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Integration of Inventory Control and Scheduling Using Binary Particle Swarm Optimization Algorithm

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ABSTRACT

An integrated approach for guaranteeing consistency to some extent between decisions taken at tactical and operational levels of production management was presented, thus avoiding the shortcomings of traditional approaches in which decisions are taken sequentially. Integrated problem are solved by using the exact capacity constraint from a standard scheduling problem to the lot sizing problem. However this combinatorial optimization problem can be solved by using soft computing techniques in reasonable time. In the present work Binary Particle Swarm optimization (BPSO) technique to the Single item single level, multi-level and Multi item Lot sizing problems with and without applying the Scheduling constraint is used. The obtained results are compared with Lot sizing problems without constraint and it is concluded that in all instances the results are improved compared to simple lot sizing problems.

KEYWORDS: MRP, Binary Particle Swarm optimization (BPSO),

INTRODUCTION

Today's business environment has become highly competitive. Manufacturing firms have started recognizing the importance of manufacturing strategy in their businesses. Firms are increasingly facing external pressures to improve customer response time, increase product offerings, manage demand variability and be price competitive. In order to meet these challenges, firms often find themselves in situations with critical shortages of some products and excess inventories of other products. This raises the issue of finding the right balance between cutting costs and maintaining customer responsiveness. Previously, production specialists used multiple and sometimes contradictory or confusing databases, data gathered from machine operators, and past experience to gauge what was needed to meet production goals. Problems always take place on shop floor when generating MRP and production schedule are separately taken into account since both MRP and schedule aim for different objectives which are not synchronized. MRP is computer software based production planning and inventory control system used to ensure that all materials required are ready for production and requested products are available for delivery to customers with the lowest possible level of inventory. Using conventional MRP and classic shop floor scheduling separately cannot solve the problem. Integration of inventory control and scheduling is one of the solutions.

MATHEMATICAL FORMULA

a) Mathematical formulation to the Single level Lot sizing Problem (SISL)

The incapacitated single item no shortages allowed and single level lot sizing model is the simplest model in the inventory lot sizing problems. Lot sizing formulation for this kind of lot sizing problem takes the following form

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$$\min\left(\sum_{i}^{n}{}_{1}\left(Ax_i + cI_i\right)\right) \qquad (1)$$

$$subject \quad to:$$

$$I_0 \quad 0 \quad \vee_i \qquad (2)$$

$$I_{i-1} + x_i Q_i - I_i - R_i \quad \forall_i \qquad (3)$$

$$I_i \geq 0 \quad \vee_i \qquad (4)$$

$$Q_i \geq 0 \quad \forall_i \qquad (5)$$

$$x_i \subset \{0,1\} \quad \vee_i \qquad (6)$$

Where,
A=ordering/setup cost per period
c=holding cost per unit per period
I_i=projected inventory balance for period i
n=number of periods
R_i=net requirement for period i
X_i=1 if an order is placed in period i, Xi=0 otherwise.

b) Mathematical formulation to the Multi level Lot sizing Problem (MLLS)

$$\min\sum_{i=1}^{P}\sum_{t=1}^{T}(s_i y_{it} + h_i I_{it}) \rightarrow (1)$$

$$I_{it} = I_{i,t-1} + x_{it} - d_{it} \rightarrow (2)$$

$$d_{it} = \sum_{j \in ^2(i)} c_{ij} x_{jt} \rightarrow (3)$$

$$x_{it} - My_{it} \leq 0, y_{it} \in \{0,1\} \rightarrow (4)$$

$$I_{it} \geq 0, x_{it} \geq 0 \rightarrow (5)$$

Necessary notations:
c_{ij} : quantity of item i required to produce one unit of items j.
$D_{i,t}$: external requirement for items i in period t.
h_i: holding cost for items i (Following small instance standard).
$I_{i,0}$: initial inventory of product i.
S_i : setup cost for items i (Following small instance standard).
T: total number of periods.
Γ (i): set of immediate successors of items i.
Γ^{-1}(i): set of immediate predecessors of items i.

Decision and auxiliary variables:

$d_{i,t}$: total requirement for item i in period t.
$I_{i,t}$: Inventory level of item i at the end of period t.
$X_{i,t}$: delivered quantity of items i at the beginning of the period t.
$Y_{i,t}$: binary variable which indicates if an item i is produced in period t, ($y_{i,t} = 1$) or not ($y_{i,t} = 0$).

INTEGRATED FORMULATION OF PLANNING AND SCHEDULING

The problem is formulated as

$$\min\sum_{t=1}^{T}\sum_{i=1}^{n}(c_{it}^{+}.I_{it}^{+} + c_{it}^{-}.I_{it}^{-} + c_{it}^{pr}.X_{it})$$

$$(I_{it}^{+} - I_{it}^{-}) - (I_{it-1}^{+} - I_{it-1}^{-}) - X_{it} + D_{it} = 0, i = 1,...n; t = 1,...,T \rightarrow (1)$$

$$X_{it} \geq 0, \forall i,t \rightarrow (2)$$

$$I_{it}^{+} \geq 0, \forall i,t \rightarrow (3)$$

$$I_{it}^{-} \geq 0, \forall i,t \rightarrow (4)$$

$$t_{ijkt} - t_{ij'k't} - p_{ij'k't}^{u}.X_{it} \geq 0, \forall(o_{ij'k't}, o_{ijkt}) \in A \rightarrow (5)$$

$$t_{ijkt} \geq 0, \forall o_{ijkt} \in N \rightarrow (6)$$

$$t_{ijkt} - t_{i'j'kt'} - p_{i'j'kt'}^{u}.X_{i't'} \geq 0, \forall(o_{i'j'kt'}, o_{ijkt}) \in S(y) \rightarrow (7)$$

$$t_{ijkt} + p_{ijkt}^{u}.X_{it} \leq \sum_{l=1}^{t} c_l, \forall o_{ijkt} \in L \rightarrow (8)$$

$$t_{ijkt} + p_{ijkt}^{u}.X_{it} \geq \sum_{l=1}^{t-1} c_l, \forall o_{ijkt} \in L \rightarrow (9)$$

IMPLEMENTATION OF BPSO TO INTEGRATED PROBLEM

Binary Particle Swarm Optimization Algorithm (BPSO)

Pseudo code of the general PSO is given as

Begin
Step 1: Initialization
- Initialize swarm, including swarm size, each particle's position and velocity;
- Evaluate the each particle fitness;
- Initialize gbestposition with particle with the lowest fitness in the swarm;
- Initialize pbest position with a copy of particle itself;
- Give initial value: W_{max},W_{min},C_1,$C_2$and generation=0;

Step 2: Computation
While (the maximum of generation is not met)
Do {
Generation++;
Generate next swarm by equation (1a) and (1b);
Evaluate Swarm {
Find new gbest and pbest;
Update gbestof the swarm and pbest of each particle;
}
}
Step 3: Output optimization results
End

RESULT:

a) Single item Multi level Problem

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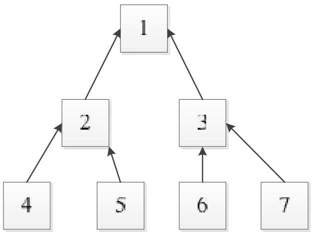

Fig.1 BOM Structure of 7×6 problem

Comparison of results with and without scheduling constraint tested at different iterations.

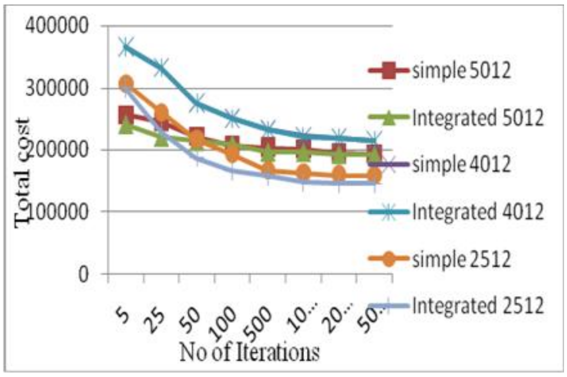

Fig. 2 Convergence of Four SIML problems solutions at different iterations

b) Multi item level Problem

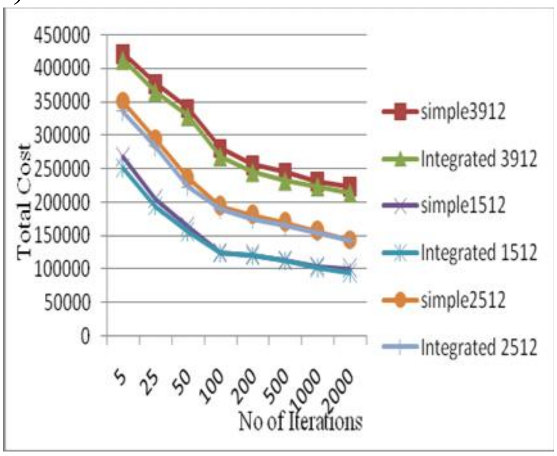

Fig. 3 Convergence of three MIML problems solutions at different iterations

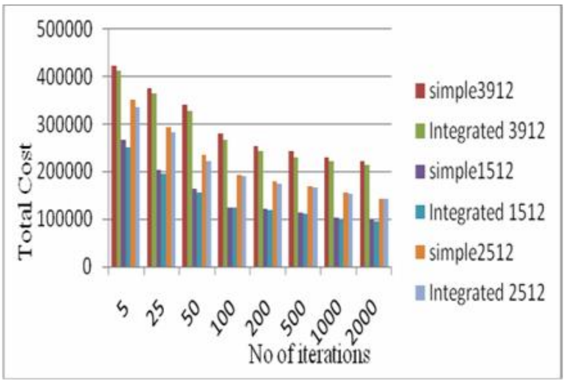

Fig. 4 Comparison of three MIML problems solutions at different iterations

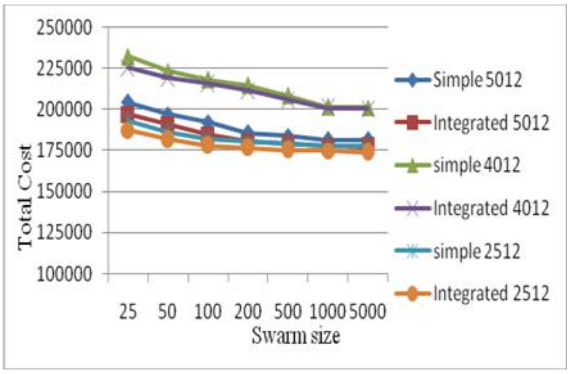

Fig. 5 Convergence of three SIML problems solutions at different Swarm sizes

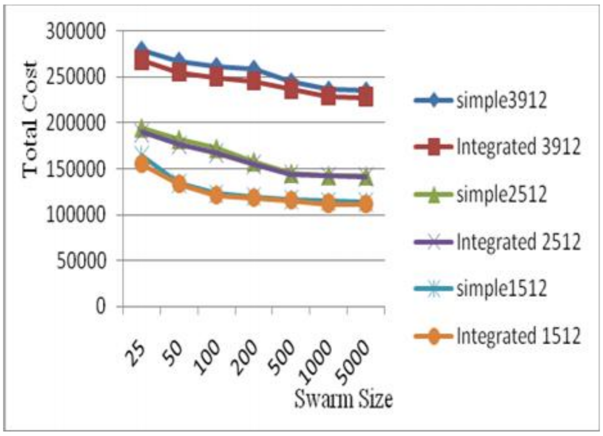

Fig.6 Convergence of three MIML problems solutions at different Swarm sizes

CONCLUSIONS

To the best of knowledge no work related to the integration problem by using BPSO technique has been published so far in the contemporary literature. BPSO technique have been successfully applied to integrated model and tested for different

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lot sizing problems such as single item single level, single item multi-level and multi item problems with three different product structures. In all the problem instances improvement in inventory cost by introducing the scheduling constraint in the lot sizing problems is found. The problem solutions are converging at higher number of iterations and Swarm sizes. Computational experience of BPSO algorithm to the combinatorial optimization problems in manufacturing decision making problems is good and its implementation to manufacturing problems is easy as it is having few number of control parameters in algorithms compared to other evolutionary algorithms.

REFERENCES

[1] Staggemeier, A.T., et Clark, A.R.: A survey of lot-sizing and scheduling models, 23rd Annual Symposium of the Brazilian Operational Research Society, (2001) 603-617.

[2] M. Fatih Taşgetiren & Yun-Chia Liang, a binary particle swarm optimization algorithm for the lot sizing problem, Journal of Economic and Social Research 5 (2), 1-20.

[3] Wagner H. M and Whitin T. M, “Dynamic Version of the Economic Lot Size Model”, Management Science, Vol. 5, 1958.

[4] Kennedy J. and Eberhart R. C., “A Discrete Binary Version of the Particle Swarm Optimization”, Proc. Of the conference on Systems, Man, and Cybernetics SMC97, pp. 4104-4109, 1997.

[5] Klorklear Wajanawichakon1† , Rapeepan Pitakaso2, Solving large unconstrained multi level lot-sizing problem by a binary particle swarm optimization, International Journal of Management Science and Engineering Management, 6(2): 134-141, 2011.

[6] Afentakis. P. and Gavish. B, (1986). Optimal lot-sizing algorithms for complex product structures. Operation Research, 34(2):237–249.

[7] N.P. Dellaert a, J. Jeunet, Randomized multi-level lot-sizing heuristics for general product structures, European Journal of Operational Research 148 (2003) 211–228.

[8] Kennedy, J., Eberhart, R., and Shi, Y. (2006). Swarm intelligence. Handbook of Nature-Inspired and Innovative Computing, 187–219.

[9] Fleischmann B & Meyr H, The General Lot sizing and Scheduling Problem, OR Spektrum 19,Vol. 1, pp. 11-21, 1997.

[10] Dauzère- Pérès, S. and Lasserre, J.B.: On the importance of sequencing decisions in production planning and scheduling, International Transaction in Operational Research Vol. 9, No. 6 (2002) 779-793.

[11] Meyr H**,** Simultaneous Lot sizing and Scheduling by Combining Local Search with Dual Reoptimization, European Journal of Operational Research 120, pp 311-326, 2000.

[12] Drexl A & Kimms A, Lot sizing and scheduling - Survey and extensions, European Journal of Operational Research 99, pp 221-235, 1997.

[13] Kimms A, A genetic algorithm for multi-level, multi-machine lot sizing and scheduling, Computers & Operations Research 26, pp. 829-848, 1999.

[14] Héla OUERFELLI, Abdelaziz DAMMAK, Emna KALLEL CHTOUROU / Benders-based approach for an integrated Lot-Sizing and Scheduling problem. © International Journal of Combinatorial Optimization Problems and Informatics, Vol. 3, No. 3, Sep-Dec 2012.

[15] Stephane Dauzère-Pérès and Jean Beranard Lasserre, on the importance of sequencing decisions in production planning and scheduling, International Transactions in operation research, 9 (2002) 779-793.

ISSN 2395-3594
9 772395 359001