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Litrature reviewEnhancing Manufacturing System Performance through Modeling and Simulation

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Abstract

This paper delves into the design and development of various activities that underscore the application of simulation capabilities as a tool for facilitating continuous improvement in manufacturing processes. It primarily focuses on analyzing standard approaches to modeling production systems. Simulation proves to be a potent tool for companies, enabling them to save both time and costs.Simulation serves multiple purposes, not only in measuring plant performance but also in comprehending the behavior of existing systems, assessing various operational strategies, or allowing users to simulate operations without disrupting the system itself. By employing simulation methods, numerous advantages can be realized, including reduced time spent on factory layout rearrangement, cost savings, increased profitability, enhanced productivity, decreased idle time, reduced lead time, and more.

Keywords:

Simulation and Modeling: Model of layout; Production Processes.

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1. Introduction

TheSimulation involves creating a model of a process and then conducting experiments on the model to assess its behavior under different conditions. It's a method used to design a model of a real system and perform experiments with it to understand system behavior or evaluate various operational strategies. Simulation isn't limited to industrial applications; it can be utilized across various sectors such as services, education, entertainment (movies and games), training, and more.Once a model is validated and the actual system is established, simulations can be used to study the current layout of a shop floor to identify opportunities for performance enhancement.

Simulation allows users to gain insights from operating target equipment without risking damage to the equipment or disruption to the system. It can expedite design cycles, reduce costs, and augment knowledge.Productivity, typically defined as the ratio of output to the resources used in production, varies in meaning depending on context. In industry, productivity often refers to departmental effectiveness or output over time. Improving productivity involves optimizing resources like labor, capital, materials, and machinery across different organizational frameworks. Plant layout improvement is one strategy to address increasing industrial

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productivity.Various software programs, such as FlexSim, AnyLogic, Arena, Process Simulate, and Simio, are tailored for simulating production processes. These tools aid in Industrial and Systems Engineering solutions for diverse service and production systems.The challenges tackled in this study reflect the recent advancements in simulation techniques within Manufacturing Systems over the past five years. Contrasted with prior research from 2014, this paper delves into the evolution, progress, and contemporary technologies of simulation tools. Moreover, it outlines future trends while providing an extensive historical analysis. Undoubtedly, simulation's role in the design and operation of Manufacturing Systems has undergone significant transformation in recent years, fostering new avenues for research and analysis.

Digitalization has emerged as a pivotal factor in shaping the factories of tomorrow. However, Digitalization encompasses a broad spectrum of topics, and to accurately assess its impact on simulation, further exploration of cutting-edge digital technologies is crucial. Thus, this paper concentrates on scrutinizing newly emerging technologies, such as Cyber-Physical Systems (CPS), Internet of Things (IoT), Cloud Computing, Design of Manufacturing Networks, Augmented and Virtual Reality (AR & VR), Hybrid Simulation, and Digital Twins. The Current Status and Future Trends', delves into various aspects of simulation within the product and production lifecycle, while also exploring the realm of research pertaining to the Design and Planning of Manufacturing Networks, Hybrid Simulation, and Digital Twins within the context of the Virtual Factory paradigm, thereby delineating new research avenues within the field of Simulation.

Desirable features of simulation software include user-friendliness, modular construction, customization options for users to incorporate their routines, material-flow capability, generation of standard output statistics (e.g., cycle times, utilization, wait times), graphical display of product flow with animation, among others.Advantages of simulation software include its independence from the real system, aiding in understanding system details, providing numerical data for different scenarios useful in engineering solutions, offering a more realistic replication of the system compared to mathematical models, and enabling transient period analysis.However, simulation software also has its drawbacks, such as potential reliability issues, time-consuming model structuring, potentially less accuracy compared to mathematical models due to random number generation, and a lack of standardization in problem-solving approaches.

2. Litrature Review

Luis Gonzaga Trabasso et al. [1] introduced a paper focusing on a Proposal Simulation Method aimed at Continuous Improvement in Discrete Manufacturing. Their work delves into systematic analysis concerning layout modifications conducted during kaizen events in discrete manufacturing firms. Given the necessity for flexible manufacturing systems in meeting fluctuating product demand while maintaining quality and time-to-market efficiency, many companies have turned to Kaizen events for shop floor enhancements. These events, characterized by direct experimentation and trial-and-error cycles, can benefit from collaborative tools for manufacturing environment simulation, aligning with corporate practices. The paper's primary contribution lies in systematically merging a traditional discrete event simulation method with the Kaizen event approach.

N.H. Saad et al. [2] presented a paper on manufacturing plant performance analysis using simulation techniques. Their focus is on the management process of discrete event simulation projects. Following the general principles recommended in the PMBOK, they aim to integrate simulation methods to enhance project execution performance. Their paper outlines a management plan based on PMBOK's knowledge areas, emphasizing steps involved in project management to improve execution efficiency.

Mateusz Kikolski et al. [3] discussed the identification of production bottlenecks using Plant Simulation software. They emphasize the importance of pinpointing workstation delays before implementing improvements. Their approach aligns with the Theory of Constraints, beginning with bottleneck identification as the initial stage in constraint management. They outline subsequent stages for managing constraints, which can be applied in computer-assisted simulation models.

Dominika Łęks and co-authors [5] explored the application of FlexSim for modeling and simulating the production process. They highlight FlexSim's utility in modeling, simulating, and visualizing business processes, particularly in addressing inventory and work in progress (WIP) challenges, optimizing production lines, and managing bottlenecks. FlexSim's capability to create and animate 3D models and develop models directly using C++ is emphasized.

Akshay D. Wankhade et al. [6] presented a case study on productivity improvement through optimal plant layout utilization. Their research focuses on small industries, aiming to enhance efficiency and reliability. By optimizing plant layouts and addressing material flow obstructions, they aim to maximize productivity. The study underscores the complexity of optimization due to various factors such as workflow and machine relationships.

Jianliang Peng [7] discussed the simulation and optimization of production logistics system layout using Flexsim. Their work aims to understand statistics and dynamic performance in material transport and storage processes. They highlight Flexsim's role in facilitating effective layout design optimization and system commissioning, thus saving time and resources.Vijay Bhaskar and colleagues [8] presented a paper on modeling and analyzing manufacturing plants using discrete event simulation. They highlight simulation as a representative model for real situations, offering insights into potential outcomes under various operating conditions.

E. Tokgoz et al. [9] shared their experience in industrial engineering and simulation using FlexSim software. They emphasize the role of simulation software in optimizing complex processes, systems, or organizations, aiming to eliminate waste and improve efficiency.Liu Haidong et al. [10] discussed workshop facility layout optimization design using SLP and Flexsim. Their comprehensive approach utilizes simulation software to improve production efficiency, streamline logistics, reduce carrying distances, and optimize space utilization in workshop facilities.

3. Simulation Model

A simulation model serves as a stand-in for real-world experimentation with manufacturing systems, which can often be impractical or costly. Consequently, it's crucial for a simulation analyst to assess whether the simulation model accurately mirrors the system under study, in other words, whether the model is valid. Here are some key ideas and techniques for determining the appropriate level of detail in validating a simulation model and for creating a highly credible model:

Clearly define the issues to be addressed and the performance measures for evaluating system design at the outset of the study.Gather information on system layout and operating procedures by consulting with experts from each part of the system.Document all assumptions and data summaries in an assumptions document, which serves as the primary documentation for the model.Regularly engage with managers to ensure the correct problem is being addressed and to enhance model credibility.Conduct a structured walk-through of the conceptual simulation model, as outlined in the assumptions document, before key project personnel.Use sensitivity analyses to identify crucial model factors that require careful modeling.Simulate the existing manufacturing system and compare model performance measures with those of the actual system.

Most organizations that simulate manufacturing or material-handling systems opt for commercial simulation software products over general-purpose programming languages. The primary criteria for selecting simulation software are typically modeling flexibility and ease of use. Simulation languages are software packages where model development involves programming. While traditionally programming meant writing code, there's been a shift toward graphical model-building approaches. Good simulation languages offer modeling flexibility but require programming expertise.

Manufacturing simulators are geared toward manufacturing and require minimal programming compared to simulation languages. However, built-in modeling constructs like machines, parts, and conveyors may not perfectly reflect real-world complexity. The distinction between simulation languages and simulators has blurred over time, with languages adopting graphical interfaces for usability and simulators incorporating programming for modeling flexibility.Since simulation models of manufacturing systems are driven by random samples from input probability distributions, output data are also random. Therefore, it's essential to accurately model system randomness and design and analyze simulation experiments properly.

4. Conclusion

The study delved into the management procedures involved in discrete event simulation projects. As a result, we considered the specifications stemming from such simulation projects and proposed collaborative research areas that integrate principles of project management into simulation projects. The Flexsim program emerged as a potent analysis tool aiding engineers and planners in making informed decisions regarding system design and operation. The objective of our paper was twofold: to elucidate the challenges inherent in modeling and simulation and to outline the fundamental tools employed in this process.

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