PRODUCTIVITY OPTIMIZATION OF MANUFACTURING SYSTEM USING COMPUTER SIMULATION, DESIGN OF EXPERIMENT AND RESPONSE SURFACE METHODOLOGY

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A project report submitted in partial fulfilment of
the requirments for the award of the degree of
Master of Engineering (Industrial Engineering)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

SEPTEMBER 2013

I dedicated this thesis To my beloved mother, father, brothers, Sheila, Hasan, Mokhtar and Mobin because of their love, support, patience and understanding .

ACKNOWLEDGEMENT

First and foremost, I am grateful to the Peerless Clement God. Special thanks to my family especially to my beloved mother, father and my dear brothers who always encourage and support me in all my life and my study. I would like to sincerely express the deepest gratitude to my supervisor, Mr. Jafri Bin Mohd Rohani, who has the attitude of a genius. I thank him for his endless guidance, encouragement and continuous support given throughout my project that enabled me to develop an understanding of the subject. His immense help has kept me to overcome the problems encountered during the whole course of this study. I am heartily thankful to my co-supervisor, Dr. Wong Kuan Yew who had accepted me as his student to help me in my project. Special thanks to Mr. Mohammadreza Haghighi, industrial engineer of Color factory, for helping me in this project. In addition, my greatest appreciation and friendship goes to Dr. Mohammad Roghangar Ranjbar, my lecturer who encouraged me to continue my education in Malaysia. Finally, I would like to thank Faculty of Mechanical Engineering's staff, Universiti Technologi Malaysia for their kind cooperation.

ABSTRACT

Productivity plays a significant role for most companies in order to measure the efficiency. In reality there is an essential need to evaluate the different factors which increasing productivity and achieving the high level of quality, a high production rate and machine utilization. Therefore, in the manufacturing industry, managers and engineers are seeking to find methods in order to eliminate the common problems in manufacturing systems such as bottlenecks and waiting times. This is because that all of these kinds of problems impose extra cost to the companies. In addition, manufacturing companies are striving to sustain their competitiveness by improving productivity, efficiency and quality of manufacturing industry for instance high throughput and high resource utilization. So it can be acquired by finding ways to deal with various industrial problems which have affected the productivity of manufacturing systems such as high lead time and work-in-progress (WIP) and etc. This thesis concentrates on the application of design of experiment (DOE) and computer simulation to recognize and to weight the significance of different factors in the production line as well as to achieve the optimum productivity. Arena 13.9 software was selected as the simulation software. A case study of color industry was chosen to implement and evaluate the result of applying DOE and response surface methodology (RSM) by using Minitab 16 and Expert-Design 6.5. Data required for developing the simulation model were gathered from the factory documents and stop-watch method. The results reveal that applying computer simulation and design of experiment in the manufacturing systems is very useful and helpful where the weakness of the system will be found after doing the experimentation. Based on the main objectives of this thesis the effect of the factors which have the most significant influence on the productivity was assessed and determined. Finally the best factor setting which result in the maximum productivity was determined.

ABSTRAK

Produktiviti memainkan peranan yang signifikan bagi kebanyakan syarikat dalam mengukur tahap kecekapan. Pada hakikatnya ia adalah keperluan yang penting untuk menilai faktor-faktor bagi meningkatkan produktiviti dan juga mencapai tahap kualiti yang tinggi, kadar pengeluaran yang tinggi dan penggunaan mesin. Oleh itu, dalam industri pembuatan, pengurus dan jurutera mencari pelbagai kaedah dalam menghapuskan masalah dalam sistem pembuatan seperti kesesakan dan masa menunggu. Ini adalah kerana masalah sebegini akan melibatkan kos tambahan kepada syarikat. Maka ia boleh diperolehi dengan mencari cara-cara untuk menangani dengan pelbagai masalah perindustrian yang telah memberi kesan kepada produktiviti sistem pembuatan seperti tempoh masa yang lama dan "work-in-progress" (WIP) dan lain-lain. Tesis ini menumpukan kepada aplikasi reka bentuk eksperimen (DOE) dan simulasi komputer untuk mengenal dan menitik beratkan signifikan faktor-faktor penting dalam dan ketika pemasangan atau pengilangan untuk mencapai produktiviti yang optimum. Perisian Arena 13.9 telah dipilih dan digunapakai sebagai perisian simulasi. Satu kajian kes industri warna telah dipilih untuk melaksanakan dan menilai hasil daripada penggunaan DOE dan respon permukaan metodologi (RSM) dengan menggunakan Minitab 16 dan Pakar-Design 6.5. Data yang diperlukan untuk membangunkan model simulasi telah dikumpulkan dari dokumen kilang dan kaedah berhenti-menonton. Keputusan menunjukkan bahawa pengunaan simulasi komputer dan reka bentuk eksperimen dalam sistem pengilangan pembuatan adalah sangat berguna dan membantu yang mana kelemahan sistem itu akan diketahui selepas menjalankan eksperimen tersebut. Berdasarkan objektif utama tesis ini kesan faktor-faktor yang mempunyai pengaruh yang signifikan ke atas produktiviti telah dinilai dan dikenal pasti. Akhirnya faktor persekitaran terbaik yang mengakibatkan produktiviti maksimum dapat ditentukan.

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LIST OF ABBREVIATIONS

DOE	Design of Experiment
RSM	Response Surface Methodology
OPC	Operation Process Chart
CCD	Central Composite Design

LIST OF SYMBOLS

N (m)	Number of replications
$t_{\frac{\alpha}{2},n-1}$	t-value based on the confidence level and the number of runs
S (m)	standard deviation of production output from 5 runs
Ɛ	allowable error
$\bar{X}$(m)	mean of production output from six runs

CHAPTER 1

INTRODUCTION

1.1 Introduction

In the manufacturing industry, managers and engineers are seeking to find methods in order to eliminate the common problems in manufacturing systems such as bottlenecks and waiting times. This is because that all of these kinds of problems impose extra cost to the companies. In addition, manufacturing companies are striving to sustain their competitiveness by improving productivity, efficiency and quality of manufacturing industry for instance high throughput and high resource utilization. It can be acquired by finding ways to deal with various industrial problems which have affected the productivity of manufacturing systems such as high lead time and Work in Progress (WIP) and etc. (Sun and Ming, 2011).

This thesis concentrates on the application of design of experiment (DOE) and computer simulation to recognize and to weight the significance of different factors in the production line as well as to achieve the optimization of productivity. First, the background of the study is discussed in this chapter, following that the problems are stated in order to define what the objectives of the thesis are. After that in the scope of the study the research method and software which are used in this thesis are explained briefly. Following that the goals of thesis and the desired results are discussed in order to depict the significance of the thesis. Finally the structure of the thesis will be explained.

1.2 Background of the Thesis

As mentioned earlier productivity plays a significant role for most companies in order to measure the efficiency. In reality there is an essential need to evaluate the different factors which increasing productivity and achieving the high level of quality, a high production rate and machine utilization. In our thesis we want to construct the simulation model of manufacturing system and run the different alternatives. Following that the results which have obtained from the simulation experiment used to conduct a full factorial experiment. After that the best combination of factors those have the most significant effect on the process productivity have selected.

According to studies that have done before (Hatami et al., 1990), applying the experimental design and simulation to improve the productivity result in important savings. Additionally the result will be more credible and reliable since all possible combinations of factors are examined. It is easier also to justify the recommendations because the verification runs have validated the result of the model (Hatami et al., 1990).

1.3 Problem Statement

1.3.1 Statement of the Thesis Problem

Manufacturing companies are seeking to achieve higher productivity such as high resource utilization and high throughput. In order to evaluate the system's performance based on these they must deal with difficulties in the manufacturing system. Therefore, managers and engineers define the planning horizon for these aims. In the operative aims one of the most challenging is the bottlenecks. Indeed they try to identify and eliminate the bottlenecks in the production line. This thesis

proposes using the statistical analysis Design of experiment (DOE) and computer simulation to find the root causes of the decreased productivity. The problem considered in this thesis to be solved by developing a simulation model of manufacturing system to replicate the current process. Having built and validated the simulation model, significant factors are identified by conducting the DOE.

1.3.2 Thesis Questions

1.3 How could a manufacturing system be modelled using computer simulation?
1.4 How can we conduct the DOE and simulation run to evaluate the system performance?
1.5 What are the most significant factors which have affected the productivity of process?
1.6 What is the optimum measure of factors?

1.4 Objective of the Thesis

The main goal of this thesis is to find the optimum measure of total output production of manufacturing system. To achieve this goal this thesis proposes using the statistical analysis namely DOE and computer simulation to recognize the main factors which have affected the productivity of manufacturing process. Following that, the Response Surface Methodology (RSM) is used for optimizing the results. In the following points we mention some of research goals:

1. To develop the computer simulation model of manufacturing process in order to run the experiment.
2. To determine which factors, (x) are most influential on the response, y (performance).
3. To get the optimal solution by implementing the response surface methodology techniques.

4. To verify the optimal solutions.

1.5 Scope of the Thesis

This thesis presents the application of design of experiment and computer simulation to recognize the main factors affecting the productivity. The scope of this thesis limited to:

1. The production line of a manufacturing system is simulated in order to run the experiment.
2. Arena 13.9 software is applied for development of simulation model.
3. Having building the simulation model, Design of Experiment (DOE) is conducted to identify the main factor have affecting the productivity of manufacturing system.
4. Response Surface Methodology (RSM) is used for optimizing the results of combined design of experiment and simulation running.
5. Minitab 16 is used as statistical analysis software for implementing the design of experiment.
6. Design-Expert 6.5 is applied to conduct the RSM approach.
7. A Color factory in IRAN is selected as a Case study for doing the thesis.

1.6 Significance of Findings

Manufacturing managers tend to use the effective tool and approaches due to enhance the productivity of the production line. This investigation effort judiciously combined design of experiment and computer simulation to determine the various factors that impact productivity improvement in a manufacturing system. Additionally, this thesis also endeavor focuses on optimize the solutions by implementing the response surface methodology. This means that performing this

investigation will help the companies, managers and engineers to optimize resource usage in order to increase total output production and improve productivity.

1.7 Thesis Structure

This thesis consists of five chapters:

Chapter 1 is the introduction to this study. Background of the thesis, objective of the thesis, statement of problem, scope of the thesis and thesis layout is expressed.

Chapter 2 provides the information and definitions of DOE technique and manufacturing simulation approaches also the literature review of the DOE application and the simulation manufacturing system method are explained. In addition the DOE and simulation software used in this thesis, namely respectively Minitab 16, Expert-Design 6.5 and Arena 13.9 are introduced. After that, the rest of chapter two dedicated to explain the past researches which have done before about the applying of DOE and manufacturing simulation.

Chapter 3 is dedicated to the research methodology for this study. In this chapter, the experimental steps are discussed in detail. The soft wares that are used in this thesis will be explained. In addition the case study will be described.

Chapter 4 is divided to four parts. The first part dedicated to introduce the case study. Second the simulation model of the manufacturing system is constructed. In this part the validation of the developed simulation model are also done. After that the simulation model will be run in order to find the response. Then, the DOE is conducted for the result of simulation experiment. In this part the analysis of the result using Minitab software is done to fond the significant factors. Finally, the

optimum setting of factors is determined by using RSM method which will be done by Expert-Design software.

Chapter 5 summarizes the work done in this thesis and some limitations and recommendations for future work are also made.

1.8 Conclusion

As mentioned earlier, this chapter is dedicated to thesis introduction. The thesis objective is introduced as well as it aims at solving the problems and questions, the scope to which the thesis is limited, the expected significant results, and finally the structure in which the thesis is conducted.

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