General lotsizing problem in a closed-loop supply chain with uncertain returns

Guillaume Amand
HEC-ULg, QuantOM
guillaume.amand@ulg.ac.be

Yasemin Arda
HEC-ULg, QuantOM
yasemin.arda@ulg.ac.be

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1 Problem description

The economic and ecological necessity of remanufacturing used products into new ones creates new challenges in production management. One of these challenges is to handle the uncertainty in quantity and in quality of the returned materials in a production process. Inspired from the practical case of a Belgian bottler, we analyze a stochastic version of the general lotsizing and scheduling problem [2].

We consider a manufacturer who has to satisfy the deterministic demand of N different products over a finite rolling horizon. The manufacturer disposes a single capacitated production line. The capacity of the line may vary between periods and each item produced consumes some amount of this capacity depending on its type. The manufacturer may build inventories for end-products while backorders are not allowed.

In a given period, whenever the production is switched from one type of product to another, setup costs and times are incurred. The setup time consumes some capacity of the production line. We consider sequence dependant setups [1], i.e, the setup costs and times are determined based on the product produced before the changeover and the product produced after the changeover. We also consider setup carryover, i.e, the production line configuration at the beginning of a period is the same as the configuration at the end of the preceding period.

There are N different types of raw materials and the manufacturer needs one unit of raw material i (for $i = 1, \ldots, N$) to produce one unit of end-product i. The raw materials used for production originate from two different sources : uncapacitated reserves of new items, and inventories of returned items. Each returned item inventory is fed by a return process which cannot be controlled by the manufacturer. We consider that the quantity of returned items received at the beginning of each period is uncertain. The manufacturer can use returned items for free, while he incurs a purchasing cost per new item used.

The aim of the manufacturer is to find a feasible production schedule that minimizes the expected costs over the planning horizon. A production schedule determines the quantity to be produced for each end-product, and the production sequence used for each period.

2 Solution method

An approximate dynamic programming method [3] is used in order to solve the considered problem. The basic idea of the method is to iteratively solve an approximation of the deterministic problem, and to use the obtained result to affine the approximation at the end of the iteration.

An iteration of the algorithm starts by the random selection of a scenario. In the considered case, a scenario defines the quantities of returned items received in each period. Then, the algorithm solves a sub-problem for each period where the future expected cost in the objective function is replaced by an approximation. Finally, the approximation used in each sub-problem is updated using the obtained results.

We present the preliminary results obtained for a single item case

References

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