Research on Optimization Method of Originating Direct Transportation Organization

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Abstract. Organizing nonstop train is one of the effective ways to organize traffic flow. This article introduces the conditions, principles and schemes of the nonstop transport organization. On this basis, this paper establishes a mathematical model with the goal of minimizing the total consumption of traffic in the loading and unloading areas and during operation. This model is constrained by the uniqueness of the plan and the restriction of direct traffic flow. This paper constructs an example to test the actual application of the model, verify its effectiveness, and explain the advantages of organizing nonstop train.

Keywords: Nonstop from departure, organization scheme, mathematical model.

1. Introduction
Nonstop train is organized at one or more points of the loading station, using self-loading wagons to directly marshal the nonstop train(David R.Martinelli and Hualiang Teng,1996). Organizing nonstop train can bring various benefits to the railway industry, such as easing the tension of the capacity of marshalling stations along the way, saving on vehicle hours during operation, and then obtaining corresponding economic benefits. Therefore, it is of great significance to reasonably and efficiently organize nonstop transport.

2. Model

2.1. Optimization Model
This chapter establishes a mathematical model with the goal of minimizing the total consumption of traffic in the loading and unloading areas.

The mathematical model mainly involves two variables. That is

\[ x_{ab} = \begin{cases} 1, & \text{Direct traffic to the unloading station} \\ 0, & \text{Other situations} \end{cases} \] (1)
The first adaptation station of traffic flow is $m$

\[
x_{ab}^m = \begin{cases} 1, & \text{Other situations} \\ 0, & \text{The first adaptation station of traffic flow is m} \end{cases}
\]

(2)

The plan for organizing nonstop train is unique. That is

Direct traffic needs to be within the allowable range. That is

\[
f_{ab} q \left( \sum_{b \in Q(a)} x_{ab}^m \right) - \sum_{b \in Q(a)} m_{ab} x_{ab}^m \leq 0
\]

(4)

There are four symbols to explain. If $f_{ab} \geq f_{ab}$, then $q_{ab} = 1$. $f_{ab}$ is the sum of the permitted loading and unloading of the traffic flow, $\rho(a,b)$ is total number of technical stations passing by. $Q(a)$ is the collection of the unloading station where the loading station goes.

2.2. Program

According to the characteristics of the loading traffic (the size of each loading destination), the form of organization can be divided as shown in Figure 1.

![Figure 1. The form of organization.](image)

Different traffic flow organization schemes are different in terms of transportation expenditure. Based on the situation of each loading destination and the flow of traffic, a more targeted traffic flow organization scheme is selected to form a certain-scale road network's starting nonstop train operation scheme (Lin Bailiang, Zhu Songnian, Shi Deyao, He Shiwei, 1995).

Nonstop train can be divided into the following categories (Fan Zhenping, Lin Bailiang, Niu Huixiang, 2007).

(1) Starting line

A train consisting of freight cars loaded in a station and passing through one or more marshalling stations without reorganization operation.

(2) Step in line

The train is composed of freight cars loaded at several stations in the same or two adjacent dispatching sections and passing through one or more marshalling stations without reorganization operation.
(3) In line with the base
The train is composed of freight cars loaded at one or more stations of the loading base and does not carry out reorganization operation through one or more marshalling stations.

(4) Technology in line
The train marshalling at the technical station and passing through one or more marshalling stations without reorganization operation.

2.2.1. Principle. The organization of nonstop transport needs to meet the following three principles:

(1) First organize direct trains with specific requirements, such as heavy-duty trains, five scheduled trains;

(2) First organize direct trains arriving at the same station or the same dedicated line, and then organize direct trains arriving at several stations in the same section or hub;

(3) Under certain conditions, the method of direct access to the base or joint departure area is used to collect scattered traffic to organize direct trains (Yuan Minhong, Zhang Chao, 2007).

2.2.2. Condition. Organizing nonstop train at the loading site, the delivery unit or unloading station must have a certain amount of freight and direct train traffic (Masoud Yaghini, Mohsen Momeni, Mohammadreza Sarmadi, 2012).

The storage capacity and unloading capacity of the receiving unit or the unloading station can ensure the requirements of the entire train or batches.

The supply of vehicles must be guaranteed. It must be in line with the current train marshalling plan at technical stations.

For direct trains that need to change the weight standard during the journey, there should be equipment conditions at the variable station to facilitate the technical operation of the trailers (Teodor Gabriel Crainic, Jacques A Ferland, Jean Marc Rousseau, 1984).

Meeting the above conditions, the organization of nonstop train can effectively avoid problems such as difficulties in loading and unloading vehicles, prolonged truck stays, and increased storage costs for enterprises.

2.2.3. Function. The goal is to set the minimum total vehicle hours. The objective function expression is

$$\min Z_{ab} = \sum_{i=1}^{3} z_i$$

The first part of the above expression is traffic consumption of traffic flow during operation. $N_{ab}$ is the traffic from loading station to unloading station. $V(m, b)$ is the collection of technical stations on the way. That is

$$z_1 = N_{ab} \sum_{m \in R(a, b)} \sum_{w \in V(m, b)} b_w x_{ab}^m \\ \ (6)$$

The second part of the above expression is the consumption of vehicle flow at loading and unloading stations. This section can be divided into two cases $z_2$ means the first case. Traffic goes directly to the unloading station $z_3$ means the second case. Traffic flow to technical station ahead for technical traffic or nonstop train. $c_{ab}$ represent the consumption of each vehicle in the loading area and the unloading area under the corresponding type.

$$z_2 = N_{ab} c_{ab} x_{ab}^m \\ \ (7)$$

$$z_3 = N_{ab} (c_{ab}^r + c_{ab}^w) x_{ab}^m \\ \ (8)$$
3. Model

The above model can be given by a simple example. Road network form and traffic flow structure are shown in Figure 2.

According to the figure above, the model is established as follows.

\[
\begin{align*}
\min N_4 \left( (c_4 + \sum_{i \in F(1,4)} t_i)x_4^1 + (c'_4 + \sum_{i \in F(2,4)} t_i)x_4^2 + c'_4x_4 \right) \\
+ N_5 \left( (c_5 + \sum_{i \in F(1,5)} t_i)x_5^1 + (c'_5 + \sum_{i \in F(2,5)} t_i)x_5^2 + c'_5x_5 \right) \\
+ N_6 \left( (c_6 + \sum_{i \in F(1,6)} t_i)x_6^1 + \sum_{k=2}^3 (c'_6 + \sum_{i \in F(k,6)} t_i)x_6^k + c'_6x_6 \right)
\end{align*}
\]

\[
\begin{align*}
I_4x_4 + x_4^1 + x_4^2 &= 1 \\
I_5x_5 + x_5^1 + x_5^2 &= 1 \\
I_6x_6 + x_6^1 + x_6^2 + x_6^3 &= 1 \\
\begin{align*}
&\text{s.t.} \\
&\sum_{i \in F} I_4(x_4^1 + x_4^2 + x_4^3) - f_4x_4^1 - f_5x_5^2 - f_6x_6^2 \leq 0 \\
&\sum_{i \in F} I_5x_5^1 - f_5x_6^3 \leq 0 \\
&\forall x_i = 0 \text{ or } 1 \\
&\forall x_i^k = 0 \text{ or } 1
\end{align*}
\]

4. Conclusion

In this paper, a mathematical model is constructed for the nonstop transport organization, and a numerical example is analyzed. The main contents and conclusions are as follows:

This article analyzes the three types of total vehicle hour consumption at the loading and unloading stations and calculates the adapted consumption that may be generated during the operation of the
vehicle flow. The goal is to set the minimum total vehicle hours for the two most of the above Mathematical model, so the organization plan of the nonstop train is obtained. Through the analysis of examples, the actual application of the model is specifically expressed. The model is accurate and convenient in specific applications, and it is worth continuing to improve and popularize.

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