Simulation and Optimal Design of Refuse Collection System of Home Community Based on Witness Software

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Abstract: With the acceleration of urbanization in China, it has become increasingly important to deal with the refuse collection and classification in the home community. How to process city refuse effectively and realize the recycling of resource has escalated from environmental problem to social problem, therefore, the construction of city refuse recycling logistics has become a matter of social economic and social benefit concern. The paper starts from constitution and construction of city refuse collection logistics network, and works out a practical simulation model for refuse collection and recycling logistics by classification of waste from five refuse collection sections in one residential community. The computer model is constructed and simulated by application of Witness Software; after simulation clock running for a period of time, the system is then optimized based on the results of simulation.

Keywords: Recycling logistics; Witness; Simulation and optimization

1. Introduction

There are five fixed refuse collection sections in one residential community, with one recyclable and one unrecyclable garbage can available in each section. The refuse disposal company will transport the waste from refuse collection sections through transfer station to refuse disposal center by garbage trucks.

The simulation model of refuse transportation is constructed by means of Witness Software to seek the strategy of lowest total logistics cost for refuse disposal company, after meeting the requirements of time and load limit. The information involved in the system covers the number of trucks, load capacity, the staff number in the truck, customer satisfaction, number of residents in the refuse collection sections, daily refuse quantity per capita, etc.

Information such as number of residents in the refuse collection sections, distance between refuse collection section and the transportation vehicles, distance between refuse collection section and transfer station is shown in Table 1.

Table 1. The distance between refuse collection section and transfer station

Refuse collection section name	Collect sections residents/Thousand people	Distance between refuse collection section and transfer station	The shortest distance between the stations and the transport stations
Dump001	1.36	11	22
Dump002	1.75	17	31
Dump003	1.48	24	29
Dump004	1.90	28	27
Dump005	1.77	23	28

The fixed cost refers to purchasing expense of the vehicles. The variable cost includes the travel expense and maintenance cost. The wage of employees means the expense of staff in the truck. The running speed includes running speed of empty trucks and loaded trucks. The collection time refers to time period of refuse collection and the unloading time refers to time period of unloading waste from transfer station. The refuse quantity per capita indicates refuse quantity of each resident every day. The waste percentage is the percentage of each component in the waste.

In the model, daily refuse quantity per capita is supposed to accord to Erlang distribution -1.2kg/day. The waste will be classified in to recyclable and un-reusable waste which needs to be disposed, with the ratio of 1:5. The refuse recycling of one month will be simulated and tonnage and working staff for the vehicles of two models dispatched so as to reduce the TLC (Total Logistics Cost) which covers the fixed cost, variable cost, cost of service time and cost of staff to the greatest extent.

2. Logical Structure of System

There are five sub-modules of logical structure of refuse recycling logistics system, including waste generation module, truck dispatching module, collection module, end-of-work module and data processing module.

3. Design of Simulation Model

According to the logical structure and data information, a refuse recycling logistics simulation system model including five refuse collection sections and a transfer station is constructed by means of Witness Software.

3.1. Defining Elements and Visualized Design

In construction of simulation model, the elements involved will be first defined and design visualized. Moreover, real type function Objfun() will be defined in the model as well for computing and counting the total cost of system after one year. The layout of entity elements in the model will be presented in Figure 1.

Figure 1. The visual interface of the waste recycling logistics simulation system

3.2. Detailed Design of Each Element

The shift working system adopted will be 8 hours per day and the simulation clock runs in minutes. The logical relation of loaded waste will be defined in the model and the details of elements in the system will be designed.

(1) Detailed Design of Refuse in Each Community

In which, Meandump refers to refuse quantity generated in each community per day, calculated from the number of residents in each community.

The detailed design of Dumpa1 will be shown in Figure 2.

The details of the garbage bin are shown in Figure 3:

3.3 Model Execution and Data Analysis

The simulation model will be executed according to the two configurations in Table 2, with the simulation time lasting for one month (i.e. 30x480min, assuming there are 30 days in one month and eight hours in a day for the convenience of calculation), with the rest elements and numbers exactly the same in the two schemes.

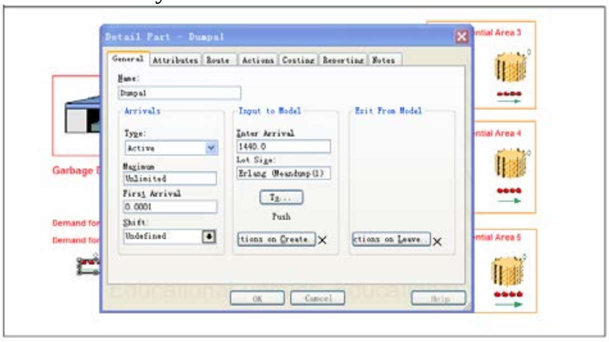

Figure 2. Dumpa1 detail design

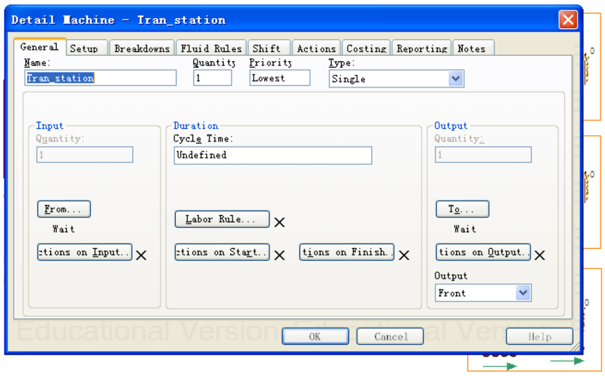

Figure 3. Detail design of the garbage box

Table 2. Different data tables for two configurations

	Vehicle name	Load/t	Personnel number with car	Time penalty factor
Plan one	Dumpcart(1)	2.5	1	2
	Dumpcart(2)	1.8	1	2
Plan two	Dumpcart(1)	4.5	2	2
	Dumpcart(2)	2.8	2	2

After 14400min operation of the simulation model, the results of scheme 1 will be presented in Table 3 and scheme 2 shown in Table 4. The total cost in Table 3 and Table 4 is the sum of variable cost, fixed cost and wages for staff. Time cost measures the satisfaction of residents for efficiency of refuse disposal, which is excluded from the total cost.

Table 3. Plan one statistical data

Plan one	Running distance /km	Running time /h	Time cost	Collection time/h	Unload time/h	Variable cost	Fixed cost	Staff wages	Total cost
Dumpcart(1)	15231	65426	14. 6	34517	25326	58.5	6	3.4	67.9
Dumpcart(2)	16372	67351	-12.7	45312	14246	29.6	4.6	3.4	37.6
Two vehicle data	31603	132777	1.9	79829	39572	88.1	10.6	6.8	105.5

Table 4. Plan two statistical data

Plan two	Running distance /km	Running time /h	Time cost	Collection time/h	Unload time/h	Variable cost	Fixed cost	Staff wages	Total cost
Dumpcart(1)	131615	34554	-1526	21326	47532	58.3	8	5.6	71.9
Dumpcart(2)	14268	37846	-1642	18742	5246	39.8	6	5.6	51.4
Two vehicle data	145883	72400	-3168	40068	52778	98.1	14	11.2	123.3

For comparison, histogram will be graphed out of variable cost, fixed cost, wages of employees and total cost, etc. in Table 3 and Table 4, as is shown in Figure 4.

As is seen from Figure 4, in scheme 2, with the increase of tonnage and loading staff, variable cost, fixed cost, wages of staff and total cost will be greater than those in scheme 1. However, the recycling speed will be faster than that of scheme 1, thus it will win more satisfaction of residents in the community. It is revealed from the time cost in table 3 and table 4, the time cost in scheme 1 reaches as much as 19,000 RMB, while time cost in scheme 2 is -31,680,000 RMB, meaning good residents' evaluation and brand effect of refuse disposal company; on the contrary, if time cost is above zero, meaning slow refuse collection speed, i.e. the staff will usually pick up the refuse after twelve o'clock.

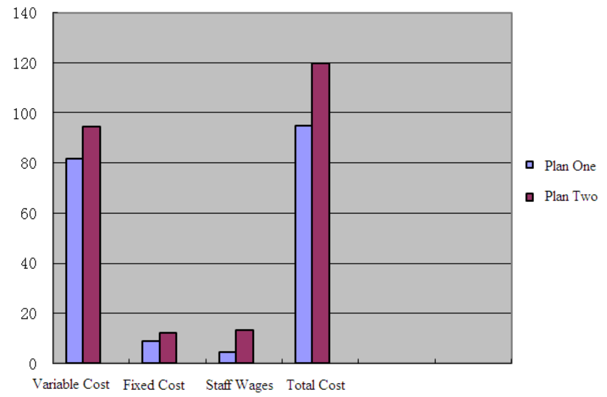

Figure 4. Comparison Chart on two kinds of plans

Histogram will be graphed out of travel distance, time of travel, collection time and unloading time, etc. in table 3 and table 4.

As is seen from Figure 5, though cost of scheme 2 is obviously higher than that of scheme 1, travel distance, time of travel, collection time and unloading time are all lower than those in scheme 1. It is just because short travel distance, time of travel, collection time and unloading time that results in much lower time cost of scheme 2 compare with scheme 1. However, as for the total cost, the total cost of scheme 2 is greater than that of scheme 1. Consequently, the decision makers have to weigh and regard both the total cost and time cost to decide which scheme to adopt.

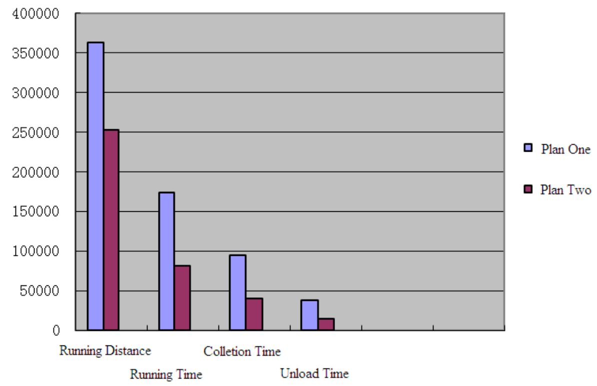

Figure 5. Comparison Chart on distance and time

4. Acknowledgement

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