Investigation of the Influence of Forming Routes from Empty Cars on the Processing Capacity of Codriving Slides

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Abstract. The article discusses issues related to the formation of empty cars according to the type of rolling stock and by owners, their possible assembly points, an analysis of the formation plan from empty cars is carried out in order to select a station for the concentration of empty cars according to the type of rolling stock and the routes of their access to them. The analysis of groups of wagons that can be organized into exit routes is carried out. The criteria of the set optimization task for the moving of empty cars and improvement of the quality indicators of operational work for JSC Russian Railways have been substantiated. The dependence of the destination capacity on the number of destinations formed by trains at the Khabarovsk II station has been determined.

The scientific challenge to be solved by the project: the irrational use of the car fleet and the estimated capacity of the gravity humps.

1. Introduction
Suggested methods and approaches: development of technology for the formation of sending empty routes on non-public routes.

In order to speed up the delivery of goods, reduce transport and operating costs, the carriage of goods can be carried out by means of exit routes and provided for in contracts for the organization of carriage of goods on railway [1].

2. Relevance
The coal-mining industry at the current stage of development of innovations and nanotechnology continues to be one of the most important sectors of the world economy. This is due to the fact that the use of coal in some cases is more economically feasible than the use of oil or natural gas, and modern technologies make it possible to change the attitude towards coal as an environmentally “dirty” fuel. World coal consumption has been growing at a slow pace since the 1980s, and there are all factors for this trend to continue. In addition to Japan and the United States, growth in coal consumption has been observed in developing countries in Asia. In these countries, industrial development can be expected, accompanied by the construction of a variety of infrastructure, which should increase the needs of these countries for more efficient energy sources [2].

Freight traffic to the ports of the Far East is growing by 6%. According to the Central Directorate of Traffic Management, the handling of 1st class cargo grew ahead of schedule in the first quarter, primarily due to coal, the transportation of which increased compared to 2018 by 9.2% or by 7.7 million tons. The cargo of Class 3 also grew by 3.6%. Shipments of scrap metal, chemicals, fertilizers and containerized cargo grew the most [3].
3. Formulation of the problem
A specific task within the framework of the problem to be solved by the project: acceleration of delivery of goods, reduction of transport and operating costs of transportation of goods, reduction of empty freight car miles, release of estimated capacities of marshalling yards.

4. Theoretical part
An exit route is regarded as a train set of a specified weight or length, formed by a consignor on an organization’s railway sidings or under an agreement with a railway at a railway station with the obligatory dismissal of at least one technical station from processing such a train, provided for by the current freight train formation plan.

Routes can be organized:
- direct, when transported to one station of destination (transshipment) to the address of one or several consignees (freight cars to the address of each consignee must be in a separate group);
- in diffusion, during transportation by assignment at the station of breaking up according to the plan for the formation of freight trains or by assignment to the announced points (stations) of divided routes, where the addressing (indication of destination stations and consignees) of wagons at the unloading station to specific consignees is carried out, or by assignment to entrance and distribution stations receiving fuel cargo, with further carriage addressing at the unloading station [4].

The consignor agrees with the consignee on the possibility of accepting routes of an estimated weight or length for unloading.

Routes from the loading station to the destination station within two or more railways are regarded as network routes; within the limits of one railway – to intra-road.

The weight and length of the network routes are set by the head of the railway or his deputy.

The established norms of weight and length of routes are announced to shippers of the railway line.

If there are downward changes in train weight (breakpoints) on the route of the stations, the routes are organized from the core (the main part of the sending route of the set weight, which follows without re-forming to the destination railway station in case of a change in train weight along the route) and the trailer part, next as part of the route to the points of weight break.

The weight and length of the route core are set in the same order as for routes in general.

In the Far East, the most popular type of rolling stock is open-top wagons (gondola cars), since the main freight flows are coal.

The following is an analysis of the gondola car fleet by owner firms.

Of the total number of wagons, the gondola car fleet accounts for more than 70% of the total wagon fleet.

The organization and procedure for the direction of car traffic at the Khabarovsk II station is carried out according to the approved plan for the formation of freight trains of the Far Eastern Railway for a certain period.

The freight train formation plan consists of:
- plan for the formation of freight trains in international traffic;
- a network plan for the formation of freight trains of Russian Railways;
- an intra-road plan for the formation of freight trains.

At stations where the formation of separate trains from empty own and leased wagons is not provided, these wagons are sent to the destination station indicated by the senders of the empty wagons in the shipping documents, in accordance with the plan for the formation of freight trains [5].

Trains from empty wagons form:
- a) on non-public railway tracks;
- b) on public railway tracks of large unloading stations from wagons that are vacated after unloading;
- c) on public railway tracks of car preparation stations (repair, washing, preparation for loading);
- d) on public railway tracks of marshalling and sectional stations from wagons arriving from other stations.
Depending on the conditions, the selection by the type of rolling stock trains from empty cars is divided into:

a) single-group – from wagons of the same kind (open wagons, tanks, etc.) without selection by category of suitability for loading or wagon belonging;

b) group – from wagons of two or three types and (or) categories of suitability for loading, selected in groups;

c) mixed – from wagons of various kinds without their selection into separate groups;

d) combined – from loaded and empty wagons; these trains can be group and mixed.

According to the established formation plan for the period 2018 - 2019, the Khabarovsk II station should form 28 assignments, of which 15 are even and 13 are odd. In January 2020, the number of assignments increased compared to the approved formation plan.

The increase was 8 assignments, namely 6 in the even and 2 in the odd direction. In February, March and April, the total number of assigned callings did not change compared to January, but it did change individually in each sorting system [6].

Comparison of the number of generated assignments of the approved formation plan with the modified formation plan by type of train at the Khabarovsk II station is presented in Table 1.

**Table 1. Number of generated assignments by train type at the station Khabarovsk II.**

| Sorting Yard | Train Type | APFT 2018-2019 | January 2019 | February 2019 | March 2019 | April 2019 |
|--------------|------------|----------------|--------------|--------------|------------|------------|
| Through      | 12         | 16             | 16           | 17           | 17         |
| Through-group| 1          | 3              | 3            | 3            | 3          |
| District     | 1          | 1              | 1            | 1            | 1          |
| Local freight| 1          | 1              | 1            | 1            | 1          |
| Total in even sorting yard | 15 | 21             | 21           | 22           | 22         |
| Through      | 9          | 11             | 11           | 10           | 10         |
| Through-group| 1          | 0              | 0            | 0            | 0          |
| District     | 1          | 1              | 1            | 1            | 1          |
| Local freight| 1          | 1              | 1            | 1            | 1          |
| Transfer     | 1          | 2              | 2            | 2            | 2          |
| Total in odd sorting yard | 13 | 15             | 15           | 14           | 14         |
| Total directions formed | 28 | 36             | 36           | 36           | 36         |

The organization and procedure for the direction of car traffic at the Khabarovsk II station is carried out according to the approved plan for the formation of freight trains (APFT) of the Far Eastern Railway for a certain period.

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– plan for the formation of freight trains in international traffic;
– a network plan for the formation of freight trains of Russian Railways;
– an intra-road plan for the formation of freight trains.

According to the approved plan for the formation of trains for the period 2018 - 2019, an odd number of assignments amounted to 13 assignments, of which 9 are network and 4 are intra-road.

Over the course of four months, the number of assignments in the odd sorting system has been adjusted [7].

In January 2019, additional assignments were added to the approved formation plan:

1. Khabarovsk I (empty wagon-tank from under the dark filling);
2. Krasnoyarsk-Vostochny (empty);
3. Izvestkovaya.

From these listed assignments, a transfer train Khabarovsk-1 (empty wagon-tanks from under a dark filling) and a through assignment Krasnoyarsk-Vostochny (empty) were added. The additional assignment of the Izvestkovaya formation plan is not independent and is included in the group train for assignment of Birobidzhan-1.

The assignment in the established formation plan to Novokuznetsk-Vostochny is considered a canceled assignment.

According to the established formation plan, the assignment of Neryungri-Gruzovaya should be through-group, and in the adjusted formation plan it is considered as a through one.

5. Practical significance
Khabarovsk II station forms 12 assignments according to the established formation plan and 3 additional assignments. Therefore, in the odd sorting system, only 15 assignments are formed, of which 9 are network directions and 6 are intra-road.

There was no change in the number of assignments in February 2019. This month, the station continues to work according to the corrected plan of formation in January [8].

![Figure 1. Comparison of the number of assignments by type of train in an odd sorting yard.](image)

In March 2019, the through assignment Krasnoyarsk-Vostochny (loaded), which was in the approved formation plan, is canceled.

As a result, the total number of assignments according to the formation plan this month decreases and becomes equal to 14, of which 8 are network directions and 6 are intra-road.

The cars sent by the stations and following in certain directions form a car traffic. The correct organization of this car traffic ensures the acceleration of the car turnover, the lowest expenditure of shunting means, and savings in operating costs.

The system for organizing and moving loaded and empty car traffic to destinations is determined by the train formation plan.

Since 2013, the total car traffic volume at the station has been increasing every year. According to the data for 2019, the total car traffic volume was 15 855 cars, and for 4 months of 2020, 16 561 cars.
Car traffic for 4 months of 2019:
- January - 16,971 cars;
- February - 17,282 cars;
- March - 17,495 cars;
- April - 14,499 cars.

The difference between the maximum permissible car traffic and the average actual car traffic for 4 months is 5,563 cars.

Figure 2 shows the odd and even freight cars turnovers for 2016, which demonstrate that the even system receives the majority of transit cars without rehandling. In the odd system, the situation is radically different; most of the cars arrive for rehandling.

![Pie chart showing odd and even freight cars turnover in 2019.](image)

**Figure 2.** Odd and even freight cars turnover in 2019.

On the basis of Table 2, the diagrams of even and odd freight cars turnovers for 4 months of 2020 are built, which show the same situation as last year.

The odd-numbered sorting system has a lower design wagon processing capacity than the even-numbered sorting system, but it receives more transit wagons with rehandling. Therefore, it is possible to suggest increasing the number of tracks in an odd sorting yard by constructing a 4 bundle consisting of 3 tracks and constructing a second dividing route. This will help increase the processing capacity of the odd sorting system [9].

| Operation | January | February | March | April |
|-----------|---------|----------|-------|-------|
| Received cars With rehandling Ч | 51 114 | 46 154 | 48 707 | 44 252 |
| | Н | 95 821 | 88 580 | 94 118 | 80 927 |
| With-out rehandling Ч | 84 644 | 78 109 | 90 294 | 89 423 |
| | Н | 31 413 | 29 623 | 38 229 | 45 981 |
| Its own formation Ч | 47 783 | 42 785 | 45 630 | 42 237 |
| | Н | 99 115 | 91 277 | 96 750 | 83 197 |
| Sent cars With-out rehandling Ч | 85 047 | 78 164 | 90 335 | 90 055 |
| | Н | 31 106 | 29 583 | 37 851 | 46 071 |
And also for the unloading of the receiving park “B”, in order to increase the number of tracks for transit cars with processing, to build an odd transit park. It will also help reduce downtime.

6. Output
The number of tracks in sorting yards is set depending on the number of assignments according to the train formation plan, the daily number of cars for each destination, taking into account the length of the park’s tracks and the peculiarities of the station operation technology for the formation of trains.

7. References
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Figure 3. Even and odd freight cars turnover for 4 months of 2020.