UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

SPARE PART MANAGEMENT USING ECONOMIC ORDER QUANTITY MODEL WITH FUZZY-ANALYTICAL HIERARCHY PROCESS (FUZZY-AHP) OPTIMIZATION

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KHAIRUN NAJMI BIN KAMALUDIN

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ABSTRACT

Maintenance is one of the pillar in developing world class manufacturing. One of the accountability of maintenance team is the control of spare parts inventory. For a high transaction spare part, controlling the correct quantity is a real challenge. Several methods have been proposed by researchers to cater the issue. Owing to this reason, this project investigates economic order quantity (EOQ) application in a spare part management and inventory, and optimization of EOQ with Fuzzy Logic Analytic Hierarchy Process AHP (Fuzzy AHP). The objective is to determine the best combination of material and fabricator of a specified spare part using AHP and triangular and trapezoidal Fuzzy AHP. EOQ model was used to quantify the ideal quantity of the spare part to be purchased. For the three AHP models, five main criteria were used to decide; cost, quality, productivity, delivery time and quantity, and to support, another sets of sub-criteria to the five criteria as mentioned. Eight solutions or alternatives were to be chosen from. One of the alternative from the AHP hierarchy, has consistently been produced as the result calculated from AHP and Fuzzy AHP. Based on the final result, it is recorded that the first rank is alternative 8 (OPTION 8), thus for AHP is at 16.466%, triangular AHP at 13.115% and trapezoidal AHP at 13.332%. This consolidate that Fuzzy AHP are able to support AHP result with the correct data analyzed. From this alternative, an EOQ model is calculated, and then simulated in a visual form for a time period. Numerical examples are provided to illustrate the model from a case study. 87 pieces of the spare part is suggested as the EOQ for the specified part. Other quantity such as maximum quantity, minimum quantity and ordering point were also defined. Other decision making tool such as Analytic Network Process (ANP), AHP with Technique for Order of Preference by Similarity to Ideal Solution (AHP-TOPSIS) and Preference Ranking Organization Method for Enrichment of Evaluations (Promethee) are extensions for this research. Finally, industrial application is in the best interest to fully understand the impact of this research.

ABSTRAK

Penyelenggaraan adalah salah satu tiang dalam membangunkan pembuatan kelas dunia. Salah satu akauntabiliti pasukan penyelenggaraan adalah kawalan inventori alat ganti. Untuk alat ganti bertransaksi tinggi, mengawal kuantiti yang betul adalah cabaran. Beberapa kaedah yang dicadangkan oleh para penyelidik untuk mengatasi cabaran berkenaan. Oleh kerana ini, projek ini menyiasat aplikasi kuantiti pesanan ekonomi (Economic Order Quantity, EOQ) dalam pengurusan dan inventori alat ganti, dan pengoptimuman EOQ dipadan bersama Logik Fuzzy Proses Analitik Hirarki AHP (Fuzzy AHP). Objektif kajian ini adalah untuk menentukan gabungan bahan dan fabrikasi yang terbaik bagi bahagian alat ganti yang ditentukan menggunakan AHP dan Fuzzy AHP segitiga dan trapezoid . Kuantiti yang ideal bagi alat ganti untuk dipesan akan menggunakan model EOQ. Bagi ketiga-tiga model AHP, lima kriteria utama digunakan untuk membuat keputusan; kos, kualiti, produktiviti, masa penghantaran dan kuantiti, dan untuk menyokong analisa, satu set subkriteria lain kepada lima kriteria juga ditambah. Terdapat lapan pilihan penyelesaian atau alternatif yang perlu dipilih. Salah satu daripada alternatif dari hirarki AHP, secara konsisten telah dihasilkan sebagai hasil daripada kiraan AHP dan Fuzzy AHP. Berdasarkan keputusan terakhir, alternatif utama ialah alternatif 8 (OPTION 8) iaitu untuk AHP bersamaan 16.466%, AHP segitiga bersamaan 13.115% dan AHP trapezoid bersamaan 13.332%. Ini menyimpulkan juga bahawa AHP Fuzzy dapat menyokong hasil AHP dengan data yang betul dianalisis. Dari alternatif ini juga, model EOQ dikira, dan kemudian disimulasikan dalam bentuk visual untuk tempoh masa. Contoh-contoh berangka disediakan untuk menggambarkan model dari kajian kes. 87 keping disarankan sebagai EOQ untuk alat ganti kajian. Kuantiti lain seperti kuantiti maksimum, kuantiti minimum dan titik pesanan juga ditentukan. Kaedah penentu keputusan lain seperti proses rangkaian analitik (ANP), AHP bersama teknik perintah utama oleh kesamaan dan penyelesaian ideal (AHP-TOPSIS) dan kaedah kedudukan organisasi untuk memperkaya penilaian (Promethee) adalah sambungan kajian yang baik. Akhirnya, aplikasi perindustrian adalah penggunaan terbaik untuk memahami sepenuhnya kesan penyelidikan ini.

DEDICATION

To my mother, Azizah bin Yusof, father, Kamaludin bin Omar.

To my wife Shahrun Nazida, my children Nafidz Zafran and Nadra Zafreen, and the baby to come. And to all my brothers and family.

You are all the inspiration and strength for this journey. I love you, and thank you.

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بسم الله الرحمن الرحيم

In the name of Allah, the most gracious and the most merciful.

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Last but not least, I would like to thank everyone else who has helped me in this journey. Without you, this would be impossible. You have given me the strength and will power to overcome what I had thought was heavy for me. Thank you sincerely.

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% - Percentage

A - Matrix A

W_i - Priority vector

λ_{max} - Eigenvalue

$\hat{r}i$ - Geometric mean of Fuzzy comparison value

α - Weightage of criteria in Fuzzy linguistic term l

β - Weightage of criteria in Fuzzy linguistic term m

γ - Weightage of criteria in Fuzzy linguistic term n

δ - Weightage of criteria in Fuzzy linguistic term s

ω_i - Fuzzy weights

N - Crisp value

W - Overall Fuzzy weight

M_i - Defuzzified Fuzzy weight

N_i - Normalized M_i

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CHAPTER 1

INTRODUCTION

This chapter extensively explains the overall project introduction. The introduction of spare part management role in a manufacturing environment, and the tools that can be used to manage a high consumable spare-part. Problem statement, objectives, scope of project will be discussed in this chapter.

1.1 Background

According to Palucha (Palucha 2012), a World Class Manufacturing organization will have the basic pillars as Figure 1.1 shows.

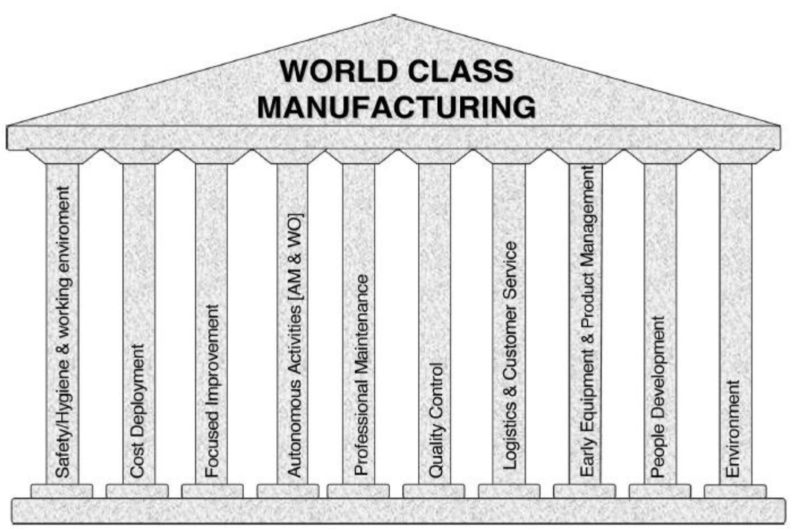

Figure 1.1: Ten pillars of a Wold Class Manufacturing, WCM (Palucha K., 2012)

The WCM pillars are:

i. Safety/Hygiene working area

ii. Cost Deployment

iii. Focused Improvement

iv. Autonomous Activity

v. Professional Maintenance

vi. Quality Control

vii. Logistics and Customer Service

viii. Early Equipment & Product Management

ix. People Development

x. Environment

It is worth to take note, referring to point number five, which is "Professional Maintenance" as one of the pillars. Without this, the WCM is not attainable. To summarize the scope of these pillars are activities that focuses on controlling the failure-cause analysis, further qualifications of maintenance service staff, collaboration with staff members responsible for autonomous maintenance, etc. Number of equipment or machine failures that occur in an organization enables this pillar to be highlighted.

According to Mohamad (Mohamad et al., 2009), the accountability of maintenance is to provide services to enable an organization to achieve its missions and visions. The specific account-abilities differ from one organization to another; however they generally include the following according to Duffuaa (Duffuaa et. al., 1998):

i. Keeping assets and equipment in good condition, well configured and safe to perform their intended functions;

ii. Perform all maintenance activities including preventive, predictive; corrective, overhauls, design modification and emergency maintenance in an efficient and effective manner;

iii. Conserve and control the use of spare parts and material;

iv. Commission new plants and plant expansions; and

v. Operate utilities and conserve energy

The above account-abilities and objectives impact the organization structure for Maintenance. To conserve and control the use of spare parts and material, will be the substance enhanced for this project. For many companies, the expenses incurred for keeping spare parts until they are used increase significantly the cost of their finished goods. Huge costs related to the inventory management of those parts have triggered studies on the provisioning and management decisions made in the process of acquiring and holding spare parts stocks.

According to Bošnjaković (Bošnjaković et. al., 2010), inventory control of spare parts is essential to many organizations. Excess inventory leads to high holding costs and a large commitment of funds. In the other hand stock outs can have a great impact on production or service. The author proposes a methodology for spare parts inventory control applying multi-criteria inventory model. It is based on ranking and classifying the spare parts in groups according to similar attributes. Each group of spares, depending on attributes of the spares that belong to it, joins the appropriate inventory policy model and forecasting demand model.

In the analysis of storage of spare parts an objective problem is in their specific, often unpredictable, nature of demand. Some spare parts have great demand, some very small (one to several years), which significantly complicates predicting the need for replacement parts.In the management of spare parts inventory there is a need to answer the following questions:

i. Generally, a part will be stored if the benefit of current availability is greater than the cost of holding inventories. This is especially important for spares with low demand. Comparing the storage costs and the costs related to stock out at the time of the spare needs, gives the answer to this question.

ii. When the decision has been made to stock an item, the next question to answer is how many to order at once. To determine an optimal order quantity, a well-known classical Economic order quantity (EOQ) formula can be used.

1.2 Problem statement

Economic order quantity (EOQ) is a basic technique being utilized for stock or inventory control. For a high consumption spare-part within a manufacturing organization, it serves as a base model to order from the same source, as the source will reflect into one of it's variables. The results of the same variables, will have a constant same consumption graph for visual.

Upon the criterion of the source differs, the selection for EOQ variable is expected to change. Analytic Hierarchy Process (AHP) and Fuzzy AHP is used to analyze the criterion for EOQ. The case study for this research is all about analysis of the criterion, with the use of AHP and Fuzzy AHP, with EOQ and the consumption curve, and stock control of the spare parts.

In this project, a study case of a high transaction spare part, used for miniature bonding process (thermal-compression resistance welding) of copper wires to the lead-frame of a chip. Due to the nature of the part that is high in demand, with a slight variable in the demand, EOQ with a visual consumption curve is more compatible to apply rather than a small batch of spare part item for a case study. An overview of the industrial process will be presented in Chapter 3.

1.3 Objectives

The objectives of this study are:

i. To analyze and select the best combination of material and supplier of welding tip using basic Analytical Hierarchy Process, AHP, Trapezoidal Fuzzy AHP and Triangular Fuzzy AHP

ii. To select the optimum quantity of spare part via Economic order quantity, EOQ technique.

1.4 Scope of study

The scope of the project are as follows:

i. The type of welding tip used for this project is welding tip type A only.

ii. Material used for the welding tip is Tungsten metal (SD-W-02) only.

iii. Multi-criteria decision making analysis will be limited to Analytical Hierarchy Process, AHP, Triangular Fuzzy AHP and Trapezoidal Fuzzy AHP