AN INTEGRATED APPROACH FOR FACILITIES PLANNING BASED ON APPLE'S PROCEDURE AND ELECTRE METHOD

BY

ELHASAN M.Y. ELBISHARI

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Kulliyyah of Engineering
International Islamic University Malaysia

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ABSTRACT

Facility planning is concerned with the design, layout, and accommodation of people, machines and activities of a system. Most of the researchers try to investigate the production area layout and the related facilities. However, few of them try to investigate the relationship between the production space and its relationship with service departments. The aim of this research to develop a conceptual framework (CFW) that integrate different approaches in order to evaluate, analyse and select the best facilities planning method that able to explain the relationship between the production area and other supporting departments and its effect on human efforts.

To achieve the objective of this research three different approaches have been integrated: Apple's layout procedure as one of the effective tools in planning factories, ELECTRE method as one of the Multi Criteria Decision Making methods (MCDM) and modelling and simulation approach to minimize the risk o getting poor facilities planning. Dalia industries have been selected as a case study to implement our CFW. The factory have been divided two main different area: the whole facility (layout A), and the manufacturing area (layout B). After analyzing the data gathered the whole facility was divided into 11 departments, whereas the manufacturing area was divided into 10 activities. There are five factors that the alternatives were compared upon which are: Inter department satisfactory level, total distance travelled for workers, total distance travelled for the product, total time travelled for the workers, and total time travelled for the product. Three different layout alternatives have been developed for each area in addition to the original layouts. Apple's layout procedure was used to study and evaluate the different alternatives layouts, the study and evaluation of the layouts was done by calculating scores for each of the factors. After obtaining the scores from evaluating the layouts, ELECTRE method was used to compare the proposed alternatives with each other and with the existing layout. ELECTRE compares the alternatives based on their concordance and discordance indices. The alternatives were ranked from best to worst where regarding to the layouts concerned with the whole facility A.2 is the best alternative, and for the manufacturing area B.4 is the best alternative. Finally, Delmia quest software was used as a simulation program to run a simulation for the production line. A simulation was first done for the existing production line and show that the estimated production rate is 261 units/day. The results have been analysed based on utilization percentage and idle time. Two different scenarios have been proposed based on different objectives. The first scenario is by focusing on low utilization machines and their idle time, this was resulted in minimizing the number of machines used by three with the addition of the works who maintain them without having an effect on the production rate. The second scenario is to increase the production rate by upgrading the curing machine which led to the increase in the daily productivity by 7%. From 261 units to 281units.

خلاصة البحث

تخطيط المنشأت هي عبارة عن دراسة وتخطيط المشأت. يهدف تخطيط المنشأت الى الوصول إلى الإنتاجية القصوى إلى جانب الرضى لدى العمال والتقليل قدر الإمكان من التكلفة الإنتاجية للحصول على أفضل منتوج من المنشاة. خطة Appel's للتخطيط هي خطة تشرح خطوات تقيم أو خطوات بدأ منشأة جديدة, تم استخدام خطةAppel's لتقيم المنشأة الموجودة لدينا وهي مصنع Dalia وتقييم البدائل المقترحة. مصنع Dalia هوا مصنع موجود في منطقة Nilai الصناعية وتختص في انتاج أعمدة الإسمنت, في هذا البحث تم تقسيم المنشأة إلى قسمين "Layout A" مختص بالمنشأة ككل مع مواقف السيارات, المكاتب, وباقي المنشئات الخدمة . أما القسم الأخر "Layout B" فهو مختص بمنطقة التصنيع وما يدخل فيها من نشاطات لتطوير المنتج. ELECTRE هي واحدة من طرق إتخاذ القرارات بلإعتماد على عدة عوامل وتم إستخدامها لتقيم البدائل المقترحة مع بعضهن البعض ومع المخطط الموجود مسبقا, العوامل التي تم على اساسها تقيم المقترحا هي كلأتي درجة التراضي ما بين الأقسام, المسافة الكلية التي يقطعها العمال, المسافة الكلية التي يقطعها المنتج, الوقت الكلي الذي يقطعها العامل في المشي, الوقت الكلي الذي يستغرق المنتج في التنقل. بإستخدام ELECTRE تم ترتيب البدائل من الأفضل إلى الأسوء بلنسبة الى مخططات المنشأة " Layout A" فإن أفضل بديل كان المخطط " A.2" وأما بلنسبة لمخططات منطقة التصنيع فإن أفضل بديل كان المخطط "B" . Delmia Quest.4 هو برنامج محاكة تم استخدامه لإجراء محاكة لخط الإنتاج وكانت نتيجة المحاكة التي جرت ليومين هو ان عدد المنتجات الناتجة في اليومين هي 361 وحدة انتاجية, تم تقديم اكثر من مقترح لزيادة الإنتاج وتم الحصول على نتيجة إيجابية برفع عدد المنتوجات خلال يومين إلى 381 وحدة إنتاجية.

APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Manufacturing Engineering).

……..
Muataz Hazza F. AlHazza
Supervisor

……..
Erry Y T. Adesta
Co-Supervisor

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Master of Science (Manufacturing Engineering).

……..
Mohammad Yeakub Ali
Internal Examiner

……..
MD. Yusof Ismail
Internal Examiner

This dissertation was submitted to the Department of Manufacturing and Material Engineering and is accepted as a fulfillment of the requirement for the degree of Master of Science (Manufacturing Engineering).

……..
Mohd Hanafi Ani
Head, Department of
Manufacturing and Material
Engineering

This dissertation was submitted to the Kulliyyah of Engineering and is accepted as a fulfillment of the requirement for the degree of Master of Science (Manufacturing Engineering).

……..
Erry Yulian Triblas Adesta
Dean, Kulliyyah of Engineering

DECLARATION

I hereby declare that this dissertation is the result of my own investigation, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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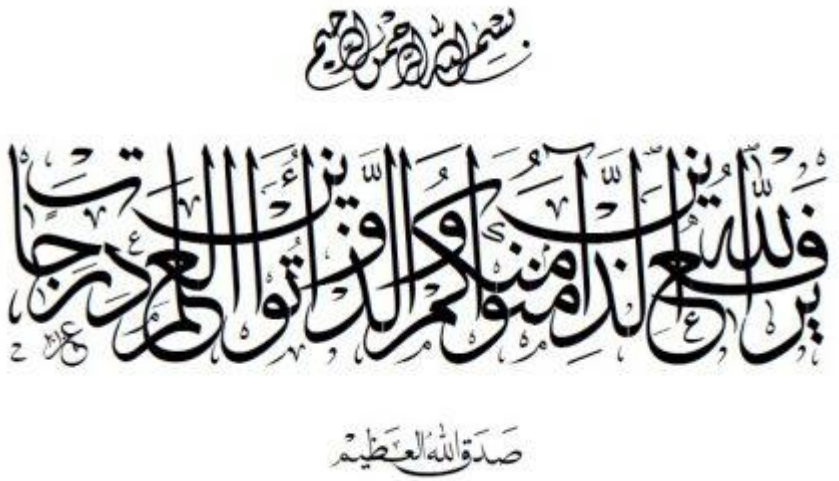

I dedicate this research work to my beloved parents, siblings and my respected supervisors.

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List of Abbreviations

ADA	American Disabilities Act
AHP	Analytic Hierarchy Process
ANP	Analytic Network Process
CMS	Cellular Manufacturing System
DM	Decision Maker
ELECTRE	Elimination Et ChoixTraduisant la REalité
FLP	Facility Layout Problem
GDSS	Group Decision Support System
MCDM	Multi Criteria Decision Making
PR	Performance Rating
PROMETHEE	Preference Ranking Organization Method for Enrichment of Evaluations
RIRO	la Revue d'Informatique et de RechercheOpérationnelle
SAW	Simple Additive Weighting
SLP	Systematic Layout Planning
WSM	Weighted Sum Model
WIP	Work In Progress

Chapter 1

Introduction

1.1 BACKGROUND OF STUDY

In today's modern age, technology made the process of developing new products from the initial stages of designing until the final stages of assembly more efficient. This paved the way for personalized, custom products to satisfy the various demands. In order to remain competitive, firms had to increase the variety while maintaining high volume to meet the changing demands of the markets.

A facility layout problem (FLP) usually compromises with the placing of machines, departments, transportation flow in a layout area objective to maximize the production rate of the system. The majority of the FLP use flow relationship between machines to reduce the material handling costs and increasing the machines utilization. According to Tompkins (1996), material handling costs can account for 20–30% of total production costs. A FLP can be defined as one which aims to place the resources or departments in optimal locations which are essential for running a successful production system within the available space.

The relationship between the facility layout in production area have been analysed by different researchers such as (Hungerländer&Rendl, 2013; Kothari & Ghosh, 2014;Anjos et al., 2016; Allahyari&Azab, 2017).

Many of them used the artificial intelligent methods such as genetic algorithm (Mak et al., 1998; Datta et al., 2011), simulation annealing method (McKendal et al.,

2006;Mavridou&Pardalos1997) and others used particle swarm (Samarghandi et al., 2010; Kulturel-Konak&Konak, 2011).However, very few researchers tried to investigate and analyse the effect of service and supporting departments on the work efficiency and the human efforts

Maximizing the efficiency of the factory layout usually is evaluated by the material handling system and the human efforts to have a smooth flow of the raw material, work in progress and final products in conjunction with the needs of the human and manpower. This will increase the cost dependency on the distances between the different locations of machines, cells and other departments in the manufacturing systems. Therefore, the most used factor in facility layout design is the flow–distance metric based on weighted average between the material transferred and the distance travelled. However, material handling process for materials such as the raw material, semi-finished products and final products are affected directly by many factors such as: manufacturing flexibility, manpower capacity, lead time, handling cost and efficiency of material flow. Therefore, facility layout design based on the flow–distance is insufficient. Selecting of the handling method and equipment based on factory layout during the design phase of the manufacturing system is one of the main complicated tasks that may affect the production rate and shortening the time to market of the products. Finally, the development of new technology such as the concept of digital factory may support the decision maker in selecting the best alternative

1.2 PURPOSE OF THE STUDY

The purpose of this paper is to successfully employ resources including people, equipment, space, and energy in addition improving the material handling system in a facility. Dalia Industries has been chosen for this study. To improve the facility, Apple's plant layout procedure was used to utilize the layout as well as the material handling system. Using Apple's procedure, departments were rearranged to improve overall collaboration and to effectively make use of space and resources. Facility planning and designing helps in accelerating an economy as it is a basis for time management, it also could improve quality standards and services at companies and industries.

1.3 PROBLEM STATEMENT

Nowadays, all manufacturing firm pays a great concern for improving productivity to survive and due to high demand in today's competitive market. To survive and maintain their share in the market, the manufacturer should follow lean principles. One of the most effective practices is by reducing the human effort inside the factory. Human resource and manpower is the main resource in most of industries. Humans contribute to handling systems and other activities of the factory such as inventory and manufacturing space. Therefore, a better design and layout for factory facilities will lead to better performance and higher productivity. Facility layout design involves the smooth flow of the work, transportation of the humans, equipment, materials handling, inventories, distribution of the machines and other facilities that associated

with the effectiveness of the manufacturing system. However, Most of the researchers try to investigate the production area layout but few of them try to investigate the relationship between the production space an the service departments. In this research, the relationship between the production area and other supporting departments and its effect of human efforts has been analysed. Many factors may affect the final layout of the factory, but the most important factor is the distances that the manpower resources need to move to achieve the objectives of the organization. Decision making decisions usually requires the consideration of many conflicting objectives. Therefore, select the best layout needs a powerful multi criteria decision making method (MCDM). There are many multi- criteria methods MCDM) can be used. These methods help in selecting the best layout that maximizes the efficiency of the manufacturing system and then simulate the result by using one of the effective simulation tools. In this research ELECTRE (EliminationEtChoixTraduisant la REalité) will be used as multi criteria decisions tool.

1.4 RESEARCH OBJECTIVES

The main objectives of this research are

1. To investigate and review the effectiveness of different multi criteria decision making methods that can be used in facilities layout including their material handling systems.
2. To develop a new conceptual framework that can guide to better facilities planning by integrating MCDM and Apple's procedure of planning
3. To investigate a real industrial case study in terms of facilities layout using simulation methods using different alternatives layouts

4. To propose anew layout facilities using ELECTRE method that improve and enhance the productivity by reducing the human efforts
5. To analyse and improve the production line efficiency using Delmia Quest software

This can be concluded in: flow–distance, average work-in-process, and the number of required material handling devices. These conflicting objectives can be solved through thus selection the appropriate layout and material handling system need

1.5 RESEARCH SCOPE

1. The facilities layout is based on the different factory layout factors. However, this research will focus on Factors that related to material handling system in manufacturing systems for discrete events principles such as Cellular Manufacturing System (CMS).
2. The research will consider the work in progress (WIP) parts in terms of handling facilities and its relation to facilities layout
3. The research will consider the time and distance measurements as the main factor
4. ELECTRE I method will be implemented as one of the effective and advanced methods in multi criteria decision analysis

Chapter 2

Literature Review

2.1 OVERVIEW

In this chapter literature review the chapter will start with an introduction in section 2.2, then in the following section 2.3 facility planning will be discussed the section will view everything surrounding facility planning in which apple's layout procedure is introduced with some other layout procedures, the last section 2.4 will discuss multi criteria decision making methods and tools a number of methods is discussed briefly with the main method chosen which is ELECTRE is discussed in depth.

2.2 INTRODUCTION

Maximizing the efficiency of the factory layout usually is evaluated by the material handling system which measured by the cost associated with the flow of materials. This cost dependency on the distances between the different locations of machines and cells in the manufacturing systems. Therefore, the most used factor in facility layout design is the flow–distance metric based on weighted average between the material transferred and the distance travelled. However, material handling process for materials such as the raw material, semi-finished products and final products are affected directly by many factors such as: manufacturing flexibility, manpower capacity, lead time, handling cost and efficiency of material flow. Therefore, facility layout design based on the flow–distance is insufficient. Selecting of the handling

method and equipment based on factory layout during the design phase of the manufacturing system is one of the main complicated tasks that may affect the production rate and shortening the time to market of the products. Finally, the development of new technology such as the concept of digital factory may support the decision maker in selecting the best alternative (Tompkins, J. A., 2003).

2.3 FACILITY PLANNING

Facility planning is concerned with the design, layout, and accommodation of people, machines and activities of a system or enterprise within a physical spatial environment (Garcia,2008).

Furthermore, Huang states that facility layout design determines how to arrange, locate, and distribute the equipment and support services in a manufacturing facility to achieve minimization of overall production time, maximization of operational and arrangement flexibility, maximization of turnover of work-in process (WIP) and maximization of factory output in conformance with production schedules (Huang, H.,2003).

In manufacturing systems, the three main types of layout are product layout, process layout, and group layout, which is further categorized into flow line, cell, and centre. According to Tompkins, the distinction between these types of layout is made based on system characteristics such as production volume and product variety (Tompkins, J. A., 2003).

Hessen stated that product layout (flow shop) is associated with high volume production and low product variety, while process layout (job shop) is associated with

low-volume production and high product variety in a large search space (Arostegui. M, K. S., 2006).

It is often used when the search space is discrete. For certain problems, simulated annealing may be more effective than exhaustive enumeration, provided that the goal is merely to find an acceptably good solution in a fixed amount of time, rather than the best possible solution (Balakhrishnan, J. C., 2007).

2.3.1 Strategic Facilities Planning Issues

Number, location, and sizes of warehouses and/or distribution centres, Centralized versus decentralized storage supplies, raw materials, work-in-process, and finished goods for single- and multi-building sites, as well as single- and multi-site companies also Acquisition of existing facilities versus design of model factories and distribution centres of the future, Flexibility required because of market and technological uncertainties, Interface between storage and manufacturing. Also level of vertical integration, including "subcontract versus manufacture" decisions, Control systems, including materials control and equipment control and Movement of materials between buildings, between sites, Changes in customers' and suppliers' technology as well as firm's own manufacturing technology and materials handling, storage, and control technology, last but not least Design-to-cost goals for facilities (Tompkins, J. A., 2003).

2.3.2 Facility planning objectives

The objectives of facility planning are first; support the organization's vision through improved material handling, material control, and good housekeeping. Second, effectively utilize people, equipment, space, and energy. Third, minimize capital