UNIVERSITI PUTRA MALAYSIA

THE EFFECT OF IMPLEMENTING DIFFERENT MAINTENANCE POLICIES ON THE PRODUCTION RATE OF A FLEXIBLE MANUFACTURING CELL

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By

SEPIDE NAJAFIAN

Thesis Submitted to the School of Graduate Studies, University Putra Malaysia, in Fulfillment of the Requirement for the Degree of Master of Science

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DEDICATION

Dedicated to my parents for their love, support and encouragement.

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Abstract of thesis presented to the Senate of University Putra Malaysia in fulfillment of the requirement for the degree of Master of Science

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November 2008

Chairman: Associate Professor Dr. Ir Md. Yusof Ismail

Faculty: Engineering

Today, world-class competitiveness is a must for companies. Competitive world made the companies increase the productivity, quality of the product, lower price and better service and support with respect to safety and environment perspectives. Maintenance is one of the tools that can help the companies reach these objectives.

Flexible manufacturing cells (FMCs) as a group of machines designed to produce a variety of similar products, often operate with increasing failure rate due to extensive utilization and wear-outs of equipment. While maintenance plans can eliminate wear-out failures, random failures are still unavoidable.

This research develops several simulation studies to compare the performance of a flexible manufacturing cell under six different maintenance polices namely: No maintenance policy, Corrective maintenance policy, Block-based policy, Age-based policy, Opportunity-triggered policy and conditional opportunity triggered policy.

The simulation studies used in this thesis demonstrate production rate subject to maintenance policies under different mean time between failures. The software chosen for the simulation is Show Flow.

The main focus of this work is to compare traditional corrective maintenance policies with different preventive maintenance policies that utilize real-time sensory information to assist in decisions regarding maintenance management and component replacement. It can be concluded that any FMC system under consideration must be analyzed with respect to several maintenance policies and the best policy should be selected before implementing a policy.

The maintenance policy of FMC which is monitored in this research is block-based policy. Maintenance and production rate Information of this policy is used as a base to simulate for the other five policies. The analysis shows that different maintenances schedules have important effects on production rate of FMC. The best policy is Opportunity-triggered maintenance policy (OTP) with the best production rate near to fully reliable cell and the worst policy is the corrective maintenance policy (CMP) with the worst production rate in all of the MTBF to compare with other policies. From these results it could be said with a few changes in schedule time of preventive maintenance, a company can have better production rate.

This research has been conducted using information obtained from Proton Company (car factory) in Malaysia but the results are not limited to this company or other car factories. It can be used for every factory that has flexible manufacturing cell.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

PRODUKTIVITI SEL PEMBUATAN FLEKSIBEL MELALUI PERLAKSANAAN POLISI PENYELENGGARAAN

Oleh

SEPIDE NAJAFIAN

Jun 2008

Pengerusi: Prof. Madya Dr. Ir Md. Yusof Ismail

Fakulti: Kejuruteraan

Hari ini persaingan peringkat dunia tidak dapat dielakkan lagi. Dunia persaingan menyebabkan syarikat syarikat meningkatkan produktiviti dan kualiti produk. Persaingan juga menyebabkan harga barangan turun, mutu perkhidmatan dan sokongan meningkat terhadap keselamatan dan persekitaran. Penyelenggaraan adalah antara yang dapat membantu syarikat mencapai objektif.

Sel sel pembuatan feksibel seringkali beroperasi dengan peningkatan kadar kerosakan disebabkan kegunaan dan kehausan peralatan. Walaupun pelan penyelenggaraan dapat mengelakkan kerosakan akibat kehausan, kerosakan rawak tidak dapat dielakkan.

Kajian ini telah dapat menghasilkan beberapa simulasi untuk tujuan perbandingan prestasi sel sel pembuatan fleksibel di bawah polisi penyelenggaraan yang berbeza yakni: Tiada polisi penyelenggaraan, Polisi penyelenggaraan pembetulan (CMP), Polisi berasaskan blok (BBP), Polisi berasaskan usia (ABP), Polisi cetusan peluang (CMP) dan Polisi cetusan peluang bersyarat(OTP).

Kajian simulasi menunjukkan kadar pengeluaran berdasarkan polisi penyelenggaraan di bawah MTBF yang berbeza beza. Perisian yang telah digunakan ialah 'Show Flow'.

Fokus utama dari kajian ini adalah untuk membandingkan polisi penyelenggaraan pembaikan tradisionil dengan lain lain polisi penyelenggaraan pencegahan. Polisi penyelenggaran pencegahan ini menggunakan maklumat 'realtime' dan dapat membantu keputusan berkaitan pengurusan penyelenggaraan dan penggantian komponen. Sebarang sistem FMC yang dikaji hendaklah dianalisis terhadap beberapa polisi penyelenggaraan dan polisi terbaik dipilih sebelum melaksanakan sebarang polisi.

Polisi penyelenggaraan FMC yang dipantau di dalam kajian ini adalah polisi berasaskan blok. Maklumat penyelenggaraan dan kadar pengeluaraan dari polisi ini digunakan sebagai asas untuk simulasi bagi lima lagi polisi yang lain. Analisis menunjukkan bahawa jadual penyelenggaraan yang berbeza mempunyai kesan penting terhadap kadar pengeluaran dari FMC. Polisi terbaik adalah OTP manakala yang terburuk adalah CMP.

Berdasarkan pengeluaran yang diperolehi, syarikat boleh mendapat kadar pengeluaran yang lebih baik hanya dengan sedikit perubahan di dalam jadual masa penyelenggaran pencegahan.

Penyelidikan ini telah dijalankan dengan menggunakan maklumat yang telah diperolehi daripada syarikat PROTON. Namun demikian keputusan daripada hasil kajian dapat juga digunakan terhadap mana mana kilang yang mempunyai sel pembuatan fleksibel.

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Last but not least, I would like to express my heartiest gratitude and appreciation to my parents for their support, my dear sister Azadeh for her patience and encouragement when I needed it most, my friends Kamran Yahyazadeh, Alireza Esfandyari and especially Farzad Tahriri who helped me throughout this research.

I certify that an Examination Committee has met on 18th of November to conduct the final examination of Sepide Najafian on her Master of Science thesis entitled "The effect of implementing different maintenance policies on the production rate of a flexible manufacturing cell" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfillment of the requirement for the degree of Master of Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotation and citations, which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

SEPIDE NAJAFIAN

Date:

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LIST OF ABBREVIATIONS

FMS	Flexible Manufacturing System
FMC	Flexible Manufacturing Cell
PM	Preventive Maintenance
MPM	Maintenance Performance Measurement
HRM	Human Regarding Management
ARP	Age Replacement Policy
ALC	Automated Line Control
CM	Corrective Maintenance
CMP	Corrective Maintenance Policy
BBP	Block-Based PM with CM policy
ABP	Age-Based PM with CM policy
OTP	Opportunity-Triggered PM with CM policy
COP	Conditional Opportunity-triggered PM with CM policy
MTBF	Mean Time Between Failures
D/T	Down Time
FRC	Fully Reliable Cell

CHAPTER 1

INTRODUCTION

1.1 Introduction

The survival of any business depends on its ability to compete effectively. One of the primary responsibilities of a manager is to achieve productive use of an organization's resources. Productivity has important implications for business organizations and for entire nations. For nonprofit organizations, higher productivity means lower costs; for profit-based organizations, productivity is an important factor in determining how competitive a company is. For a nation, the rate of productivity growth is of great importance. Productivity growth is the increase in productivity from one period to the next relative to the productivity in the preceding period.

Productivity growth is a key factor in a country's rate of inflation and the standard of living of its people.

Maintenance analysis is an important issue since the cost of maintenance in industrial facilities can go up to 15–40% of total production costs (Sheu and Krajewski, 1994).

Proper maintenance does not only help to keep the life cycle cost down; it also contributes positively to the overall performance of the company.

Industrial maintenance has two essential objectives: (1) A high availability of production equipment. (2) Low maintenance cost

The managers have to pay even more attention to maintain the complex equipment and to keep them in available state because of the increasing rate of automation.

Table 1.1 is showing maintenance in a time perspective. There is a shift from failure-based to use-based maintenance. As regards human resources, highly qualified personnel are being demanded and continuous training efforts are needed. Maintenance has become more and more integrated.

Table1.1: Maintenance in a time perspective (Waeyenbergh and Pintelon, 2000)

<1950	1950-1975	>1975	→ 2000 →
Manpower(simple)	Mechanization(complex)	Automation (more complex)	Globalization (crossing boundaries)
Maintenance is "A production task"	Maintenance is "A task of maintenance dept."	Maintenance is "(maybe) not an isolated function" integration efforts	Maintenance is "External and internal partnerships "maintenance meets production
"Necessary evil"	"Technical matter"	"Profit contributor"	"partnership"

There are three types of maintenance task: (1) breakdown, (2) corrective, and (3) preventive (Mobley et al, 2008).

The principal difference in these occurs at the point when the repair or maintenance task is implemented. In breakdown maintenance, repairs do not occur until the machine fails to function. Preventive maintenance tasks are implemented before a problem is evident and corrective tasks are scheduled to correct specific problems that have been identified in plant systems.

In most plants, preventive maintenance is limited to periodic lubrication, adjustments, and other time-driven maintenance tasks. These programs are not true preventive programs. In fact, most continue to rely on breakdowns as the principal motivation for maintenance activities.

A comprehensive preventive maintenance program will include predictive maintenance, time-driven maintenance tasks, and corrective maintenance to provide comprehensive support for all plant production or manufacturing systems.

Preventive maintenance is an investment and it is expected to receive benefits from preventive maintenance that are greater than investment.

Making preventive investment tradeoffs require consideration of the time value of money whether the organization is profit-driven, not-for-profit, private, public, or government. All resources cost money. The three dimensions of payback analysis are: the money involved in the flow, the period over which the flow occurs, and the appropriate cost of money expected over that period.

At present, the most feasible approach for automating the job shop process seems to be through flexible manufacturing cells (FMCs), which require lower investment, less risk, and also satisfy many of the benefits gained through flexible manufacturing systems

(FMSs). While FMSs are very expensive and generally require investments in millions of dollars, FMCs are less costly, smaller and less complex systems (Sander, 1986 and Chan D,bedworth, 1990).

1.2 Problem statement

During a flexible manufacturing cell's (which is subset or a smaller version of flexible manufacturing system) extended useful life, it will not experience the same amount of wear and tear as a traditional machine tool operating over this time because FMC will typically operate at 70-80% utilization whereas a traditional machine tool's utilization runs about 20% . This will result in the FMC incurring four times the wear during any given time period. It will increase the importance of maintenance and maintenance-related activities (Vineyard and Meredith, 1992).

Proton Company is like the other companies that using FMC often operates with increasing failure rate due to extensive utilization and wear-outs of equipment.
Considering the existing problems in the company initiating from random failures such as have cutting chips inside machines, owing to the human mistakes or suspected environment machine high temperature and other similar and unexpected problems, shows the need for a suitable maintenance policy. This will cause in better productivity and in return better benefits.

To solve the problem, simulation is created in order to understand how an improvement in maintenance policies in a flexible manufacturing cell affects the production rate.

Maintenance policies analysis is used to determine if preventive maintenance will be effective. This is shown by policies with preventive maintenance and also without preventive maintenance and then, if the preventive maintenance is effective, chooses one of the several possible alternatives.

1.3 Objective of the research

The objectives of this research are as follows:

i. To simulate the performance of a flexible manufacturing cell under different maintenance policies.

ii. To evaluate the production rate of a flexible manufacturing cell (FMC) under different maintenance policies.

1.4 Scope of the Research

This research concentrates on production rate for a FMC. It is carried out in a cell of Engine Shop of Proton Company. The study investigates the effect of apply different maintenance policies on the production rate of this cell. The mean time between failures is used as a factor to compare the production rate when maintenance policies are changing.

1.5 Importance of the research

Optimizing the efficiency of assets has a significant impact on the quality and productivity and affects the overall profitability of an organization. Often, this may determine whether or not the organization has the ability to compete or even survive. Although in most cases management may realize the benefits that can be gained from a well-executed asset management program, implementation of such programs usually requires a significant shift in the culture of the enterprise.

Performing preventive maintenance will help a plant proactively avoid equipment failures. Indeed, monitoring production equipment status and analyzing equipment failure causes and effects provide support for knowing how often to perform preventive maintenance.

1.6 Limitation of the research

Preventive maintenance (PM) does involve risk. The risk here refers to the potential for creating defects of various types while performing the PM task. In other words, human errors committed during the PM task and infant mortality of newly installed components eventually lead to additional failures of the equipment on which the PM was performed. Frequently, these failures occur very soon after the PM is performed. Typically, the following errors or damage errors or damage occur during PM's and other types of maintenance outage.

- Damage to adjacent equipment during a PM task.

- Damage to the equipment receiving the PM task to include such things as:
    - Damage during the performance of an inspection, repair, adjustment, or installation of a replacement part.
    - Installation material that is defective, incorrectly installing a replacement part, or incorrectly reassembling material.
- Reintroducing infant mortality by installing new parts or materials.
- Damage due to an error in reinstalling equipment into its original location.

The key to a successful Preventive Maintenance (PM) program is scheduling and execution.

CHAPTER 2

LITRETURE REVIEW

2.1 Introduction

Traditionally, maintenance has been considered as a necessary evil, but in fact it is a profit center rather than just unpredictable and unavoidable expense (Najjar et al, 2004). Most of the previous studies have concentrated on finding an optimum balance between the costs and benefits of preventive maintenance.

Maintenance performance measurement (MPM) has received a great amount of attention by researchers and practitioners in recent years due to a paradigm shift in maintenance, as explained in figure 2.1. Prior to early 1900s, maintenance was considered as a necessary evil. Technology was not at a state of advanced development, there was no alternative for avoiding failure, and the general attitude to maintenance was," It costs what it costs." With the advent of technological changes and after the Second World War, maintenance came to be considered as an important support function for production and manufacturing. During 1950-1980, with the advent of techniques like preventive maintenance and condition monitoring, the maintenance cost perception changed to: "It can be planned and controlled." Today maintenance is considered as an integral part of the business process and it is perceived as: "It creates additional value". The measurement of maintenance performance has also become an essential requirement for the industry of today.

The efficiency and effectiveness of the maintenance system play a pivotal role in the organization's success and survivability. Therefore, the system's performance needs to be measured using a performance measurement technique.

A performance measurement system is defined as the set of metrics used to quantify the efficiency and effectiveness of actions. For many asset-intensive industries, the maintenance costs are a significant portion of the operational cost. In addition, breakdowns and downtime have an impact on the plant capacity, product quality, and cost of production, as well as health, safety and the environment (Parida and Kumar, 2006).

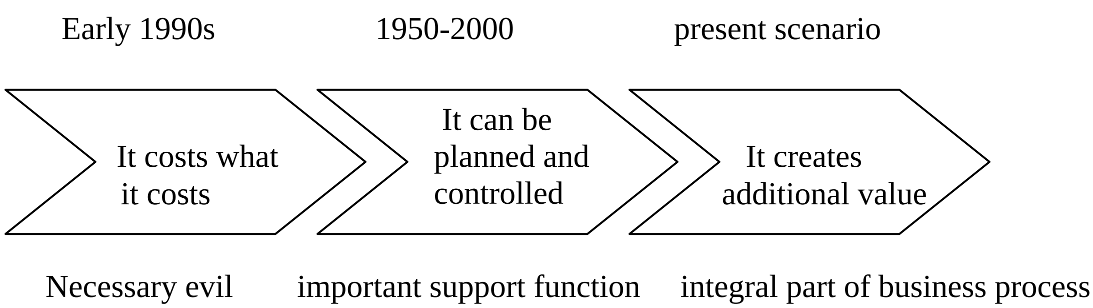

Figure 2.1: Paradigm Shift in Maintenance (Liyanage and Kumar, 2003)

Three maintenance factors can be pointed out as critical success factors of a maintenance concept (Pintelon et al, 1997):

(1) Thorough knowledge of maintenance technology: the direct production personnel as well as the maintenance workers need knowledge and competence to prevent disruptions at an early stage of the production process.