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Optimal Model of the Multi-Item Transportation With Different Trucks

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----------ABSTRACT----------
Aimed at the low efficiency of the road transportation, the optimal model with the maximization of the loading capacity rate and the volume capacity rate was established, which is based on the characteristic of the muti-item transportation.

KEY WORDS: loading of goods; muti-item; transportation; optimization.

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1. INTRODUCTION

Almost all of the city logistics transportation is completed on the road. This is because, compared with the railway transportation, road transportation can provide more convenient, lower cost and higher levels of distribution service. However, in comparison with other modes of transportation, the road transportation existed a lot of problems such as low loading rate, high cost and so on.In the distribution center, how to make full use of the trucks' loading weight and capacity under the premise of meeting a variety of loading limitations, can bring great benefits for the enterprise and society. It has a double meaning. From the company's perspective, correct and reasonable arrangements for cargo loading can improve the loading capacity rate, reduce the empty-loaded rate, reduce the damage to the goods, reduce the transportation costs, improve the quality of customer service and economic benefits of the company, finally achieving the scientific management. From the social's perspective, reasonable loading can improve the utilization rate of trucks, reduce the road occupancy, short the time of transportation. Then the goods will be timely to the customer. Our society will become more and more harmonious.Due to the complexity of its theory and the wide application in real life, the loading problem has attracted a lot of Chinese and foreign scholars to participate and have obtained a more effective progress. For details about loading problem see the paper of Dowland and other scholars [1-4]. These studies have different considerations on weight, volume, center of gravity and other constraints, but did not consider the problem of some goods can not be mixed.According to the number of trucks which will be loaded, the loading problem can be divided into single-truck loading and multi-truck loading. The problem considered in this paper is the multi-truck loading with different models of truck.

Given a different kinds and different sizes batch of goods which are to be loaded, the optimal model is set up aimed at the minimum number of trucks. With the volume constraint, weight constraint, some of the goods can not be mixed taken into consideration, and the value of the goods themselves are not taken into account, this model can tell us the suitable number of trucks as well as the quantity and the type of goods loaded on every truck.

1 Assumptions

(1) All the goods arrive at the same destination;
(2) Any goods can be placed in any type of truck;
(3) The extrusion deformation of goods can be ignored;
(4) The volume or weight of any good can not exceed the maximum loading capacity of any truck;
(5) The total volume or weight of goods which are loaded on the same truck can not be more than the maximum loading capacity of this truck;
(6) Some goods can not be mixed, such as food and chemical products. Then we need to consider the quarantine restrictions;
Dividing the goods into heavy and light based on their weight. When packing, the heavy goods can be calculated by 80% of the truck loading weight. The light goods can be calculated by 50% of the truck loading weight or 80% of the truck volume, the calculation method in this paper is 50% of the truck loading weight[5].
(8) Tthe same kind of good is best loaded on the same truck.

II. MODELING AND ANALYSIS

2.1 Symbols assumption

n : Total number of the goods to be loaded

m_i : Quality of the good i, $i = 1,2,\cdots,n$

v_i : Volume of the good i, $i = 1,2,\cdots,n$;

r_{pi} : Whether good p and good i are mixed or not.

$r_{pi} = 1$ means good p and good i can be mixed, otherwise $r_{pi} = 0$. $p, i = 1,2,\cdots,n$

m : Total number of the trucks can be loaded

G_j : Maximum load of truck j, $j = 1,2,\cdots,m$

V_j : Volume of truck j, $j = 1,2,\cdots,m$

x_{ij} : Decision variable.

$x_{ij} = 1$ means good i is loaded into truck j, otherwise x_{ij} =0. $i = 1,2,\cdots,n$, $j = 1,2,\cdots,m$

Y_j : Depending on the state of x_{ij}.

If $\sum_{i=1}^{n} x_{ij} > 0$, then $Y_j = 1$, it means the truck j has been used, otherwise $Y_j = 0$ [5].

α : Truck loading capacity utilization rate, 80% for heavy goods and 50% for light goods.

2.2 Modeling

Based on the above assumptions, mathematical model is set up as follows.

The optimization objective is to minimize the number of trucks, so the objective function can be expressed as:

$$\min \sum_{j=1}^{m} Y_j$$

The model should satisfy the following conditions:

(1) Every good must be loaded on one of the trucks.

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

(2) The weight of the goods loaded on the same truck can not exceed the maximum loading capacity of this truck.

$$\sum_{i=1}^{n} m_i x_{ij} \le \alpha G_j, \; j = 1,2,\cdots,m .$$

(3) The volume of the goods loaded on the same truck can not exceed the volume of this truck.

$$\sum_{i=1}^{n} v_i x_{ij} \le V_j, \; j = 1,2,\cdots,m .$$

(4) $x_{ij} = 1$ means good i is loaded into truck j, otherwise x_{ij} =0.

$$x_{ij} = 0 \text{ 或} 1, i = 1,2,\cdots,n, \quad j = 1,2,\cdots,m .$$

(5) The loading scheme should satisfy the separation limited of different goods.

$$x_{ik} x_{jk} (1 - r_{ij}) = 0, k = 1,2,\cdots,m; \quad i, j = 1,2,\cdots,n .$$

(6) The value of Y_j depends on the state of x_{ij}.

If $\sum_{i=1}^{n} x_{ij} > 0$, then $Y_j = 1$, otherwise $Y_j = 0$.

III. LOADING OPTIMIZATION AND SIMULATION EXAMPLE

Suppose there is a batch of goods. The weight of goods and the type of trucks are described in the following table. In the case of some kinds of goods cannot be mixed, the requirement is to

minimize the number of selected trucks and to make full use of the loading capacity of the truck.

Table 1 The weight of goods

Types		Total weight (t)	Remarks
Heavy goods	1	3260.0	The heavy goods and the light goods can not be mixed.
	2	42.0	
	3	170.0	
Light goods	4	178.0	
	5	87.5	
	6	7.8	

Table 2 The type of trucks can be used for loading

Types	Long * wide * high (mm)	Loading capacity (kg)
1	8830*2100*2480	5990
2	10155*2490*2870	17800
3	1968*2438*1219	3000

Table 3 The optimization results

Types	1	2	3
Number	25	146	8

IV. CONCLUSION

This paper studies the complex constraints of truck loading optimization problem. Considering the practical constraints, such as truck loading capacity, volume constraint, goods separation constraint and loading utilization, the optimization model was set up, and its feasibility has been proved by an example. It can be directly used in practical application.

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