Collection and production planning on systems with returns flow

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1 Introduction :

Since the protection of the environment has become a concern of humanity, the treatment of returns becomes increasingly crucial. In the sense of the industrial economy, treatment of returns products must be an economical way to help in minimizing costs and stabilizing the relationship with customers. For these reasons, the problem of lot sizing in systems incorporating treatment options or remanufacturing returns attracts more and more interest from firms and the researchers as well.

2 Problemdefinition :

In the present study, we discuss the production planning with remanufacturing option while taking into consideration the returns collection phase from the customers.

Many proposed models try to involve procurement cycle,Wang et al. [2] study a model with an outsourcing option. The model presented shows that the client's needs are satisfied by new items manufacturing, remanufactured items, or outsourcing, which explains the introduction of the outsourcing costs (transport, handling…).

The system studied is a single production line where both regular production and remanufacturing process are considered with different set up costs for each operation. We consider also a collection phase of returned products from a certain number of customers / distributors. The collected quantities are deterministic in each period throughout a planning horizon.

3 The Mathematical Model :

The following notations were used to describe the variables used throughout our model. t (Planning horizon), C (customers Number), Dt (Demand in period t), K, Kr, Km (respectively the preparation cost , the set up cost for remanufacturing and manufacturing), hr, hs, hc (respectively the holding cost for returns, serviceables products and for our suppliers of returns), I_t^r , I_t^s, I_t^c (respectively the inventory level at the end of period t of returns , end-products and customer c),x_t^r, x_t^m (Number of products remanufactured and manufactured respectively in period t), Q_t^c (Number of products collected at the period t from the customer c), r_t^c (Number of articles available in the period t as the customer inventory), P_c(delivery time for the customer c), δ_t, δ_t^r, δ_t^m (0–1 Binary variable respectively for preparation cost, remanufacturing and manufacturing set-up).

The proposed mathematical model minimizes the following objective function.This model was used to find solutions with Cplex.

Minimize:$FO = \sum_{t=1}^{T}\left[K\delta_t + K^r\delta_t^r + K^m\delta_t^m + h^r I_t^r + h^S I_t^S + \sum_{c=1}^{C}(I_t^c h^c + Q_t^c T^c)\right]$ (1)

Subject to:

$I_t^r = I_{t-1}^c + \sum_{c=1}^{C} Q_{t-p_c}^c - x_t^r$ *(2)*

$I_t^s = I_{t-1}^s + x_t^r + x_t^m - d_t$ *(3)*

$I_t^c = I_{t-1}^c + r_t^c - Q_t^c$ *(4)*

$x_t^r \leq D_{t,T}\delta_t^r$ *(5)*

$x_t^m \leq D_{t,T}\delta_t^m$ *(6)*

$Q_t^c \leq I_{t-1}^c + r_t^c$ (7)

$\delta_t \geq \delta_t^m$ *(8)*

$\delta_t \geq \delta_t^r$ *(9)*

$\delta_t \leq \delta_t^r + \delta_t^m$ *(10)*

$I_t^r, I_t^s, I_t^c, x_t^r, x_t^m, Q_t^c \geq 0$ (11)

$\delta_t, \delta_t^r, \delta_t^m \in \{0,1\}$ (12)

$I_1^r = I_1^s = I_1^c = 0$ (13)

4 Silver&Mealheuristic :

In the sequel, we propose an adaptation of the Silver & Meal heuristic to the case of a model integrating aproduction system with manufacturing, remanufacturing and an outsourcing cycle of returns.If we produce in period *s* to meet the demand of periods *s*, ..,*s+t*, the total cost incurred has the following form:

Cost (s, s+ t) = preparation cost + setup costs + holding cost (s, s+ t)+ procurement cost + transportation cost.

Typically, when *t* increases, the average cost per period C(*s*, *s+t*)/(*s+t*) is first decreasing (since the fixed set up costs are amortized over several periods) and then it starts to increase since the holding, procurement and transportation costs become more important. The Silver Meal heuristic strategy is to produce in order to meet the demands of periods s to *s*+*t*, where *s*+*t*is the last period for which the average cost per period is decreasing.

5 Hybrid method:

Hybrid Algorithms are used by many researchers for Lot-Sizing problems. Puchinger et al. [1] review the literature on algorithms combining metaheuristics and exact algorithms in combinatorial optimization.

We propose a resolution approach based on a Hybrid Algorithm which combines a metaheuristic which is the Greedy Randomized Adaptive Search Procedure (GRASP) with an exact local search based on the mathematical model. At each iteration of the GRASP, the randomized heuristic proposes the set of periods on which manufacturing and/or remanufacturing could be launched and the set of customers from which the returns would be procured. Production and Sourcing propositions generated by the randomized heuristic as a binary coding are integrated in the mathematical model as decision variables which are then solved by Cplex.The solution returned by Cplex defines the optimal quantities to produce and to collect according to the production periods proposed by the randomized heuristics.

6 Numerical experiments:

The instances are derived from the article of Teunter et al. [3]. Five different types of demand and return patterns (stationary, linearly increasing and decreasing, seasonal peak in the middel, and valley in the middel).(The numerical experiments are currently under construction)

References

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