ABSTRACT

This paper includes the fundamental information about ERP, MRP, Finite Capacity Planning, mathematical modelling and a comparison of the results of the same capacity problem obtained by both mathematical modelling and finite capacity MRP using a heuristic method. In our project we are working with Egeria, a consultant firm for Baylan Water Meters for IFS-ERP. Baylan Water Meters has purchased IFS ERP to improve the way they use their production capacity. We have defined the conditions of Baylan Water Meters' current production and developed our own mathematical model to solve their capacity problem and compare the results with the IFS ERP module's alternative solution software "Advanced Planning Board". With our mathematical model we will attempt to solve the capacity overloading problem at Baylan Water Meters and show the resulting comparing through the use of Gantt charts.

Keywords: *ERP, MRP, Finite Capacity Planning, Advanced Planning and Scheduling, Mixed Integer Programming, Gantt Chart*

MATHEMATICAL MODEL

We have developed a mixed integer mathematical model to improve and form the IFS's Advance Planning Board module (APB) into a solution method which gives us more well-determined and much more realistic results as possible.

In our mixed integer model we have used the two types of products that we have mentioned at the problem definition.

<u>Indexes:</u>

m = machine index, m = (1, …..,M)

p = 1 if product type is "BU0030010001", 2 if product type is "BU0040000009", $p \in n$

i,t = order index , i = (1,……..,v)

j,q = operation index j = (1,……, s)

Parameters:

n = number of products

s = number of distinct operations

v = number of orders in one period

M = number of total machines in all workstations

Q_{pi} = order quantity of product p in order i

T_{jpm} = process time of operation j of product p in machine m

A = a large positive number

D_{jm} = set of operation j that assign to machine m

L_i = last operation of order i [L1 = j("41") , L_2 = j("60")]

P_j = set of immediate predecessors of operation j

Variables

F_{jim} = finish time of operation j of order i at machine m

C_{max} = production makespan

S_{jim} = start time of operation j of order i at machine m

C_i = production completion time of order i

X_{jiqtm} = 1, if operation j of order i precedes operation q of order t in machine m; 0 otherwise

Y_{jim} = 1, if operation j of order i is assigned to machine m; 0 otherwise

Constraints

$C_i \leq C_{max}$, ∀ i (1)

$\sum_{m=1}^{M} F_{Li,i,m} = C_i$, ∀ i (2)

$\sum_{m=1}^{M} m \in D_{jm} S_{j,1,m} + \sum_{m=1}^{M} m \in D_{jm} (T_{j,1,m} * Q_{1,1} * Y_{j,1,m}) = \sum_{m=1}^{M} m \in D_{jm} F_{j,1,m}$

∀j (3)

$\sum_{m=1}^{M} m \in D_{jm} S_{j,2,m} + \sum_{m=1}^{M} m \in D_{jm} (T_{j,2,m} * Q_{2,2} * Y_{j,2,m}) = \sum_{m=1}^{M} m \in D_{jm} F_{j,2,m}$

∀ j (4)

$S_{qtm} \geq S_{jim} + (T_{jpm} * Q_{pi}) - A (1 - X_{jiqtm})$, ∀ j, i, q, t, m, p, q≠j ,t≠i (5)

$S_{jim} \geq S_{qtm} + (T_{jpm} * Q_{pi}) - A (X_{jiqtm}) - A (1 - Y_{jim}) - A (1 - Y_{qim})$

,∀ j, i, q, t, m, p , q≠j, t≠i (6)

$Y_{jim} + Y_{qtm} \geq 2 * (X_{jiqtm} + X_{qtjim})$, ∀ j, i, q, t, m, q≠j, t≠i (7)

$Y_{jim} + Y_{qtm} \leq X_{jiqtm} + X_{qtjim} + 1$, ∀ j, i, q, t, m ,q≠j, t≠i (8)

$S_{jim} \leq A * Y_{jim}$, ∀ j, i, m (9)

$\sum_{m=1}^{M} m \in D_{jm} \quad Y_{jim} = 1$, ∀ j, i (10)

$Y_{jim} \leq D_{jm}$, ∀ j, i, m (11)

$C_{max} \geq 0$ (12)

$S_{jim} \geq 0$, ∀ j, i, m (13)

$C_i \geq 0$, ∀ i (14)

$\sum_{m=1}^{M} m_{\in Djm} \; S_{j,i,m} \geq \sum_{m=1}^{M} m_{\in Djm} \; F_{q,i,m}$ ∀ i , j, q ∈ P_j (15)

Objective function:

Minimize

$$M * C_{max} - \left[\sum_{i=1}^{v} \sum_{p=1}^{n} \sum_{j=1}^{s} \sum_{m=1}^{M} T_{jpm} * Q_{pi} \right]$$

Constraint (1) shows that the completion time of any order has to be less than or equal to production makespan. Constraint (2) refers to the finish time of last operation of any order must be equal to the completion time of that order. In constraint (3) and (4), finishing times of each operation is set to be equal to the starting that specific operation in addition with its processing time. Constraint (5), (6), (7) and (8) ensures the requirements of the machine eligibility. In Constraint (5), states that if any operation is scheduled before another operation on the same machine m, starting time of second operation must be later or at least equal to the finishing time of the first operation. In Constraint (7), if two operations are scheduled successively on machine m, both of the operations must be pre-assignable to that machine. In constraint (8), if two operations are assigned to the same machine, one of them must be scheduled before the other. Constraint (9) provide the start time of any operation to be equal to zero for the machines which that operation not assign to. Constraint (10) ensures the each operation can be assigned to the one machine for in its eligible machine set. Constraint (11) ensures that if an operation has the 1 value in the assignment matrix of the operation-machine matrix then that assignment can be made. Constraints (12), (13) and (14) are the non-negativity constraints of production makespan, start time of any operation and finishing time of any order. Total available time is computed by multiplying total number of machines in production lines with production makespan. Subtracting the total production time of the orders from the previous multiplication yields us with the idle time. Constraint (15) represents the precedence relationships give into the model as an input by a matrix (these precedence relationships can be seen at pre-mentioned **Appendix 6-6A**). Also, precedence relationships between operations which we used in Gams code can be found in **Appendix-9**.