Systems Engineering - Theory & Practice
Volume 27, Issue 12, December 2007
Online English edition of the Chinese language journal

Available online at www.sciencedirect.

ScienceDirect

Cite this article as: SETP, 2007, 27(12): 151–157

RESEARCH PAPER

Study on CODP Position of Process Industry Implemented Mass Customization

JI Jian-hua, Qi Li-li, GU Qiao-lun

Antai College of Economics & Management, Shanghai Jiaotong University, Shanghai 200052, China

Abstract: As the core strategy of MC (Mass Customization), CODP (Customer Order Decoupling Point) positioning of the process industry implemented mass customization is the focus of this article. The article builds a CODP positioning model with the delivery lead time constraint and capacity constraint, aiming at total cost minimization. Based on the analytical and numerical comparisons conducted by MATLAB, this article presents 4 inferences and 4 observations and gains insights on how various factors affect the CODP position.

Key Words: process industry; mass customization; CODP; postponement strategy

1 Introduction

At present, to implement mass customization in the manufacturing, whether it is a continuous process or discrete product manufacturing, we need to determine the Customer Order Decoupling Point (CODP). CODP is the breaking point between productions for stock based on forecast and customization that respond to customer demand. It is also the breaking point between MTS and MTO, namely, activities before CODP are driven by forecast while activities after CODP are driven by real customer order demand. As to the process industry, there are two characteristics in choosing CODP: firstly, the production process of the process industry is very complex and the quantities of product differentiation points are very limited. In the discrete industry, product differentiation points may appear in each stage, but in the process industry, they are usually related to the production technology and often occur in the storage link, raw material adding link, and so on. Secondly, more factors should be considered. The setup time in the process industry is long and the requirements for equipment production load are rather strict. In addition, the raw materials, work in process, and the finished products are often perishable goods; therefore, the storage conditions are very demanding. Thus, there are several considerations in choosing CODP in the process industry, such as production technology cost, customer service level, production utilization rate, and the requirements of work in process for storage conditions and time. To implement mass customization, we usually partly change products or production technology, which is named as re-manufacturing.

In the literatures abroad on CODP, Aviv[1] analyzed the influence of the postponement strategy on multi-product inventory system with production capacity constraints, but he did not suggest a position model of CODP. Su[2] built models based on the Queuing Theory and offered a comparative analysis between form postponement and time postponement according to the measure of the two performance indexes: total cost and customer waiting time. Diwakar[3] studied the costs and incomes caused by the postponement strategy based on the Queuing Theory, put forward the optimal position model of CODP, and constructed an approximate solution. Lee[4] considered that the position of CODP was related to not only inventory cost, but also to the disposal cost, the investment cost, and so on, through model results analysis. The main consideration of his model was cost but the lead time constrains were not involved. On the basis of literature [1], Gara[5] conducted a research on multi-differentiation points with decentralized inventory control strategy and centralized inventory control strategy, but his model only considered inventory cost and supposed that there was no limit on the inventory. Lead time constrains were also not involved in his article. Aviv[6] analyzed the benefits brought about by the postponement strategy with uncertain distribution of demand and made quantitative analysis on the benefits brought by the postponement strategy with different order costs. However, he did not consider the production capacity constraints and lead time constrains. All the literatures above focus on the discrete industry.

In the literatures on CODP in China, Qi[7] presented that CODP should be moved to downstream as far as possible so as to reduce the costs in design, manufacture, assembly, etc., which were caused by meeting customers' special requirements. Liu[8] considered that the position of CODP was related to the scale of postponement activity, postponement type, and customization degree; besides, enterprise operation features will also affect the position of CODP. Shao[9] built models with the following considerations such as lead time constrains, decentralized inventory control strategy, and centralized inventory control strategy. He presented that it was not better to move CODP to downstream as far as possible and the position of CODP was impacted by demand, production cycle of each stage, and inventory cost. These

Received date: September 26, 2007
∗ **Corresponding author:** Tel: +86-21-62932696; E-mail: jhji@sjtu.edu.cn
Foundation item: Supported by the National Nature Science Foundation (No.70472030)

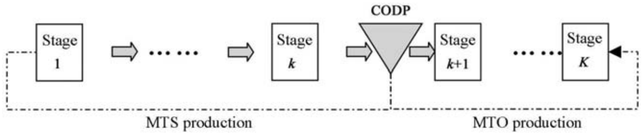

Figure 1. Position of CODP

literatures focus on the discrete industry as well.

The relevant researches and models on CODP positioning of the process industry are rather rare. Lian[10] took it as the study direction of her doctorial paper and conducted the primary research. Thus, this article built a CODP positioning model with the delivery lead time constraints and capacity constraints, aiming at the minimization of the total cost, according to the characteristics of the process industry, and on this basis, the impact factors were analyzed and some relevant suggestions were put forward.

2 Problem description and model assumptions

The entire production logistics system of the process industry in this article is shown in Figure 1. There are K independent stages in the production system. Each stage can process only one unit at a time. Also, there are no setup costs or setup times. No inventories of finished products exist in the system. The products will be delivered to customers as soon as possible after completion. As to work in process, the basic inventory strategy was adopted, namely, as long as the inventory level is not met, replenishment will be ongoing to achieve the determined inventory level.

Suppose K as an alternative point, where production can be interrupted.

In the discrete industry, k can be any integer between 1 to K, but in the process industry, because of non-splittability of conditions of work in process, and technology constrains, there will not be any interrupt point between some stages. As a result, CODP cannot be set up under this condition. Therefore, only available interrupt points can be involved in the model of this article.

Model assumptions:

Assumption 1 The quality of finished products is independent of the CODP position.

Assumption 2 The delivery lead time and unit inventory cost of work in process in each stage are independent of the CODP position.

Assumption 3 The work in the process inventory in stage j is independent of the CODP position[11].

Assumption 4 The delivery lead time is the same for each customer order and all customer orders are handled in accordance with the "first come, first served" principle.

Assumption 5 There are no setup costs or setup times.

Assumption 6 No inventories of finished products exist in the system. The products will be delivered to customers as soon as possible after completion.

Assumption 7 The buffer inventory of work in process is set up in CODP, and before CODP, there are no buffer inventories.

Model formulation and notation:

i: Types of finished products, $i = 1, 2, \cdots, M$, the demand of product i is Poisson distributed;

λ_i: The arrive rate;

Λ: The demand rate of all the products;

J: The stage set, $J = \{1, 2, \cdots, K\}$;

K: Alternative CODP;

μ: The service rate at stage j;

T_j: The unit production times at each stage, which are exponentially distributed and the average $E(T_j) = \frac{1}{\mu_j}$;

ρ: Capacity utilization rate, and the capacity utilization rate of stage j is $\rho_j = \Lambda E(T_j), \rho_j \leq 1$;

b: The basestock level;

$Z(k, b)$: The minimum cost to implement mass customization when the basestock level of work in process is b and CODP is set up in stage k;

$h(k)$: The inventory cost of unit work in process in unit time, when CODP is set up in stage k;

$\bar{I}(k, b)$: The average inventory of work in process when the inventory level is b and CODP is set up in stage k;

$c(k)$: The re-manufacturing cost of products/process, when CODP is set up in stage k;

$F(k, b)$: The postponing time for order delivery when the basestock level is and CODP is set up in stage k. $\bar{F}(k, b)$ is the average delivery postponing time;

α: A determined parameter, $\alpha > 0$;

r: The quantity of work in process in the CODP k.

3 CODP position model

3.1 Model

The service objective of the production material system in the process industry is to minimize system cost under certain service level. The model is as follows:

$$\min Z(k, b) = h(k)\bar{I}(k, b) + c(k) \tag{1}$$

s.t.

$$\bar{F}(k, b) \leq \alpha \tag{2}$$

$$k \leq K \tag{3}$$

$$k, b \geq 0 \tag{4}$$

The objective function (1) represents achieving the goal of minimum cost to implement mass customization when the basestock level of work in process is b and CODP is set up in stage k; Both k and b are independent variables. Under certain service level, the costs of implementing mass customization include the inventory cost and the product/process re-manufacturing cost, $Z(k, b) = h(k)\bar{I}(k, b) + c(k)$. $h(k)\bar{I}(k, b)$ represents the inventory cost of work in process, when the basestock level is and CODP is b set up in stage k.

In constraint condition (2), $\bar{F}(k, b) \leq \alpha$ denotes that the average delivery postponing time must be not more than α, when the basestock level is b and CODP is set up after stage k. α indexes the constraint on the postponing time, which is the measure standard of the customer service level. The lesser the α, the higher will be the customer service level, namely, the enterprise can deliver the customized products to the customers very fast and achieve high customer satisfaction. Constraints (3) and (4) indicate the value ranges of parameters.

In the model above, calculating $\bar{I}(k, b)$ is very difficult. To solve this problem, we introduce other intermediate variables. Literature [11] summarized the classic tandem-queue