Faculty of Manufacturing Engineering

HYBRID POLCA IN A JOB SHOP ENVIRONMENT

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DECLARATION

I declare that this thesis entitled “Hybrid POLCA in a Job Shop Environment.” is the result of my own research except as cited in the references. The thesis has not been accepted for any master or degree and is not concurrently submitted in candidature of any other master or degree.

Signature : .....

Name : .....

Date : .....

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 Master of Science in Manufacturing Engineering.

Signature :……

Supervisor Name :……

Date :…….

DEDICATION

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

ABSTRACT

In Malaysia, Small and Medium Enterprises (SMEs) are important engines of economic growth and development of the country. By 2020, Malaysian SMEs aim to contribute 42% to the country's gross domestic product (GDP). However, in the present scenario, most SMEs which supply low-volume products and custom-engineered manufacturers are confronted with various challenges in retaining their competitive advantages in the global market. This study was conducted in a precision component manufacturing company that experiences low on-time delivery (OTD) of about 70%. The aim of the study was to improve the manufacturing critical-path time (MCT) and hence ensure on-time delivery to customers by adopting Quick Response Manufacturing practices and tools in the shop floor of the company. The Paired-cell Overlapping Loops of Cards with Authorization (POLCA) mechanism was employed to control material flow betwen workstations. Two modules were first built to automate the mapping of MCT for all products and to calculate the required number of POLCA cards. These informaton were then fed into a simulation model of the production floor from the company. A simulation base model was built and validated followed by experimentations ofthe original POLCA and 2 hybrid POLCA variants i.e. short processing time (SPT- POLCA) and Due Date (DD-POLCA) variants. The performance measures of these models: throughput (TP), work-in-process (WIP), average MCT per job and On-time delivery (OTD) were analysed and compared. Results showed that SPT-POLCA performed best in comparison to the other control systems. SPT-POLCA recorded the highest throughput and OTD, lowest WIP and average MCT per job. Finally, a POLCA game was developed as a teaching and training tool for engineering undergraduates and industry personnel respectively. The game provided the simplicity and hands-on experience for the players to understand the POLCA mechanism. The game was also flexible in allowing experimentations with the different POLCA variants and other manufacturing techniques.

ABSTRAK

Di Malaysia, Perbadanan Perusahaan Kecil dan Sederhana (PKS) adalah penggerak utama pertumbuhan ekonomi dan pembangunan negara. Menjelang tahun 2020, PKS Malaysia berhasrat untuk menyumbang 42% kepada keluaran dalam negara kasar (KDNK). Walau bagaimanapun, kebelakangan ini kebanyakan PKS, yang menghasilkan produk yang unik dengan jumlah yang rendah sedang menghadapi pelbagai cabaran untuk mengekalkan daya saing di pasaran global. Kajian ini dijalankan di sebuah syarikat pembuatan komponen yang mengalami masalah penghantaran produk dalam masa yang ditetapkan. Syarikat ini hanya mencapai purata 70% dalam kategori ini. Tujuan kajian ini adalah untuk meningkatkan masa pembuatan produk. Dengan itu, syarikat ini cuba menggunakan teori dan teknik Quick Response Manufacturing. Teori ini mengamalkan satu teknik yang bernama Paired-cell Overlapping Loops of Cards with Authorization (POLCA) mekanisma. Ia digunakan untuk mengawal aliran barang antara stesen kerja. Pertama, dua modul telah dibina untuk mengautomasikan plot masa pembuatan produk untuk semua produk dan juga mengira bilangan kad POLCA yang diperlukan. Seterusnya, informasi ini akan dimasukkan ke dalam model simulasi syarikat ini. Model simulasi ini yang telah dibina dan disahkan diikuti dengan membuat uji kaji 3 versi POLCA iaitu asal POLCA, shortprocessing time POLCA (SPT- POLCA) dan Due Date (DD-POLCA). Ukuran prestasi model ini ialah throughput (TP), work-in-process (WIP), masa pembuatan produk bagi setiap kerja dan penghantaran produk dalam masa yang dijangkakan (OTD) yang turut dianalisis dan dibandingkan. Hasil kajian menunjukkan bahawa SPT-POLCA melakukan yang terbaik berbanding dengan sistem kawalan yang lain. SPT-POLCA mencatatkan jumlah tertinggi dalam keputusan througpput dan OTD, paling rendah dalam keputusan WIP dan masa pembuatan produk bagi setiap kerja. Akhirnya, permainanan POLCA dibina dan dijadikan sebagai alat pengajaran dan latihan untuk mahasiswa kejuruteraan dan kakitangan industri. Permainan ini menyediakan pengalaman praktikal untuk peserta bagi memahami mekanisma POLCA. Permainan ini juga fleksibel dalam membenarkan uji kaji bagi versi POLCA yang berbeza dan teknik pembuatan yang lain.

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AM	Agile Manufacturing
ASB	Assembly
AT	Arrival Time
AWT	Average weighted tardiness
CNC5	CNC 5axis
CNCG	CNC Grinding
CONWIP	Constant Work in Progress
COVERT	Cost over time
DD-POLCA	Due date POLCA
DEWIP	Decentralized load in process
EDD	Earliest Due Date
EDM	Electrostatic Discharge Machine
FIFO	First in First Out
GF1	Surface Grinding
GF2	Rough Grinding
GPOLCA	Generic POLCA
HMS	Holonic Manufacturing System
JG	Jig Grinding
LB-POLCA	Load-Based POLCA

LM	Lean Manufacturing
LOOR	Load-oriented order release
MC	Mass Customization
MC	CNC Milling
MCT	Manufacturing Critical-Path Time
MFC	Material Flow Control
MI	Milling
MTO	Make-to-order
MTS	Make-to-stock
NCL	CNC turning
NEM	New Economic Model
ODD	Operation Due Date
OSD	Operation synchronization date
OTD	On-time delivery
PCS	Production Control Strategies
PG	Profile Grinding
PMFC	Production material flow control
POLCA	Paired Cell Overlapping Loop with Authorization
PPC	Production Planning Control
PT+WINQ	Process time plus work-in next queue
PT+WINQ+AT	Process time plus work-in-next queue plus arrival time
PT+WINQ+SL	Bottleneck dynamics with uniform pricing scheme and process time plus work-in-queue
PTJ	Proportion of tardy job

QRM	Quick Response Manufacturing
RR	Raghu and Rajendran
S/OPN	Slack per remaining operation
SD	Super Drilling
SME	Small and medium enterprises
SMED	Singel-Minute Exchange Die
SPT	Short Processing Time
SPT-POLCA	Short-processing time POLCA
TBC	Time-based Competition
TL	Turning
TP	Throughput
TPM	Toyota Production Maintenance
TPS	Toyota Production System
VBA	Visual Basic Application
WC	Wire Cutting
WINQ	Total work-content of jobs in the queue of the next operation of a job
WIP	Work-in-process
WIPOTC	WIP-oriented throughput control