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Simulation optimization based DSS application: A diamond tool production line in industry

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Abstract

A diamond tool manufacturing system simulation is developed to predict the number of machines and the number of workers necessary to maintain desired levels of production for a company in Ankara, Turkey. The current manufacturing system is analysed by a simulation model emphasizing the bottlenecks and the poorly utilized machines. Validated simulation outputs are collected and used to build a multiple regression meta-model as a simulation optimization based decision support system (DSS). The proposed DSS involves analysis and evaluation of the system's behaviour through the use of a meta-model with an integrated optimization module. It enables the decision maker to perform sensitivity analysis by considering several combinations of decision variables. The aim of this study is two fold. The first is to represent a simulation optimization based DSS application for a real system by considering all the required steps. The second is to analyse the performance of the current production system and determine the optimum working conditions by simulation with greatly reduced cost, time, and effort.
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Keywords: Multi-stage multi-server production line; Multiple regression meta-model; Decision support system; Simulation optimization; Sensitivity analysis

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1. Introduction

In today's highly competitive industry, a company must be able to adapt to its customers' ever-changing needs and improve the quality of its products in order to survive. It is important that the company responds quickly to rapid changes in technology, demand fluctuations, and design changes. These needs have forced many companies to put emphasis on automated systems to improve productivity and quality, while reducing cost simultaneously. When the systems under investigation are complex—as is often the case in manufacturing environments—it becomes impossible to find analytical solutions. Because of the complex stochastic characteristics of such systems, simulation is used to predict their behaviour as a powerful management science and operations research (MS and OR) technique. In other words, simulation—an alternative method to analytic tools—overcomes the complexities of large-scale stochastic systems. However, the major drawback of simulation for practical applications is that it is computationally time consuming. This study demonstrates how the outputs from a complex DSS were transformed into a simple DSS and how a meta-model and an optimization module were integrated. Simulation models show the dependence between the controllable variables and the outcomes. Simulation models yield probabilistic (variable) outputs. A DSS is an interactive, flexible and adaptable computer-based information system that utilizes decision rules, a model, and a model base with a comprehensive database. Thus, a DSS supports a complex decision-making process and increases its effectiveness. Garry and Scott-Morton [9] and Keen and Scott-Morton [10] aid the decision maker in addressing unstructured or semi-structured decisions.

1.1. A case study: diamond tool production line in industry

A typical socket product is the main part of a diamond circular saw and ancillary equipment, which are produced on a multi-stage, multi-server production line at a diamond tool company. Socket production lines usually include multi-stage processes involving cold press, hot press, stoning and grinding stations where each station has multiple servers (identical machines). In other words, these production lines can be considered as a multi-stage, multi-server production line with variable processing times. In order to enhance the efficiency of the production line and to maximize throughput, it is desired to achieve the shortest production time in these stations. In general, the main problems on such production lines are the bottlenecks and low utilization rates at some stages. Therefore, a flow process analysis becomes necessary to achieve a balanced and efficient system—considering the number of machines and the number of workers. This is a very complex optimization problem and is considered to be an important management decision affecting the desired performance level.

This study was carried out at a diamond tool manufacturing company located in Ankara, Turkey. The company has been serving the mineral exploration sector by manufacturing diamond bits and ancillary equipment. The quantity of part types produced is based on the orders. This study investigates the required number of

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