Postponement of Stock Order management using Multi Decoupling Point on Bill-Of-Materials Structure

Shinsuke Nomoto
Kozo Keikaku Engineering Inc.
4-5-4 Chuo Nakano-ku Tokyo, 164-0011 Japan
nomoto@kke.co.jp

Yasuyuki Nishioka
Hosei University
2-33 Ichigaya Tamachi Shinjuku-ku Tokyo, 162-843 Japan
nishioka@hosei.ac.jp

Abstract

In the manufacturing order management that deals with both designed components and repetitive components, hybrid decision making systems including MRP and other traditional methods are required. For those production systems which have push and pull controls can be managed using decoupling point definition and related strategies. Using Bill of Materials structure information, this paper formulates two kinds of decoupling points, and models some definitions by clarifying its expressions and constraints. Finally, the paper shows some strategies for practical production management, and determination method of decoupling point based on strategies.

Keywords: Decoupling Point, Bill of Materials, Supply Chain Management, Production and Inventory Management

1. INTRODUCTION

There are two production types of a manufacturing system, when it is classified roughly. One is production of the general-purpose component which may receive the order of the Item same in a repetition. Another one is the production of an individual designed component without a repetition in which a customer's request-for-price-quotation spec is included.

In the production management of the repetitive components, since it is necessary to pegging inventory efficiently, MRP (Material Requirement Planning) systems are used. On the other hand, in production of a designed component, the pegging of materials is fixed, and the job number control system which does not change the pegging through the end of production has spread.

However, in the manufacturing system which exists really, not all of products or production processes produce either the general-purpose component of repetition production, or a designed component. There is a casing where both are intermingled. In such a case, there are merits and demerits by both of the production-management systems. A system, such as performing a production management combining both, is proposed. That is, the job number control system is used for the segment of a designed component, and MRP is used for the segment of repetitive components [1]. However, since it is divided by two control systems and becomes complicated, the new production control system which integrated these is required.

A decoupling point is a border of the factory line of a push type, and the factory line of a pull (Make to Order) style [2]. The factory line of a push type is Make-to-Stock, and the factory line of a pull style is Make-to-Order. In order to build the management system which consists of such a complex factory line, the effective management of a decoupling point is needed.

This paper formulize about two kinds of decoupling points, the decoupling point determined from a product structure, and the decoupling point determined from the balance of supply and demand. After that, some constraints are clarified. Next, in the case where multi decoupling points exist in a production system, this paper propose the count methodology of the production lead time according to a BOM (Bill of Materials) configuration and inventory strategy. And finally, the determination method of the decoupling point is proposed, reflecting the strategy of some production managements.
2. CLASSIFICATION OF DECOUPLING POINTS

Two different types of decoupling point existing in product value chains, namely, Product Structure Decoupling Point (PSDP), and Supply Structure Decoupling Point (SSDP) [3].

A PSDP is a point determined by the design configuration which a product has, and it is a point which divides a repetitive component and a designed component in the tree structure of a product and components. On the other hand, an SSDP is a border of a component which produces by a Make-to-Stock and the component which produces by a Make-to-Order, in an actual production management. It is known that two or more decoupling points exist on a supply chain, and they are called Multi Decoupling Points [3].

The purpose of this Paper is to propose the methodology of determining a SSDP, under the environment where a multi-decoupling point exists, based on the information given as a BOM configuration.

![Diagram of BOM structure](image)

**Fig. 1** BOM structure, include both designed component and repetitive component.

3. A FORMULATION OF DECOUPLING POINT

The definition for clarifying PSDP and SSDP on BOM is shown below.

\[ M(i) \] The Item number of the node i on BOM
\[ BOM(i,j) \] Material requirement quantity of M(i) to manufacture item M(i).

When this value is 0, it is shown that there is no link on BOM.

\[ \text{TN} \] Set of Top-Item node. This is a final product which receives an order.

\[ \text{BN} \] Set of End-Item node. This is purchase materials from supplier.

\[ D(i) \] designed classification \( D(i) \in \{0,1\} \)

When this value is 0, Item M(i) is a repetitive components and, in the case of 1, it is a designed component.

\[ S(i) \] Make to Stock classification \( S(i) \in \{-1,0,1\} \)

When this value is 0, M(i) is make-to-stock item, which produced by forecasting, and when other, it shall not carry out prospective production.

In addition, the node i whose value of Make to Stock classification \( S(i) \) is 0, is a SSDP. This is a decision variable when building a production control system. This point is a boundary, when the value of Make to Stock classification is positive, the item is located downstream side of the supply chain, and in a negative case, it located on upstream side. Moreover, a PSDP is the point that \( D(i) \) changes from a designed component to a repetitive components in a BOM configuration, on a definition. Therefore, a PSDP and a SSDP are defined as follows.

\[ \text{PDP} \] A set of PSDP.

\[ \text{PDP} = \{ \forall i | D(i) = 0, BOM(j,i) \geq 0 \} \]

\[ \text{SDP} \] A set of SSDP.

\[ \text{SDP} = \{ \forall i | S(i) = 0 \} \]

Here, about designed-classification \( D(i) \) and Make to Stock classification \( S(i) \), some constraints are defined and summarize the content. First, "configuration constraint" shows the BOM relationship of the node of a designed component, and the node of a repetitive component. It is the constraint "the repetitive components cannot be manufactured from a designed component as a configuration item". And "inventory constraint" is constraint that there to a final product and to an end Item do not have inventory, when it has inventory by Make-to-Stock production. And "Make to Stock constraint" is constraint that the designed component cannot be produced by Make-to-Stock. These constraints can be described as follows.

\[ D(i) \geq D(j) \land \forall i, \forall j, BOM(i,j) > 0 \]

\[ \cdots \] (1) configuration constraint

\[ S(i) \geq S(j) \land \forall i, \forall j, BOM(i,j) > 0 \]

\[ \cdots \] (2) inventory constraint

\[ S(i) \geq D(i) \land \forall i \]

\[ \cdots \] (3) Make to Stock constraint
4. THE CRITICAL PATH OF DESIGNED COMPONENT

Some definitions about a lead time are shown as a preparation for defining a SSDP.

$LT(i)$: Production lead time. Time until the Item is manufactured from the status which all configuration items have prepared. In the case of an end Item, it is equivalent to a purchase lead time.

$L\bar{T}(i)$: Minimum lead time. Accumulation time which is needed in order to acquire the Item. Where in case designed-classification $D(i) = 0$, $L\bar{T}(i) = 0$.

$L\bar{T}^2(i)$: Inventory lead time. Accumulation time which is needed in order to acquire the Item. Where in case Make to Stock classification $S(i) = 0$, $L\bar{T}^2(i) = 0$.

In this definition, the difference between the minimum lead time and an inventory lead time is as follows. The minimum lead time assumes holding inventory in the PSDP. On the other hand, the inventory lead time assumes holding inventory in the SSDP in a repetitive components.

The lead time of final-product node $i \in TN$ is calculated by applying the above-mentioned definition equation sequentially from end-Item node. There is a request lead time which a customer wishes in the product represented by a final-product node. Based on these lead times, this paper discuss about the determination methodology of a Supply Structure Decoupling Point in the following paragraph.

$RL(i)$: Request lead time. The lead time which the customer defined beforehand. It is defined to a final product.

$RL(i) \geq L\bar{T}^2(i) \geq L\bar{T}(i), \forall i \in TN$ (4)

5. DETERMINATION METHOD OF SSDP

The purpose of setting a SSDP is for shortening the lead time from an order received to deliver, and moving an inventory point to the upstream side of a supply chain as much as possible. A customer's demand lead time $RL(i)$ cannot be less than the value of $L\bar{T}(i)$ which is the shortest lead time theoretically as shown in the formula (4). In the case $RT(i) < L\bar{T}(i)$, the product structure itself cannot meet a customer's request, unless an designed component's production lead time is shortened. Therefore, I attain the mentioned purpose by determining $S(i)$ which satisfies a constraint of a formula (1) to a formula (4), and determining a SSDP. A methodology of defining a reasonable SSDP, based on the following three kinds of strategies are next.

1) Risk minimized strategy ($\min. \text{sum.} L\bar{T}^2(i)$)

Let all the repetitive components on a PSDP are SSDPs. Since inventory is held in the place near a final product as much as possible, the shortest lead time is guaranteed and it is robust at risk, such as a trouble.

2) Lead time leveling strategy ($\min. \text{max.} L\bar{T}^2(i)$)

With guaranteeing that the lead time of a final product is the shortest, let move the SSDP in the upstream side, and reduce the waiting time of a meeting point. It is the strategy of reducing inventory cost, guaranteeing a final lead time. Since there is nature in which inventory cost is reduced when inventory move to upstream side more.

3) Inventory cost minimized strategy ($\max. \text{sum.} L\bar{T}^2(i)$)

It is a strategy which minimizes inventory cost by making the Inventory lead time of a final product equal to a customer's demand lead time, and also moving SSDP to the upstream side up as possible. When change of a customer request or the work balance of a factory line collapse, it becomes impossible to keep due date immediately. The Risk is high.

6. CONCLUSION

This paper clarified the architecture of a decoupling point and the constraint in the BOM structure in which designed components and repetitive components are intermingled. And it clarified the relationship about the production lead time of an Item, and the actual lead time which changes with sets of the Make to Stock Items. By above mentioned, the profitability of defining the SSDP for holding inventory of a repetitive components logically was shown, and this paper proposed about the strategy for it concretely.

Study of the determination methodology of the proper volume of inventories of a SSDP and study of the data model which can integrate the production management of designed components and repetitive components are future tasks.

References