AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Design and Production Engineering

Multi-Manned Assembly Line Balancing

A Thesis submitted in partial fulfilment of the requirements of the degree of

Doctor of Philosophy in Mechanical Engineering

(Design and Production Engineering)

by

Nessren Mohamed Lotfy Zamzam

Master of Science in Mechanical Engineering

(Design and Production Engineering)

Faculty of Engineering, Ain Shams University, 2012

Supervised By

Prof. Dr. Amin Kaml El-Kharbotly

Prof. Dr. Nahid Hussein Afia

Dr. Yomna Mahmoud Sadek

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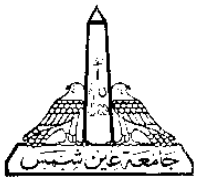

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Examiners' Committee

Name and Affiliation	**Signature**
Prof. Dr. Adel Zaky El-Shabrawy Design and Production , Higher Technological Institute at the10th of Ramadan City.	…….
Prof. Dr Moahmed Foad Hosney Abdin Design and Production , Ain Shams University	…….
Prof Dr. Amin Mohamed Kamel El-Kharbotly Design and Production , Ain Shams University	…….

Date:18 July 2016

Statement

This thesis is submitted as a partial fulfilment of Doctor of Philosophy in Mechanical Engineering, Faculty of Engineering, Ain shams University.

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

Nessren Mohamed Lofty Zamzam

Signature

……...…….

Date: 16 July 2016

Researcher Data

Name	: Nessren Mohamed Lotfy Zamzam
Date of birth	: 11/9/1986
Place of birth	: Cairo
Last academic degree	: Master of Science in Mechanical Engineering
Field of specialization	: Design and production engineering
University issued the degree	: Ain shams university
Date of issued degree	: 2012
Current job	: Lecturer assistant at faculty of engineering

Thesis Summary

Assembly line balancing problem is the problem of finding an optimum feasible solution of assigning tasks to stations to minimize or maximize a certain objective. Large products that need assembly on both of its sides such as cars, buses, helicopters, and trucks are assembled with multi-workers in fixed positions on both sides of the product. These types of assembly lines are known as two sided or multi-manned lines.

Two-sided lines result in assembly lines that require larger number of stations which affect negatively the space utilization of the line. Multi-manned when applied to assembly lines may oblige the worker to move all-around the product. This in turn will result in additional travelling distances made by the workers, as well as interference in motions among workers. Such unavoidable drawbacks are expected to lower the line performance compared to theoretically planned line.

Physical effort exerted by the workers in assembly of large-sized products varies considerably from one task to another. The physical effort depends on type of work required in each task. The task may be simple and needs small effort to be exerted such as in the case of tightening of screws and nuts. It may also need the worker to exert relatively high effort in cases such as carrying and lifting heavy weight parts of different sizes and moving them for certain a distance during the task duration time. In general, exerted energy causes fatigue of the worker as it lowers his performance rate, increases the cycle time and disrupts the line balance.

The aim of the present research is to introduce new type of assembly line that utilizes two line concepts which are working on two sides of the product by a number of workers. The line will be suitable for the assembly of specific types of products which are large in size as to permit more than worker to work simultaneously without interfering each other, and have specific parts dedicated to each side. The assembly line is called Two-Sided Multi-Manned Assembly Line (TSMMAL). This type of assembly lines has the advantage of increased space utilization as workers can work simultaneously on both sides.

A genetic algorithm (GA) with limited number of chromosomes is proposed to address the TSMMAL balancing problem with the objective of minimizing the number of workers and the number of mated stations for a given cycle time. A controlling parameter (β) was proposed and added to the algorithm to give flexibility to the decision-maker to make trade-off between the number of workers and the number of mated stations. In addition to these two objectives, a third unprecedented objective is added to smooth the physical effort among the workers. The maximum acceptable work duration time and the rest periods to recover from the fatigue are determined. The number of rest periods and the actual production rate are deduced.

The results showed that using the solutions obtained from solving the assembly line balancing problem by well-known algorithm as starting elite chromosomes has raised the efficiency of the used genetic algorithm solution. The GA solutions reached the optimal solution in most of the cases in very few numbers of generations and therefore, small computational time. The proposed algorithm proved the superiority of TSMMAL to the traditional two-sided lines. It saves up to 50% of the line length with the same number of workers depending on the problem configuration. Adding β to the algorithm provides a tool to the decision makers to choose among solutions. Results show that larger β's directs the solution towards less number of mated stations (NMS) and high number of workers (NW). In the contrary, Low values for β directs the solution towards less number of workers (NW) and high number of mated stations (NMS).

The results, also, showed that smoothing the physical effort among the workers decreases the variation in the energy exerted by the workers, increases the maximum acceptable work duration, and decreases the number of rest periods. Consequently, effort smoothening increases the actual production rate, besides increasing justice and comfort between workers. Although the results showed that continuous work without giving rest periods to the workers may increase the line throughput rate, it will have a negative effect on physical fitness that will result in reduced quality and increased errors on the long run, besides violating the work law. Offering the worker early rest periods before complete fatigue may result in higher production rate as compared to late offered rest periods.

It is suggested for future work to extend the model to consider more operational constraints such as synchronous, and non-synchronous tasks, and positional constraint.

Also, it is recommended to assume different metabolic rates for workers since as it is assumed constant in the present work.

Key words: Multi-manned assembly line, Two-sided assembly line, Genetic algorithm, physical effort of workers, effort smoothness index.

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Table of Contents

List of Figures