Research on Modeling of Waste Electronic Products Logistics Recycling System

Yanjun LI
Weifang University of Science and Technology
Shouguang 262700, China

***Abstract*—This paper summarizes the characteristics of waste electronic products, and has carried on the classification to it. The paper firstly explains the concept of waste electronic products reverse logistics, and discuss on the necessity that our country carry out the waste electronic products reverse logistics. The article establishes a mixed integer programming model of waste electronic products reverse logistics network, and then taking recycling treatment capacity as a linear function of the investment cost. And use examples to validate the model.**

Keywords: Electronic waste; Products of reverse logistics; Network optimization design;

I. INTRODUCTION

At present, our country has achieved fruitful research results in many of the reverse logistics of waste electronic products, however, the majority of these studies are qualitative structural analysis or case study, and limited to the recycling network independently, there is no unified reverse recovery network with forward logistics and distribution network is very good, at the same time, also has not formed the perfect theory system. Recycling of waste electronic products using, and the common electronic products are distribution logistics is the difference, the author tries to from a different scheme, summed up the general method of waste electronic products logistics network structure design, the relationship between the processing capacity of waste electronic products and processing center and the capability and cost as the key consideration, make it has the universal significance.

II. THE DESIGN OF RECYCLING NETWORK MODEL FOR WASTE ELECTRONIC PRODUCTS

A. Establishment of recycling network model

The model for the waste electronic products have high recovery value. Designers of waste electrical and electronic product recycling network can be product supplier or manufacturer, also can be the waste electronic products processing enterprises to receive. And it doesn't consider the competition between the different waste electronic products recycling between enterprises. Flow of waste electronic products recycling is as shown in Figure 1. Recycling of waste electronic products in recycling station will be treatment and cyclic utilization by the re-treatment center through the transport. In view of the quality characteristics of waste electronic products, the processing center will be dismantling, the resource recycling and other procedures. As to deal with the problem for convenience, assumptions on this process of the classification of products is also completed by the reprocessing center. The classification of this process, the products are divided into: it can be directly reused and need to be treated before use.

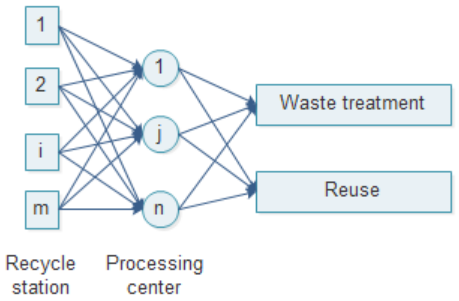

Fig.1 Recycling network structure of waste electronic products

The cost of waste electronic products recycling is as shown in Figure 2.

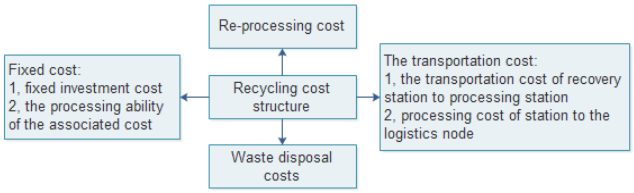

Fig.2 The cost structure of waste electronic products recycling

B. The establishment of products recycling model

Based on the above ideas, this paper established the corresponding mathematical model of waste electrical and electronic product recycling network design. Variable description:

m: The number of recovery station;

n: The number of reprocessing center that proposed to build.

i: recovery station i=1,2,…,m.

j: To be proposed re-processing center j=1,2,…,n;

α : The proportion of useful element in waste electronic products;

β : The proportion of useful stuff in waiting for waste electronic products after processing center sorting;

xj=1: Build NO.i re-processing center;

xj=0: Don't build NO.i re-processing center;

uij: the transport volume of waste electronic products from the first i recycling station to j treatment center;

b1: unit processing cost that waste electronic products will be treatment in re-processing center;

b2: Comprehensive cost that completely disposal useless wastes;

υ j1: The total logistics from the first j re-processing center to logistics node;

υ j 2: The total logistics of waste at the first j re-processing center;

cj: Unit transportation cost for useful goods from the i processing center to logistics node.

ui: The total number of first recycling stations in all grade mixed waste electronic products.

Fj: The total costs that build j processing center;

fj: The fixed costs that build j processing center.

θ : The parameters reflecting the reprocessing center between the non-fixed cost and treatment capacity;

h: Minimum processing ability of reprocessing center will be build;

aij: Freight units of waste electronic products from the I recycling station to j processing center;

M: A sufficiently large positive number;

According to the above variable definition, the relation was established:

$$\sum_{j=1}^{n} u_{ij} = u_i \quad , i = 1, 2...m \tag{1}$$

That is, all the consumption quantity of waste electronic products from the i recycling center be equal to overall logistics flow of the first I recycling center to each re-processing center.

$$v_{j1} = \sum_{i=1}^{m} u_{ij}\alpha + \sum_{i=1}^{m} u_{ij}(1-\alpha)\beta \quad j = 1, 2...n \tag{2}$$

That is, logistics gross from the j re-processing center transported to the logistics node be equal to the total of items total can be directly used from all the recycling station to transport j re-processing center and can be use items after treatment.

$$v_{j2} = \sum_{i=1}^{m} u_{ij}(1-\alpha)(1-\beta) \quad j = 1, 2...n \tag{3}$$

The total logistics of j waste disposal and treatment center be equal to the final waste sum can't use from all the recycling station to transport j re-treatment center

$$F_j = f_j + \theta \sum_{i=1}^{m} u_{ij}(1-\alpha)\beta, \quad j = 1, 2...n \tag{4}$$

The construction total cost of the first j reprocessing center is equal to the fixed costs and related costs and storage capacity, which should obtain the statistical data according to the cost and the processing ability of the specific facilities.

This paper presents the following mathematical model and ability to solve the location problem of waste electronic products recycling network facilities.

$$\min \sum_{j=1}^{n} F_j x_j + \sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij}u_{ij} + b_1 \sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij}u_{ij}(1-\alpha) + b_2 \sum_{j=1}^{n} v_{j2} + \sum_{j=1}^{n} c_j v_{j2} \tag{5}$$

The first item is the investment cost of building and processing center; second and third is an electronic waste transport costs and the third is to make electronic waste; to restore the handling charge value, the fifth is the waste harmless disposal costs ultimately unable to use electronic waste.

$$\sum_{j=1}^{n} u_{ij} = u_i \quad , i = 1, 2...m.....$$

$$v_{j1} = \sum_{i=1}^{m} u_{ij}\alpha + \sum_{i=1}^{m} u_{ij}(1-\alpha)\beta \quad , j = 1, 2...n \tag{6)-(8}$$

$$v_{j2} = \sum_{i=1}^{m} u_{ij}(1-\alpha)(1-\beta) \quad , j = 1, 2...n.....$$

In the constraint condition, equation (6-8) is the flow balance constraint recycling discarded electronic products in the network.

$$F_j = f_j + \theta \sum_{i=1}^{m} u_{ij}(1-\alpha), \quad j = 1, 2...n \tag{9}$$

Equation (9) gives a fully meet the construction case of reprocessing center investment cost of processing capacity in facilities.

$$\begin{aligned} & x_j \in \{0,1\}, \ j = 1, 2...n... \\ & u_{ij}, v_{j1}, v_{j2} \le M x_j, i = 1, 2...m, \ j = 1, 2...n \\ & h x_j \le \sum_{i=1}^{m} u_{ij}(1-\alpha), \ \ j = 1, 2...n \\ & u_{ij}, v_{j1}, v_{j2} \ge 0, \ i = 1, 2...m, j = 1, 2...n \end{aligned} \tag{10-13}$$

Type (10) is the location decision variables 0-1 constraints. Inequality (11) constrained assignment criterion constructed location strategy, namely the waste electronic products flow only in the plan to build reprocessing center allocation, in not be built and then processing center distribution of the flow is zero, inequality (12) says that all be built further processing center has the processing capacity must be greater than the minimum processing capacity constraints. Inequality (13) is non negative constraint.

III. SOLVING THE MODEL AND RESULT ANALYSIS

An electronic product company have 6 sale points, the company plans to build the waste electronic products recycling network of waste electronic products recycling. Considering the use of existing resources, 6 points of sale of the company responsible for the recovery of the electronic product, so long as the investment to build reprocessing center can. After market research, the company build reprocessing center at the X1, X2, X3, X4.

The parameter settings are as follows:

$m = 6, n = 4$

$u_i = 400, 500, 350, 400, 500, 600$

$\alpha = 0.2$

$f_i = 350000, 300000, 380000, 40$

$\beta = 0.7$

$b_1 = 60$

$b_2 = 18$

$c_i = 6, 6, 7, 8$

$M = 30000000$

$\theta = 180$

$h = 580$

Freight cost from the i recycle bin to j processing center

$$a_{ij} = \begin{pmatrix} 11 & 14 & 6 & 8 \\ 7 & 13 & 12 & 13 \\ 6 & 8 & 11 & 9 \\ 10 & 6 & 8 & 9 \\ 11 & 12 & 6 & 9 \\ 7 & 8 & 9 & 10 \end{pmatrix}$$

Using LINGO to solve. Results of the operation procedure to get an optimal x (1, 2,3, 4) = (0,1,0,0), that can be re-processing center on the second alternative, all back for recycling waste electronic products are shipped to the re processing center for centralized process again, after re treatment or reuse or for waste disposal. Total operation cost of the waste electrical and electronic product recycling network is 852420 yuan, the final result is shown in figure 3:

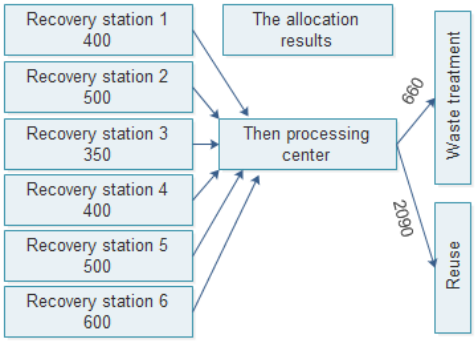

Fig.3 Assignment results

IV. CONCLUSIONS

In recent years, the number of waste electronic products increase day by day, it is a resource recycling, there is also a waste endangers the social environment, has obvious dualism, and processing difficulty. Waste electronic products reverse logistics is carried out the collection, classification, storage, transport of waste electronic products, and buried objects entity flow. Implementation of waste electronic products reverse logistics can not only reduce the pollution of the environment and save resources, but also it has positive significance for the sustainable development of enterprises and national trade, promote the development of circular economy.

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