Capacitated disassembly lot-sizing under yield uncertainty

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1 Introduction

Due to its crucial role in the recovery of materials and products, disassembly has gained significant importance in recent years, with manufacturers increasingly dedicated to recycling and remanufacturing their products in response to environmental and economic constraints [2].

In the disassembly environments, discarded products differ in terms of quality: sometimes they are in good condition and relatively new, and at other times they are old and contain defective components. The unknown quality of products leads to uncertainty in disassembly yields, which are the quantities of components obtained in good condition from disassembly [1].

In this work, we consider the capacitated disassembly lot-sizing under yield uncertainty for complex product structures. We solve the problem using a two-stage joint chance-constrained stochastic program that takes into account all the possible yield scenarios.

2 Problem description

We consider a multi-period, capacitated disassembly lot-sizing for one type of products with a multi-level structures and random yields, as illustrated in Figure (1). The disassembly yields

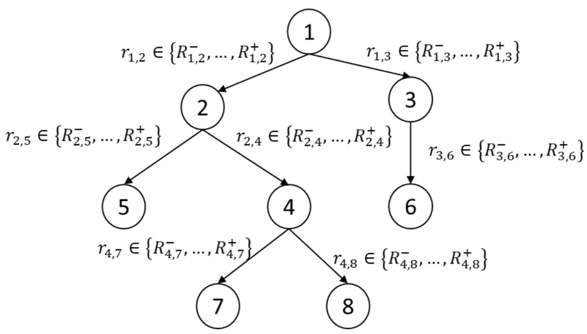

FIG. 1: Multi-level disassembly system

$r_{i,\phi(i)}$ of each discarded product or its sub-assemblies presents the quantity of item i obtained from disassembling one unit of its parent item $\phi(i)$. $r_{i,\phi(i)}$ is random and bounded over known intervals $\left[R^-_{\phi(i),i}, R^+_{\phi(i),i}\right]$ where $R^-_{\phi(i),i}$ and $R^+_{\phi(i),i}$ are respectively the minimum and maximum yields of item i from its parent $\phi(i)$. We assume that at least one component is obtained in good condition, i.e. $R^{-}_{\phi(i),i} = 1$, and that the availability of the products for disassembly is deterministic and constant. Since the disassembly yields are uncertain, backlog and storage are allowed to meet missed and future demands, and their initial values are considered null. The demands for components are known and dynamic, and the disassembly available time capacity and added time capacity are limited.

The disassembly lot-sizing problem of this work aims to find the optimal quantities of discarded products and their disassembly timing while minimizing the expected total cost composed by the inventory and backlogging costs as well as the set-up and added capacity costs.

3 Solution approach

We propose a two-stage chance-constrained program to formulate the capacitated disassembly lot-sizing problem under yield uncertainty. The first stage include the decision variables determined prior to observing the yield scenarios, which are the disassembly quantities, the binary indicator of setup for each item, and the added capacity time in each period. The second stage consists of the inventory and backlog levels for each component that are determined after the realization of the yield scenario. The joint chance constraints are used to ensure that the demands of the components are satisfied within all the planning horizon, while the backlog level is limited to a predetermined value ϵ. Since we consider all the possible scenarios for each component, we defined a scenario set for each component i.

The two-stage chance-constrained program is formulated as a two-stage chance constrained Mixed Integer Linear Program (MILP), and a scenario reduction approach is proposed to reduce the search space of the joint chance constraints. The MILP is solved by C++ and CPLEX solver and the computational experiments shows that the scenario reduction approach finds the solutions in less computational time.

4 Conclusion and perspectives

We considered a disassembly lot-sizing problem for multi-level disassembly systems under yield uncertainty. We formulated the problem as a two-stage joint chance-constrained MILP and proposed a scenario reduction approach to reduce the scenarios observed in the chance constraints. We found that as the disassembly levels and the complexity of product structures rise, the complexity of the problem increase, and that the proposed approach provides optimal solutions in less time than the original formulation for the small and medium instances and near-optimal solutions for large instances within the calculation time limit.

For future research works, we aim to take into account the uncertainty of the availability of products to be disassembled, since the quantities of the collected products are unknown in real industrial cases.

References

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