Applied Soft Computing 11 (2011) 5621–5629

Contents lists available at ScienceDirect

Applied Soft Computing

journal homepage: www.elsevier.com/locate/asoc

Continuous materials requirements planning (CMRP) approach when order type is lot for lot and safety stock is zero and its applications

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ARTICLE INFO

Article history:
Received 1 February 2010
Received in revised form 27 February 2011
Accepted 6 April 2011
Available online 16 April 2011

Keywords:
Discrete materials requirements planning (DMRP)
Continuous materials requirements planning (CMRP)
Order type (OT)
Lot for lot (L4L)
Safety stock (SS)

ABSTRACT

The materials requirements planning (MRP) approach, applied in production planning and management has some weaknesses. One of those is the discreteness of time so called *time periods* in this approach which makes it impossible to order the requirements at irregular time moments or periods. In this paper, a new form of MRP, named as continuous materials requirements planning (CMRP) approach, is introduced. Moreover, the priorities and advantages of this approach over the discrete MRP (DMRP) one are further discussed and the conditions and manner of CMPR application in different types of problems are analyzed. The CMRP system, introduced in this paper does not have any safety stock (SS) and its order type (OT) is lot for lot (L4L). For applying this system, several algorithms and lemmas along with their proofs are also described. Also two numerical examples with one real case study are presented.

1. Introduction

MRP was first introduced in 1970s; thereafter, many researchers, papers, books, industries, companies and even different sciences have applied it [1,3,8,11,14].

This system was formed as an approach of production planning and management. Orlicky [12] introduced this system in a help book in 1975. The introduced MRP was the first version of MRP system, named as materials requirements planning (MRP I). Later, several MRP systems were extended into other versions including manufacturing resources planning (MRP II) and enterprise resources planning (ERP) [1].

In some researches, the advantages and disadvantages of MRPs have been explained (see [1,2,6,7,10,15,16]). In this paper, some other advantages and disadvantages of this approach will be pointed out.

Almost in all of related researches, MRP system has been considered as a DMRP; since orders, demands, scheduled receipts etc., are defined in discrete time or distinguished time periods [4,5,9,13].

In this paper, we explain the weaknesses of a DMRP approach and the manner of applying CMRP approach in some problems. In the following sections, some needed definitions and the manner of modeling CMRP are pointed out and some problems related to CMRP are solved.

Note that all over this paper, continuous production means a production with continuous time and not continuous supply or demand, and DMRP can also be applied when supply and demand are continuous.

Some of the priorities of CMRP over DMRP are as follows:

- DMRP cannot be applied in the industries of petrochemical, gas, oil, water and waste and other continuous production industries, while CMRP can be.
- Selecting a suitable and applicable time period in DMRP is difficult, while in CMRP such a selection is not needed at all.
- In CMRP approach, instead of gross requirements (GR), scheduled receipts (SR), on hand (OH) inventory and other parameters applied in discrete form, some continuous functions such as regression functions, interpolations, extrapolations and even multi rules functions can be defined, which enables us to perform sensitivity analysis and forecast on the required parameters of the model.
- In CMRP approach, users can supply and demand in any point of time and not necessarily in the beginning or the end of a time period; hence, this method can help in obtaining more benefits or decreasing waiting time.

All in all CMRP directs anything towards its real place.

Many researches have studied the different dimensions of MRP, and almost all of they have used MRP approach discretely. This paper is going to show the capabilities of MRP approach. One of

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doi:10.1016/j.asoc.2011.04.002

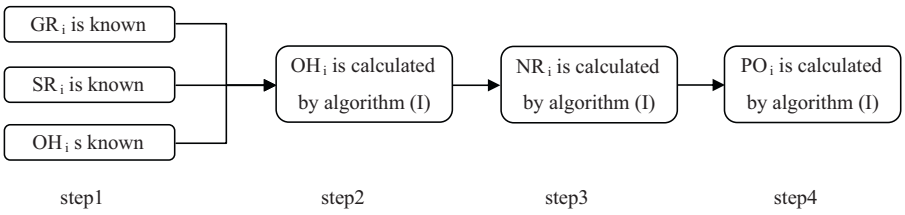

Fig. 1. Hierarchy calculations in DMRP approach.

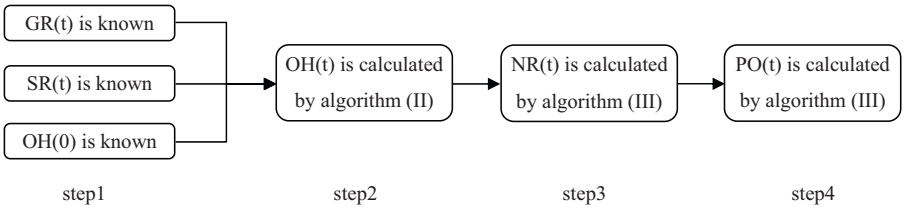

Fig. 2. Hierarchy calculations in CMRP approach.

those is that MRP approach can be continuously applied throughout time.

2. Research methodology

In next sections, some needed definitions and notations are introduced. Also, three algorithms for obtaining the parameters in DMRP approach, the manner of determining $OH(t)$ in CMRP approach and how to finding the functions of $NR(t)$ and $PO(t)$ in CMRP approach, with three lemmas are explained. Several numerical examples are presented too.

The notations in both DMRP and CMRP approach have a little difference. In DMRP approach, the parameters are defined during a time period, while in CMRP approach; the parameters are defined in a time moment. Each MRP approach (DMRP or CMRP), has several basic parameters, so that if the parameters are known, MRP approach is complete. The basic parameters are *GR*, *SR*, *OH*, *NR* and *PO*. These parameters are introduced in next section completely.

Note, *GR* and *SR*, during all time periods, and *OH*, in the beginning of planning horizon, are known. Other parameters are unknown, and can be obtained by the known ones. To do so, the algorithms of next sections can be applied. The hierarchies of parameters' calculations and their orders may be drawn similar to following figures (see Figs. 1 and 2).

All algorithms have obtained by several proved lemmas. The lemmas show how to convert DMRP approach into a CMRP approach. Indeed, readers can convert any DMRP system into a CMRP system by the steps of the mentioned algorithms.

3. Definitions and notations

Generally, in DMRP approach, the following notations are used, which may vary in some Refs. [1,5]:

GR_i: gross requirements during time period i,
SR_i: scheduled receipts during time period i,
OH_i: on hand inventory during time period i,
NR_i: net requirements during time period i,
PO_i: planned orders during time period i.

where *GR* and *SR*, during all time periods, and *OH*, in the beginning of planning horizon, are known, the unknown parameters can be obtained by the known ones. To do so, the following algorithm can be applied.

Algorithm I. The steps of obtaining the parameters in DMRP approach

Step 0: Begin
Step 1: Let $OH_1, SR_1, \ldots, SR_T, GR_1, \ldots, GR_T, T, TT$ be specified, where the planning horizon is $[1,T]$, TT is operations' total time for each piece of product when is defined as sum of four types of time consisting of queue time (QT), process time (PT), carrying time (CT) and setup time (ST) as follows:

$$TT = QT + PT + CT + ST$$

Note TT is different from Lead Time (LT), while in some researches, LT is wrongly used as TT.
Step 2: For $i = 1$ to T do the steps 3 to 4
Step 3: Determine NR_i with respect to the specified OT, subject to $NR_i \geq GR_i - SR_i - OH_i$.
Note that if OT is Lot for Lot so:

$$NR_i = GR_i - SR_i - OH_i \quad (1)$$

If $NR_i < 0$, it means that there is not any net requirement, so NR_i is considered equal to zero.
Step 4:

$$OH_{i+1} = NR_i + OH_i + SR_i - GR_i \quad (2)$$

Step 5: For $i = 0$ to T-TT do $PO_i = NR_{i+TT}$
Step 6: End

Lemma 1. *If order type is L4L and* $\exists i \in \{1, 2, \ldots, T\}$; $NR_i > 0$ *then* $OH_{i+1} = 0$.

Proof. See Appendix A.

Note, the above lemma for each order type may not be correct.

All of the above definitions and notations are only used in DMRP approach. In CMRP approach they are defined as follows:

$GR(t)$: gross requirements in time moment t,
$SR(t)$: scheduled receipts in time moment t,
$OH(t)$: on hand inventory in time moment t,
$NR(t)$: net requirements in time moment t,
$PO(t)$: planned orders in time moment t.

The above parameters are defined as continuous functions, which enable us to perform sensitivity analysis and forecast the required parameters of the model.