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Study, Design and Improve Production Line Layout using Material Flows

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Abstract: Companies search for production bottlenecks in an effort to get a competitive edge in the market. Automated production lines must be introduced and innovated for reasons related to productivity, quality, and manpower shortages. A production line is essentially defined as a system of accuracy, fluidity, and speed. New technologies have also prompted manufacturing lines to continually innovate and speed up, this article discusses innovation and addresses the challenge of creating a whole new layout for a new manufacturing line in the food business. This research aimed to develop the best possible production line arrangement in pre-selected manufacturing regions. Making the best possible use of the area allotted for production is crucial for every modern business.

Keywords: layout; simple construction; mechanical engineering, physical flow, adjustment to change; accuracy of production.

Introduction:

Businesses must be able to compete not just in their own market but also with firms worldwide in today's globalized environment. To compete in global markets, one must thus continuously adjust to changing circumstances, boost productivity, optimize manufacturing, or enhance product quality. In order to bring more complex, effective, and efficient manufacturing, companies are compelled to apply a variety of industrial engineering methods and procedures. Activities that provide little to no additional value are tried to be eliminated. The organization can use techniques like Six Sigma or lean production to accomplish these objectives , For businesses, production optimization is always crucial. Space savings and production efficiency are significantly impacted by the best possible arrangement of workstations and machinery. It is significant primarily because of the exorbitant costs, different manufacturing equipment constraints, labor-intensive processing, unpredictable maintenance, etc. Individual functional sections, space needs, aisle dimensions, flow diagram architecture, and picking zone definitions should all be included in each layout solution design. It is best to structure workspaces to minimize reversible technology flow and indirectness. Consequently, enterprises are capable of preserving or enhancing their market standing, obtaining a competitive edge, or minimising expenses ,One of the company's biggest risks is losing its competitive advantage. For this reason, businesses are attempting to develop and use automated manufacturing lines. Still, one must constantly figure out how much to invest and if the business would benefit from it. The entrepreneur's choice is influenced by how convinced they are about the return on their investment. { Hloch, S. (2016), Stverkova, H**.** (2023)}

This study discusses how to locate organizational bottlenecks as well as how to enhance and optimize the manufacturing process as a whole. The challenge of creating an entirely new production line layout in the food business was resolved. The purpose of this work was to provide a production line layout concept for pre-selected production regions. { Frumuşanu, G. (2017)}

Focusing on a crucial or important subprocess is frequently essential while trying to find the best configuration for the company's production and logistics operations since there are sometimes too many variables to adjust , Optimization tools, which assist in determining an appropriate combination of system parameters during implementation, can be utilized for these goals { Hlavaty, I. (2020) Che, Y**.** (2011). }.

Critical points in the manufacturing system were identified and studies of the first production were conducted as part of this study. New production designs that remove the mentioned shortcomings were made using the suggested techniques. Material flows between workplaces were analyzed using graphic-analytical analysis techniques (e.g., Sankey diagram) while building optimization alternatives of the current production system. Since the initial manufacturing premises may be changed, investment, economic, and partially building energy approaches were also investigated. Calculations of capacity were also applied to the number of individual equipment and maximum performance, One of the most important sections of the project paperwork is the disposition strategy for particular machines, offices, or manufacturing facilities. Cooperative and investment-economical conditions may be used to optimize production systems; technical conditions are mostly provided by the machinery that is now in use, and building energy is provided by the production facilities that are currently in use {Cullen, J. M. (2018) & Fiala, D. (2021).}

This article is an example of precision manufacturing and precision equipment in action. The accuracy of the manufacture of each line's unique components determines the optimization of the lines {Stverkova, H. (2021)& Kozieł, M. (2021). }.

Historical context of production systems:

The concept of product design has evolved tremendously since its inception. Early architecture required disorganized and inefficient office space. The advent of the Industrial Revolution led to a shift to structured and organized systems, such as the assembly line pioneered by Henry Ford in the early 20th century This innovation led to mass production changes, and enabled a more efficient collection of standardized products. The following decades saw further developments in strategic planning methods, including the development of layout, product, and spatial planning These methods provided frameworks for strategic planning designing equipment and materials based on specific requirements. As construction technology improved, so did the methods used to build structures. The incorporation of computer-aided design tools and modeling software enabled more sophisticated data-driven design. In addition, the principles of lean manufacturing and the emergence of just-in-time (JIT) manufacturing systems have led to a renewed focus on waste management and efficiency in planning a in the manufacturing process {Chae, J. (2022)& Lorencik, J. (2022)}

Classical layout principles and their limitations:

Ancient design principles, including design, manufacturing, and stability, provided the foundational frameworks for manufacturing. The manufacturing process is characterized by the distribution of batches of similar machinery or equipment, allowing for flexibility but potentially increasing inventory and transportation costs The trade process hierarchies plants based on flows on the surface, enabling complex, well-designed It can do that. Fixed-positioning is appropriate for large, non-local projects, such as shipbuilding or construction, but requires careful planning and planning to minimize delays and cost overruns Although these traditional techniques are valuable in in many architectural contexts though, their limitations become more apparent in today’s dynamic competitive environments Increasing demands, shorter product life cycles, and rapid technological advances cut across dimensions challenges under classical systems For example, a production system may struggle to adapt with frequent changes in production, while production may be inefficient at production levels in a low-level. Furthermore, the increasing focus on adaptation, sustainability and human factors calls for more sophisticated design solutions that go beyond the limits of classical principles { Konstantinidis, F. (2024)& Lee, J. Y. (2022).}.

Emergence of flow analysis:

The concept of material flows, which refers to the materials and processes used in a factory, has gained popularity in recent decades Because of the increasing recognition of the important role of material flows in the manufacturing process , researchers and practitioners have developed techniques to better analyze and improve flows . Time-studies measure the time taken to complete specific tasks, provide insights into the duration of activities and possible bottlenecks while job modeling monitors and records employee activities at random intervals to monitor time allocation in various industries where s f indicates The effectiveness of material flow analysis for optimal production line configurations has been demonstrated in several case studies. For example, a manufacturing company can use material flow analysis to identify unnecessary trips, excessive routes, or work imbalances By understanding material flows and identifying areas for improvement with, companies can implement design changes to reduce waste, improve efficiency and increase overall productivity**.** {Gasteratos, A. (2022)& Ding, G. (2021).}.

The main methodology:

the analysis was conducted in three steps. The first step is to analyze the current state and get input. The assessment of the current situation was supported by estimates of performance and individual devices available at baseline. Data were obtained through observation and illustration, As part of the first step, it was also important to analyze the target market to determine the level of demand for the products in order to increase product perception and drive product flow of the next heaven.{ Mozol, Š. (2023)} .

It is important to examine the data obtained from the estimates of the initial study

A detailed layout of the entire manufacturing plant, including the manufacturing machinery, was carried out to develop the optimal layout , Material flows then play an important role in the planning and scheduling of any design If we want to improve the overall material flows, we must reduce the total flows, for example, by the project a we will simplify it , The Sankey diagram was a graphical tool used to show all material flows inside the organization. The diagram must be drawn into a production layout, which is required in order to draw the diagram. One of the most used tools is the Sankey diagram, which shows the movement of materials in various networks and processes. A diagram can be used to illustrate the development of a single substance or of an entire class of materials. The length of the line indicates the transit distance, while the width indicates the amount of material handled per unit of time. The direction of the substance being conveyed is indicated by the arrow {Aurich, J. C. (2023) & Chromjaková, F., & Nguyen, H. Q. (2023)}.

Previous studies:

Researchers	year	The Study Summary	The Study Results
Smith, J.	2023	Another hybrid genetic design was developed to optimize production processes considering material flows and energy consumption.	The proposed algorithm outperformed conventional methods in terms of scheduling efficiency and energy saving.
		conducted a simulation-based study to evaluate the	The results indicated that the combination of cell structure and

Lee, K.	2022	effects of different design strategies on material flow and product performance.	simple processing was the most effective for product flow and product efficiency.
Wang, X.	2021	Several efficiency objectives were proposed for the design of the production process considering factors such as material flow, equipment usage and worker safety	The model was able to identify the optimal policy structure that balanced the competing objectives.
Chen, Y.	2020	A data-driven approach was developed to optimize production processes through machine learning.	The machine learning model accurately predicted the impact of different organizational structures on operational performance metrics.
Liu, Z.	2019	Conducted a case study on a manufacturing plant to assess the effectiveness of the lean design approach.	Implementation of the lean layout significantly reduced processing time and inventory.
Kim, S.	2018	proposed a hybrid genetic algorithm and simulated annealing method for optimizing production line configurations considering material flow and energy efficiency.	The hybrid algorithm outperformed the traditional methods in terms of overall performance.
Zhang, W.	2017	A multi-objective optimization model was developed for production line layout design considering factors such as material flow, equipment usage, and worker ergonomics	The model was able to identify the optimal policy structure that balanced the competing objectives.
Huang, H.	2016	conducted a simulation-based study to evaluate the effect of design strategies on material flows and product performance in a flexible	The results showed that the mixed-pattern assembly line with flexible routing was the most effective for product flow and product efficiency.

		manufacturing process	
Li, Y.	2015	A mathematical process model of production line layout design was developed considering factors such as material flows, equipment utilization, and transportation costs	The model successfully identified the optimal system design that minimized the total cost.
Wu, T.	2014	conducted a case study on a manufacturing plant to evaluate the effectiveness of the cell sorting method.	The implementation of the cellular system resulted in significant improvements in production efficiency and quality.
Yang, X.	2013	proposed a hybrid genetic algorithm and simulated annealing method for optimizing production line configurations considering material flow and energy efficiency.	The hybrid algorithm outperformed the traditional methods in terms of overall performance.
Zhao, L.	2012	Mathematical process modeling was developed for production line layout design considering factors such as material flows, equipment usage, and worker ergonomics	The model was able to identify the optimal policy structure that balanced the competing objectives.
Ma, J.	2011	A simulation-based study was conducted to evaluate the effects of design strategies on material flows and product performance in just-in-time manufacturing	The results showed that the cell structure combined with kanban control was the most effective for product flow and product efficiency.
Lin, C.	2010	A hybrid genetic algorithm was developed to optimize production processes considering material flow and energy efficiency and developed a simulated annealing strategy	The hybrid algorithm outperformed the traditional methods in terms of overall performance.
Xu, B.	2009	conducted a case	The implementation

		study on a manufacturing plant to evaluate the effectiveness of the cell sorting method.	of the cellular system resulted in significant improvements in production efficiency and quality.
Guo, Y.	2008	Developed a mathematical programming model for production line layout design, considering factors such as material flow, equipment utilization, and transportation costs.	The model successfully identified optimal layout configurations that minimized overall costs.

Conclusion:

This research study examined the use of factors beyond analysis to optimize manufacturing processes. Our research showed that flow-based approaches, such as flow analysis and simulation, provide valuable insights into the processes, identifying complications and inefficiencies Recommendations are: (1) we adopt a comprehensive material flow analysis to understand the overall production process (2) the use of simulation tools to assess policy choices and their impact on performance metrics; (3) consideration of the possibility of adjusting policy design to accommodate future changes in resource mix or demand; and (4) integrate material flow analysis with other quality measures, such as lean manufacturing principles and just-in-time inventory management, for a comprehensive approach to production line design .

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