Ain Shams University
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TWO-SIDED ASSEMBLY LINE BALANCING PROBLEM

A Thesis
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Statement

This thesis is submitted in the partial fulfilment of master degree in Mechanical Engineering to Ain Shams University.

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other university.

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TWO SIDED ASSEMBLY LINE BALANCING PROBLEM

Abstract

Assembly line balancing researches have traditionally focused on the simple assembly line balancing problem which has some restricted assumptions. Recently, researchers try to solve more realistic problems that are close to real assembly line problems. In this thesis, the problem addressed is two sided-assembly line balancing. Two-sided assembly lines are often used in assembly of large-sized high–volume products, such as buses, cars and trucks. In this type of a production line, the left side and the right side of the line are used in parallel. The complexity of solving such problems arises from the large number of combinations which made from the large number of candidate tasks for each work station. The aim of this thesis is to develop an efficient model to balance two-sided assembly lines with the objective of minimizing the number of mated work stations as a primary objective, and minimizing the number of work stations as a secondery objective for a given cycle time. The developed algorithm proved to be effective solving the problem. Competitive results were obtained and compared with other heuristic algorithms.

Keywords: Two-sided assembly line balancing, line balancing, Ranked Positional Weight (RPW).

Summary of the M.Sc. Thesis

"TWO-SIDED ASSEMBLY LINE BALANCING PROBLEM"

Assembly lines have been widely used in various production systems to produce high volume standardized products. An assembly line includes a series of stations arranged along a material handling system. The components are processed depending on a set of tasks for a given cycle time.

Assembly lines can be categorized in two groups as one-sided assembly lines and two-sided assembly line. The differences between them are associated with the design of the assembly line. The left side and the right side of the line are used in parallel in two-sided assembly lines, whereas only one side of the line is used in one-sided assembly lines. Two-sided assembly lines are typically found in assembling large-sized high volume products, such as cars, trucks, and buses.

The advantages of two-sided assembly lines are (a) the assembly line length can be shorter than a one-sided assembly line, (b) it can reduce material handling cost, workers movement, set up time, and the amount of throughput, and (c) it can also reduce cost of tools and fixtures.

A large number of exact solution algorithms and heuristics have been developed to balance the well-known classical one-sided assembly lines. However, little attention has been paid to the balancing of the two-sided lines. Moreover, the literature shows that there is almost no published work in balancing of the two-sided assembly line with techniques that yield exact solutions.

The aim of present research is to introduce a heuristic algorithm for balancing two-sided assembly lines with the objective of minimizing the

number of mated work stations as a primary objective, and to minimize the number of work stations as a secondary objective as possible. The balancing is made for a given cycle time while the precedence constraints, synchronous tasks, and non- synchronous tasks are respected. The algorithm chooses element with maximum Ranked Positional Weight (RPW) to be assigned to the station of minimum early start as a dominance rule.

The performance of the developed algorithm is compared to that of the existing approaches based on the results of solving benchmark problems of different sizes ranging from 9 elements up to 205 work elements. The results show that the proposed heuristic algorithm is capable of balancing assembly lines with large number of work elements number with high performance.

The practical applicability of the proposed algorithm was also examined through balancing a real life assembly line problem. The results show that the developed heuristic algorithm is efficient in practical application, as it yields an improvmet in the number of workers in the order of 22.7%.

The effect of some variables on the heuristic algorithm solution results was also examined. These variables are the elements times' standard deviation (σ), and the order strength (D). The results proved the superiority and advantages of the two-sided assembly line balancing over the one-sided assembly line balancing.

It is recommended that future studies may focus on the balancing of stochastic two-sided mixed model problems. Also it is recommended to consider some realistic constraints with the problem, such as positional constraints, and develop an appropriate heuristic for its solution.

Table of Contents

Subject	***Page***

Subject		**Page**
Chapter 4.	**Design of experiments**	**36**
	4.1. Introduction	36
	4.2. Comparing the performance of the developed heuristic algorithm with existing heuristics	36
	4.3. Study the effect of some parameters on design of two-sided assembly line	37
	4.3.1. The standard deviation of line work elements times (σ)	37
	4.3.2. Assembly line order strength (*D*)	38
	4.4. Investigate the advantages of the two-sided assembly lines over the one-sided assembly lines	39
	4.5. Application of the present algorithm to real life case study	39
Chapter 5.	**Results and discussions**	**40**
	5.1. Introduction	40
	5.2. Study the performance of the proposed heuristic algorithm	40
	5.2.1. Results of P24	44
	5.3. Computational experience	45
	5.4. Study the effect of different parameters on the assembly line balancing problem solution	49
	5.4.1. Effect of elemental times standard deviation (σ) on the assembly line balancing problem solution	49
	5.4.2. Effect of order strength (D) on the assembly line balancing problem solution	51
	5.5. Advantages the two-sided assembly lines over one-sided assembly lines	53
	5.6. Real life case study	55

List of Tables

List of Figures

Nomenclature

D	:	Order strength
N	:	Total number of elements
CT	:	Cycle time
Ns	:	Number of stations
RPW	:	Ranked Positional Weight
P_{ij}	:	Precedence matrix
t_i	:	Time of element i
RPW_i	:	Ranked positional weight of task i
t_j	:	Time of element j
Ns_l	:	Lower bound of number of stations
Np_l	:	Lower bound of number of positions
Pred. (i)	:	Number of precedence tasks to task i
S_c	:	Set of candidate elements
ES	:	Early start

REM_L^K : Remaining time of K station at left

REM_R^K : Remaining time of K station at right

t_{UR} : Total time of unassigned right elements

t_{UL} : Total time of unassigned left elements

S_{AL}^K : Set of assigned elements at station K at left

S_{AR}^K : Set of assigned elements at station K at right

S_{NA}^L : Set of unassigned left elements

S_{NA}^R : Set of unassigned right elements

I : Idle time

I_L^K : Idle time of K station k left

I_R^K : Idle time of K station at right

t_C : Time of candidated element