Development of Practical Opportunistic Maintenance (OM) Policy Based Model for Manufacturing System

by

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DEVELOPMENT OF PRACTICAL OPPORTUNISTIC MAINTENANCE (OM) POLICY BASED MODEL FOR MANUFACTURING SYSTEM

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IN THE NAME OF ALLAH, THE MOST GRACIOUS AND MOST MERCIFUL

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LIST OF SYMBOLS

δ	Number of working days
C_c	Cost of CM task conducted.
C_p	Cost of PM task conducted
n_c	Number of CM task conducted
n_p	Number of PM task conducted
μ	Means of Variance
C	Maintenance Cost
f	Failure
n	Number of measurements conducted
p	Probability
T	Time failure of the machine (component)
t	Time
T_{act}	Actual production time
T_{pdt}	Planned downtime
T_{plan}	Planned production time
T_{updt}	Unplanned downtime
Xi	individual measurements
σ	Standard Deviation

LIST OF ABBREVIATIONS

ARP	Age Replacement Policy
BRP	Block Replacement Policy
CBM	Condition Based Maintenance
CDF	Cumulative Distribution Function
CL	Centre Line
CM	Corrective Maintenance
CMMS	Computerized Maintenance Management System
DDTS	Daily Downtime Tracking System
FBD	Functional Block Diagram
FMEA	Failure Mode and Effect Analysis
LCL	Lower Control Limit
MORT	Management Overnight and Risk Tree
MTBF	Mean Time Between Failures
OEMs	Original Equipment Manufacturers
OM	Opportunistic Maintenance
OMISSYS	Opportunistic Model-based Diagnosis System
OMS	Optimal Maintenance System
OPTOMS	Opportunistic Principle towards Optimal Maintenance System
PCB	Printed Circuit Board
PdM	Predictive Maintenance
PDT	Planned Downtime
PM	Preventive Maintenance
RCM	Reliability Centred Maintenance
RPN	Risk Priority Number

SMT	Surface-Mount Technology
SPC	Statistical Process Control
TPM	Total Productive Maintenance
UCL	Upper Control Limit
UPDT	Unplanned Downtime
WIP	Work In Progress

PEMBANGUNAN MODEL YANG PRAKTIKAL BERDASARKAN POLISI PENYENGGARAAN OPORTUNIS UNTUK SISTEM PEMBUATAN

ABSTRAK

Penyenggaraan dijalankan untuk memastikan bahawa semua peralatan di dalam sebuah syarikat dibaiki, diganti, diselaraskan dan diubah suai mengikut keperluan pengeluaran. Sistem penyenggaraan yang berkesan dan dioptimumkan amat diperlukan di dalam sistem pembuatan pada hari ini. Dengan kemajuan teknologi dan kerumitan sistem, terdapat satu pendekatan baru yang dipanggil penyenggaraan prospek di mana polisi ini adalah 'penyenggaraan oportunis' (OM). OM boleh ditakrifkan sebagai aktiviti penyenggaraan yang dijalankan untuk membaiki komponen yang rosak dan pada masa yang sama menggunakan peluang yang ada untuk membaiki / menggantikan komponen lain di dalam sistem dengan tujuan untuk mengelakkan kegagalan pada masa hadapan dan mengurangkan bilangan masa henti mesin. Ia adalah gabungan penyenggaraan membetul (CM) yang digunakan apabila sebarang kegagalan berlaku, dengan penyenggaraan cegahan (PM) –pendekatan penyenggaraan yang dirancang dan dijadualkan untuk mencegah kegagalan berlaku. Apa-apa pemberhentian mesin kerana kegagalan adalah 'peluang' untuk menjalankan PM. Walau bagaimanapun, cabaran untuk mencapai sistem penyenggaraan yang optimum menggunakan dasar OM adalah untuk mencari keseimbangan yang optimum antara kos penyenggaraan dan umur komponen umur mesin dan ciri-ciri kebolehpercayaan. Tahun demi tahun, penyelidikan yang telah diterbitkan berkisar tentang seluruh teori konsep dan analisis berangka polisi tetapi kekurangan model yang realistik dan praktikal untuk penggunaan. Fokus kajian ini adalah menjurus ke arah isu-isu penggunaan OM dalam mencapai sistem penyenggaraan yang optimum. Berdasarkan pengenalan gagasan prinsip, konsep dan ciri-ciri dasar OM, sebuah model membuat keputusan telah dibangunkan. Dengan akronim sebagai OPTOMS untuk Opportunistic Policy towards Optimal Maintenance System, model ini dibangunkan dalam lima fasa dengan penggunaan Check Sheet dan Stacked-Bar Chart untuk fasa pemilihan mesin, Failure Mode and Effect Analysis (FMEA)untuk analisis kegagalan dan Control Chart untuk fasa pengukuran prestasi. Di dalam model ini, prinsip OM dikaji dan dibangunkan menjadi set peraturan dengan beberapa batasan dan andaian untuk disesuaikan dengan dasar ke dalam persekitaran praktikal. Butiran perbincangan disediakan untuk membuat OM dasar dengan sebaik mungkin dalam mencapai sistem penyenggaraan yang optimum. Model ini disemak dan disahkan di sebuah syarikat semikonduktor. Hasil kajian kes ini mengesahkan penggunaan dan amali model OPTOMS sebagai sistem sokongan keputusan dalam mengguna pakai dasar OM. Model yang dibangunkan ini membantu syarikat dalam perangcangan dan penjadualan aktiviti penyenggaraan bagi mengurangkan kos dan masa henti mesin serta meningkatkan kebolehsediaan dan kebolehharapan mesin sehingga 20%.

DEVELOPMENT OF PRACTICAL OPPORTUNISTIC MAINTENANCE (OM) POLICY BASED MODEL FOR MANUFACTURING SYSTEM

ABSTRACT

Maintenance is conducted to ensure that all equipment in a company are repaired, replaced, adjusted and modified according to production requirements. Effective and optimized maintenance system are highly acquired in today's manufacturing system. With the advancement of technologies and complexity of systems, there is a new maintenance approach called prospective maintenance where the policy is 'opportunistic maintenance' (OM). OM can be defined as maintenance activities that are conducted to repair a component and at the same time opportunistically repair/replace other components in the system with the aim to avoid future failures and reduce the number of machine downtime. It is the combination of corrective maintenance (CM) which is applied when any failure occurred, with preventive maintenance (PM) -a planned and scheduled maintenance approach to prevent failure to happen. Any machine stoppage due to failure is the 'opportunity' to conduct PM. However, the challenge to achieve optimal maintenance system using OM policy is to find a balanced trade-off between maintenance cost and component or machine age and reliability features. Throughout the years, literatures that had been published lingers around conceptual theory and numerical analysis of the policy yet in the realistic and practical model for the application is lacking. The focus of this research is directed towards the issues of OM application in achieving optimal maintenance system. Based on conceptual identification of principle, concept and characteristics of OM policy, a decision making model was developed. With the acronyms of OPTOMS for Opportunistic Policy towards Optimal Maintenance System, the model was developed in five phases with the usage of Check Sheet and

Stacked-Bar Chart for machine selection phase, Failure Mode and Effect Analysis (FMEA) for failure analysis and Control Chart for performance measurement phase. In this model, OM principle are studied and developed into a set of rules with some limitations and assumptions to suit the policy into practical environment. Detail discussions were provided to make OM as a practical policy in achieving optimal maintenance system. The model is validated and verified in a semiconductor company. The outcomes of this case study confirmed the application and practicality of the OPTOMS model as a decision support system in applying OM policy. The developed model helps the company to plan and to schedule maintenance activities in reducing cost and machine downtime as well as increasing up to 20% of its machine availability and reliability.

CHAPTER 1

INTRODUCTION

1.0 Overview

The first chapter is written and structured in six sections as to provide the general idea of what, why, where, who and how this research has been conducted. The first section gives an overview of maintenance system as the research field and issues that commonly arise. The second section introduces the theoretical principle of Opportunistic Maintenance (OM) as an effective and optimal maintenance policy. Then, the third section highlighted some issues in OM policy as the problem statement studied in this research. Subsequently, the fourth section deals with the research motivation under the aims and objectives section. The fifth section includes the research focus and limitations. Finally, to show the overall structure, section six highlights the contents of each chapter of this thesis.

1.1 Maintenance System

The concise translation of the word maintenance from British Standard BS 3811:1993 “Glossary of Terms in Terotechnology” is, “the combination of all technical and administrative actions, including supervision actions, intended to retain an item in, or restore it to, a state in which it can perform a required function” (Maintenance Management, 2015). Maintenance is conducted to ensure that all equipment in the company is repaired, replaced, adjusted and modified according to production requirements. This way, the whole manufacturing processes are guaranteed to have an effective and efficient operation (Arts et al., 1998; Parida and Kumar, 2006).

In recent years, maintenance is commonly viewed as a value-adding activity instead of as ‘necessary evil’ for expenses like in the past (Ben-Daya and Duffua, 1995; Al-Turki, 2011). Even though maintenance system is not related directly to the processes in product manufacturing, Alsyouf (2007) presented the scenario of an effective maintenance system with the result of less unplanned stoppages, better product quality, less production stoppages, etc. The author argued that the manufacturing cost will definitely be reduced and the company’s profit will increase. The good product quality image due to higher customer satisfaction, then will lead to an increase of a product’s price. At the end, the company will experience the increase in their productivity and profit.

The maintenance role in today’s manufacturing system is also becoming more important as companies start to adopt the system as one of its profit generating elements (Waeyenbergh and Pintelon, 2002; Sharma et al., 2011). The measured performance of maintenance system in a company will signify the current business condition of the organization to determine its successful direction (Kutucuoglu et al, 2001). However, based on the research conducted by Mobley (1990), cited by Chan et al. (2005), 15 to 40% of total production cost is spent for maintenance activities. On the other hand, Bevilacqua and Braglia, (2000) stated that maintenance cost can reach 15-70% of production costs, varying according to the type of industry. Consequently, further research by Wireman (2003) showed that up to 33% of this maintenance cost is actually wasted or spent unnecessarily. These percentages show a lot of improvements could be carried out in achieving effective and optimized maintenance system.

Effective maintenance is imperative as large losses of profit can be attributed to machine breakdown and downtime during operation (Waeyenbergh and Pintelon,