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AUTOMATED SIMULATION-BASED WORKPLACE DESIGN THAT CONSIDERS ERGONOMICS AND PRODUCTIVITY

Harari, Y.[*,**]; Bechar, A.[**]; Raschke, U.[***] & Riemer, R.[*]
[*] Department of Industrial Engineering and Management, Ben-Gurion University of the Negev, Beer-Sheva, Israel
[**] Institute of Agricultural Engineering, Agricultural Research Organization, Bet Dagan, Israel
[***] Siemens Industry Sector, Siemens Product Lifecycle Management Software Inc., Ann Arbor, MI, USA
E-Mail: rriemer@bgu.ac.il

Abstract
When designing a workplace with manual material handling tasks, it is important to consider both production and ergonomics. We developed an automated workplace design methodology that addresses production and ergonomics for tasks involving a handled mass of up to 23 kg. This process combines optimisation and a Digital Human Modelling (DHM) simulation, which yield the production and ergonomic measures. The task cycle time in current DHM simulations is based on Predetermined Motion Time Systems (PMTS). To address reservations about the time prediction accuracy of PMTS, we developed a new time prediction model that takes the influence of the handled mass into consideration. Our model and optimisation process were evaluated by using a case study of a box conveying workplace design. The time prediction model results did indeed agree with the real mass handling behaviour. Three design approaches (objective functions) were compared: considering only production, only ergonomics and both production and ergonomics. Each approach resulted in a different optimal solution.
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Key Words: Workplace Design, Optimisation, Simulation, Ergonomics, Predetermined Time Prediction

1. INTRODUCTION

An important trend in industrial workplace design [1] is the growing focus on both economic and ergonomic measures [2]. Against this background, the most desirable design would be the one that gives a combination of the highest production rate (*PR*) [3] and a minimum risk for musculoskeletal disorders [4]. Because such disorders constitute a large financial burden on industries [5], many ergonomic assessment methods have been developed to reduce the risk of injury. Common ergonomic assessment methods include: the National Institute for Occupational Safety and Health (NIOSH) lifting equation [6], which determines the recommended weight limits; Lower Back Analysis (*LBA*), which estimates the spinal compression and shear forces acting on the worker's lower back [7-9]; and Rapid Upper Limb Assessment (*RULA*), which provides an assessment of neck, trunk and upper limb posture [10]. All these assessments can be executed using Digital Human Modelling (DHM) simulations, e.g., Jack™, AnyBody™, and Delmia™, all of which are effective for workplace design [11, 12]. By using DHM, it is possible not only to design a workplace but also to assess the effects of the workplace design by using operational and ergonomic measures [13, 14]. DHM software usually predicts the duration of tasks executed by a virtual worker using Predetermined Motion Time Systems (PMTS), such as Methods Time Measurement (MTM) and the Maynard Operation Sequence Technique (MOST).

However, several studies have questioned the prediction accuracy of PMTS as compared to the actual performance of real workers [15, 16]. Genaidy et al. [17], for example, concluded that one of the major disparities occurs in tasks involving the handling of a heavy