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TECHNO-ECONOMIC EVALUATION OF THE EFFICIENCY OF IMPROVEMENT OF TECHNIQUES RATIONING FIXING ROLLING STOCK ON THE STATION TRACKS

Мета. Стаття присвячена оцінці ефективності вдосконаленої методики нормування кількості гальмових башмаків для закріплення рухомого складу на станційних коліях, яка була запропонована в результаті попередніх досліджень. **Методи дослідження.** У дослідженні використовується імітаційне моделювання роботи станції для розрахунку простоїв рухомого складу на коліях станцій. Методика техніко-економічного порівняння варіантів використовується для оцінки ефективності вдосконалення методики нормування кількості гальмових башмаків для закріплення рухомого складу. **Результати.** Визначено економічний ефект від запровадження нової методики нормування закріплення рухомого складу. Було виявлено, що впровадження більш досконалої методики нормування закріплення рухомого складу призведе до істотної економії експлуатаційних витрат залізниці. **Наукова новизна.** Удосконалена методика нормування кількості гальмових башмаків для закріплення рухомого складу на станційних коліях запропонована вперше, тому техніко-економічна оцінка її ефективності також виконана вперше для залізниць України. **Практична значимість.** Результати цього дослідження показують, що використання удосконаленої методики розрахунку кількості башмаків для закріплення рухомого складу призведе до економії експлуатаційних витрат залізниць за рахунок зменшення простоїв рухомого складу на станціях.

Ключові слова: закріплення рухомого складу, гальмові башмаки, безпека руху, економічна ефективність, експлуатаційні витрати

Цель. Статья посвящена оценке эффективности усовершенствованной методики нормирования количества тормозных башмаков для закрепления подвижного состава на станционных путях, которая была предложена в ходе предыдущих исследований. **Методы исследования.** В исследовании используется имитационное моделирование работы станции для расчета простоев подвижного состава на путях станций. Методика технико-экономического сравнения вариантов используется для оценки эффективности совершенствования методики нормирования количества тормозных башмаков для закрепления подвижного состава. **Результаты.** Определены экономический эффект от внедрения новой методики нормирования закрепления подвижного состава. Было обнаружено, что внедрение более совершенной методики нормирования закрепления подвижного состава приведет к существенной экономии эксплуатационных расходов железной дороги. **Научная новизна.** Усовершенствованная методика нормирования количества тормозных башмаков для закрепления подвижного состава на станционных путях предложена впервые, поэтому технико-экономическая оценка ее эффективности также выполнена впервые для железных дорог Украины. **Практическая значимость.** Результаты этого исследования показывают, что использование усовершенствованной методики расчета количества башмаков для закрепления подвижного состава приведет к экономии эксплуатационных расходов железных дорог за счет уменьшения простоев подвижного состава на станциях.

Ключевые слова: закрепление подвижного состава, тормозные башмаки, безопасность движения, экономическая эффективность, эксплуатационные расходы

Purpose. This is dedicated to evaluation of the efficiency of improvement of the advanced method of normalization of quantity of wheel chocks for fixing rolling stock on station tracks, which was proposed as a result of former study. **Methodology.** In this study the simulation modeling of station work is used for calculation of rolling stock downtime. The method of techno-economic comparison is used to evaluate the efficiency of improvement of the new method of rationing number of wheel chocks for fixing rolling stock. **Findings**. The effect of the proposed method to the conditions of work of the railway stations had been analyzed. It was revealed that the introduction of improved methods of rationing fixing rolling stock will lead to substantial savings in operating costs of the railway. **Originality.** The advanced method of normalization of quantity of wheel chocks for fixing rolling stock on station tracks is proposed at first, that's why the techno-economic evaluation of its efficiency has also been made for the first time. **Practical value.** The result of this study shows that use of the advanced method of evaluation of wheel chocks number for fixing rolling stock will lead to savings in railway's operating costs because of decreasing rolling stock downtime.

Keywords: fixing the rolling stock, wheel chock, traffic safety, economic efficiency, operating costs

Introduction

Improved method of valuation of wheel chocks for fixing of rolling stock, as shown by studies performed [1], may reduce the duration of downtime rolling stock on the tracks of the station. That's why the question of technical and economic evaluation of effectiveness of the improved method of valuation of fixing rolling stock is topical.

Purpose

The purpose of this article is the economic evaluation of the efficiency of improvement of the advanced method of normalization of quantity of wheel chocks for fixing rolling stock on station tracks.

Main

From the technological processes of marshalling yards [2, 3] it is known that during fixing rolling stock and removing wheel chocks cars, trains and locomotives with crews idle. Thus, reducing the number of wheel chocks (Δ) for fixing rolling stock in arrival area is saving downtime of train locomotives with wagons and locomotive crews:

$$E_{\text{lay}} = \frac{\Delta \cdot t_{\text{c}} \cdot N_{\text{d}} \cdot \left(e_{\text{lh}} + m \cdot e_{\text{wh}}\right)}{60}, \qquad (1)$$

where t_{c} is the average duration of laying of wheel chock, minutes;

e_{lh}, e_{wh} are expenditure rates for 1 hour, respectively, a locomotive with a crew and wagon downtime;

N_{d} is the number of trains entering the disbandment per day;

m is the average number of cars in train.

Overall savings from reducing the number of wheel chocks during their removing is:

$$E_{\text{rem}} = 365\frac{\left(\Delta \cdot t_{\text{c}} \cdot N_{\text{d}} \cdot m + t_{\text{w}} \cdot M_{\text{h}}\right) \cdot e_{\text{wh}}}{60}, \qquad (2)$$

where M_{h} is total number of cars processed through sorting hump, including angular car transfers and cars that are collected from the sidings.

The total cost savings in the admission park through reducing the number of wheel chocks for fixing the rolling stock may be calculated using the following expression:

$$E_{\text{a}} = 365 \cdot \left[\frac{\Delta \cdot t_{\text{c}} \cdot N_{\text{d}} \cdot e_{\text{lh}}}{60} + \frac{\left(\Delta \cdot \left(t_{\text{c}} + t_{\text{cr}}\right) \cdot N_{\text{d}} \cdot m + t_{\text{w}} \cdot M_{\text{h}}\right) \cdot e_{\text{wh}}}{60}\right] \qquad (3)$$

The economic effect of reducing the number of wheel chocks for fixing transit trains may be calculated as

$$E_{\text{T}} = 365 \cdot \Delta \cdot N_{\text{T}} \cdot \frac{\Delta \cdot t_{\text{c}} \cdot N_{\text{d}} \cdot \left(e_{\text{lh}} + m e_{\text{wh}}\right)}{60}, \qquad (4)$$

where $N_{\text{т}}$ is the quantity of transit trains per day.

As for trains that are formed on particular station, the operation of fixing cars on the tracks leads to increasing of time of their rearrangement from sorting area to the departure area, and operation of removal of wheel chocks leads to increasing of train locomotives, carriages and locomotive crews downtime. In addition, the operation of removal of wheel chocks is an element of technological cycle of the work of train formation locomotive. Consequently, this affects the cars downtime during awaiting of completion of the formation and rearrangement. The economic effect of reducing the number of wheel chocks for fixing trains its own formation may be evaluated using the following expression:

$$E_{\text{dep}} = 365 \cdot \left[\frac{\Delta \cdot t_{\text{cr}} \cdot N_{\text{f}} \cdot e_{\text{lh}}}{60} + \frac{\left(\Delta \cdot \left(t_{\text{c}} + t_{\text{cr}}\right) \cdot N_{\text{f}} \cdot m + t_{\text{wf}} \cdot M_{\text{h}}\right) \cdot e_{\text{wh}}}{60}\right] \qquad (5)$$

where N_f is the number of trains formed per day.

To determine the additional downtime of cars in anticipation of dissolution and end of shunting operations, there was used a time-dependence of shunting operations [4], which is listed below (Table 1).

As a result, the approximation of waiting time before disbandment depending on the load of locomotive polynomial of the second degree the following expression was obtained:

$$t_{\text{w}} = 160{,}61 \cdot \psi^2 - 139{,}85 \cdot \psi + 31{,}409 \qquad (6)$$

where ψ is the level of locomotive loading.

The load of locomotive after reducing of wheel chocks quantity (using the new method [1]) will be:

$$t_{\text{l}}' = t_{\text{l}} - \Delta \cdot t_{\text{c}} \cdot N_{\text{d}} \qquad (7)$$

As a result, the approximation of waiting time of the end of train formation depending on the load of locomotive polynomial of the second degree the following expression was obtained:

$$t_{\text{wf}} = 566{,}67 \cdot \psi^2 - 700{,}71 \cdot \psi + 228{,}98. \qquad (8)$$

Table 1

Dependence of downtime of cars in anticipation of technological operations of loading shunting locomotives

Level of shunting locomotive loading	Duration of anticipation of dissolution t_w, minutes	Duration of anticipation of ending formation t_{wf}, minutes
0,50	2	8
0,55	3	10
0,60	5	12
0,65	8	14
0,70	12	16
0,75	17	22
0,80	23	30
0,85	29	44
0,90	35	57

Analysis of the structure of train flows at Nizhnedneprovsk-Uzel station shows that only 16,7 % of transit trains consist of both loaded and empty wagons. Other 83,3 % of trains consist only of loaded or only of empty cars or have wagons with axle loaded more than 15 tons per axis in the fixing zone (where wheel chocks are set up on the rails). The average decreasing of wheel chock number in this case is about 1.1 wheel chock (from 7,1 to 6,0) and the economic effect is about 111,6 thousand UAH per year (included 53,7 thousand UAH of savings only for railway). As for trains that arrive for disbandment, 78,5 % of them have axle load less than 15 tons per axle, so that they need more wheel chocks to be fixed on track. The average needed quantity of wheel chocks for their fixing is about 8,8 (using the existing method) and can be reduced up to 6,2 (using the improved method). Thus, the total cost savings by changing the method of valuation of wheel chocks in the park "Z" is 358,3 thousand UAH per year, including cost savings of the railway – 104,5 thousand UAH. This effect is mostly from increasing the number of cases of using 5-7 wheel chocks instead of 11-13 wheel chocks due to the existing method. Changing the method of valuation of wheel chocks for fixing trains, formed at the station, reduces the average number of wheel chocks from 11,8 to 9,5 ones in the park "E". If there are 23-25 trains formed per day, the effect will be about 333.6 thousand UAH, including 63,8 thousand UAH saved for railway. In the park "L" the effect will be about 153,2 thousand UAH (when the average number of formed and transit trains is 33-35 per day).

Thus, the total savings of operating costs at Nizhnedneprovsk-Uzel station will be about 956,7 thousand UAH, including 267,3 thousand UAH of cost savings of the railway. At Pyatihatki-Stykova station the new method provides average $\Delta = 2,8$ wheel chocks (from 10,2 to 7,4), and savings of operating costs reach 325 thousand UAH per year (158,3 thousand UAH for railway).

As for Krivoy Rog-Sorting, Zaporozhie-Levoe and Dzhankoy stations, their tracks have the coerced slope from 0.1 up to 0.7 ‰, that's why the maximum quantity of wheel chocks for fixing rolling stock is not more than 5 (both due to existing and improved methods of calculation). In such case the change of method for calculation of the quantity of wheel chocks practically doesn't change the operating conditions at the stations.

Results

Completed feasibility calculations show that changing the method of valuation of fixing trains can get substantial savings of operating costs. For example, for the Pridneprovskaya railway for the year, it will be approximately 1281.7 thousand UAH. At the same time, savings of the railway will be 425.9 thousand UAH per year.

Conclusion

Thus, when introduced improved methods of evaluation of wheel chocks quantity, railways of Ukraine can achieve economic benefits from reduced downtime wagons, locomotives and locomotive crews. This effect can reach several million UAH per year.

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