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Modelling, simulation and optimization of the materials flow of a multi-product assembling plant

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Abstract

Various dynamic factors impact the movement of materials within a manufacturing environment, increasingly becoming complex for multi-product assembling plants owing to the multiplicity and interconnectedness of these factors. Analyzing these factors can be equally complex, requiring modelling and simulation tools. This paper looks at the modelling and simulation of the materials flow of a multi-product furniture assembling plant to develop an efficient system that accomplishes timely product deliveries at minimal cost. Generic simulation models based on 2 products were developed and constructed using Arena\textsuperscript{®} Simulation Software. Following the simulation experiments and implementation of the results, the average hourly throughput was significantly increased and additional space to store materials prior to processing at workstations was created. The generic models were compatible with the company's other products and hence useful for the company's production planning and scheduling.

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1. Introduction

The key objective of any manufacturing company is to maximize on profit margins, hence the production function of manufacturing companies holds the key to the success of these organizations [1]. The case study in this research is a furniture manufacturing and timber processing company in which production flows are characterized by many dynamic and complex factors which usually result from the unpredictable manner in which orders are placed let alone the dynamic flow of materials in the factory, often leading to the failure by the company to meet customer orders on time. This was evidenced by the variability of the average number of products produced per week over a period of 3 years from 2009 to 2012. Manufacturing companies have realized the need to invest in state-of-the-art and modern methods of manufacturing coupled with computer integrated manufacture for accuracy, consistence and repeatability [2]. Most indigenous owned manufacturing companies in Zimbabwe evidently lagged behind in the acquisition of modern equipment and systems owing to limitations in financial capacity. This was exacerbated by the global recession that affected many developed and emerging economies from around 2008, especially in Sub-Saharan Africa because of weak global linkages [3]. Local companies in Zimbabwe at that time focused on production, leaving very little or no funds for research or new techniques. In the absence of proper working systems and production schedules, a lot of the work was being carried out haphazardly, resulting in delays in meeting customer orders. Following an ‘as-is-analysis’, other problems identified included; old and obsolete equipment, thus creating bottlenecks in production, backtracking and crisscrossing of process flows, resulting in long distances travelled by parts and contributing to delays in production, hence costly products. Simulation models can be built to study the effectiveness of different forms of materials handling equipment by considering their detailed parameters such as speed, process paths and control logic. This paper looks at the modelling and simulation of the company’s multi-product furniture manufacturing and assembling plant with the objective of appropriately scheduling production using the right product mixes and process flows through optimizing materials flow to accomplish timely product deliveries and thus achieve sustainable operations. Most simulation models are not generic but specific for each system that is being studied. Although the two models in this paper were developed for two products using a limited simulation software, they were generic in that only slight modifications were required in order to experiment on other products at the company.

2. Background to modelling and simulation

Models to be simulated can represent a real-world process more realistically because fewer restrictive assumptions are required [5]. Consequently, simulation provides a more realistic replication of the dynamic nature of the flow of materials within a factory rather than to rely completely on static analysis, which can be misleading in establishing a good system [6]. Production schedules, variation in product mixes, availability of materials handling equipment, and random breakdowns create varying loads on the system [4]. Static and dynamic analysis should both be utilized in evaluating the efficiency of a plant layout in terms of flow of materials for complete, accurate and timely analysis. More essentially, the simulation approach does not disrupt the on-going activities on the factory setup but it provides a problem identification and solving tool that is flexible and less costly than physical prototyping and experimentation. The approach also allows time compression, whereby simulation accomplishes in minutes what might require years of actual experimentation. One way of accomplishing timely product deliveries is through designing an efficient materials flow system by modelling and experimenting on product mixes depending on orders that would have been received and thus assisting in production scheduling. Modelling and simulation normally starts with the proper identification of the problem which entails specification of objectives and identification of the relevant controllable and uncontrollable variables of the system to be studied [7, 15]. Due to the nature and complexity of simulation to problem-solving, it should really be used as a last resort, after ascertaining that other approaches such as queuing theory cannot be used to solve the particular problem, a vital aspect in the initial stages of modelling and simulation. [8, 9]. The first step in constructing a simulation model is determining which properties of a real system should be fixed (parameters) and which should be allowed to vary throughout the simulation run (variables). Variables for models are specified by either of the two categories of distributions used for simulation; empirical frequency distributions and standard mathematical distributions. Such distributions have to be determined by direct observation or detailed analysis of records but other situations can reasonably be assumed to closely approximate a standard mathematical distribution such as normal or Poisson [10, 16]. The length of the simulation runs depend on the purpose
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