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New methodological framework to improve productivity and ergonomics in assembly system design

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ABSTRACT

This work analyses how ergonomics and assembly system design techniques are intimately related. It also develops a new theoretical framework to assess a concurrent engineering approach to assembly systems design problems, in conjunction with an ergonomics optimization of the workplace. Its purpose is to provide professionals with a new and detailed approach to assembly system design procedures that includes ergonomics issues.

The methodological framework offered takes into account technological variables (related to work times and methods), environmental variables (i.e. absenteeism, staff turnover, work force motivation) and ergonomics evaluations (i.e. human diversity) to create a comprehensive analysis.

At conclusion of the study, the work reports data and insights from two real industrial cases, where an advanced simulation software is used, to validate the procedure and support methodology applicability. *Relevance to industries:* This work provides an extremely valuable methodological framework to companies who recognize the link between assembly and ergonomics. The methodology underlines the necessity to analyze and classify the assembly system layout configuration in relation to both technological and environmental parameters- as reported in the framework.

1. Introduction and literature review

Generally, an assembly line could be dedicated to produce a single product model or multiple product models, where many items could be processed simultaneously in batches or handled in lot sizes of one item for each product model. Three main kinds of Assembly Line Balancing Problem (ALBP) are represented in literature (Becker and Scholl, 2006 and Scholl, 1995):

- Single-model assembly line balancing problem (SALBP).
- Batch-model assembly line balancing problem (BMALBP).
- Mixed-model assembly line balancing problem (MALBP).

Published literature on assembly systems design often focuses on balancing and sequencing procedures and addresses the MALBP in relation with different layout configurations (i.e. serial layout, U-shaped, fixed position, two-sided, parallel lines) developing exact or heuristic methods (Battini et al., 2007, 2008). A number of papers, reviewed in a survey by Becker and Scholl (2006), aim to optimize pre-existing systems or balance new assembly configurations, without scrutinizing the workplace ergonomics or task times value feasibility and correctness. Since several activities performed in assembly systems, in particular those associated with repetitive movements and with considerable level of stress or with extended assumption of uncomfortable postures, might be correlated to the insurgence of work related musculoskeletal disorders -WMSDs- (Wick and McKinnis, 1998), we can now clearly notice a strong link between assembly systems and ergonomics, both in theory and in practice. Benefits provided by ergonomics application in assembly systems design are first of all linked to the reduction in occupational injury risks and to the improvement of physical and psychosocial conditions of the workforce with a drastic reduction in all costs linked to absence, medical insurance, and rehabilitation (Carey and Gallwey, 2002).

In addition, ergonomics improvements improve quality and operators productivity (Drury, 2000; and Eklund, 1995, 1997). Usually, ergonomics evaluations are performed by ergonomists, while workplace layouts are designed by planning engineers, and the results are often unsatisfactory and do not improve productivity (Carey and Gallwey, 2002). Previous projects on this topic demonstrated the extra value of combining assembly engineering with ergonomics (Van Lingen et al., 2002; De Looze et al., 2003),

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