早稲田大学大学院情報生産システム研究科

博 士 論 文 概 要

論 文 題 目

Modeling and Optimization of Reverse Logistics for Reuse and Remanufacture

申 請 者
JeongEun LEE

情報生産システム工学専攻
システム制御研究

Reverse logistics (RL) is now the focus of attention in logistics field to realize resources recycling and low carbon society. The target of the reverse logistics is the flow from recovered end-of-life products to their reusable products. Increasing the environment regulation, the reverse logistics has been emphasized by the following reasons: the economic effect resulted from the cost reduction of raw materials in manufacturing process, the propensity to consume changed to environment-friendly products, and the business strategy tried to improve a corporate image.

However, the reverse logistics is different from the traditional forward logistics in which new materials or parts are produced and sold to customers. In the reverse logistics, it is not only hard to predict the appearing time or amount of arrivals by a period of use or conditions of recovered products, but also their recovery routes are complex as a large number of recovery centers. Moreover, even though the recovery products are environment-friendly, its market is not large yet because of the stereotype of customers who regard the recovery product as the used goods. Also, the reverse logistics costs more than the traditional forward logistics to construct and operate the system.

The reverse logistics can be divided into reusable recovery, remanufacturing recovery, and recycling recovery by conditions and processing operations of the recovered products until the reusable products. As the operations of the reverse logistics, the disassembling, cleaning, refilling, disposal, and recycling considering characteristics of the reusable recovery, the remanufacturing recovery, and the recycling recovery are required, and the reverse logistics models for calculating reverse logistics costs are also required for the reverse logistics problems.

The reverse logistics models for the remanufacturing recovery as well as the reusable recovery are built and their optimizing methods are proposed in this study.

1) Remanufacturing reverse logistics models considering transportation costs, and operation and holding costs
2) Remanufacturing reverse logistics models considering transportation costs and conditions of disassembled recovery product
3) Remanufacturing reverse logistics model considering transportation costs and inventory costs in a time period
4) Reusable reverse logistics model considering decision of order or next arrival of goods

This study focuses on following three points to build realistic models and solve the reverse logistics problems.

1) Building models considering various constraints such as processing

operations, routes, multi-products, time period, inventory, and order

2) Comparing the proposed genetic algorithm with the optimization software LINGO
3) Demonstrating the effectiveness of the proposed method through a case study

All of the above reverse logistics models are classified as NP-hard problems, therefore, such kind of problem is very difficult to solve by general and conventional approaches. This study deals with an effective evolutionary approach based on genetic algorithm for solving each RL problem.

In each chapter, the procedures of proposed approaches are described. For several models, the effectiveness is evaluated through the comparison of optimal solution with optimization software LINGO.

This dissertation consists of 6 chapters as follows.

In chapter 1, the background and its organization of this study, and the general view of the reverse logistics are introduced.

In chapter 2, the working mechanism of evolutional algorithms, which is used as the main solving method for this study, is explained.

In chapter 3, new three reverse logistics models in the remanufacturing recovery are built as follows:

1) Reverses logistics model of the remanufacturing recovery considering disassembling, cleaning, and refilling operations included in processing centers, and transportation costs from returning centers to the processing centers and a manufacturer.
2) Reverse logistics model of the remanufacturing recovery considering deliveries of the reusable parts to a recycling center and the unusable parts to a disposal center based on the disassembled conditions of recovered products.
3) Reverse logistics model considering the inventory costs at each processing operation for the recovered products at the returning center.

A modified priority-based genetic chromosome representation is proposed and the effectiveness of the proposed methods is verified by comparing with Prüfer number-based GA (pnGA) in numerical experiments. Also, the total costs of each model are improved by 5.78[%], 5.90[%], and 0.56[%] on average, respectively. The numerical experiments are performed to demonstrate the efficiency and effectiveness of a modified priority-based genetic algorithm (mpriGA) approach for solving the reverse logistics problems. Although the storage capacity of the priority-based genetic chromosome representation is required more than pnGA, this

representation has two important advantages. One is the ease with its implementation, and the other is always possible to obtain feasible solutions. Based on these models, the mpriGA with weight mapping crossover (WMX) is demonstrated to show the best performance according to solution quality.

In chapter 4, a new reverse logistics model of the reusable recovery is built considering the decision of order or next arrival of goods. An optimization method to minimize transportation costs and the volume of order or next arrival of goods occurred by Just-in-Time delivery of the final delivery stage from the manufacturer to processing centers is proposed. A modified priority-based genetic representation and a fuzzy logic controller, which improves search ability of GA by adjusting parameters appropriately in each generation and making situation by optimum solution search, are used as optimization methods of the reusable reverse logistics. Through the optimization algorithms using the modified priority-based genetic algorithm and a modified hybrid genetic algorithm (mhGA), sub-optimal delivery routes are determined. The improvement of total cost is verified by 2.41[%] on average by comparing with the mpriGA and the mhGA through the numerical experiments, and the result is almost same by 0.38[%] on average in comparison with LINGO.

In chapter 5, a model of the reusable reverse logistics for the empty bottles of a distilling and sales company in Busan in Korea is built as a case study. The recovery transportation cost can be reduced by 18.40[%] through the rearranging reverse logistics plans of the distilling and sales company, and the effectiveness of proposed method is verified.

In chapter 6, the conclusions of main results are given and some topics for future researches are described.

The main performances on the new three reverse logistics models and the case study using the evolutionary approach are summarized as follows:

1) The reverse logistics models that could be applied to the real-world problems are built with consideration of various constraints.
2) The proposed genetic algorithm is compared with the optimization software LINGO.
3) The effectiveness of the proposed method is confirmed by the case study.