Operators Skill Level Evaluation Method for Balancing of an Apparel Assembly Line

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ABSTRACT

The Assembly Line Balancing Problem (ALBP) engages the interest of many researchers. However, the number of researchers that treat this problem is still small in the field of apparel manufacturing. The fact that an apparel assembly line is labour intensive and insufficiently automated further complicates the problem. Operator Skill Level (OSL) as a category that has a significant effect on ALBP in the industry also has not been analysed enough. This study presents a model for evaluation and comparison of the OSL and based on that, designs algorithm for optimal scheduling of the operators on the production line in response to customer demand. The application of this model is demonstrated through conducting a case study in an apparel company. It is determined that the proposed model can lead to significant improvement of the performance of the production line by better operator allocation based on skill levels. The model can ensure improvements related to increasing the line efficiency for 28%, daily output for 27.3% and decrease labour force for 18.5% and production time for 20%.

Keywords: Apparel, Assembly Line Balancing Problem (ALBP), Customer Demand, Efficiency, Operator Skill Level (OSL)

1. INTRODUCTION

Apparel assembly line is a system of people and machines arranged in a specific order to transform raw material, over semi-product, into a final product. People are arranged to work on one or more different machines, based on their skills. The balance of the assembly line is closely related to OSL and this important parameter needs to be taken in account while obtaining an optimal operator allocation.

So far, the balancing of the assembly line in the apparel industry is still a significant problem for the area of production management. This problem is particularly evident in the sewing department, where the degree of automation is relatively low. In this department the performance of the assembly line is largely dependent on the capabilities of the operators (Solinger, 1980; Chuter, 1995). The fact that apparel assembly line is labour intensive includes balancing among the group of NP-hard problems (Chen et al, 2012).
Across the significant number of apparel companies, degrees of assembly line balance depend on the experience of the line supervisors and those balancing techniques used, which are mostly manual (Chuter, 1995). This kind of balance is scientifically unfounded and leaves room for discussion about the competence of the person responsible for balancing and performance techniques used on the line. ALBPs have been known to researchers over a several decades (Ghosh and Gagnon, 1989; Becker and Scholl, 2006; Boysen et al. 2007) and specific ways to solve these problems are already applied in the automotive industry (Black, 2007). It goes without saying that the apparel industry by its nature differs in large part from the automotive industry. Because of that, the successful implementation of methods to solve ALBPs in car manufacturing must be adapted to the demands and characteristics of the apparel industry.

Most of the studies related to ALBPs in the apparel industry analyse different balancing techniques or different aspects that influence the balancing ratio of the assembly line. Eryuruk et al, (2008) compare the results of using two ALB techniques: the Ranked positional weight technique and the Probabilistic line balancing technique. Later, Karabay (2014) compares balancing result by using practical assembly line balancing techniques with Rank Positional Weight (RPW): he suggests RPW is heuristic and suggests a combination of balancing techniques for a better result. Unal et al. (2009) transform the traditional assembly line into a U-shaped assembly line to achieve better performance and operator utilisation. Subramaniam et al. (2009) emphasise the importance of machine efficiency and manpower utilisation as key measurements in the production planning process and give suggestions for their incorporation into on-line data management systems. Kumar and Mahto (2013) analyze assembly line productivity improvement by applying group technology and minimising total production costs and the number of workstations.

However, the studies that examine different OSLs as ways to obviate ALBPs are still few. Racine et al. (1993) present three efficiency prediction models – the training, switching and forgetting models – which incorporate those factors that influence operator efficiency and need to be considered during production planning. Leung et al. (1999) analyze factors that suggest variations in standard operation time, using the findings to achieve better line balance. Song et al. (2006) made significant contribution to ALB in garment manufacture by proposing a recursive operator allocation algorithm that takes into account an operator’s efficiency. This algorithm was devised to find the optimal operator allocation by identifying three aspects of manufacture: the lowest standard deviation of operation efficiency, the highest production line efficiency and the least total waste of operational efficiency. Song et al. (2007) also adjusted this algorithm for operator allocation on the assembly line, analyzing different conditions of operator availability, later Song et al. (2008) incorporating the findings into theirs Intelligent Real-time Optimization Decision Support System (IRODSS) for ALB. Chen et al. (2012) use a grouping genetic algorithm (GGA) as a solution for ALBPs in sewing lines which demonstrate different levels of skill in the garment industry.

This study has an objective to fill the gap with the manual line balancing in the apparel industry and ensure more scientific approach in the whole process by incorporation of the already existing experience of production managers and line balancing praxis into a balancing algorithm that can be applied in different cases. Also, the model presented in this study will solve the problem with tracking of the dynamic change of operator’s skills and help in better monitoring, measuring and updating the OSL. In this study we analyse OSL as a complex category and propose a model to evaluate and compare operator skills. Bearing this in mind, the aim is to design an algorithm that defines optimal operator allocation on the assembly line. The OSL consists of discrete segments:
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