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STUDY OF TIME CHARACTERISTICS OF GRAIN RECEIVING FROM AUTO TRANSPORT AT PROCUREMENT ELEVATORS

Abstract

At harvesting elevators and grain receiving enterprises, the operation of receiving grain from motor vehicles is the main one. Many elevators of other types also accept grain from motor vehicles due to the fact that it allows to improve the economic performance of the enterprise, and in general, the combination of functions inherent in elevators of different types is a feature of enterprises in the elevator industry of our country. For almost all elevators or grain terminals, the issue of car queues before the entrance is acute. The introduction of various high-performance car unloaders helps to increase the capacity of elevators for unloading grain from cars and road trains of all types. The process of receiving grain from vehicles consists of several operations, and each operation in this chain is important in reducing the time the vehicle stays at the enterprise, and therefore, increasing its throughput. We analyzed the process of unloading cars on U-15URAG-U car unloaders installed at two procurement elevators in the Mykolaiv and Zhytomyr regions. In the course of carrying out this scientific study, we timed the unloading process of 20 single cars (that is, without trailers), which were used to deliver grain to the enterprise. The main stages of unloading cars in the reception facilities of the studied enterprises were highlighted and the average (most reliable), minimum and maximum execution time of each stage was determined. Schedules of the unloading of vehicles with wheat grain at the harvesting elevators, where the research was carried out, were constructed. The results of the timing of the unloading of cars in the receiving device showed that the longest stage is the lifting of the platform of the car loader and the pouring of grain, and the least lasting is the exit of the driver from the cab. The average unloading time was 561.5 seconds for the first enterprise (Mykolaiv Region) and 565 seconds for the second (Zhytomyr Region). It should be noted that the time of raising and lowering the platforms of U15-URAG-U truck unloaders at both considered enterprises corresponds to the passport data, that is, the truck unloaders are not working at maximum efficiency.

Key words: receiving grain, receiving device, car unloader, timing.

Introduction

In Ukraine, in recent years (before the beginning of the Russian Federation's full-scale aggression against our country), a steady trend of increasing the volume of grain production was observed. That led to an increase in the load on vehicles used to transport grain from the field to elevators and other grain storage facilities, to transshipment points for other types of transport.

Grain transportation across Ukraine is carried out in 3 ways − by rail, water and motor transport. The choice depends on the distance and the final point of transportation. The leading position is occupied by the transportation of grain by railway transport, but in recent years we have observed a reorientation towards motor vehicles [1].

Road transport is the most popular mode of transport in the supply chain of grain and oil crops used by suppliers and enterprises. Road transport of grain is divided into 2 types of shipments: "from the field" and "from the elevator". The main distinguishing feature from other types of logistics is the construction of flexible routes between settlements and cities, operational organization of transport and delivery to the loading/unloading point, selection of transport dimensions according to the technical characteristics of the customer enterprise [2].

Literary review

Thus, in 2021, the specific weight of motor vehicles in the transportation of goods amounted to 74% (134,398.22 thousand tons), of which grain cargoes accounted for 12,680.79 thousand tons [3].

It is especially important to remember that grain, which during the harvest campaign is transported directly from the fields, needs to be quickly taken to the elevator for further processing (cleaning, drying, active ventilation) in order to prevent deterioration of its quality.

Advantages of grain transportation by road [2]:

− prompt delivery of cargo to the port (for example, spot trading);

− direct loading of the crop in the field (supplies of truck grain trucks are carried out directly under the harvester);

− internal movements over short distances;

− prompt coordination of delivery conditions, terms, types of cars according to the client's conditions, cost of transportation;

− preservation and safety of movement of grain cargoes, GPS monitoring of each car and cargo online;

− operational document flow, absence of additional bureaucracy when preparing documents for freight transportation;

− individual approach to pricing depending on the distance of movement and volume of cargo;

− state road construction programs allowed to carry out a route within a day to remote delivery points along strategic routes;

− availability in working with private enterprises and agricultural producers.

Disadvantages of automobile grain logistics:

− possible delays in the delivery of cargo to final destinations due to the need to comply with the conditions of the "thermal regime" in the summer season;

− the mass of grain transported by a single car should not exceed 25 tons, which leads to an increase in the number of motor vehicles and the number of cars when moving a large volume of grain;

− shortage of cars at the request of shippers during the "high season";

− transfer payment in case of returning cars from reception points back to the farm;

− probability of cargo loss in case of force majeure and unforeseen circumstances;

− increase in transportation tariffs depending on changes in the price of PMM;

− the cost of transportation is higher than by railway wagons.

At the same time, it is necessary to state the fact that if 5-6 years ago there was an acute shortage of grain transport vehicles in agricultural companies, today this problem has been partially overcome. More and more often, farm owners realize that having their fleet of grain trucks significantly expands their capabilities, reducing dependence on third-party companies and making grain transportation by motor vehicle cheaper.

Not all farms have the opportunity to purchase the required number of grain trucks. However, there have been obvious changes in this area. In particular, this concerns the development of domestic enterprises producing platforms and trailers, as well as the reorientation of the market to the production and purchase of grain transportation equipment with a lightweight design.

The duration of loading the car body with grain depends on the features of the grain harvester design and can vary from two to five minutes.

The introduction of mechanization of unloading operations, the use of dump trucks and unloading platforms allows to reduce the time for unloading grain from a vehicle. In order to avoid loss and spoilage of grain during transportation, the bodies of cars, trailers and semi-trailers should be equipped with seals and have awnings that protect the grain from atmospheric precipitation [1, 2].

To transport grain over long distances, grain carriers-road trains are used, which are equipped with a special body in the form of a tank or a bunker. There are three types of bodies of grain trucks: stationary, trailer, semi-trailer. There are two options for their execution: closed and open. The grain semi-trailer is equipped with an awning with a mechanical winding device. According to the method of unloading, there are grain trucks with rear and side unloading.

Currently, tractors with dump semi-trailers of large capacity and capacity (European grain trucks produced by the companies "Daf", "Scania", "Renault", "Man") have become widespread. These grain trucks and semi-trailers can unload grain independently, which allows to reduce time costs [4].

The fleet of grain trucks is diverse, body volumes are up to 60-70 m3, load capacity is up to 40-45 t, the height of the side is from 2.7 to 4 m. The peculiarity of the design of Euro grain trucks makes it possible to lift them with the help of a hydraulic device during dump unloading. 12-meter semi-trailers up to an angle of 60 degrees, which significantly facilitates the unloading of grain [1].

It should be noted that the largest share of grain is transported by road transport during the harvesting campaign, that is, in a very short period of time, a large number of cars of various types and carrying capacities, which require quick unloading, arrive at the harvesting elevators.

It is especially important to remember that the grain, which during the harvesting campaign is transported directly from the fields, needs to be quickly taken to the elevator for further processing (cleaning, drying, active ventilation) in order to prevent deterioration of its quality.

Thus, it depends on the correct organization of the operation of receiving grain from road transport, whether the enterprises will be able to accept, place and process all the grain of various purposes and quality coming from producers, with minimal losses of grain and downtime of road transport.

The successful implementation of receiving grain from road transport depends on the number and performance of the equipment of receiving devices, which must correspond to the nature of the incoming motor vehicle: its type and carrying capacity, the number and volume of batches of grain of various crops delivered to the enterprise, and the quality of the grain [5-9].

Formulation of the problem

The purpose of the work is to study the efficiency of the car unloaders at harvesting elevators by determining the timing characteristics of receiving grain from vehicles.

The object of our research is receiving devices from motor vehicles at two procurement elevators located in the Mykolaiv and Zhytomyr regions, with installed U-15URAG-U car unloaders.

Objectives of the study:

− determination of arithmetic mean values of the duration of each stage of car unloading;

− determination of the total time of external operation of the receiving device from motor vehicles;

− performing an assessment of the average variability σ of the results and calculating the coefficients of variation V for each stage of car unloading;

− determining the average productivity of unloading cars.

Materials and methods

The main methods of researching the efficiency of the reception device are: timing of the process of unloading cars and the grapho-analytical method.

Timing of the process of unloading cars is carried out using the current time method, that is, recording the start and end time of each stage [5-7]. Most often, the

moment of the end of one stage coincides with the beginning of the next. Depending on the duration of the stages and the entire process of unloading the car, the time is recorded in minutes and seconds. Thus, the unloading process of at least 20 cars of the same type is timed.

The grapho-analytical method consists in constructing cyclogram graphs that visually show the sequence and average (arithmetic) duration of all stages of car unloading.

Results of the study and their discussion

In the course of carrying out this scientific study, we timed the unloading process of single cars (that is, without trailers), which were used to deliver wheat grain with a moisture content of 12.4...13.8% to enterprises – 20 cars each with a carrying capacity (net) of 20.23 to 30.8 tons at each of the procurement elevators considered.

We identified the following main stages in the process of unloading cars in the receiving devices of these elevators:

1. Entry of the car onto the platform;
2. Driver leaving the cab;
3. Fixing the car on the platform with a chain;
4. Opening the side of the car;
5. Lifting the platform of the car unloader and dumping the grain;
6. Lowering the platform;
7. Closing the side of the car;
8. Removing chains;
9. Driving off the platform.

Based on the timing sheets, the duration of each stage of car unloading was determined in seconds and the total duration of car unloading was calculated.

Further, mathematical processing of the data was carried out, during which an estimate of the average variability (ie, the calculated mean squared (standard) deviation) of the results σ was performed and the coefficients of variation V were calculated for each stage of car unloading.

The mean square (standard) deviation of the results σ was calculated according to the formula:

$$\sigma = \sqrt{\frac{\sum(x_i - \bar{x})^2}{n-1}}, \quad (1)$$

where x_i — is the duration of a separate unloading stage of the i-th car;

$\bar{x}$ — is the average arithmetic value of the duration of the car unloading stage;

n — the number of researched cars, pcs.

The coefficient of variation V was determined by the formula:

$$V = \frac{\sigma * 100}{\bar{x}}, \ \% \quad (2)$$

The smaller the deviation of each option from the arithmetic mean, the smaller the coefficient of variation will be. In technology, the value of variation coefficients can be used to characterize the stability of regimes, grain quality indicators, equipment efficiency indicators, reproducibility of methods, etc. With good parallel results of determinations, the value of the coefficient of variation ranges up to 10%.

Then, the minimum and maximum duration of each stage of car unloading and the arithmetic mean (most reliable) time of their execution were determined, according to which schedules of the external operation of the receiving device from motor vehicles for unloading cars with grain were then constructed.

Table 1 – Main technical characteristics of the U15-URAG-U car unloader [10]

Parameter names	U15-URAG-U
Technical productivity, t/h	330
Nominal load capacity (max, at maximum pressure), t, no more - a large platform - side platform	70(80) 50 20
Platform length, mm: - a large platform - side platform	 15700 6400
Tilt time, s, no more than: - a large platform - side platform	 180 20
Descent time, s, not more than: - a large platform - side platform	 150 15
Angle of inclination of the platform, degrees.	0…38
Motor	hydraulic
Number of telescopic three-plunger hydraulic jacks, pcs.: - a large platform - side platform	 2 1
Diameter of the plunger of the first stage, mm Working stroke of the plunger of the first stage, mm Diameter of the plunger of the second stage, mm Working stroke of the plunger of the second stage, mm Diameter of the plunger of the third stage, mm Working stroke of the plunger of the third stage, mm	235 2217 190 2340 150 2418
Nominal pressure in the hydraulic system, MPa (kg/cm^2) Maximum (safety valve trigger pressure), MPa (kg/cm^2)	10(100) 12,5(125)
Hydro system capacity, l	600
Drive control type	electric
Nominal voltage, V: power chain control chain	 380 220
Nominal power of the electric motor, kW	30
Degree of protection of electrical equipment	IP55
Mass, kg, no more	2200

At the last stage of the work, we determined the average carrying capacity of the car $G_{average}$ and calculated the average unloading productivity $Q_{average}$ according to the formulas:

$$G_{average} = \frac{\sum G}{n}, \text{ t} \quad (3)$$

where ΣG — total carrying capacity of all cars, t;

n — number of cars, pcs.

$$Q_{cp} = \frac{3600 * \Gamma_{cp}}{T_{average}^{external}}, \text{ t/h}, \quad (4)$$

where $G_{average}$ – average (arithmetic) carrying capacity of the car, t;

$T_{average}^{external}$ – average (arithmetic) total duration of car unloading, p.

At present, at grain storage and processing enterprises, the main part of the total volume of loading and unloading operations is provided with the use of truck unloaders of various types, designs and modifications, carrying capacity and performance, of which there are currently about forty.

At the enterprises where the research was conducted, the most unified and most adapted from the point of view of practicality of use and ease of operation, as well as economic expediency, widely known and most often used in the production activities of most enterprises, the U-15URAG-U car unloader was installed.

The U-15URAG-U car unloader is designed for unloading grain through the open rear side of single cars and tractor-trailers with semi-trailers and unloading through the open side side of single cars and trailers without uncoupling the trailers from cars. The main technical characteristics of the U15-URAG-U car unloader are listed in table. 1 [10].

According to the timing sheets, we determined the duration of each stage and the total time of unloading the cars, after which mathematical processing of the received data was performed. The calculations showed the stability of the performance of each stage of car unloading, as the obtained coefficients of variation did not exceed 10%.

On the basis of the data obtained during the study of the timing of the process of unloading cars, we determined the minimum and maximum times for each stage of unloading cars and the arithmetic mean time of their execution, as well as calculated the total duration of unloading cars with grain of different crops and different moisture content. The results of these calculations are given in table. 2.

According to the table 2 (on the basis of the arithmetic mean time of all operations) schedules of the unloading of vehicles with wheat grain at the harvesting elevators where the research was conducted are plotted (Fig. 1).

Analysis of the graphs showed that stage (5) of raising the platform of the car unloader and dumping grain took the longest at both enterprises – 148.1 s and 157.5 s, respectively, for the first and second enterprises. In second place in terms of duration is stage (6) of lowering the platform – 147.8 s on the first elevator and 150 s on the second. The shortest stage (2) is the exit of the driver from the cabin and it is 8.3 s on the first elevator and 7.8 s on the second.

It should be noted that the actual time of raising and lowering the platform at the considered enterprises is less than the passport data - 180 s and 150 s, respectively. The average duration of unloading cars was 554.8 seconds for the first company (Mykolaiv Region) and 564.9 seconds for the second (Zhytomyr Region).

Based on the obtained data, the average loading capacity of the truck unloader and its unloading performance were determined. It was established that for the first enterprise (Mykolaiv region) the average carrying capacity of the car is 23.48 tons, and the average unloading productivity is 152.4 tons/hour. For the second enterprise (Zhytomyr region), the average carrying capacity of the car is 30.8 t, the average unloading productivity is 196.24 t/h.

Conclusions

In order to establish the efficiency of the U-15URAG-U car unloaders, a study was conducted of the timing characteristics of receiving wheat grain with a

Table 2 – Data on the timing of the unloading of cars at the receiving devices of procurement elevators

Performed operations	Duration of operations, p					
	Enterprise I (Mykolaiv Region)			Enterprise II (Zhytomyr Region)		
	min	max	arithmetic mean	min	max	arithmetic mean
1. Entry of the car onto the platform of the car unloader	40	40	40	40	40	40
2. Driver leaving the cab	5	10	8,3	6	9	7,8
3. Fixing the car on the platform	40	70	56	55	65	60
4. Opening the side of the car	20	40	32	25	32	28,5
5. Raising the platform and dumping the grain	144	153	148,1	150	165	157,5
6. Lowering the platform	144	150	147,8	150	150	150
7. Closing the side of the car	30	39	31,9	23	30	26,5
8. Removal of chains	50	68	55,2	48	60	54,6
9. Driving off the platform	30	60	37	28	54	40
Total duration of the cycle	**546**	**570**	**554,8**	**525**	**605**	**564,9**

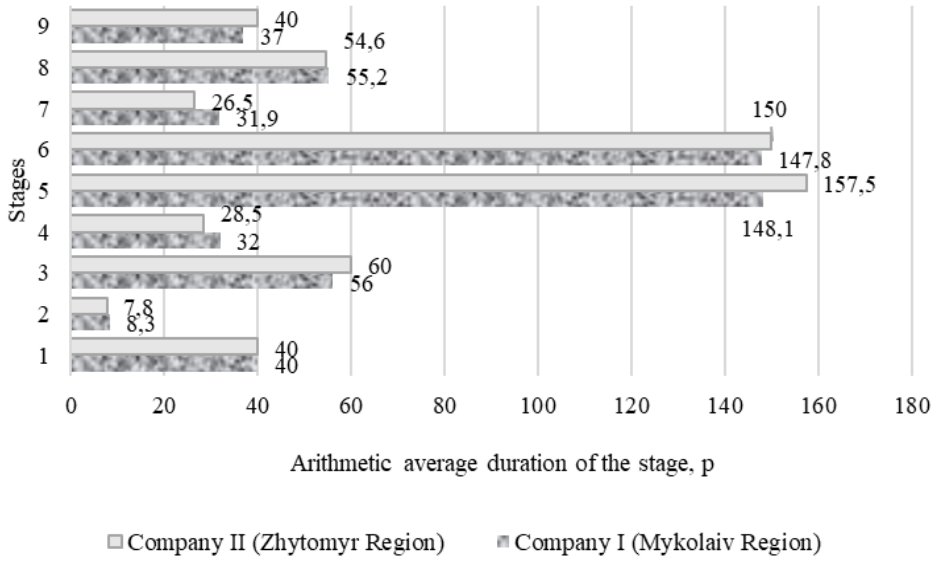

Fig. 1 – Schedules of the unloading of vehicles with wheat grain at harvesting elevators in the Mykolaiv and Zhytomyr regions

moisture content of 12.4...13.8% from cars with a carrying capacity (net) of 20.23 to 30.80 tons at two harvesting elevators located in the Mykolayiv (I enterprise) and Zhytomyr regions (II enterprise).

Based on the results of these studies, the average arithmetic values of the duration of each of the stages of car unloading were determined, and this made it possible to establish that:

- the longest is the stage of lifting the platform of the truck unloader and dumping grain - 148.1 s and 157.5 s, at the first and second enterprises, respectively, but its duration does not exceed the passport data of the truck unloader - 180 s;

- the platform lowering time is 147.8 and 150 seconds, respectively, at the first and second enterprises, and corresponds to the technical characteristics of the U-15URAG-U truck unloader;

- the least long stage is the driver's exit from the cab, which is 8.3 s and 7.8 s at the 1st and 2nd enterprises, respectively.

The total average (arithmetic) duration of car unloading that we established was 9.25 min (554.8 s) for the first enterprise and 9.42 min (564.9 s) for the second.

The calculations showed the stability of the performance of each stage of car unloading, as the obtained coefficients of variation did not exceed 10%.

The estimated average (arithmetic) actual productivity of U-15URAG-U truck unloaders turned out to be significantly less than the passport productivity of Q_{tech}=330 t/h (152.4 t/h for the first enterprise and 196.24 t/h for the second). This is explained by the fact that the passport productivity of truck unloaders is given without taking into account the time lost for performing operations that are not specifically related to the work of the truck unloader.

U-15 URAG-U truck unloaders in the receiving devices of the researched harvesting elevators work stably, and the operation of the elevators for receiving grain from vehicles is established.

REFERENCES

1. Voinolovuch O. Bezpeka pratsi pid chas perevezennya zerna avtotransportom. Chastuna 1. Ohorona pratsi i pozhezhna bezpeka // Elektronniy resurs. Rezhim dostupu: https://oppb.com.ua/articles/bezpeka-praci-pid-chas-perevezennya-zerna-avtotransportom-chastyna-1.
2. Logistuka zerna. Sposobu transportuvannya zernovuh // Elektronniy resurs. Rezhim dostupu: https://www.05366.com.ua/list/331917.
3. Transport i zvyazok Ukrainu 2018. Statustuchnuy zbirnuk // Elektronniy resurs. Rezhim dostupu: http://www.ukrstat.gov.ua/druk/publicat/kat_u/2019/zb/08/zb_tr2018pdf.pdf.
4. Logistuka export zerna // Elektronniy resurs. Rezhim dostupu: https://ambarexport.ua/ru/blog/grain-export-logistics.
5. Stankevich G., Strahova T., Buduk L. Dunamika i period nadhodzhennya zerna avtomobilnum transportom na pidpruemstva pivdennuh ta tsentralnuh regioniv Ukrainy. Naukovi pratsi Odeskoi natsionalnoi akademii harchovuh tehnologii. 2011 // Elektronniy resurs. Rezhim dostupu: https://www.onaft.edu.ua›abstract›Abstract-Shpak.
6. Butsenko I.M. Doslidzhennya propusknoi zdatnosti pruimannya zerna z avtomobilnogo transportu na PrAT Ukrelevetorprom. Hranenie i pererabotka zerna. 2013. 11. P.26-28.
7. Butsenko I.M. Doslidzhennya propusknoi zdatnosti pruimannya zerna z avtomobilnogo transportu na PrAT Ukrelevetorprom. Naukovi pratsi ONAHT. Odesa. 2013. 44. P.87-90.
8. Strahova T., Borta A.V., Shpak V.M. Analiz ephektuvnosti robotu tehnologichnoi linii pruimannya zerna z avtomobilnogo transportu na PrAT Ukrelevetorprom. Zbiruk tez dopovideu 77 naukovoi konferentsii vukladachiv akademii. 2017. P.24-26.
9. Dmitrenko L.D., Kats A.K., Shpak V.M. Vidminnosti pruimannya zerna z avtotransportu na zagotivelnuh elevatorah i zernovuch terminalah. Zbiruk tez dopovideu 78 naukovoi konferentsii vukladachiv akademii. 2018. P.23-25.
10. Podgorodetskiu M.O. Tehnicheskoe reshenie konstruktsii ustroistv dlya razgruzki transportnuh sredstv. Hranenie I pererabotka zerna // Elektronniy resurs. Rezhim dostupu: https://hipzmag.com/tehnologii/hranenie/tehnicheskoe-reshenie-konstruktsii-ustrojstva-dlya-razgruzki-transportnyh-sredstv/

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ДОСЛІДЖЕННЯ ХРОНОМЕТРАЖНИХ ХАРАКТЕРИСТИК ПРИЙМАННЯ ЗЕРНА З АВТОТРАНСПОРТУНА ЗАГОТВЕЛЬНИХ ЕЛЕВАТОРАХ

Анотація

На заготівельних елеваторах та хлібоприймальних підприємствах операція приймання зерна з автотранспорту є основною. Багато елеваторів інших типів також здійснюють приймання зерна з автотранспорту завдяки тому, що це дозволяє покращити економічні показники роботи підприємства та в загалі − комбінування функцій, притаманних елеваторам різних типів, є особливістю підприємств елеваторної галузі нашої країни. Практично для всіх елеваторів або зернових терміналів гостро стоїть питання автомобільних черг перед в'їздом. Впровадження різних високопродуктивних автомобілерозвантажувачів сприяє підвищенню пропускної спроможності елеваторів з розвантаження зерна з автомобілів і автопоїздів всіх видів. Процес приймання зерна з автотранспорту складається з декількох операцій, і кожна операція у цьому ланцюгу має важливе значення в скороченні часу перебування автомобіля на підприємстві, а отже, і збільшенні його пропускної здатності. Нами проаналізовано процес розвантажування автомобілів на автомобілерозвантажувачах У-15УРАГ-У, що встановлені на двох елеваторах Миколаївської та Житомирської областях. Здійснено хронометраж процесу вивантаження 20-ті одинарних автомобілів (тобто, без причепів), якими на підприємство було доставлено зерно. Виділено основні етапи вивантаження автомобілів у приймальних пристроях досліджуваних підприємств та визначені середній (найбільш достовірний), мінімальний та максимальний час виконання кожного етапу. Побудовано графіки хронометражу вивантаження автотранспорту з зерном пшениці на заготівельних елеваторах, де проводились дослідження. Результати хронометражу показали, що найбільш тривалим є етап підйому платформи автомобілерозвантажувача та висипання зерна, а найменш тривалим – вихід водія з кабіни. Середня тривалість розвантаження склала 561,5 с для першого підприємства (Миколаївська обл.) та 565 с для другого (Житомирська обл.). Слід зазначити, що час підняття та опускання платформ автомобілерозвантажувачів У15-УРАГ-У на обох розглянутих підприємствах відповідає паспортним даним, тобто вони працюють не з максимальною ефективністю.

Ключові слова: приймання зерна, приймальний пристрій, автомобілерозвантажувач, хронометраж.

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