

Quick Response Manufacturing (QRM) In Job Shop
Environment

WONG YUN SHI

B050810034

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2012



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Quick Response Manufacturing (QRM) In Job Shop Environment

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering Management (Hons).

by

WONG YUN SHI

B050810034

880807-08-5462

FACULTY OF MANUFACTURING ENGINEERING

2012

ABSTRAK

Pada masa kini, syarikat-syarikat pengeluar perlu membekalkan kepelbagaian jenis produk atau product kejuruteraan untuk memenuhi keperluan pelanggan-pelanggan. Dengan ini, syarikat dapat terlebih dahulu dalam pasaran daya saing yang kuat. Walau bagaimanapun, syarikat-syarikat ini mendapati bahawa konsep *Lean Manufacturing* tidak membantu dalam meningkatkan keperluan mereka dalam persekitaran sedemikian. Sebaliknya, kelemahan seperti lewat penghantaran pesanan pelanggan dan tinggi inventori WIP akan muncul jika *Lean Manufacturing* memohon di perbuatan industri yang berjenis membekal produk kebanyakan jenis dan pengeluaran rendah pesanan pelanggan. Satu kaedah yang dinamakan *Quick Response Manufacturing* (QRM) adalah lebih sesuai bagi perbuatan industri yang bejenis begitu. Salah satu teknik daripada QRM adalah *Paired-cell Overlapping Loops of Cards with Authorization* (POLCA) bertujuan untuk mengawal pergerakan bahan di tempat pengeluaran. Dengan ini, inventori WIP and tempoh masa penghantaran pesanan pelanggan dapat dikurangkan. Bilangan kad POLCA bagi setiap pasangan memainkan peranan yang penting dalam pelaksanaan POLCA. Dalam projek ini, spreadsheet dibangunkan untuk menentukan pasangan gelung POLCA dan untuk mengira bilangan kad POLCA bagi setiap gelung berpasangan. Selain itu, cadangan tentang susun atur mesin berdasarkan kekerapan yang tinggi gelung POLCA berpasangan dicadangkan dan susun atur ini boleh menyumbang kepada kelebihan pengendalian bahan yang lebih baik dan plumbum masa yang pendek.

ABSTRACT

Today, manufacturing companies have to supply high variety or custom engineered products to fulfill customers' requirement and thereby advance to competitive advantage. However these companies found that Lean Manufacturing concepts are not helping improve their needs in such environment. On the other hand, drawbacks such as longer lead times and increased WIP inventories are generated with these lean concepts if applied at those high mix and low volume manufacturing environment. In a high mix and low volume manufacturing environment, Quick Response Manufacturing (QRM) is more suitable to improve company's performance. One of the tools of QRM is Paired-cell Overlapping Loops of Cards with Authorization (POLCA), a technique used to control material movement in order to control the level of WIP and reduce lead time. POLCA card was used to control the material movement and hence shorten the lead time and improve delivery performance. The number of POLCA card of each paired loop is the key role in the POLCA implementation. In this project, a spreadsheet is developed to determine the POLCA paired loop and to calculate the number of POLCA card for each paired loop. Moreover, a suggestion about the machine layout based on the high frequency of POLCA paired loop is suggested and this layout could contribute to the advantages of better material handling and shorter lead time.

DEDICATION

I would like to dedicate this report to my supervisor who gave the right advice and guide to me, to my beloved family who have never fail to give moral supports to me in everything during the time I developed this report.

ACKNOWLEDGEMENT

The special thank to my supervisor, Professor Dr. Chong Kuan Eng. The supervision, advice and support that he gave truly help the progression of my final year project.

I also wish to express my sincere appreciation to the company that I attached in. The co-operation is much indeed appreciated.

Great appreciation to the contribution of my faculty, Faculty of Manufacturing in helping us completes this project by providing the project guidelines.

TABLE OF CONTENT

| | |
|---------------------------------------|----------|
| Abstrak | i |
| Abstract | ii |
| Dedication | iii |
| Acknowledgement | iv |
| Table of Content | v |
| List of Tables | x |
| List of Figures | xi |
| List of Abbreviation | xiii |
| | |
| CHAPTER 1 | 1 |
| 1.1 Background of Study | 1 |
| 1.2 Problem Statement | 2 |
| 1.3 Objectives | 3 |
| 1.4 Scope | 3 |
| 1.5 Organization of the Report | 4 |
| | |
| CHAPTER 2 | 5 |
| 2.1 Production System Characteristics | 5 |
| 2.1.1 Mix | 6 |
| 2.1.2 Volume | 6 |
| 2.1.3 Demand variability | 7 |
| 2.1.4 Degree of Customization | 7 |
| 2.2 Lean Manufacturing | 7 |

| | | |
|-------|---|----|
| 2.2.1 | Lean Concept | 8 |
| | 2.2.1.1 Elimination Muda | 8 |
| | 2.2.1.2 Implementing flow | 9 |
| | 2.2.1.3 Implementing Pull | 9 |
| 2.3 | Quick Response Manufacturing | 10 |
| 2.3.1 | Four Core Concepts | 11 |
| | 2.3.1.1 The Power of Time | 11 |
| | 2.3.1.2 Restructuring Organization | 11 |
| | 2.3.1.3 Understand and Exploit System Dynamics Principles | 13 |
| | 2.3.1.4 A Unified Strategy | 13 |
| 2.3.2 | QRM Principles | 13 |
| 2.4 | Drawbacks of Traditional Principles | 20 |
| 2.4.1 | Pitfalls of On-Time Delivery Measures | 20 |
| 2.4.2 | Drawbacks of Efficiency and Utilization Measures | 21 |
| 2.4.3 | Response time spiral | 21 |
| | 2.4.3.1 The Response Time Spiral for a Make-To-Order Company | 22 |
| | 2.4.3.2 The Response Time Spiral for a Make- To- Stock company | 23 |
| | 2.4.3.3 The Response Time Spiral for an Engineer-to-Order Company | 24 |
| 2.4.4 | Cost-based Organization | 24 |
| 2.5 | Production Control Method | 25 |
| 2.5.1 | Push System | 25 |
| 2.5.2 | Pull System | 25 |
| 2.5.3 | POLCA | 26 |
| | 2.5.3.1 POLCA Cards Vs Kanban | 27 |
| | 2.5.3.2 Flow of POLCA Cards | 28 |

| | | |
|----------------------|---|-----------|
| 2.5.3.3 | Advantages of POLCA over Push (MRP) and Pull (Kanban) Systems | 31 |
| 2.6 | Case Studies on POLCA Implementation | 32 |
| 2.6.1 | Bosch Hinge in Doethinchem | 32 |
| 2.6.2 | Olsen Engineering in Eldridge | 33 |
| 2.6.3 | Rockwell Automation in Wisconsin | 34 |
| 2.7 | Prerequisites for Successful Implementation of QRM | 35 |
| 2.8 | Conclusion | 36 |
| CHAPTER 3 | | 37 |
| 3.1 | Overview of Methodology | 37 |
| 3.1.1 | Project Planning | 37 |
| 3.1.2 | Literature Review and Information Collection | 39 |
| 3.1.3 | Method Design | 39 |
| 3.1.3.1 | Developing the POLCA Technique | 39 |
| 3.1.3.2 | Identifying the Possible POLCA Loops | 39 |
| 3.1.3.3 | Designing the POLCA Cards | 41 |
| 3.1.3.4 | Developing the Spreadsheet | 41 |
| 3.1.3.5 | Determining the POLCA loops in the planning period | 41 |
| 3.1.3.6 | Computing the Number of POLCA Cards | 41 |
| 3.1.3.7 | Spreadsheet Testing and Evaluation | 42 |
| 3.1.4 | Review | 42 |
| CHAPTER 4 | | 43 |
| 4.1 | Shop Floor Activities in the Case Company | 43 |
| 4.2 | Spreadsheet Model | 44 |
| 4.2.1 | Worksheet “Jan_ Wk 1-2” | 44 |

| | | |
|----------------------|--|-----------|
| 4.2.1.1 | Job Number and Job Sequences | 46 |
| 4.2.1.2 | Loop | 47 |
| 4.2.1.3 | Button LOOP COUNT | 48 |
| 4.2.1.4 | Button CANCEL COUNT | 49 |
| 4.2.1.5 | Button COLOR CHECK | 50 |
| 4.2.1.6 | Button CANCEL COLOR | 52 |
| 4.2.1.7 | Button POLCA CARD | 52 |
| 4.2.1.8 | Worksheet “POLCA CARD (MONTHLY)” | 58 |
| 4.3 | Summary of User Guideline | 60 |
| CHAPTER 5 | | 61 |
| 5.1 | Operation in Case Company | 61 |
| 5.2 | Spreadsheet Testing Result | 62 |
| 5.2.1 | Result of POLCA Paired Loop in Worksheet “Jan_Wk 1-2” and “Jan_Wk 3-4” | 62 |
| 5.2.2 | Result of Number of POLCA Card in Worksheet “POLCA CARD (MONTHLY)” | 63 |
| 5.3 | Discussion | 65 |
| 5.3.1 | Formulation of POLCA Card | 65 |
| 5.3.2 | Flow of POLCA Card in Shop Floor | 68 |
| 5.3.3 | Machine Layout Cell-Based | 73 |
| 5.4 | Summary | 75 |
| CHAPTER 6 | | 76 |
| 6.1 | Introduction | 76 |
| 6.2 | Conclusions | 77 |
| 6.3 | Recommendation for Future Work | 78 |

REFERENCES

79

APPENDICES

- A Gantt chart for Entire Project (PSM 1 & PSM 2)
- B Procedure to Define a Range
- C Procedure to Define an Undefined Loop
- D Customer's Data
- E Result in Worksheet "Jan_Wk 1-2"

LIST OF TABLES

| | | |
|-----|---|----|
| 4.1 | Summarized of user guideline | 60 |
| 5.1 | Types of process | 61 |
| 5.2 | Parameters for POLCA card calculation in this project | 65 |
| 5.3 | Manual POCLA card calculation | 66 |
| 5.4 | Summarized of result | 66 |
| 5.5 | High frequency occurrence of paired loop | 74 |

LIST OF FIGURES

| | | |
|-----|---|----|
| 2.1 | Key production system characteristics continuum | 6 |
| 2.2 | Comparison of cost-based and time-Based (QRM) approaches | 14 |
| 2.3 | Examples of organizational waste due to long lead times | 15 |
| 2.4 | Traditional versus QRM views of capacity and lot sizing | 17 |
| 2.5 | The response time spiral for a make-to-order company | 23 |
| 2.6 | Organization of cells at CFP corporation | 29 |
| 2.7 | POLCA cards flow for a particular order at CFP corporation | 29 |
| 2.8 | Example of a POLCA card | 29 |
| | | |
| 3.1 | Project framework | 38 |
| 3.2 | Spreadsheet development framework | 40 |
| | | |
| 4.1 | Spreadsheet model | 45 |
| 4.2 | The correct way to type in data in worksheet | 46 |
| 4.3 | The possible paired loop in the process flow | 47 |
| 4.4 | Summarized paired loops from seven customers' samples data | 48 |
| 4.5 | Result of occurrence of the paired loop by clicking the button "LOOP COUNT" | 48 |
| 4.6 | VBA for loop count | 49 |
| 4.7 | VBA for cancel loop count | 50 |
| 4.8 | Colour showed for each paired loop by clicking the button "COLOR CHECK". | 51 |
| 4.9 | VBA for colour check. | 51 |

| | | |
|------|---|----|
| 4.10 | VBA for cancel displayed colour | 52 |
| 4.11 | Parameters for POLCA card calculation | 53 |
| 4.12 | Table Week 1-2 in worksheet “POLCA CARD (WEEKLY)” | 54 |
| 4.13 | Formula used to copy planning period from parameter | 54 |
| 4.14 | Formula “HLOOKUP” used to copy planned lead time from table parameter | 55 |
| 4.15 | Upstream and downstream process for each paired loop | 56 |
| 4.16 | Formula used to copy value of estimated number of order from worksheet “Jan_Wk 1-2” | 57 |
| 4.17 | Formula used to calculate number of POLCA card | 58 |
| 4.18 | Worksheet “POLCA CARD (MONTHLY)” | 59 |
| | | |
| 5.1 | Result of frequency of the paired loop in worksheet “Jan_Wk 1-2” | 63 |
| 5.2 | Result of number of POLCA card in worksheet “POLCA CARD (MONTHLY)” | 64 |
| 5.3 | A POLCA card | 68 |
| 5.4 | POLCA card flow for a particular order | 68 |
| 5.5 | Job launch into cell M | 69 |
| 5.6 | The job and MC-ML card proceed to the input buffer for cell ML | 70 |
| 5.7 | Job launch into cell ML | 71 |
| 5.8 | The job and MC-ML card proceed to the input buffer for cell ML | 72 |
| 5.9 | Subset of processes location in a cell a, b, and c | 74 |

LIST OF ABBREVIATION

| | | |
|--------|---|---|
| CNC | - | Computer Numerical Control |
| DEBUR | - | Deburring |
| EDM | - | Electric Discharge Machining |
| ENG | - | Engraving |
| GF | - | Surface Grinding |
| HL/MRP | - | High Level material requirements planning system |
| HT | - | Heat Treatment (Outsourced) |
| JIT | - | Just In Time |
| MC | - | CNC Milling |
| MRP | - | Material Requirement Planning |
| ML | - | Milling |
| P | - | Parting |
| PG | - | Profiling Grinding |
| POLCA | - | Paired-cell Overlapping Loops of Cards with Authorization |
| Q-ROC | - | Quick Response Office Cell |
| QRM | - | Quick Response Manufacturing |
| SD | - | Speed Drilling |
| TBC | - | time-based competition |
| TM | - | Treatment (Hardness, outsourced) |
| TP | - | Tapping |
| WC | - | Wire Cut |
| WIP | - | Work in Process |

CHAPTER 1

INTRODUCTION

This chapter describes the background of this study, and then followed by problem statement of the project, objectives and scope of the project.

1.1 Background of Study

Lean Manufacturing is a popular welcome philosophy almost implemented in every industry or even in office operations. The core idea of lean is to reduce costs, improve quality and reduce product cycle times in many manufacturing environments. The ultimate goal of lean is to provide perfect value to customer through perfect value process steps that without any wastes. Lean is considered as successful when the production is characterized by high volume such as in assembly line. Normally there is the stable demand in assembly production line.

However, the 21st century market is not usual as the former market. Customers today expect high variety and custom engineered products. And yet those high variety or custom engineered products are ordered in low volume with unstable. In this case, lean manufacturing is not suitable to improve production meanwhile drawbacks are introduced in the production line.

Today production managers are expected to find a new ways to support the increase in product variety and meet production targets with minimal inventories, shorter lead times and lower costs. While, production engineers are seeking the new ways to rapidly introduce new products to exploit emerging market opportunities. Across the

enterprise, supply chain managers are seeking new ways to complement their in-house operations with a supply base that has the capacity and ability to quickly respond to fluctuations in customer requests.

The concept of Quick Response Manufacturing (QRM) introduced by Professor Rajan Suri from University of Wisconsin is shown to be more suitable for high mix and low volume manufacturing environment. QRM concept is focused on lead time reduction across the enterprise and provides organizations the competitive advantages.

1.2 Problem Statement

This project is conducted in a case company which manufactures high precision components in a job shop environment. There is high mix production and low volume demand. The processes involved in this company are CNC machining, turning, milling, surface grinding, and wire cutting. Lead time and speed play a crucial role in this company. Speed to delivery customer order, speed to competition market are emphasized by the company. Long lead time within the processes or supply chain would make a company failure in term of speed.

The general manager of the company said the company has facing around 30 percent of late deliveries. Furthermore, he would like to reduce the overall processing time of an order. For instance, a lead time for a component A could be reduced from 10 days to 6 days. Lead time reduction is the object of interest of the company.

1.3 Objectives

The objectives of this project are:

- i. To study current processes and products in the case company.
- ii. To propose Quick Response Manufacturing (QRM) by using Paired-cell Overlapping Loops of Cards with Authorization (POLCA) technique to improve the lead time in shop floor.
- iii. To develop a method by using spreadsheet to determine the possible paired loops for POLCA implementation and to determine the number of POLCA card for each paired loop.

1.4 Scope

The project is limited to a specific family of product. The product family is selected based on the profitability and demand. The overall process flow of manufacturing a product family is study before attempts to implement the POLCA. The method to determine the possible paired loops and the number of POLCA card is developed for this project. The proposed method only implemented in shop floor and does not include activities in office operations and supply chain. This project does not focus on quality and cost.

1.5 Organization of the Report

The report is organized along the following outline. This report consists of five chapters as described below:

- i. The first chapter introduces the background, problem statement, objectives, and scope of the project.
- ii. Chapter two presents the literature review of the related subject.
- iii. Chapter three describes the methodology of the project.
- iv. Chapter four explains the spreadsheet development.
- v. Chapter five shows the result of spreadsheet testing and discusses the obtained result.
- vi. Chapter six is the conclusion of the report.

CHAPTER 2

LITERATURE REVIEW

This chapter provides the summary of searched information from journals, articles, technical report, books and other related resources. This chapter covering the background of lean manufacturing, QRM concepts, POLCA technique, the difference between POLCA and others production control method such as Push and Pull system, and also the case study of POLCA implementation. This chapter acts as the guideline in methodology design and the information summarized here are the evidences to support the result and discussion in next chapter.

2.1 Production System Characteristics

The four major production system characteristics are mix, volume, demand variability and degree of customization are plotted on a continuum as shown in figure 1.

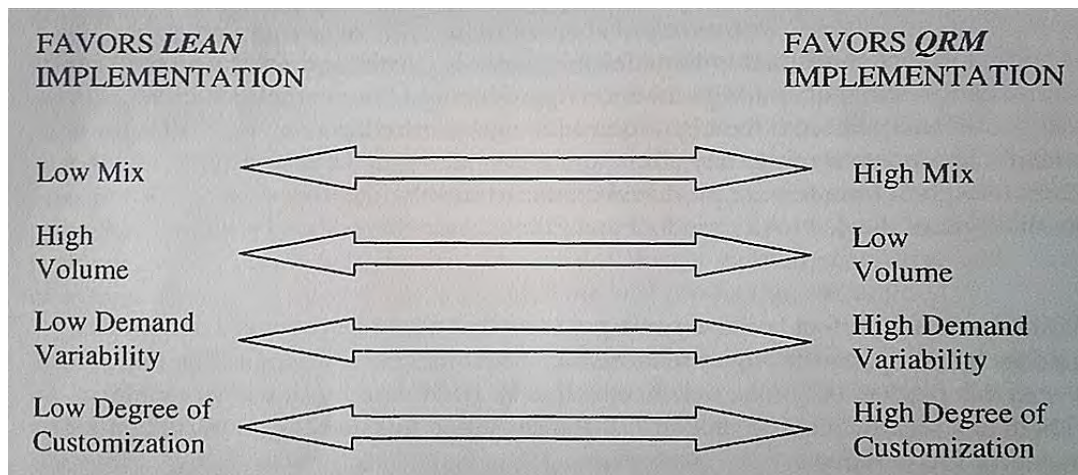


Figure 2.1: Key production system characteristics continuum (Matthew, 2004).

When starting an improvement, the first thing must be known is where a particular manufacturing system is located along this continuum for each key system characteristics. From Figure 2.1, Lean Manufacturing fall to left handside four system characteristics. However, Quick Responses Manufacturing is designed for systems whose key characteristics fall to the right on the continuum.

2.1.1 Mix

What means by Mix? Mix refers to the number of different products that are produced within a certain production system (Matthew, 2004). The differences are number of parts, functionality, appearance, etc. Moreover, the different on processing times of the products could contribute significantly to the factory mix.

2.1.2 Volume

Volume is the quantity of a product to be produced over a specified period of time. Definition of high volume or low volume is difficult to define because it depends on one's perspective. Let's say a company produces millions of a product in a year

overtly fall into high-volume category while for a product with a 100 unit per month would be considered low volume.

2.1.3 Demand Variability

Demand variability means changes in customer demand from period to period. The more demand for specific products fluctuates from order to order, the higher the demand variability (Matthew, 2004). The demand variables may base on effort in marketing or promotions, seasonality, holidays, special events and other extrinsic factors (Matthew, 2004).

2.1.4 Degree of Customization

Customization refers to providing products that are created to the customer's specifications and the product may produce only once. Matthew (2004) stated in his study, "the international space station is such a product: although some components might have other uses, this is a one-of-a-kind product that is highly customized".

2.2 Lean Manufacturing

The most significant operations and supply management approach of the past 50 years is lean production (Jacobs and Chase, 2011). Lean production or lean manufacturing focuses on eliminating wastes as much as possible. The wastes indicated by Jacobs and Chase (2011) are unnecessary movements, unnecessary processing, and excess inventory. These are the target for improvement and to make sure anything steps are create value (value-added), and removes all those do not create value (non-value added).

The basic of lean thinking came from just-in-time (JIT) production concepts pioneered in Japan at Toyota. In lean manufacturing is to emphasis on cut out the “fat” or waste in the manufacturing process. Value added is the activities transform materials and information into the customer want, the value is something that customer willing to pay for. Whereas, non-value added also called as waste, is defined as activities consumes resources and do not directly contribute to the end product desired by the customer, in other words, there is anything does not add value from the customer’s perspective. These wastes are to be eliminated by lean.

2.2.1 Lean Concept

In additional, lean concepts are contrasts with the corresponding principles in QRM discussed by Suri (1998). The three lean concepts are:

1. Elimination of *Muda*
2. Implementing flow
3. Implementing pull

2.2.1.1 Elimination Muda

In JIT, elimination of *muda* through eliminating non-value-added waste, resulting in reduced lead times, improved quality, and reduced costs. However, QRM emphasis on reduction in lead time, resulting in the elimination of non-value-added waste, improved quality and reduced costs. Since wastes are caused by long lead times, Suri (1998) said that once adopt the QRM approaches, more wastes are identified compared to JIT approaches. Another different between JIT and QRM is JIT system requires inventory in many intermediate stages of the materials replenishment system and QRM is not to introduce any inventory into the system until there is the customer order. QRM found that the inventory is one types of the waste.