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BALANCING ASSEMBLY LINE WITH A SIMULATION-OPTIMIZATION MODEL: A CASE STUDY IN THE FOOTWEAR INDUSTRY

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ABSTRACT

Fashion is one of the world's most important industries, driving a significant part of the global economy representing, if it was a country, the seventh-largest GDP in the world in terms of market size. Focusing on the footwear industry, assembly line balancing and sequencing represents one of the more significant challenges fashion companies have to face with. This paper presents the results of a simulation-optimization framework implementation in such industry, highlighting the benefits of the use of simulation together with a finite capacity scheduling optimization model. The developed simulation-optimization framework includes the conduction of a scenario analysis that compares production KPIs (in terms of average advance, delay and resource saturation) related to different scenario that include or not one or more type of stochastic events (i.e. rush orders and/or delays in the expected critical components delivery date).

1 INTRODUCTION

Assembly line balancing and sequencing represent one of the most important challenges widely discussed in the literature. Even if several classifications and optimization models can be found, as a matter of fact, in not traditional industries, such the fashion one, where quality and craftsmanship are the main Critical Success Factors (CSFs), empirical rules and not optimal solution are still applied (d'Avolio et al., 2015). According to this, the work aims to present the result of a case study, where a structured framework able to optimize the production planning and scheduling of the production has been applied, with the use of a solver and a simulator.

2 PRODUCTION OPTIMIZATION IN THE FOOTWEAR INDUSTRY

The problem of the line balancing has been discussed several times in the literature. The first published paper of the ALB problem has been the one of Salveson (1955), who suggested a linear programming solution. Research on this topic has been increased with the development of new technologies, like the AI techniques, that enabled the possibility to solve complex problems. Nerveless, only few papers deal with the fashion industry (Sadeghi et al., 2018), whilst most of them are referred to traditional industries like automotive, especially when techniques, like JIT, are applied. Moreover, the use of the simulation is justify by the variability of the product demand (Fani et al., 2017).

3 MODEL DESCRIPTION

The simulation-optimization framework utilized within this work has been previously published by the authors in (Fani et al., 2017; Fani et al., 2018). The model is composed by an optimization tool, developed using an open source solver named OpenSolver (www.opensolver.org) and a commercial simulator named

Anylogic® (www.anylogic.com). The optimization model has been developed in order to fit the different companies' peculiarities including an OF defined as a combination of weighted parameters chosen by the single company and reflecting its CSFs. In fact, the weighted sum OF reflects the commercial agreement between these companies and the brands: different weights for different sub-objectives. Moreover, a solution implementable with an open source solver and a commercial spreadsheet has been chosen according to their low IT investment capability. Anylogic has been chosen for the possibility to implements different type of simulation approaches and for the easy interface with commercial databases.

4 RESULTS

Starting from the literature review previously described, the proposed framework has been used in order to resolve MALB problem of type F (i.e. MALBP-F), using the parameters rpbw (the resources balancing-related weight considering the whole resources pool considering the whole production plan) and rbw (the resources balancing-related weight considering the single resource r Є RR considering the whole production plan) in the linear model optimization and including the objective function to minimize the horizontal balancing. The elementary objectives included in the OF have been chosen because better fit the CSFs of companies working in the footwear industry, and they are the minimization of the delays and of the advantages. The results of the optimization model implementation have been validated comparing themselves to both the historical data and the production manager's experience. Simulation has been used in order to compare the KPI evaluated with an analytical optimization with the KPI obtained with statistical data. The pilot has been carried out in a footwear company producing leather shoes for a big Italian Luxury brand, and the working phase analysed has been the conveyor. In the optimization model, the cycle time and the number of stations have not been considered as variables because their values have been already defined at the tactical level. The reason why the mix balancing has been defined as a weighted part of the OF and not as a constraint is that it cannot be assumed that the demand is an exact multiple of the optimal balancing. The technique utilized to collect the data has been the one named Bedaux (Weatherburn, 2014). Every processing time has been recorded 10 times and then the standard time has been evaluated. In the end, the standard time has been defined as the registered time plus an extra-time considering: Increases for physiologic factors, Increases for wearying and Increases for unexpected events.

5 CONCLUSION

The present work describes the results of the application of a framework that combines simulation and optimization into a model for supporting production planning and scheduling in a fashion footwear company. In detail, once the optimized plan has been chosen, several sequencing rules have been simulated firstly in a deterministic and considering four different stochastic environments. Analyzing the deterministic scenario, one sequencing rule has been chosen and then it has compared with the four different stochastics scenarios. The results show how the presented simulation-optimization framework can be applied in not-traditional sectors (i.e. the fashion one), where quality and craftsmanship are the main Critical Success Factors (CSFs), and empirical rules and not optimal solution are still applied.

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