Effective organization of acceleration of local train movement at railway transport departments

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Abstract. In the mentioned article, an analysis was conducted on the delay in providing services to local wagons due to the distance of up to 200 km between the sections located in the “UTY” joint-stock company. In this regard, works to improve the schedule of local trains have been carried out by extending the distance between two technical stations to 600-800 km. As a result of analyzing the options for transporting local wagons to technical stations in this article, movement schemes for local trains have been developed. The proposed schemes specify the movement of local trains from the initial station to the final station within the sections, as well as determining the movement from the initial station to halfway through the section. Through these schemes, operations carried out at intermediate and freight stations between two section stations in a mathematical manner have been investigated. These operations include operations such as coupling, uncoupling, and providing technical and cargo services to the wagons within the movement composition. In providing services to local trains on the section, two options were analyzed to obtain results: with the help of the second scheme we developed, during the movement of each train within the section, a possibility of saving 16 minutes of time was created.

1 Introduction

Currently, in the case of delivery of goods in local transportation in railway transport, the delivery period is determined based on the norms in force at the specified destination after receiving the goods.

The term of delivery of goods in local transportation is determined based on the rules of freight transportation and is defined as follows in accordance with Chapter 26 of the Rules of Freight Transportation in Railway Transport of the Republic of Uzbekistan [1-2]:

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Currently, due to deficiencies in the timely delivery of goods at the Joint Stock Company “O’zbekistan temir yo’llari”, lawsuits are received by customers using railway services.

Due to the agreements made by the railway employees at the locations with the customers and the customers having to work with the railway in the future, no claims were filed by them [3, 4].

This paper proposes an efficient method to reduce the travel times of local trains running between two technical stations. In the article, the operations performed by local trains from one section station to the next section station are analyzed, and a mathematical model for normalizing the movement time of local trains is developed.

2 Research methods and tools

It is known that local trains are mainly served at intermediate stations.

Local trains are designed to collect and distribute wagons from intermediate and freight stations (Fig. 1). Local trains are formed at technical stations. During movement along the section, this train collects unloaded and loaded wagons at intermediate stations and replaces them with wagons intended for loading and unloading operations at these stations [5].

![Fig. 1. Traffic sections of freight trains.](image)

The following operations are performed with wagons brought to intermediate stations on a local train: separation from the train, transfer to the freight front for loading and unloading, transfer from one loading-unloading place to another, assembly of loaded-unloaded wagons and connecting to the train [3, 6-8].

We can conditionally define local trains running in pair and odd directions according to the usual running graph by the following elements:

- \( m \) – a local train running in a pair directions;
- \( n \) – a local train moving in an odd direction;

\[ n \approx m \]

The times spent on local train operations at the site include:

- \( t_{\text{move}} \) - the time spent on moving the train;
- \( t_{\text{stop}} \) - the time spent stopping the train;
t_{coupling} - the time spent on coupling wagons to the locomotive;

t_{uncoupling} - the time spent on uncoupling wagons from the locomotive;

\( t_{checking br.} \) - the time spent on checking the automatic brakes;

\( t_{travel} \) - the average time spent on traveling through the section on local trains according to odd and pair directions on the route.

When local trains operate on a specific section, the time spent on performing the mentioned operations at the intermediate stations in the section is determined as follows: [4, 9-14]:

\[
t^n = t_{coupling} + t_{checking br.} + t_{move} + t_{travel} + t_{stop} + t_{uncoupling}
\]

\[
t^m = t_{coupling} + t_{checking br.} + t_{move} + t_{travel} + t_{stop} + t_{uncoupling}
\]

bunda: \( t^n \approx t^m \)

We determine the movement times of local trains according to odd and even directions, the overall time of movement on the route for local trains in these directions, and the total time for operations to be carried out at intermediate stations. For example, the time spent on stopping the train, the time spent on coupling wagons to the locomotive, the time spent on uncoupling wagons from the locomotive, the time spent on checking the automatic brakes, and the time spent on attaching the necessary wagons or connecting empty or loaded wagons when a local train is stopped. The local train departs from technical station A, travels to technical station B, performs freight operations, and then returns to technical station A [5, 15].

Currently, the schedule of local trains in “O’zbekiston temir yo’llari” Joint Stock Company is presented in Fig. 2.

\[\text{Fig. 2. Current schedule of local trains. A-B technical stations.}\]

The total sum of local train movements according to odd and pair directions in determining the schedules for the movement of local trains in terms of both directions is determined as follows:
Here, $\sum_{k=1}^{n} t^p$ represents the total sum of local train movement times for pair directions;

$\sum_{k=1}^{m} t^o$ - the total sum of local train movement times for odd directions;

t\_cargo - the time spent on cargo operations at the station.

$$C^1 = \sum_{k=1}^{n} t^p + t\_yuk + \sum_{k=1}^{m} t^o$$

$C^1$ - the total sum of the local train movement times in the next technical station for trains on pair directions returning on odd directions.

The movement schedule of the proposed local trains is represented in the following graph (see Fig. 3).

We express the travel times on the section separately:

In accordance with the proposed movement schedule for local trains, it is necessary for trains moving on odd directions to switch to pair directions at a specified intermediate station, located halfway along the section (at a designated intermediate station) when
and move as double trains on pair directions. Additionally, the local train departing from the pair direction returns to the designated intermediate station [10,12,13].

In this case, when the train is moving towards the designated intermediate station, it detaches wagons at intermediate stations (whether empty or loaded) until it reaches the designated station. Similarly, when returning from the designated intermediate station, it collects the wagons left at intermediate stations and proceeds to the technical station.

3 Result

We primarily calculate the total time of local train movements based on the proposed method of operation. Below (Formula 4), when the local train departs from the A station, meaning it unloads wagons along the odd direction to the designated station, a method has been proposed to determine the total time for distribution and collecting wagons on the pair direction:

\[
t_1^{O} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}}
\]

\[
t_2^{O} = t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}}
\]

\[
t_{-}^{O} = t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}}
\]

\[
t_n^{O} = t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}}
\]

\[
t_{\text{cargo}}^2
\]

\[
t_m^{p} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}}
\]

\[
t_{-}^{p} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}}
\]

\[
t_{m-1}^{p} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}}
\]

\[
t_m^{p} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}}
\]

\[
K^{O} = t_1^{O} + t_2^{O} + t_{-}^{O} + t_n^{O} + t_{\text{cargo}}^2 + t_m^{p} + t_{-}^{p} + t_{m-1}^{p} + t_m^{p}
\]

Similarly, in Formula 6, when the local train B departs from the station in the opposite direction, it unloads wagons on the pair direction to the designated station and, on the odd direction, the proposed method determines the total time for distribution and collecting wagons.
\[ t_{1}^{p} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}} \]
\[ t_{2}^{p} = t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}} \]
\[ t_{\text{m}}^{p} = t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}} \]
\[ t_{\frac{m}{2}}^{p} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} \]
\[ t_{\text{cargo}} \]

\[ t_{\text{coupling}}^{O} \]
\[ t_{\frac{n+1}{2}}^{O} = t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} + t_{\text{uncoupling}} \]
\[ t_{\text{travel}}^{O} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} \]
\[ t_{\text{cargo}}^{O} \]
\[ t_{\frac{n-1}{2}}^{O} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} \]
\[ t_{n}^{O} = t_{\text{coupling}} + t_{\text{move}} + t_{\text{travel}} + t_{\text{stop}} \]

\[ K^{p} = t_{1}^{p} + t_{2}^{p} + t_{\frac{m}{2}}^{p} + t_{\frac{m}{2}-1}^{p} + t_{\text{cargo}} + t_{\frac{n+1}{2}}^{O} + t_{\frac{n-1}{2}}^{O} + t_{n}^{O} \]

\[ C^{2} = K^{O} + K^{p} \]

\( C^{2} \) - represents the total time spent when local trains are in motion on both pair and odd directions.

In this context, the time spent on uncoupling the wagons until the local train reaches the designated station in the direction of the train’s movement from the A technical station, denoted as \( t_{\text{uncoupling}} \); the time spent on moving the train, denoted as \( t_{\text{move}} \), the time for stopping the train, denoted as \( t_{\text{stop}} \), and the time for traveling on the main track, denoted as \( t_{\text{travel}} \), are taken into account. However, the coupling time \( t_{\text{coupling}} \) is not considered in this scenario. After the local train has completed loading and unloading operations at the designated intermediate station, it proceeds in the direction of the A technical station. Similarly, upon the return of the local train from the designated station, it collects the empty and loaded wagons left at the intermediate station. When the local train returns from the designated intermediate station, the coupling time \( t_{\text{coupling}} \), moving time \( t_{\text{move}} \), stopping time \( t_{\text{stop}} \), and travel time on the main track \( t_{\text{travel}} \) are calculated, while the uncoupling time \( t_{\text{uncoupling}} \) is not taken into account. Similarly, the local train departing from the B technical station travels to the designated intermediate station and returns back.

In this case, we efficiently utilize the coupling time during the movement of local trains to the designated station. Upon return, we similarly make effective use of the uncoupling time., meaning \( \min C^{2} < \min C^{1} \).
From the Fig. 4, it can be observed that, in the existing method as opposed to the proposed one, during the movement of local trains, the coupling and uncoupling of wagons at each intermediate station, i.e., the efficiency of maneuvering operations at the intermediate station, is not effectively utilized, leading to inefficient use of maneuvering resources.

4 Conclusion

In the proposed method, two train locomotives move in opposite directions along the section. Because in this case, the train travels to the designated station, unloads the wagons at intermediate stations on its way, and upon return, it collects the wagons from the stations. From this, it can be observed that the arrival of wagons at the intermediate stations along the odd and pair directions accelerates.

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