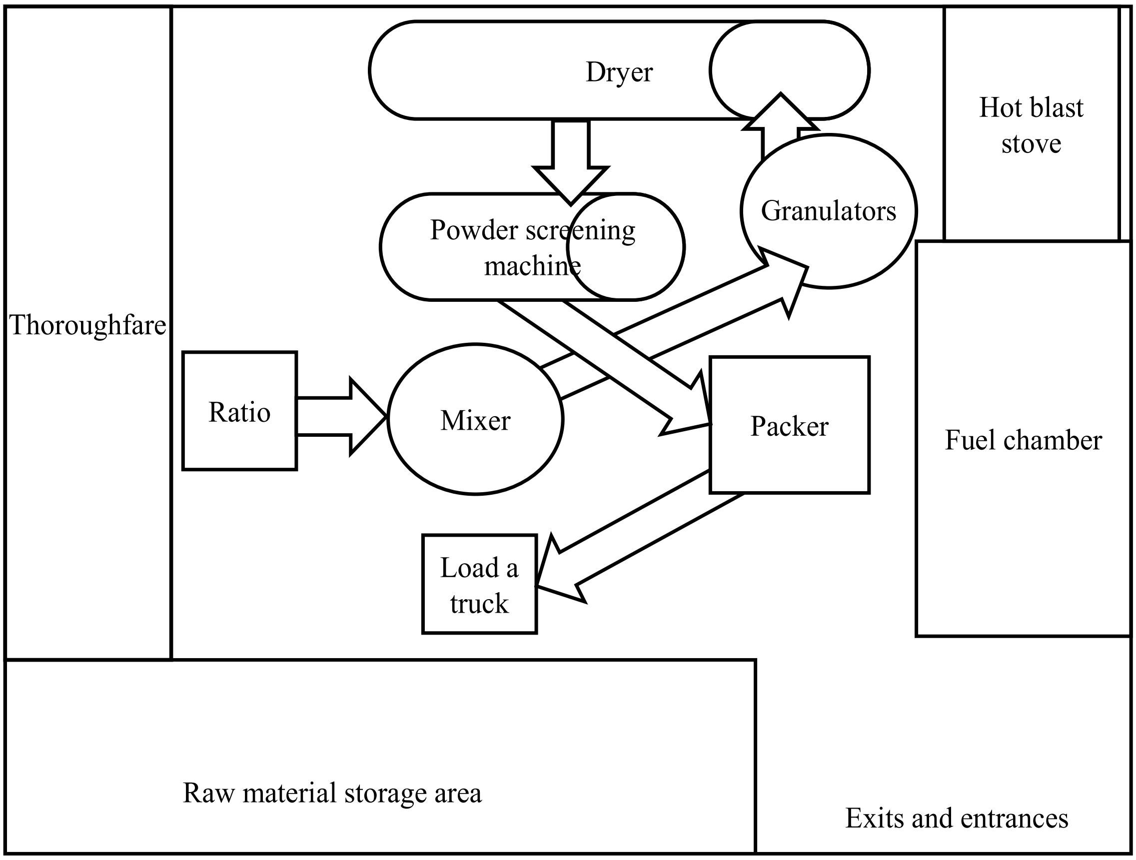

Fig. 1 Facility Layout Before Improvement

The facility layout of the production workshop is designed using Systematic Layout Planning (SLP), with the main analysis process as follows:

(1)Determining the Fundamental Elements of SLP. P (Product, Material, or Service): The product being manufactured is bio-fertilizer, with raw materials including biological bacteria and various organic substances containing nitrogen, phosphorus, and potassium. Q (Quantity or Production Volume): The daily production capacity is approximately 60 tons, with an annual production exceeding 20,000 tons. R (Routing or Process Flow): The production process follows the steps illustrated in Figure 3-1 (Process Flow Diagram). S (Supporting Services): Key supporting services include maintenance, cafeteria, shipping, and receiving. T (Time Schedule): The production or operational schedule determines the timing of manufacturing activities.

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(2) Analysis of the Relationship Between Work Units

Since H Fertilizer Plant has relatively low logistics flow, the layout design mainly considers the relationships between work units. The degree of relationship between work units is assessed based on the following factors: Process flow, Similarity of operations, Shared utility usage, Frequency of interactions between workstations. A questionnaire survey was conducted, where work unit supervisors provided input based on their experience. The planning and design team then compiled, analyzed, and summarized the data to create the work unit relationship chart, as shown in Table 1.

(3) Overall Closeness Rating Table

In constructing the Overall Closeness Rating Table, the following numerical values are assigned to different levels of relationship: A = 4, E = 3, I = 2, O = 1, U = 0, X = -1, (Where A, E, I, O, U, X represent different levels of interrelationships, decreasing in importance sequentially.) In the table, higher overall closeness ratings indicate that a unit is closer to the central position in the layout, while lower ratings suggest proximity to the peripheral areas. The Overall Closeness Rating Table is shown in Table 2.

The processes corresponding to the work unit codes in the table are listed in Table 1. Based on the data, it is determined that work unit 3 (drying process) should be positioned at the center of the layout.

(4) Comprehensive Analysis and Block Layout Planning Considering the above analysis, the following economic factors are comprehensively evaluated: Future expansion potential, Adaptability and flexibility of the process, Logistics efficiency, Storage efficiency, Space utilization, Working conditions and safety, Product quality, Maintenance and equipment utilization, Production capacity and demand fulfillment, Environmental protection. Based on these considerations, a block layout plan is developed. The facility layout diagram for the proposed scheme is illustrated in Figure 2.

Table 1. Three Scheme comparing

Number	Unit Name	1	2	3	4	5	6	7	8	9	10	11
1	Mixer		A	E	I	O	U	X	X	E	U	A
2	Granulators			A	E	I	O	U	X	I	U	E
3	Dryer				A	E	I	O	E	O	A	I
4	Cooling machine					A	E	I	X	U	U	O
5	Powder screening machine						A	E	X	X	U	U
6	Packer							A	X	X	U	X
7	Load a truck								X	X	U	X
8	Fuel chamber									X	A	X
9	Raw material storage area										U	A
10	Hot blast stove											U
11	Ratio											

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Table 2. Overall Closeness Rating Table

Number	1	2	3	4	5	6	7	8	9	10	11
1		A	E	I	O	U	X	X	E	U	A
		4	3	2	1	0	-1	-1	3	0	4
2	A		A	E	I	O	U	X	I	U	E
	4		4	3	2	1	0	-1	2	0	3
3	E	A		A	E	I	O	E	O	A	I
	3	4		4	3	2	1	3	1	4	2
4	I	E	A		A	E	I	X	U	U	O
	2	3	4		4	3	2	-1	0	0	1
5	O	I	E	A		A	E	X	X	U	U
	1	2	3	4		4	3	-1	-1	0	0
6	U	O	I	E	A		A	X	X	U	X
	0	1	2	3	4		4	-1	-1	0	-1
7	X	U	O	I	E	A		X	X	U	X
	-1	0	1	2	3	4		-1	-1	0	-1
8	X	X	E	X	X	X	X		X	A	X
	-1	-1	3	-1	-1	-1	-1		-1	4	-1
9	E	I	O	U	X	X	X	X		U	A
	3	2	1	0	-1	-1	-1	-1		0	4
10	U	U	A	U	U	U	U	A	U		U
	0	0	4	0	0	0	0	4	0		0
11	A	E	I	O	U	X	X	X	A	U	
	4	3	2	1	0	-1	-1	-1	4	0	
Comprehensive closeness degree	7	17	27	18	15	11	9	-1	6	8	11
Sort	9	3	1	2	4	5	7	11	10	8	6

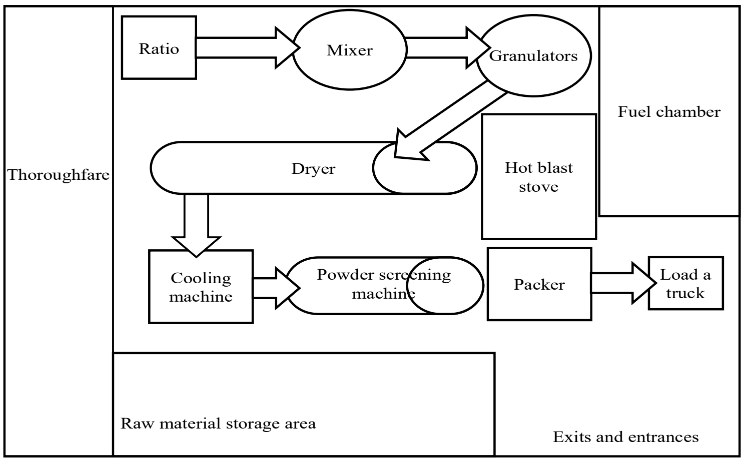

Fig. 2 Improved Facility Layout

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3. Summary

By relocating the natural gas storage area to the upper right corner of the plant, the loading process now has a workspace closer to the entry and exit points, while the storage facility is kept away from freight pathways, significantly enhancing safety and reliability. To address customer feedback regarding high product moisture, this study implemented a facility layout redesign, creating additional usable space and extending the drying drum length by one-third. These improvements effectively reduced product moisture content and enhanced product quality. Additionally, the loading area was prioritized during the facility layout adjustment. After optimization, the loading station became the closest unit to the entrance and exit, reducing the forklift travel distance from 30 meters to 8 meters. This modification significantly shortened the time required to transport products to the warehouse, further improving production efficiency.

In conclusion, these optimization measures not only enhanced operational safety and product quality but also significantly improved logistics efficiency, laying a solid foundation for the overall production process optimization.

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