

بسم الله الرحمن الرحيم



HOSSAM MAGHRABY



شبكة المعلومات الجامعية التوثيق الالكتروني والميكرو فيلم



HOSSAM MAGHRABY

جامعة عين شمس

التوثيق الإلكتروني والميكروفيلم

قسم

نقسم بالله العظيم أن المادة التي تم توثيقها وتسجيلها
على هذه الأقراص المدمجة قد أعدت دون أية تغيرات



يجب أن

تحفظ هذه الأقراص المدمجة بعيدا عن الغبار



HOSSAM MAGHRABY



بعض الوثائق الأصلية تالفة



HOSSAM MAGHRABY



بالرسالة صفحات

لم ترد بالأصل



HOSSAM MAGHRABY

B12A70

Menoufia University
Faculty of Engineering
Department of Production Engineering and Mechanical Design

IMPACT OF MACHINE DUPLICATION ON PROCESS QUALITY IN MANUFACTURING SYSTEMS

A Thesis

Submitted in Partial Fulfillment of the Requirements for
M. Sc. Degree in Engineering
"Production Engineering"

By

Omayma Abdul-Aziz Nada

B. Sc. in Production Engineering and Mechanical Design

Supervised By

Dr. Mahmoud M. El-Khabery

m-m. ElKhabery

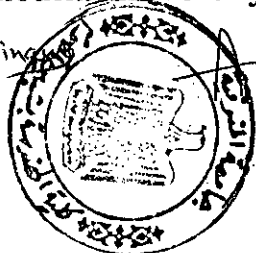
Associate Professor,
Dept. of Prod. Eng. & Mech. Des.,
Faculty of Engineering,
Menoufia University

Dr. Ahmed A. El-Sawi

A. ElSawi

Associate Professor,
Dept. of Basic Engineering
Sciences, Faculty of Engineering,
Menoufia University

A.M. King



Hady Nasser

1999

Menoufia University
Faculty of Engineering
Department of Production Engineering and Mechanical Design

IMPACT OF MACHINE DUPLICATION ON PROCESS QUALITY IN MANUFACTURING SYSTEMS

A Thesis

Submitted in Partial Fulfillment of the Requirements for
M. Sc. Degree in Engineering
"Production Engineering"

By

Omayma Abdul-Aziz Nada

B. Sc. in Production Engineering and Mechanical Design

Approved By

Prof. Mohamed S. Ali Osman

Professor of Operations Research and Vice Dean of Higher
Technological Institute, Tenth of Ramadan City.

(M. S. Ali Osman)

Prof. Adel M. Abdel Maaboud

Professor, Department of Production Engineering and Mechanical
Design, Faculty of Engineering, Menoufia University.

(Adel M. Abdel Maaboud)

Dr. Mahmoud M. El-Khabery

Associate Professor, Department of Production Engineering and
Mechanical Design, Faculty of Engineering, Menoufia University.

(M. M. El-Khabery)

Dr. Ahmed A. El-Sawi

Associate Professor, Department of Basic Engineering Sciences, Faculty
of Engineering, Menoufia University.

(A. El-Sawi)

A. M. Kinyay



A Hady Nasser

ACKNOWLEDGMENTS

The author is deeply grateful and indebted to **Dr. Mahmoud El-Khabery**, Associate Professor, Dept. of Production Engineering & Mechanical Design, Faculty of Engineering, Menoufia University and **Dr. Ahmed El-Sawi**, Associate Professor, Dept. of Basic Engineering Sciences, Faculty of Engineering, Menoufia University; her Advisory Committee, for their constant guidance, generous help and support during the preparation of this investigation. Their suggestions, encouragement and constructive criticism are greatly appreciated.

Thanks are also due to **Dr. Gamal S. Weheba**, Lecturer, Dept. of Production Engineering & Mechanical Design, Faculty of Engineering, Menoufia University for the initiation and suggestion the point of this research.

CONTENTS

Nomenclature	iv
List of Tables	vi
List of Figures	vii
Abstract	viii
Chapter 1 - INTRODUCTION	1
Chapter 2 - LITERATURE SURVEY	3
2.1 ASSEMBLY LINE BALANCING APPROACHES	3
2.1.1 Introduction	3
2.1.2 Classifications of ALB Problems	3
2.1.3 Measures of Balance Efficiency	7
2.1.4 Measures of the ALB Problem Complexity	8
2.1.5 Mathematical Formulation of ALB Problems	9
2.1.6 Solution Approaches of ALB Problems	11
2.1.7 ALB Problem with Duplication Option	14
2.2 QUALITY LOSS APPROACHES	17
2.2.1 The Concept of Quality Loss	17
2.2.2 Quality Loss Function	18
2.2.2.1 Quadratic loss function	18
2.2.2.2 Some other forms of loss functions	23
2.2.3 Average Quality Loss	24
2.2.4 Applications of the Loss Functions	25
Chapter 3 - DEFINITION OF PROBLEM AND STATEMENT OF OBJECTIVE	31

Chapter 4 - MATHEMATICAL MODEL FORMULATION	34
4.1 INTRODUCTION	34
4.2 MODEL DEVELOPMENT	34
4.2.1 Problem Definition	34
4.2.2 Objective Function	35
4.2.3 Constraints	38
4.3 ALB PROBLEM WITH THE DUPLICATION OPTION UNDER QUALITY REQUIREMENTS	41
4.4 COMPUTATIONAL ASPECTS OF THE DEVELOPED MODEL	47
Chapter 5 - APPLICATION OF THE PROPOSED MODEL	49
5.1 IMPLEMENTATION	49
5.2 ILLUSTRATIVE EXAMPLE FOR MODEL VERIFICATION	51
5.3 RESULTS AND DISCUSSIONS	55
5.3.1 Model Application	55
5.3.2 Model Application with Additional Aspects	77
Chapter 6 - CONCLUSIONS	80
FUTURE WORK	82
REFERENCES	83

NOMENCLATURE

Notations

- Cd_j costs per period to operate equipments in a duplicated work station j .
- CL_j costs per period to operate equipments in a work station j in the serial line.
- C_{pm} process capability index.
- CT_{max} theoretical maximum permissible cycle time.
- CT_{min} theoretical minimum value of cycle time for serial line.
- d task which must succeed all other tasks.
- E_i earliest station for task i .
- I set of tasks, $I = \{1, 2, \dots, i, \dots, M\}$.
- J set of work stations, $J = \{1, 2, \dots, j, \dots, N_{max}\}$.
- k quality loss coefficient.
- L_i latest station for task i .
- M number of tasks.
- m target value of the quality characteristic.
- N number of serial work stations.
- N_{max} theoretical maximum number of serial work stations.
- OC operating cost per period for all stations.
- $p(i)$ set of all predecessors of task i .

Q	average quality loss per period.
QL_a	sum of losses of assembled product individual tasks.
q	quality characteristic of interest of an item of the final product .
q_i	quality characteristic of interest of task i .
$s(i)$	set of all successors of task i .
t_i	processing time of task i .
X_{ij}	zero-one decision variable, equals 1 if task i is assigned to station j and equals 0 otherwise, $\forall i \in I, j \in J$.
Y_j	zero-one decision variable, equals 1 if station j is duplicated and equals 0 otherwise, $\forall j \in J$.
Δ_0	customer semi-tolerance.
μ	process mean.
σ^2	process variance.

Abbreviations

ALB	Assembly Line Balancing
ALBP-1	Assembly Line Balancing Problem type-1
ALBP-2	Assembly Line Balancing Problem type-2
NP	Nondeterministic Polynomial
UALBP	U-shaped ALB Problem
ULINO	U-Line Optimizer

LIST OF TABLES

- Table 5.1** Processing times and customer semi tolerance for each task.
- Table 5.2** Calculated values of the model parameters.
- Table 5.3** Solutions of the ALB problem-*Case I*.
- Table 5.4** Solutions of the ALB problem-*Case II*.
- Table 5.5** Solutions of the ALB problem-*Case III* for (k=10).
- Table 5.6** Solutions of the ALB problem-*Case III* for (k=50).
- Table 5.7** Solutions of the ALB problem-*Case III* for (k=100).
- Table 5.8** Solutions of the ALB problem-*Case III* for (k=200).
- Table 5.9** Solutions of the ALB problem-*Case III* for (k=300).
- Table 5.10** Improvement of line efficiency due to duplication *Case II*.
- Table 5.11** Cases with perfect balance.
- Table 5.12** Impact of quality loss coefficient on the number of duplicated stations.
- Table 5.13** Results of ALB problem *Case III* w/o zoning constraints.
- Table 5.14** Results of ALB problem *Case III* (k=10) with stations 1 and 2 cannot be duplicated.
- Table 5.15** Results of ALB problem with the concept of quality loss applied internal to the assembly line.

LIST OF FIGURES

- Fig. 2.1** Quadratic Loss Function (a) Nominal-the-best, (b) Smaller-the-better, (c) Larger-the-better, and (d) Asymmetric.
- Fig. 2.2** Quality loss function with different financial importance.
- Fig. 2.3** Average quality loss.
- Fig. 5.1** Precedence relations for the problem.
- Fig. 5.2** Relation between cycle time and number of work stations (*Case I*).
- Fig. 5.3** Relation between cycle time and line efficiency at $N=3$ (*Case I*).
- Fig. 5.4** Relation between cycle time and line efficiency at $N=2$ (*Case I*).
- Fig. 5.5** Relation between cycle time and line efficiency at $N=4$ (*Case I*).
- Fig. 5.6** Line capacity as a function of cycle time.
- Fig. 5.7** Assembly line layout at $CT=7.5$ (a) in *Case I*, and (b) in *Case II* and *Case III* for $k=10$.
- Fig. 5.8** Station Time at $CT=7.5$ (a) *Case I*, and (b) *Case II*.
- Fig. 5.9** Effect of using duplicated work stations on the line efficiency.
- Fig. 5.10** Relation between cycle time and number of stations (*Case II*).
- Fig. 5.11** Relation between cycle time and no. of duplicated stations for *Case II* and *Case III*.

ABSTRACT

The decision of duplicating work stations in assembly line balancing (ALB) problems is traditionally made based on production rates and economics of operations. However, duplicating production facilities is considered to be a source of variability that affects the process quality. Hence, the product quality requirements and the cost incurred due to variation in the output quality should be considered while making such a decision.

In this research, a single-model, deterministic ALB problem type-1, with the option of duplicating work stations is considered. The problem is formulated as a zero-one integer programming model with the objective of minimizing the cost per period associated with operating stations. This cost may include labor, overhead, maintenance and fixed cost of the capital investment of the equipment over its expected service life. To incorporate the quality considerations of the final assembled product while solving the problem and making duplication decisions, the concept of quality loss is applied on the final assembled product. Taguchi's quadratic loss function is used to estimate the monetary loss incurred due to deviation of product quality characteristic from its target value. The average quality loss of the final assembled product is incorporated into the objective function. This leads to the development of a quadratic zero-one integer programming model. The developed model is linearized and an illustrative problem from published literature is considered for model verification.

The results indicate that the developed model can effectively handle the considered ALB problem. Moreover any computer program for solving