UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Manufacturing Engineering

NEW HYBRID QUICK RESPONSE MANUFACTURING FRAMEWORK TO IMPROVE DELIVERY PERFORMANCE AT ENGINEER-TO-ORDER COMPANY

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A thesis submitted
in fulfillment of the requirements for the degree of Doctor of Engineering

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APPROVAL

I hereby declare that I have read this thesis and in my opinion this thesis is sufficient in terms of scope and quality for the award of Doctor of Engineering.

Signature :……………………………………

Supervisor Name :……………………………………

Date :…………………………………….

DECLARATION

I declare that this thesis entitled “New Hybrid Quick Response Manufacturing Framework To Improve Delivery Performance At Engineer-To-Order Company” is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	....
Name	:	....
Date	:	....

DEDICATION

To my beloved family, supervisor and friends for always supporting me along the way to accomplish my doctorate thesis.

ABSTRACT

The competitiveness and growth of the small and medium enterprises (SMEs) is critical for the Malaysian economy. In the last few years amidst the volatile external environment and escalating global competition, SMEs have witnessed a marked improvement in their performance. Malaysian SMEs are expected to contribute 42% to the country's gross domestic product (GDP) by 2020, remain as an important economic agent to transition the economy to a developed nation in the years to come. As such, productivity of SMEs is imperative to ensure the competitiveness of manufacturing organization in the country. The present scenario reveals that most SMEs supply custom engineered products are confronted with various challenges in retaining their competitive advantages in the global market. Hence, selecting the best practices that associated to their competitive priorities will help the company outperforms their competitors in the long term. However, many failed to do so due to their rush to emulate the success of their counterparts. This research study has set out for an engineer-to-order (ETO) manufacturing company that experiences poor on-time delivery (OTD) performance of about 54%. The aim of the study was to reduce the lead time and hence improve OTD to customers by designing a new hybrid Quick Response Manufacturing (QRM) framework in the organization. The objectives and methodologies include designing a QRM based material flow system controlled by capacity utilization to ease the overloading in the production. A simulation base model was built and validated followed by experimentations of capacity utilization based control (UBC) system. The deciding factors such as throughput (TP), work-in-process (WIP) and average manufacturing critical-path time (MCT) per job were analysed and compared. To address the limitations of QRM, the second phase is designing a system integrated with Lean and TQM practices to eliminate office wastes and to cultivate concept of self-assessment respectively. This hybrid QRM was also meant to create a balance and sustainability in the long run. The last phase is engaging a case company to validate the developed hybrid system in the real-life environment. Simulation results showed that UBC system performed better than the current cost based production in the case company. The achievement of the objectives predetermined above include WIP and MCT reduced by 30% and 18% respectively, resulting improvement of OTD from 54% to 75%. This has led to the economic impacts particularly with respect to TP and sales increased by 31% and 69% respectively after the deployment of the new system in the case company. The thesis identifies issues arising from the application of hybrid QRM in the job shops which have implications for industry practices. It concludes by outlining further research that can be undertaken in the emerging trend of Industry 4.0.

ABSTRAK

Daya saing dan pertumbuhan perusahaan kecil dan sederhana (PKS) adalah kritikal bagi ekonomi Malaysia. Dalam beberapa tahun yang lepas di mana persekitaran luaran yang tidak menentu dan persaingan global yang semakin meningkat, PKS telah menyaksikan peningkatan yang ketara dalam prestasi mereka. PKS Malaysia dijangka menyumbang 42% kepada Keluaran Dalam Negara Kasar (KDNK) menjelang 2020, kekal sebagai ejen ekonomi yang penting untuk mengembangkan ekonomi ke negara maju pada tahun yang akan datang. Oleh itu, produktiviti PKS adalah penting untuk memastikan daya saing organisasi pembuatan di negara ini. Senario sekarang mendedahkan bahawa kebanyakan PKS yang membekalkan produk kejuruteraan tersuai berhadapan dengan pelbagai cabaran untuk mengekalkan kelebihan daya saing mereka di pasaran global. Oleh itu, memilih praktik terbaik yang berkaitan dengan keutamaan kompetitif akan membantu syarikat mengalahkan pesaing mereka dalam jangka panjang. Walau bagaimanapun, banyak yang gagal melakukannya kerana tergesa-gesa untuk mencontohi kejayaan rakan sejawat mereka. Kajian penyelidikan ini telah dimulakan untuk syarikat pembuatan ETO (Engineer-To-Order) yang mengalami prestasi penghantaran tepat pada masa (On Time Delivery, OTD) yang teruk iaitu 54% sahaja. Tujuan kajian ini adalah untuk mengurangkan masa pembuatan, oleh itu memperbaiki OTD kepada pelanggan dengan merekabentuk rangka kerja Pembuatan Respons Pantas (Quick Response Manufacturing, QRM) hibrid baru. Objektif dan metodologi termasuk merekabentuk sistem aliran bahan QRM yang dikawal oleh pemuatan kapasiti untuk mengurangkan lebihan beban dalam produksi. Model asas simulasi dibina dan disahkan diikuti dengan eksperimen sistem kawalan berdasarkan pemuatan kapasiti (Utilization Based Control, UBC). Faktor-faktor penentu seperti penghantaran (Throughput, TP), kerja dalam proses (Work In Process, WIP) dan masa kritikal pembuatan (Manufacturing Critical-path Time, MCT) akan dianalisis dan dibandingkan. Untuk menangani batasan QRM, fasa kedua adalah merekabentuk sistem yang diintegrasikan dengan praktik kejat (Lean) dan pengurusan kualiti menyeluruh (Total Quality Management) untuk menyingkirkan pembaziran dan memupuk konsep penilaian diri. QRM hibrid ini juga bertujuan untuk mewujudkan keseimbangan dan kemampanan dalam jangka panjang. Fasa terakhir adalah melibatkan syarikat kes untuk mengesahkan sistem hibrid baru di dalam persekitaran sebenar. Hasil simulasi menunjukkan bahawa sistem UBC adalah lebih baik daripada produksi berasaskan kos dalam syarikat kes. Pencapaian objektif yang ditentukan awal termasuk WIP dan MCT telah dikurangkan sebanyak 30% dan 18% masing-masing, turut menambahbaikan OTD dari 54% ke 75%. Ini telah membawa kepada kesan ekonomi terutamanya berkaitan penghantaran (TP) dan jualan yang meningkat sebanyak 31% dan 69% masing-masing selepas penggunaan sistem baru dalam syarikat kes. Tesis ini telah mengenalpasti isu-isu yang timbul semasa penggunaan QRM hibrid di tempat kerja yang mempunyai implikasi untuk praktik industri. Secara kesimpulan, ia juga menggariskan penyelidikan lebih lanjut yang boleh dilaksanakan dalam tren baru Industri 4.0.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

AFI	-	Areas for Improvement
AM	-	Agile Manufacturing
ASB	-	Assembly
ATO	-	Assemble-to-Order
BI	-	Bonding Insert
BTO	-	Buy-to-Order
CM	-	CNC Milling
CNC5	-	CNC 5axis
CNCG	-	CNC Grinding
CP	-	Competitive Priorities
CODP	-	Customer-order-decoupling-point
CT	-	Cycle Time
CV	-	Cooeficient of Variation
EFQM	-	European Foundation for Quality Management
EM	-	Excellence Model
ERP	-	Enterprise Resource Planning
ETO	-	Engineer-to-Order
EDM	-	Electrostatic Discharge Machine
GDP	-	Gross Domestic Product

GF1	-	Manual Grinding
GF2	-	Surface Grinding
HMS	-	Holonic Manufacturing System
IoT	-	Internet of Things
JIT	-	Just-in-Time
JG	-	Jig Grinding
JOF	-	Job Order Form
LM	-	Lean Manufacturing
LSS	-	Lean Six Sigma
LT	-	Lead Time
MAPS	-	Manufacturing Planning System
MBEF	-	Malaysia Business Excellence Framework
MBNQA	-	Malcolm Baldrige National Quality Award
MES	-	Manufacturing Execution System
MC	-	Mass Customization
MCT	-	Manufacturing Critical-Path Time
MI	-	Milling
MPC	-	Malaysia Productivity Corporation
MRP	-	Material Requirements Planning
MTO	-	Make-to-Order
MTS	-	Make-to-Stock
NCL	-	CNC turning
NQA	-	National Quality Award
OC	-	Operating Curve

OPL	-	One Point Lesson
OPP	-	Order-penetration-point
OTD	-	On-time delivery
OTR	-	Order to Receipt
PG	-	Profile Grinding
PMIEA	-	Prime Minister Industry Excellence Award
POLCA	-	Paired Cell Overlapping Loops of Cards with Authorization
PT	-	Process Time
QBR	-	Quarterly Business Report
QC	-	Quality Control
QRM	-	Quick Response Manufacturing
QT	-	Queuing Time
RFID	-	Radio Frequency Identification
SCV	-	Squared Coefficient of Variation
SD	-	Super Drilling
STS	-	Ship-to-Stock
SME	-	Small and medium enterprises
T	-	Raw Process Time
TBC	-	Time-based Competition
TBM	-	Time-based Manufacturing
TOC	-	Theory of Constraint
TL	-	Turning
TP	-	Throughput
TQL	-	TQM-QRM-Lean

TPS	-	Toyota Production System
TQM	-	Total Quality Management
U	-	Utilization Factor
UBC	-	Utilization Based Control
UP	-	Up Time
V	-	Variability Factor
WC	-	Wire Cutting
WIP	-	Work-in-process