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A simulation based comparison: Manual and automatic distribution setup in a textile yarn rewinding unit of a yarn dyeing factory

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ABSTRACT

This paper aims to explain the production flow and the distribution logic of bobbins for rewinding process in a yarn dyeing factory, comparing the different scenarios of production (manual and automatic) using the computer simulation tools. The goal of this project is to build a model in which all the involved processes can be simulated with the consideration of all the parameters and constraints. The simulation model is used as a tool for the comparison of present manual setup and future automated setup for the production management of bobbin distribution in yarn rewinding process in terms of delays and costs. Since, the manual operation involves defaults, improper time management, errors and with the growing competitiveness globally, the companies in Europe need to automate as much as possible their production lines. The expected impacts are to increase the productivity and profitability, to have the possibility to customize the production, to develop production tools, implementation of the lean manufacturing tools.

1. Introduction

Industries in Europe are facing with pressures to reduce their production costs and to increase the efficiency of their existing staff or equipment. The customer demand is becoming more personalised which requires industries to produce small lot size, in short lead time and in unique specifications. Thus the only way for a producer is to improve their productivity, reactivity, flexibility, and quality.

The trend of mass customization and personalized production leads to fundamental changes in the material flow, plant layout and work organisation [1]. Producers have to rely on smart automation of their production system coupled with an adequate use (qualified staff, computer aided setup), efficient and intelligent planning management, and overall supervision and decision systems. This could be very challenging for some companies such as textile companies, and more particularly dyeing and winding production units which are commonly faced with large batches, long process and setup times. Therefore, it is now the requirement to determine the best possible solution and find the feasibility of such change in a very short time. This project concerns the development of automated feeding of winders in order to fight against outsourcing caused by the cheaper workforces and to fight with the lost employment in the textile sector in Europe.

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The concept behind this project is based on automation, optimal flow management (internal supply chain management), lean tools and setup comparison of the yarn rewinding processes (manual and automatic) with the support of modelling and simulation. Companies with the most optimised and automated production tools will be privileged in order to obtain the best product at an acceptable cost.

The objectives of this paper are to identify and to analyse the present scenario of the supply chain of the production plan, to develop a standard simulation model with consideration of all parameters and constraints, to identify Key Performance Indicators (KPI's), to analyse the results obtained from the simulations, to simulate and analyse different scenarios (manual and automatic input of bobbins), to compare and analyse the results obtained from the simulated scenarios and to optimise and implement the results in the actual production.

The paper is structured as follows. In Section 2, an overview of the existing literature and case studies related to this work is presented. In Section 3, the methodology of this work is described along with the detailed definition of the problem, parameters, constraints and simulation model logic. In Section 4, the validation of the simulation model and the experiments done (testing scenarios) in this work are explained. In Section 5, the results obtained from the experiments performed are analysed and formulated (comparison of results obtained from manual and automatic process simulation models). An overview of the future scopes and development of this work is explained with a global conclusion in the Section 6.

2. State of the art

2.1. Simulation in manufacturing

The simulation is widely recognised as the best and most suitable methodology for investigation and problem-solving in real-world complex systems in order to choose correctly, understand why, explore possibilities, diagnose problems, find optimal solutions and transfer R&D results to real systems [2]. There are various types of simulation models. The discrete event simulation involves the modelling of a system as it progresses through time and is particularly useful for modelling queuing systems [3]. There are many examples of queuing systems: manufacturing systems, banks, fast food restaurants, airports, etc. A major facet of discrete event simulation is its ability to model random events based on standard and non-standard distributions and to predict the complex interactions between these events. For instance, the effects of a machine breakdown on a production line can be modelled.

There are many factors which contribute to the use of the simulation in the manufacturing. The advantages include analysing the manufacturing processes, ease of use, flexibility, ability to model dynamic and stochastic nature of production systems, ability to test various scenarios of production, layout design, logistics, material handling, etc. which lead us to have a close insight into the performance of a manufacturing company [4–8]. In the following paragraphs, few successful examples concerning the applications of simulation in the manufacturing sector are discussed.

The factors that affect production flow time are explained using the simulation in [5] with the parameters which include the comparison of the two different layout plans. The simulation included the scheduling rules, machine breakdowns, batch sizes and transporters. The work demonstrated the use of simulation to play with the different setting level of manufacturing parameters which affect the performance of a facility. The application of simulation to study and analysis of internal logistics in a chemical manufacturing plant is demonstrated in [6]. The flow of materials involves a continuous flow of materials, such as liquid, gas or solid through the manufacturing and logistics processes. With the aid of simulation the capacity requirement for logistic operations were determined. The model described is extremely flexible in terms of the user's ability to make changes for different scenarios. Most of the input parameters and data are table-driven. Users can test different scenarios without changing the simulation model, and the model generates several useful reports automatically.

The concept of simulation in manufacturing can also be seen in case of a very complex system like in an automobile assembly plant, the authors of [7] demonstrated a data driven simulation model. The significance of this methodology adopted is that it provides a rapid prototyping, capability for production system modelling and enables a quick analysing and remodelling capability to respond to the fluctuation of demands. The simulation modules for assembly line and material handling system of the plant floor are analysed and are developed where the data driven approach is implemented to enable the modelling and simulation of the complex assembly plant in a real time like condition and therefore effectively improve the responsiveness and flexibility of the production line. The methodology used for simulation is very logical in relation to the development of a simulation model to analyse the complex production. The steps involved in the respective manner are: data preparation, model generation, model validation and scenario simulation. The floor operations, production type, assembly line configuration and material handling processes are defined for setting the parameters in the simulation model. The modules developed for the simulation are assembly line models and the material handling modules which are interlinked to each other.

The simulation based production decision enabled a lot of automobile manufacturers to quickly adjust the assembly lines for achieving maximum labour utilisation and lowering production cost using the concepts of Lean, JIT (just-in-time) while satisfying the market demands.

The application of simulation in manufacturing can be seen in case of some modern complex concepts like backward on-line change scheduling in production [9] where the insight is the WIP management, lean processes and reduction of idle times. Also, in the case of the analysis of lot streaming in job shops with transportation queue disciplines where there are