Implementation of Material Requirement Planning (MRP) for a MULTI-LEVEL FLEXIBLE BOM

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Abstract - *The compensation for a two level BOM from literature is improved to incorporate a compensation for a multilevel BOM. With the help of this when shortage occur in any sub assembly in second level or in any component in a lower level then a new bill of material is formulated with help of a linear programming model. The requirements of final product (like top assembly) stated in the master production schedule are met in given time by the substitution of other components or produce with a decreased number of components which are within tolerant limits. This concept is developed for multi levels but an example of top assembly is taken for three levels for presenting the concept.*

Key Words: Material requirement planning, Flexible Bill-of-Materials (BOM), Master production schedule, Linear programming, Planned order release tables.

1. INTRODUCTION

Material requirement planning (MRP) was introduced in the 1960s. It is designed and developed to operate within a predictable and stable batch manufacturing environment. MRP is a set of back scheduling techniques that uses inventory record file data, bill of material (BOM) data, and a master production schedule for the calculation of requirements of material. The Bill of material (BOM) along with the demand is used for making the master production schedule. While all aspects of production are considered as variable traditionally the BOM is invariable i.e. the quantity of parts / sub-assemblies for final product are fixed.

2. IMPLEMENTATION

In order to address flexible BOMs, a new moderate approach must be used in the BOM process. The steps in the procedure are discussed below.

Step S1. Here from start of material requirement planning, take "n" no. of component / sub-assemblies of top most assembly.

Step S2. A standard bill of material (BOM) is assumed for sub-assemblies that are being planned for production. This bill of material is taken as a default BOM and the objective is to be as close to it as possible. For example, the BOM could be a list of items that make up a certain top assembly. In addition, the parameters of bill of material, which prescribe the ranges (lower limit and upper limit) on its flexibility, must be specified. The parameters are cki, lli and uli, which are defined in Step S8. Within the assumption of default BOM, lead-time (lt), lot size (ls) is also assumed.

Step S3. Now, take (enter) gross requirement ("GR") of top assembly for "x" no. of periods.

Step S4. For the standard value of bill of material (default BOM), Planned Order Release (PORL) tables are computed for the planning horizon as in normal material requirement planning (MRP). It is also assumed that Projected On-Hand inventory at the beginning and all Scheduled Receipts are known.

Decision D1. In any specific period (called the current period), the Planned Order Receipt (PORP) for the period is compared with the corresponding PORL. There are two possibilities:

1. PORP equals or exceeds the corresponding PORL. In that case, the procedure for that period is complete and then stop, the standard bill of material (default BOM) and the normal computations are adequate for purpose.

2. PORP is less than the corresponding PORL. In this case, the procedure will be routed to another decision point (D2).

Step S5. Now enter any sub assembly in which shortage occurs.

Step S6. Enter any period of any sub assembly in which shortage comes. Shortage in units occur when scheduled receipt is not same to the PORL or units (planned on hand inventory + scheduled receipt) is less than gross requirement of that specific period which is released in lots as according to the net requirement of any specific period.

Decision D2. Based on the lead-time, determine the situation that the net requirement (NR) will be met or not. Then, there are two possibilities:

1. If net requirement (NR) will be met. This will lead or flow the procedure to S7 in order to update the PORL tables. The PORL tables obtained without any shortage.

2. Otherwise, if net requirement (NR) will not be met. This will lead or flow the procedure to S8, which is described below.

Step S7. Planned order release (PORL) tables will be computed using the same standard size of bill of material (default BOM) for the current and future periods. Since projected on-hand inventory is used to compensate for the shortage. In this way, PORL tables have been updated.

Step S8. A "new BOM" is defined by solving LP model. We need following notations (stated in the context of the top assembly example) to formulate the LP:

b(BOM)	Standard size (BOM) of sub assemblies "i" in one unit of top assembly
ck_i	Adjusted quantity of sub assemblies "i" in one unit of top assembly
dp_i, dn_i	Positive and negative deviation of ck_i relative to b
$dp_i = ck_i - b$	if $ck_i \geq b$
$dp_i = b - ck_i$	if $ck_i < b$
$PORL_t$	Planned Order Release for sub assembly in period t
POH_t^i	Projected on Hand inventory of sub assembly "i" in period t
SR_t^i	Scheduled Receipt of sub assembly " i" in period t
ll_i	Lower limit of adjusted quantity of sub assemblies
ul_i	Upper limit of adjusted quantity of sub assemblies
"n"	Number of sub-assemblies at the second level of BOM.

The LP will have the following objective function and constraints.

Objective. Minimize the deviation of adjusted bill of material from the standard BOM or

Minimize $dp_i + dn_i$ for i = 1, 2, 3,... n (BOMLP-OBJ).

Constraint C1. The adjusted quantity (in units) of the lower level sub assemblies that make up one unit of the end top assembly must be the same as in the standard BOM or

$\sum ck_i = \sum b$ for i = 1, 2, 3 ...n (BOMLP-C1).

Constraint C2. The sum of positive and negative deviations of the quantity of each lower level sub assemblies from the standard should equal the total deviations or

$ck_i - b = dp_i - dn_i$ for i =1, 2, 3 ... n

or

$ck_i - dp_i + dn_i = b$ for i =1, 2, 3... n (BOMLP-C2).

Constraint C3. The sum of the current period projected on-hand inventory and scheduled receipt should not be less than the derived demand for each sub assembly based on the planned order release for the top assembly in the current period or

$(POH_{t-1}^i + SR_t^i) \geq (ck_i * PORL_t)$ for i = 1, 2, 3... n (BOMLP-C3).

Constraint C4. The adjusted quantity (ck_i) must be between the lower limit and the upper limit of sub assembly "i" in one unit of top assembly or

$ll_i < ck_i < ul_i$ for i = 1, 2, 3 ...n (BOMLP-C4).

We will refer to the above LP formulation as BOMLP. BOM is solved to find values for ck_i for each sub assembly "i".

Decision D3. In this step, try to verify "new BOM" that whether the LP model has displaying readings to a feasible solution for the current period. There are also two possibilities that are to be followed:

1. If there is no feasible solution after using "new BOM" for the current period, Then there are some production problem. Due to that reason the procedure will stop, the ranges or limits of adjusted quantities provided in the flexible BOM are not feasible for the current period, In this case, the next step is S9.
2. If "new BOM" computed with LP model (i.e. the adjusted quantities of bill of material) is feasible. Then, update PORL tables with "new BOM". Here the next step is S10.

Decision D4. Here moving further to third level means the lower level of sub assemblies (i.e. "p" no. of components of each sub assembly). In this case (in third level) one component is common for each sub assembly and also common for top-assembly. The common component of sub assemblies is also the sub assembly of top assembly. All components in each case exit with different bill of material.

Now asking the question, "Do you have more data for components (lower level of sub assemblies means for third level)? Therefore, there are two possibilities that are as follows:

1. If answer is "no" then statement come on screen that data entered is successful, next step is S11.
2. If "Yes" then enter "p" no. of components. This type of entries takes place in step S12.

Step S13. So by following this way, partly divide BOM of sub assembly into components according to the requirement. One of component, which is common in all sub assemblies of top assembly, has different BOM (c) in each case. The parameters are cki, lli, uli, which are also defined in step S20.

Step S14. For the continuation of same procedure of material requirement planning (i.e. computation of PORL tables), lead-time (lt), lot size (ls), lower limit (ll), and upper limit (ul) for each component in all the cases in the third level is also assumed.

Step S15. As the bill of material (c) of third level components is partly divided, hence the gross requirement "GR" (units) of components is obtained.

Step S16. For the partly divided BOM (c), Planned Order Release (PORL) tables are computed for the planning horizon as in normal MRP. It is assumed that Projected On-Hand at the beginning and all Scheduled Receipts are known.

Decision D5. In any specific period (called the current period), the Planned Order Receipt (PORP) for the period is compared with the corresponding PORL. There are two possibilities:

1. Planned order receipt (PORP) equals or exceeds the corresponding PORL. In this case, the procedure for this period is complete and stop, the default BOM and the normal computations are sufficient.

2. PORP is less than the corresponding PORL. In this case, the procedure will be routed to another decision point (D6).

Step S17. Now enter any component in which shortage occurs.

Step S18. Enter any period of that selected component in which shortage comes. Shortage in units occurs when scheduled receipt is not same to the PORL or units (planned on hand inventory + scheduled receipt) is less than gross requirement of that specific period which is released in lots as according to the net requirement of any specific period.

Decision D6. Based on lead-time, determine the situation for which net requirement (NR) can be met. There are two possibilities:

1. One situation is that the NR can be met. This will lead or flow the procedure to S19 in order to update the PORL tables.

2. Another one is NR cannot be met. This will lead or flow the procedure to S20, which is prescribed below.

Step S19. PORL tables will be computed using the partly divided BOM (c) for the current and future periods. Since some of the projected on-hand inventory is used to compensate for the shortage. In this way, PORL tables have been updated.

Step S20. A "new BOM" is defined by solving LP model. We need following notations (stated in the context of the sub assembly example) to formulate the LP:

C	Partly divided standard(BOM) of components "j" in one unit of sub assembly
ck_j	Adjusted quantity of components "j" in one unit of sub assembly
dp_j, dn_j	Positive and negative deviation of ck_j relative to b
$dp_j = ck_j - c$	if $ck_j \geq c$
$dp_j = c - ck_j$	if $ck_j < c$
$PORL_t$	Planned Order Release for components in period t
POH_t^j	Projected on Hand inventory of components "j" in period t
SR_t^j	Scheduled Receipt of components "j" in period t
ck_j	Adjusted quantity of components
ll_j	Lower limit of adjusted quantity of components.
ul_j	Upper limit of adjusted quantity of components.
"p"	Number of components at the third level of BOM.

The LP will have the following objective function and constraints.

Objective. Minimize the deviation of adjusted quantity for bill material from the standard BOM or

Minimize $dp_j + dn_j$ for j = 1, 2, 3... n (BOMLP-OBJ).

Constraint C1. The adjusted quantity (in units) of the lower level components that make up one unit of the end sub assembly must be the same as in the standard BOM or

$\sum ck_j = \sum c$ for j = 1, 2, 3 ...n (BOMLP-C1).

Constraint C2. The sum of positive and negative deviations of the adjusted quantity of each lower level components from the standard should equal the total deviations or

$ck_j - c = dp_j - dn_j$ for j =1, 2, 3... n

or

$ck_j - dp_j + dn_j = c$ for j =1, 2, 3 ...n (BOMLP-C2).

Constraint C3. The sum of the current period projected on-hand inventory and scheduled receipt should not be less than the derived demand for each component based on the planned order release for the subassembly in the current period or

$(POH_t^j + SR_t^j) \geq (ck_j * PORL_t)$ for j = 1, 2, 3... n (BOMLP-C3).

Constraint C4. The quantity ck_i must be between the lower limit and the upper limit of components "j" in one unit of sub assembly or

$ll_j < ck_j < ul_j$ for j = 1, 2, 3,... n (BOMLP-C4).

We will refer to the above LP formulation as BOMLP. BOM is solved to find values for ck_i for each component "j".

Decision D7. In this step, try to verify "new BOM" that whether the LP model has displaying readings to a feasible solution for the current period. There are also two possibilities that are to be followed:

1. If there is no feasible solution after using "new BOM" for the current period, Then there are some production problem. Due to that reason the procedure will stop, the ranges or limits of adjusted quantities provided in the flexible BOM are not feasible for the current period, In this case, the next step is S21.

2. If "new BOM" computed with LP model (i.e. the adjusted quantities of bill of material) is feasible. Then, update PORL tables with "new BOM". Here the next step is S22.

Decision D8. After the completion of computation of PORL tables for first sub assembly, again asking the same question for next sub-assembly "Do you have more data for next sub-assembly". In this above discussed case having two possibilities:

1. If answer is "no" then statement come on screen that data entered is successful, next step is S23.

2. If "Yes" then enter again "p" no. of components and follow the same procedure of computation of PORL tables of sub assembly with the use of LP model for finding the "new BOM" of specific period in which shortage occur due to some unwanted reason or can say manufacturing equipment breakdowns. In this way the PORL tables of "p" no. of components in the lower levels of "n" no. of sub-assemblies computation takes place with the same procedure discussed above.

3. CONCLUSION

The results show that the concept is possible to extend beyond two levels and a multilevel BOM can be considered as flexible as demonstrated for the three level examples. The application of flexible BOMs can be in metallurgical environments when there is a formation of an alloy with no. of metals and non-metals which are relevant with each other and can vary in different proportion. For example, beryllium copper alloys like Beryllium copper ingots and rods, Nickel Beryllium alloy, Aluminum Beryllium master alloy where substitute metals and non-metals may be available. Another application of flexible BOMs can be in food industry manufacturing.

REFERENCES

1. Blackburn, J.D., Kropp, D.H. and Millen, R.A., "A comparison of strategies to dampen nervousness in MRP systems". Management Science, 1986, 32, 413–429 (Informs).
2. Murthy, D.N. and Ma, L., "MRP with uncertainty: a review and some extensions". International Journal of Production Economics, 1991, 25, 51–64 (Elsevier).
3. Zhao, X. and Lee, T.S., "Freezing the master production scheduling for material requirements planning systems under demand uncertainty". Journal of Operation Management, 1993, 11, 185–205 (Elsevier).
4. Buzacott, J.A. and Shanthikumar, J.G., "Safety stock versus safety times in MRP controlled production systems". Management Science, 1994, 40, 1678–1689.
5. Kadipasaoglu, S.N. and Sridharan, V., "Alternative approaches for reducing schedule instability in multistage manufacturing under demand uncertainty". Journal of Operation Management, 1995, 13, 193–211 (Elsevier).
6. Molinder, A., "Joint optimization of lot-sizes, safety stock and safety lead times in an MRP system". International Journal of Production Research, 1997, 35, 983–994 (Taylor & Francis).
7. Zhao, X. and Lam, K., "Lot – sizing rules and freezing the Master Production Schedule in Material Requirements Planning systems". International Journal of Production Economics, 1997, 53, 281–305 (Elsevier).
8. Chakravarty, A.K. and Balakrishnan, N. "Reacting in real-time to production contingencies in a capacitated flexible cell". European Journal of Operation Research, 1998, 110, 1–19 (Elsevier).
9. Ho, C.-J. and Ireland, T.C., "Correlating MRP system nervousness with forecast errors". International Journal of Production Research, 1998, 36, 2285–2299 (Taylor & Francis).
10. Yeung, J.H., Wong, W.C. and Ma, L., "Parameters affecting the effectiveness of MRP systems: a review". International Journal of Production Research, 1998, 36, 313–331 (Taylor & Francis).