Paper Title: **Study of Production Scenarios with the Use of Simulation Models**

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Summary: Research programs aim to study phenomena and processes using various methods, including practical observations and theoretical analyses. Computer simulation is an effective research method that reflects the studied phenomenon in a computer program, or computer model, created using a mathematical model. This method involves formulating a problem, creating a mathematical model, formulating a computer program, checking the model's appropriateness, planning simulation experiments, and performing a simulation process and analyzing the results. Simulation models are used to reduce the risk of failure and implement significant changes in manufacturing systems. Simulations can be divided into three types: understanding system principles, facilitating decision-making, and training people in decision-making. Production process simulations are based on virtual models to solve problems during the manufacturing process.

Motivation: Contemporary production involves a wide range of products, reduced life cycles, and reduced costs. Simulation studies help in real-time data collection and planning. Implementing computer solutions in production engineering reduces costs and time, and aids in effective selection of manufacturing strategies.Simulation, as each method, has its pros and cons. Benefits of a simulation:

- a simulation allows for arranging a form of a system with the use of experiments directly conducted on the studied model it may be applied for analysing large and complex decisional problems that cannot be solved with the use of other methods
- it allows for quick preparation of decisions thanks to analysing the effects of experiments conducted for many alternating periods
- it provides an answer to the “what-if...?” questions – simulation experiments allow for analysing various decisional alternatives
- it allows for analysing correlations of the effects of variable elements of a model that can influence the decision chosen in extreme conditions.

However, drawbacks include long preparation time, uniqueness of models, inability to analyze other issues, and need to account for specific and changeable conditions.

Contribution: Siemens' Tecnomatix Plant Simulation is a tool that combines technology, production engineering, and logistics to create simulation models for the entire manufacturing process. It allows for simulations and product analysis throughout the entire process, ensuring sustainable production planning and optimization of existing processes. Enterprises can perform tests and experiments according to selected scenarios, specifying the best strategies for increased efficacy, cost reduction, time-saving, and quality targets. This eliminates the need for tests in the production hall. Plant Simulation also helps in observing and eliminating potential problems, minimizing investment costs, and optimizing existing logistics and production systems by using modifications previously tested on the simulation model.

Methodology: The study uses Tecnomatix Plant Simulation software to create a production system model based on a real production department. The input data is determined based on technological data and material flow during production, with a focus on processing individual components. The simulation model is used to study the impact of changes in batch size on system efficiency. Simulation experiments are conducted to understand the effects of changing batch sizes on system efficiency. The simulation model accounts for conditions such as machine park and process topology, station parameters, simulation timing, individual activities and components, and batch volume. The tool allows for multiple simulations and observation of workstations and the system. The analysis involves three processing stations and an assembly station within a technological line with materials from one warehouse. The volume of batches in the basic process equals 30 items of each of the three components. Variants with larger and smaller batch numbers are also considered. The study found that the number of manufactured final products decreased, but the efficiency of workstations increased. Machine 1's workload increased from 80.78% to 82.33%,

machine 2's increased from 37.57% to 38.13%, and machine 3's increased from 63.38% to 64.84%. The assembly station's timing of use fell from 58.13% to 51.55% due to longer waiting times for all components.

Conclusion: The study investigated production scenarios using simulation models built in a Tecnomatix Plant Simulation system. Three scenarios were examined, and the analysis revealed that the highest efficiency was achieved within the system providing elements in 15-item batches. The study also found that increasing the batches of entered components lowered production efficiency. Simulation models are useful tools for verifying processes and allowing clear visualization of selected assumptions. Databases created for simulation models can serve as a basis for developing real processes. However, simulation experiments do not excuse managers from decision making. Simulation models provide data and information on processes that assist in making the best decisions. They facilitate numerous repetitions with the same conditions or those adjusted to research needs. Simulation models allow for preliminary analysis of process development and verification of suggested changes. The analyses required adequate software, involving one of the existing systems for designing and optimizing virtual models of production processes. The information presented in this article provides a basis for further work on modeling and simulation methods, and computer simulation may become a reliable tool for designing and studying manufacturing processes.

Limitations:

Limitation 01: Potentially long time of model preparation and every simulation model is unique – its solutions cannot be used for analysing other decisional issues

Limitation 02: it allows for preparing alternative decisional solutions in subsequent experiments, but these are not optimal solutions for all conditions.

Limitation 03: simulation models generate answers to the questions related to specific and changeable conditions. The decision□maker, while preparing decisions, needs to account for all circumstances and limitations of the analysed decisional variants.

Synthesis: This paper explores the use of simulation models in analyzing and optimizing production scenarios across various industries. It highlights the importance of simulation models in addressing operational excellence challenges and provides a virtual platform for replicating real-world production processes. The paper discusses the methodology used for developing and implementing simulation models, including discrete-event simulation, agent-based modeling, and system dynamics. The selection criteria for the most suitable simulation approach are discussed, considering factors like system complexity, data availability, and modeling objectives. The paper also discusses the practical applications of simulation models in diverse production settings, showcasing how they have been used to optimize production schedules, evaluate resource allocation strategies, and improve overall system performance. The paper also discusses the integration of emerging technologies like artificial intelligence and machine learning with simulation models to enhance predictive capabilities and decision support systems. The synergy of simulation and advanced analytics offers a holistic approach to understanding and optimizing complex production scenarios in the era of Industry 4.0. In conclusion, the study emphasizes the significance of simulation modeling as a valuable tool for studying and optimizing production scenarios, emphasizing the practical applications and benefits derived from employing simulation models in decision-making processes. The paper concludes with recommendations for future research and the continued evolution of simulation modeling techniques to address evolving challenges in production systems.