"Assessing Factor Relevance in Production Facility Simulation Models Applied to an Ultra-Precision Production Environment"

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Precision manufacturing involves complex, multi-step production processes that are challenging to optimize. This complexity is heightened by the simultaneous production of multiple products, often requiring overlapping resources. Additional factors such as planning conflicts, outsourcing issues, material shortages, and overlapping machine usage further complicate the process. Implementing changes to existing production strategies entails considerable risks, including potential income loss, reduced production yields, and increased failure costs.

Simulation software offers a viable solution to address these challenges. By analyzing various scenarios, this software enables stakeholders to assess the risks and benefits of proposed changes to production processes. Developing an effective simulation model requires thorough analysis of production steps and facilities. Simplifications are often necessary to enhance model performance and clarity; however, these must be implemented carefully to maintain the model's reliability. The results of such simulations should be validated and interpreted cautiously, with trends in the data being more significant than precise values.

One example of such technology is Siemens' Plant Simulation software, a Discrete Event Simulation (DES) tool. DES focuses on modeling events such as the movement of parts and associated intervals, rather than exact processes, geometry, or materials. This approach enables the simulation of years of production within minutes, allowing for rapid evaluation of various scenarios. These scenarios might include changes in machine availability, production schedules, or process modifications. Insights gained from DES can drive improvements in production processes and facilities, such as increasing throughput, reducing machine utilization, and lowering overall costs.

Optimization of a production process is a complicated ordeal. Optimizing for efficient production is often the greatest way to ensure competitiveness in the market, especially in high-pressure environments where dynamic market demands are at play. The quest for efficient processing whilst not foregoing other factors, quality or sustainability for example, presents multifaceted challenges which require tactical analysis and strategic frameworks in order to succeed. Modern production processes involve intricate networks of machinery, human factors, supply chain and software. Often, these elements are approached on an individual basis. Whilst this allows for a system which is often clearer and less convoluted, it does limit the scope at which a system is analyzed. Since these systems are often interdependent, a thorough understanding of the interplay of these systems and their interactions as inefficiencies in one system can propagate across the factory. Process planning and mapping are of vital importance to a consistent process output. A careful selection of planning parameters is required to ensure that production thresholds are met, and the system is working efficiently.

In the industry 4.0 framework, large-scale simulations have proven to be at the forefront of accelerating the optimization of production. Simulation modeling is the primary way in which performance of a system, resource allocation and variances in operating procedures can be analyzed in a cost-effective and time-efficient way. These simulations offer insight into areas of concern which are hard to spot, allow for self-reinforcing mechanisms for data analysis, simulation and optimization. These simulation programs can be made into digital twin environments, matching real-world production environments in both functioning and state. When optimally integrated, bidirectional data streams which couple physical data streams to digital counterparts allow for up-to date modelling and accurate decision making based on scenarios drawn from current plant states.

Using available data, investigating plausible model settings and determining proper methods, a true-to-life DES-model can be made of the complete production process of a component. This model might then be used to investigate system behavior, bottlenecking tendencies, capacity requirements and the like. Experimental runs (deviating from the baseline model in terms of production times and/ or resources) can then be used to determine the impact of the changes applied to system. This allows for great insight into the overall impact the accuracy of a parameter has on the system, in turn enabling educated choices to be made with regards to real-world data gathering priorities. These insights might be visualised in the form of graphs, surface plots (3D) with time as a variable or viewed in the 3D modelling environment in (real-time or sped up).

The production steps identified as most critical in the system cause the biggest shifts in model behavior and therefore must be given the highest priority for future data-gathering endeavors. Factors which influence the model performance and behavior the most can be condensed down to those steps which:

1. Take up the largest production times whilst having a limit to the number of parts which can be produced at once
2. Impact overall working/ operational hours of the system
3. Change the model behavior, for example by moving the saturation point of the system
4. Limit MU flow through the system

Changes such as differing operational hours, resource allocation or machine timing have all been identified with possible opportunities for optimizing the production process.