NSGA-II Algorithm for Assembly Line Balancing with Multi-Resource Constraints

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Highlights: The existing line balancing algorithm assume that any assembly task can be performed in any workstation. However, in reality, there are resource constraints to be considered such as machine, tool, skilled worker etc. In this research we consider all the resources in assembly, so that the assembly task assignment can be performed smoothly using the available resources in the manufacturing plant. In this research, we developed an Elitist Non-Dominated Sorting Genetic Algorithm (NSGA-II) to optimize assembly line balancing with resource constraint (ALB-RC).

Key words: *Line balancing; optimization.*

Introduction

Assembly Line Balancing (ALB) is an attempt to assign tasks to various workstations along a line so that the precedence relations are satisfied and some performance measures are optimized. In this system, a few tasks that use similar resources will be assigned in the same workstation by ensuring that it does not violate the precedence constraint and that the total processing time in each workstation is approximately the same and does not exceed the cycle time.

Assumption by previous researches that any assembly task can be performed in any workstation encourages the author to focus on the resource usage in ALB. Limited number of resources in the industry also becomes a vital influencer to consider this constraint in ALB. This project is important because none of the previous research considered machine, tool, and worker constraint in ALB-E. Apart from that, Elitist Non-Dominated Sorting Genetic Algorithm (NSGA-II) has not yet been implemented by previous researcher in the optimization of Assembly Line Balancing Type-E (ALB-E) itself with resource constraints.

The aim of this project is to develop an efficient algorithm model for ALB-E with resource constraints (ALBE-RC). The proposed NSGA-II algorithm was tested and verified using test problems from literature. The optimization result indicated that the NSGA-II algorithm has better performance in finding non-dominated solution due to small error ratio and small generational distance as compared to other algorithms like Multi-Objective Genetic Algorithm (MOGA) and Hybrid Genetic Algorithm (HGA). The results indicate that NSGA-II has the ability to explore the search space and has better accuracy of solution towards Pareto-optimal front.

Industrial case studies were conducted to validate the mathematical model and the optimization algorithm. The industrial case study concluded that the proposed methodology and algorithm can be implemented in industries. The cycle time of existing layout had been extensively decreased from 16.1 seconds to 13.1 seconds after the optimization. The number of workstations was decreased after the optimization from 17 workstations to nine (9) workstations. Meanwhile, the number of resources used was reduced from 43 resources to 40 resources. Apart from that, the percentage of line efficiency improved from 33.8% to 78.4%. These results indicated that the developed methodology and the proposed algorithm can reduce the utilization of resources, workstations and cycle time. In fact, the aforementioned approach also can increase the efficiency of assembly process as well as enhance the industrial productivity.

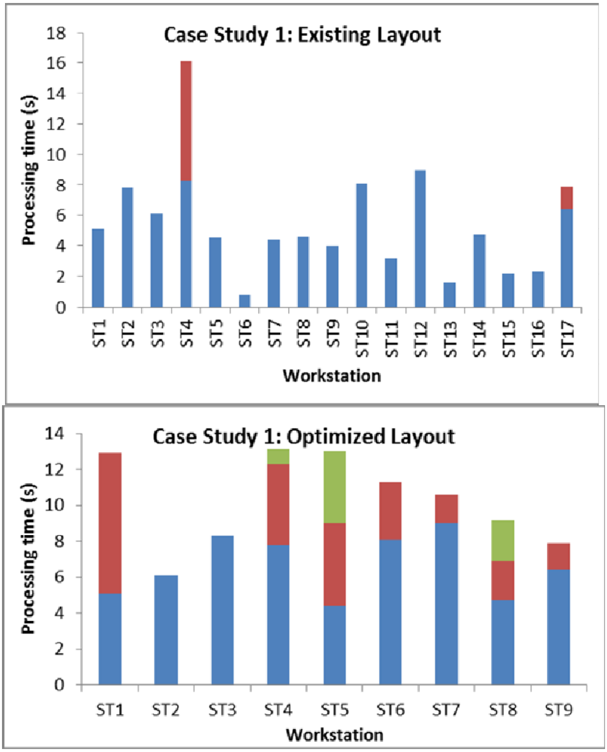

Figure 1: Comparison of Existing and Optimized Assembly Line for Case Study 1.

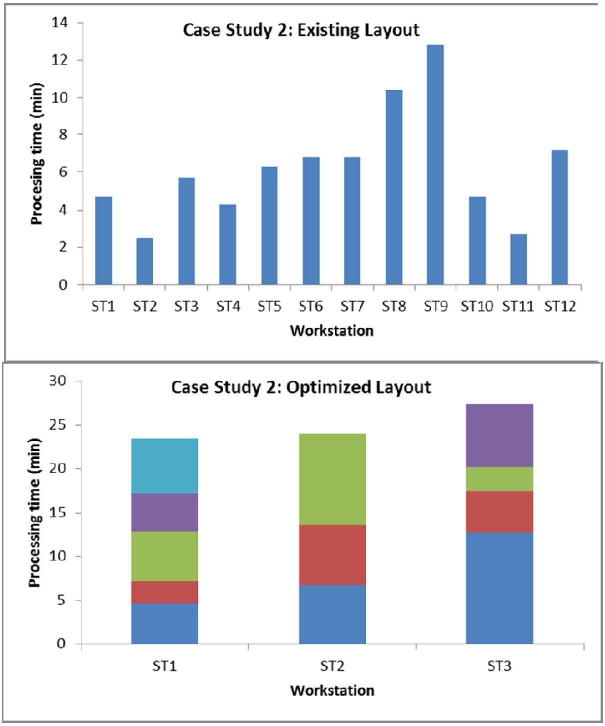

Figure 2: Comparison of Existing and Optimized Assembly Line for Case Study 2.

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