UNIVERSITI PUTRA MALAYSIA

COMPONENT PROCUREMENT INCORPORATING ASSOCIATED COST FOR MAKE TO ORDER CAPACITATED PRODUCTION

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By

MEHDI VASILI

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

January 2012

DEDICATION

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

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

COMPONENT PROCUREMENT INCORPORATING ASSOCIATED COST FOR MAKE TO ORDER CAPACITATED PRODUCTION

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January 2012

Chair: **Associate Professor Tang Sai Hong, PhD**

Faculty: **Engineering**

Component procurement strategy in multi echelon production-inventory systems over the last decades have been recognized and discussed as a crucial issue that plays an important role in punctuality of delivery of final products. The echelon inventory concept has been applied widely in characterization of inventory levels and holding cost of the available stock in the system. In a simple two echelon production-inventory system, the downstream level has the responsibility of producing final products, and the upstream level is responsible for providing the required components. Components echelon inventory in this case, is the amount of components that exist in upstream level plus all other components that still exist in downstream level which have not been delivered to the customers yet (in the form of a final product).

Lack of an appropriate component procurement strategy in the models related to make-to-order (MTO) production environment with limited available capacity is a problem that should be solved. Therefore, in this study, by developing a mathematical

model, an appropriate component procurement strategy is presented. This component procurement strategy is for a multi-products single resource capacitated customer driven production system in an MTO stochastic environment. The components are procured from resources (other than the resource allocated for production of final products) that have no restriction to provide any amount of each type of the components at the time they are needed. The required inventory in the system consists of the inventory of final products plus work-in-process (WIP) and the required components for producing them. These inventories are acquired just as the amount that is necessary for production and fulfilling the known and confirmed orders of final products in each production cycle. No unnecessary or extra production for unexpected orders of final products occurs in a production cycle. Therefore, according to the MTO specifications, zero inventories of unsold products exist at the end of the production cycle. The mean inventory that exists in the system (before delivery of final products to the customer) for components and final products plus WIP are formulated by applying Little's law in continuous settings. The concept of echelon inventory will be considered in this study.

Neglecting the components associated cost in total cost functions in capacitated MTO production environments is another problem which should be solved. Therefore, the total cost function of the system is also developed to calculate the total cost of the system for both the cost of capacity used for production of final products and the inventory holding cost for components as well as final products plus WIP. This cost function, since taking the holding cost of components into account, provides more accurate results about the system total cost. It is proved that, the total cost function is a convex function with respect to the available capacity that should be invested for production of final products. Hence, the total cost of the system then will be minimized with respect to the optimum required available capacity.

Finally, the impact of adopting the developed component procurement strategy on the system performance and also its optimality is investigated through numerical examples. Meanwhile, the results are compared with the results of other researches. For instance, it has been shown that, by adding the function of components holding cost to the developed cost functions in previously existing model, the capacity oriented work-ahead-window has decreased by 27%. Subsequently, the mean required inventory of final products to fulfill the known customers' orders based on the pre-defined service-level has reduced by 22 %, which means there is 22 % reduction in holding cost of the final products. However, the system total cost, which considers the components holding cost, is more realistic and accurate with an increase of 3.8% compared to the previous model.

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

PEMEROLEHAN KOMPONEN DAN MENGGABUNGKAN KOS BERKAITAN BAGI PENGELUARAN BERASASKAN PELANGGAN DENGAN KAPISITI TERHAD

Oleh

MEHDI VASILI

Januari 2012

Pengerusi: Profesor Madya Tang Sai Hong, PhD

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Sejak beberapa dekad yang lalu, strategi pemerolehan komponen dalam sistem pengeluaran-inventori eselon yang pelbagai telah diiktiraf dan dibincangkan, sebagai isu kritikal dan memainkan peranan yang penting bagi memastikan penghantaran produk akhir mengikut masa yang ditetapkan. Konsep inventori eselon telah diaplikasikan secara meluas bagi memperincikan tahap-tahap inventori dan kos pemegangan stok yang terdapat di dalam sistem. Di dalam dua sistem eselon pengeluaran-inventori yang mudah, bahagian hilir bertanggungjawab untuk menghasilkan produk akhir. Manakala, bahagian hulu bertanggungjawab untuk menyediakan komponen yang diperlukan. Dalam kes ini, komponen inventori eselon bermaksud jumlah komponen yang wujud di bahagian hulu termasuk semua komponen lain yang masih terdapat di peringkat hilir, yang mana belum lagi dihantar kepada pelanggan (dalam bentuk produk akhir).

Kekurangan strategi komponen perolehan yang sesuai dalam model yang berkaitan dengan *Make-To-Order* (MTO) persekitaran pengeluaran dengan kapasiti terhad

adalah suatu masalah yang perlu diselesaikan. Oleh itu, dalam kajian ini, dengan membangunkan model matematik, strategi perolehan satu komponen yang sesuai diperkenalkan. Strategi perolehan komponen ini adalah untuk pelbagai produk sumber tunggal sistem pengeluaran berkapasiti berasaskan pelanggan dalam penempahan atau *Make-To-Order* (MTO). Komponen tersebut diperolehi daripada sumber-sumber tertentu (selain daripada sumber yang diperuntukkan untuk pengeluaran produk akhir), dan tidak terikat untuk menghasilkan jumlah tertentu bagi setiap jenis komponen pada masa ia diperlukan. Inventori yang diperlukan di dalam sistem ini terdiri daripada inventori produk akhir termasuk *'Work-In-Process'* (WIP), dan komponen yang diperlukan untuk menghasilkannya. Inventori yang diperolehi ini sama dengan jumlah yang diperlukan untuk pengeluaran dan memenuhi kehendak serta penempahan produk akhir yang telah dikenal pasti bagi setiap kitaran pengeluaran. Dalam kitaran pengeluaran produk akhir, tidak ada pengeluaran yang tidak diperlukan atau penempahan yang di luar jangkaan. Berdasarkan spesifikasi MTO, inventori produk yang tidak terjual adalah sifar pada akhir kitaran pengeluaran. Purata inventori yang terdapat di dalam sistem (sebelum produk akhir dihantar kepada pelanggan) untuk komponen dan produk akhir termasuk WIP dihasilkan dengan mengaplikasikan undang-undang Little dalam persekitaran yang berterusan. Dalam kajian ini, konsep inventori eselon akan dipertimbangkan.

Dengan mengabaikan komponen yang berkaitan dengan kos dalam kos keseluruhan pengeluaran persekitaran berkapasiti MTO adalah satu lagi masalah yang perlu diselesaikan. Oleh itu, fungsi kos keseluruhan untuk sistem telah dibina bagi mengira keseluruhan kos kedua-dua sistem, iaitu kos penggunaan kapasiti untuk pengeluaran produk akhir dan kos pemegangan inventori untuk komponen produk akhir termasuk

WIP. Fungsi kos ini, membawa kepada anggaran yang lebih tepat terhadap keseluruhan kos apabila kos pemegangan sesuatu komponen diambil kira. Telah dibuktikan bahawa fungsi kos keseluruhan adalah fungsi cembung dengan mematuhi kapasiti sedia ada, yang sepatutnya dilaburkan untuk pengeluaran produk akhir. Keseluruhan kos sistem kemudiannya akan diminimumkan bagi mematuhi kapasiti optimum.

Kesimpulannya, kesan pelaksanaan strategi pemerolehan komponen yang telah dibangunkan terhadap sistem prestasi dan optimaliti telah disiasat melalui contoh berangka. Pada masa yang sama, keputusan yang diperolehi akan dibandingkan dengan hasil kajian lepas. Sebagai contoh, kajian menunjukkan bahawa dengan menambah fungsi kos pemegangan komponen kepada fungsi kos yang dibangunkan dalam model yang sedia ada, keupayaan berorientasikan *work-ahead-window* telah menurun sebanyak 27%. Selain itu, purata inventori yang dikehendaki bagi produk akhir untuk memenuhi penempahan pelanggan yang dikenal pasti berdasarkan kepada tahap perkhidmatan yang ditetapkan, telah berkurangan sebanyak 22%. Dengan kata lain, terdapat pengurangan sebanyak 22% dalam kos pemegangan produk akhir. Walau bagaimanapun, keseluruhan kos sistem ini yang mengambil kira kos pemegangan adalah lebih realistik dan tepat berbanding pengiraan sebelum ini, iaitu peningkatan sebanyak 3.8% sahaja.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Compassionate, the Most Merciful. All praise is due be to Allah, Lord of the Worlds, The Most Compassionate, the Most Merciful. Sovereign of the Day of Judgement. You alone we worship, and to You alone we turn for help. Guide us to the straight way; The way of those whom You have favoured, Not of those who have incurred Your wrath, Nor of those who have gone astray (Al-Fatiha, the Opening chapter of the Holy Quran).

I would like to express my sincere appreciation to all who contributed in my research. My greatest gratitude forwarded to my project supervisor, Assoc. Prof. Dr. Tang Sai Hong for his guidance, constructive comments, untiring support, invaluable advices and suggestions to complete my research successfully.

My sincere appreciation is also extended to Prof. Dr. Napsiah Ismail for her guidance, effort and encouragement throughout this research.

Finally, I would like to express my heartiest gratitude and appreciation to my family and all my friends who helped me throughout my research.

I certify that a Thesis Examination Committee has met on 10th January 2012 to conduct the final examination of Mehdi Vasili on his thesis entitled “Component Procurement Incorporating Associated Cost for Make to Order Capacitated Production” in accordance with Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the degree of Master of Science.

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

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DECLARATION

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

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MEHDI VASILI

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