

Abstract

Building an exemplary green reputation has become essential for industries in all sectors. To this end, and with the aim of reducing production waste, resource consumption, and greenhouse gas emissions, manufacturers are turning to the adoption of the circular economy concept. Among the processes used in this context, we find remanufacturing, which extends the life cycle and use of products in three main steps : recovery and collection of used products, remanufacturing operations, and redistribution of remanufactured products.

In this thesis, we are interested in an application of the remanufacturing process as a preventive measure. We consider products in use by customers, over a finite horizon, and we proceed to the recovery of these products at predetermined times to refurbish them or improve their working condition, and then to redistribute them for further use. The overall objective is to develop economically and environmentally efficient remanufacturing strategies, integrating the different phases of remanufacturing and considering the characteristics of the product and the conditions of its use.

First, we consider two major decisions in the remanufacturing activity. The first one is related to the stock capacity and consists in selecting the products to be recovered and their number. Since each product is characterized by a grade, we are interested in the second decision to determine the level of remanufacturing and the grade to be reached for each recovered product.

Second, by extension of the first problem, we integrate the characteristics of the products and the profiles of the customers. We focus on the structure of the product composed of several functionalities and characterized by a performance determining its grade and depending on the quality of execution of the functionalities. We also consider the profile of the product user, based on the frequency of usage impacting the realization of the product functionalities and grade. Thus, a high frequency of usage gives a lower execution quality of the features. We develop the mathematical model to make the link between the performance of a product and the quality of execution of its features. We propose at this stage the multi-objective optimization of the recovery stage independently of the other remanufacturing action decisions.

Finally, we consider that a product is made of several components, each of which intervenes in a specific way in the execution of the functionalities offered by the product. Moreover, each component is characterized by a given performance. In this case, the customer profile, i.e., the frequency of use, impacts the performance of each component and thus the overall performance of the product. We develop the mathematical model that allows calculating the performance of a product according to the performance of its components and their relationship with its functionalities. In addition to decisions on product selection and remanufacturing levels, we integrate the optimization of the transportation and recovery stage of used products.

For each problem studied, a multi-objective mathematical model is developed, solved using metaheuristics and/or heuristics. In addition, multi-criteria decision analysis is performed to help the decision-maker to determine the best remanufacturing alternatives to implement. Several numerical experiments have been performed to illustrate the applicability of the different approaches proposed.

Keywords : Remanufacturing, recovery, optimization, heuristic, metaheuristic.