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INVESTIGATION OF CHARACTERISTICS OF THE GRAIN RECEIVING FROM RAILWAY TO THE GRAIN TRANSSHIPMENT TERMINAL

Abstract

In the future, in Ukraine it is planned to increase the sown area for cereals, legumes and oilseeds, to increase the gross grain harvest to 80 million tons, and its export abroad was increased twice. Intensive construction in the southern ports of Ukraine of grain transshipment terminals with large metal silos will solve the problem of increasing grain export in the future. At these powerful terminals, the bulk of the grain comes mainly by rail, and is shipped to water.

The aim of the work was to study the characteristics of the grain receiving from railway transport to the grain transshipment terminal of LLC "Ukrelevatorprom" in order to improve its works efficiency. The object of the study was the development of technology of grain receiving at the grain transshipment terminal; the subject of research is cereals, legume sand oil crops, as well as data from daily volumes of receiving and dispensing operations at the grain transshipment terminal of LLC "Ukrelevatorprom" for 2015-2016.

The studies were carried out on the basis of processing data from the consignment notes for 2015-2016, according to which there was a summed amount of grain (net) daily transported by the railway. Further processing of the obtained data was carried out by a combined graphoanalytical method, for which, on the basis of tabular values for each studied year, the corresponding histograms and graphs were built and the necessary indicators were determined.

Analysis of the structure of grain crops supplied by railway to LLC "Ukrelevatorprom" in 2015 and 2016 and their ratio showed that the main share was occupied by cereal crops (78.0 % and 73.1 % respectively), which were mainly represented by corn, share which was significantly dominated by other crops (wheat of various classes and barley) and amounted to 45.8 % and 44.5 %, respectively, which can be explained by its high demand in the international grain market, in which Ukraine occupies a leading position. Oilseeds (rapeseed) were taken in accordance with 19.1 % and 14.9 %, and legumes (soybeans) — 2.9 % and 12.0 %.

An analysis of the timing of the unloading of grain wagons (hopper cars) showed that the total duration of this process, depending on the crops, averages 37...59 minutes. The longest steps for unloading wagons are to determine the grain quality indicators, especially rapeseed, and to spill grain from the wagons, therefore, to reduce their duration, it is necessary to form feeds of wagons with grain batches of the same quality and use more modern express analyzers to determine grain quality indicators, which will increase the productivity of the grain receiving line from the railway. According to the research results, the enterprise has the potential to increase by about 30 % the volume of grain intake.

It was established that the periods of the grain receipt at the enterprise in 2015-2016 amounted to 349 and 353 days, respectively, the actual coefficients of the daily irregularity K_{daily} for the grain receipt from the railway in these years are equal to 1.47 and 1.52, and the monthly irregularity K_{month}, respectively 1.33 and 1.21, does not exceed the standard values K_{daily} = 2.5 and K_{month}= 2.0. This made it possible to clarify the database from the actual characteristics of the process of grain receiving by railway and can be used in design and verification calculations of equipment in technological lines for receiving grain from railway transport, and will contribute to increasing the efficiency of grain transshipment terminals.

Key words: *grain crops, grain receipts by railway, grain wagons, hopper car, timekeeping, uneven coefficients.*

Formulation of the problem

The development of the global crisis, as well as Ukraine's entry into the World Trade Organization, caused a need for a search for ways to improve the quality and volume of export of grain and food products. Ukraine accounts for 8.7 % of the world's area of black soil [1], which allows it to solve this problem. Already today Ukraine occupies a worthy place among world grain exporters.

In the future, in Ukraine it is planned to increase the sown area for cereals, legumes and oilseeds, to expand the gross grain harvest to 80 million tons, and to enlarge its export abroad in two times. Such a forecast makes the burning issue of a building new, as well as a reconstructing and expanding existing grain receiving enterprises (GRE) and elevators for various purposes, which are operated for 30 years or more.

However, the intensive construction in the southern ports of Ukraine of grain transshipment terminals with large-capacity metal silos will only solve the problem of exporting grain, which has been put in perspective, but not its post-harvest processing. Most of terminals receive the dry food grain from automobile and railway transport according to its commodity classification, such that it has already passed the post-harvest processing.

The total capacity of granaries in Ukraine, according to experts, is at least 35 million tons. Elevators

account for about 40 % of the total grain storage capacity or 14 million tons of one-time storage. In the overall structure of the elevator industry, one tenth of all volumes of one-time grain storage is related to port capacities (approximately 3,500,000 tons). At the same time, port capacities for one-time storage of 200 thousand tons of grain are in state ownership (at Odessa and Nikolaev port elevators). A number of investors who entered the Ukrainian grain market began their own construction of the production facilities. Modern highly mechanized port elevators and terminals were built, the vast majority of which were metal silos only, oriented to export operations. Now in Ukraine more than 40 elevators of this type with a capacity of 15 to 200 thousand tons of one-time storage have been commissioned. The bulk of the grain goes to these elevators by railway, and is shipped to water transport [2].

The grain industry of Ukraine over the past decade has significantly increased exports. In the 2013/2014 marketing year (MY), it amounted to more than 30 million tons, which allowed to surpass Canada, Brazil, Argentina and enter the top three leading world grain exporters with the USA and the EU [3]. In the marketing season 2015-2016, Ukraine has exported 39.4 million tons of grains, which is 13 % more than during the previous 2014-2015 MY [4]. Over the past 10 years, Ukraine has record growth in grain exports up to 56.7 million tons in 2019, which is 4 times higher than grain exports in 2010 [5]. According to experts, by 2022 the volume of the grain production in Ukraine will increase to 100 million tons, and exports will reach 70 million tons [6]. Therefore, for further development of grain exports abroad, it is absolutely necessary to pay particular attention to grain terminals — to increase the efficiency of existing ones and to build modern new ones.

The purpose and objectives of the study

The purpose of the research was to study the characteristics of grain receiving from the railway transport to the grain transshipment terminal, which will improve its efficiency.

To accomplish this, the following tasks were required:

– to investigate the quantitative and qualitative characteristics of crops coming to the terminal;

– to conduct timing of the process of unloading grain from the railway and to determine the actual duration of unloading of hopper cars (hopper wagons);

– to determine the average daily actual productivity of grain reception by the railway and the coefficients of daily and monthly irregularity of grain intake for the studied period.

Object and subject of research

The object of the study was the development of technology of grain receiving at a new transshipment terminal; *the subject of research* was cereals, legumes and oilseeds grain, as well as data from daily intake operations at the grain transshipment terminal of LLC "Ukrelevatorprom" for two calendar years from January 1, 2015 to December 31, 2016.

The terminal was built as a modern enterprise; it is equipped with the latest technology. Part of the territory was created artificially, as is customary in the world practice of building elevators located on the seashore and where ships have recently moored, now unload wagons. The work of two sections that receive grain from road and railway transport provides high productivity — 120 hopper wagons (8400 tons of grain) and 200 hopper trucks (5000 tons of grain) per day.

Research methods

To determine the patterns of the quantitative and qualitative grain inflow to the terminal from the railway transport, the statistical material was collected, in which there was a summed amount of grain (net) daily transported by railway, it was based on the analysis and processing of data from consignment notes for 2015-2016. Summary results were entered in the table for each year of the grain receiving. Further analysis was carried out using the construction and analysis of histograms and graphs constructed on the basis of statistical data of the enterprise for the period from 01/01/2015 to 12/31/2016. When conducting research, methodological guidelines were used, which were developed at the Department of Grain Storage Technology of Odessa National Academy of Food Technologies [7].

To carry out timekeeping of the elevator's external work in unloading grain-carrier hopper wagons (hopper cars), a number of successive steps were identified: installing a feed wagon at the "point" for unloading it, removing fillings from loading hatches, taking the grain samples from the wagon, performing analyzes and providing an enable signal for unloading grain from the wagon, removing seals from hatches under the wagon, opening latches under them, hanging panels of grain from the wagon and cleaning the wagon, closing the latches of hatches, cleaning the wagon from the "point" un-loaded. Timing of the unloading of the wagon was carried out by the method of "current time", that is, fixing the time of the beginning and end of the each stage. The duration of the each stage was determined as the average value from the results of unloading at least 10 hopper wagons.

Processing of the obtained tabular data was carried out by a combined graphoanalytic method, for which, on the basis of the tabular values of the daily grain supply for each studied year, histograms and graphs were constructed that gave a visual representation of the patterns of grain supply.

The unevenness coefficients of daily K_{daily} and monthly K_{month} of grain supply to the enterprise by railway were determined in the following sequence.

The average monthly and average daily grain supply for a particular year was calculated by the formulas:

$$A_{\text{aver.month}} = A_{\text{total.annual}} / P_{\text{m}} \quad (1)$$

$$A_{\text{annual.day}} = A_{\text{total.annual}} / P_{\text{d}}, \quad (2)$$

where $A_{\text{aver.month}}$, $A_{\text{aver.daily}}$ — average monthly and average daily volumes of grain supply, t/month, t/day;

$A_{\text{total.annual}}$ — total annual grain supply, t;

P_{m}, P_{d} — summer periods of grain receipt at the enterprise, months, days.

Further, from the total annual period of grain supply, three months of intense (maximum) grain supply

were selected. For each of these months, three days of maximum grain supplywere also chosen. According to the data obtained, the maximum average monthly and average daily values of grain supply for each year were calculated according to the formulas:

$$A^{3\,max}_{aver.month} = A_{3month}/n\,; \quad (3)$$

$$A^{3\,max}_{aver.day} = A_{3\,day}/n\,, \quad (4)$$

where $A^{3\,max}_{aver.month}$, $A^{3\,max}_{aver.day}$ —maximum monthly and average daily grain supply, t/month, t/day;

A_{3month}, A_{3day} — the total amount of grain supply in accordance with 3 months and 3 days of its maximum receipt, t/month, t/day;

n — the number of days of maximum grain supply (respectively n = 3 months or days).

The coefficients of monthly and daily irregularities in the supply of grain were determined by the formulas:

$$K_{month} = A^{3\,max}_{aver.month}/A_{aver.month}\,, \quad (5)$$

$$K_{daily} = A^{3\,max}_{aver.daily}/A_{aver.daily}\,, \quad (6)$$

where $A_{aver.month}$, $A_{aver.daily}$ — average monthly and average daily grain supply for a particular year, t/month, t/day.

Research results

At the first stage of the study, the quantitative and qualitative composition of grain that was supplied by railway to LLC "Ukrelevatorprom" from 01/01/15 to 12/31/16 was analyzed. The results are presented in the form of histograms that show the distribution of volumes individual crops have been studied for years, as well as their ratio according to the main groups of crops (Fig. 1).

After analyzing the histograms of the grain receipt of various crop groups by railway at LLC "Ukrelevatorprom" for 2015-2016 (Fig. 1), it can be noted that the main share of revenue in 2015 and 2016 was occupied by cereals — 78.0 % and 73.1 % respectively (a decrease of almost 5 %). Further, according to the annual supply, there were oilseeds (rapeseed 1 and the highest class were 19.1 % and 14.9 %, respectively). Least of all the company received legumes (soybeans) — 2.9 % and 12.0 %, although it is clear that soybean receipts in 2016 increased by 9.1 % (more than 3 times). A significant share of the reception and, consequently, the subsequent export of cereals can be explained by their high demand in the international grain market, in which Ukraine occupies a leading position.

If we consider the supply of individual crops at the enterprise, it can be seen (Fig. 1) that cereals in 2015 and 2016 were mainly represented by corn grain, the share of which was significantly dominated by other crops (wheat of different classes and barley) and amounted to 45.8 % and 44.5 % respectively.

Second place of volumes of supply after corn in 2015-2016 consistently occupied class 3 wheat (15.7 % and 12.3 %, respectively), and together with other classes, wheat occupied 26.2 % and 21.2 % over the years, respectively. As for wheat of other classes, their supply was significantly less (in %, respectively, in 2015 and 2016): 6 classes — 6.4 % and 5.3 %; 2 classes — 2.4 % and 2.3 %; classes 1 and 4 of wheat were in the range of 0…0.2 % (and in 2016 there was no class 4 wheat at all). Another cereal crop, barley, in those years occupied 6.0 % and 7.5 % of the total grain supply by railway, respectively.

At the next stage of the study, the unloading of wagons with grain of different crops was timed, the results of which are shown in Fig. 2. It can be seen that the longest operation with the unloading of wagons is the analysis to determine the quality of rapeseeds, which lasts 28.2 minutes and differs significantly from the analysis for other crops (corn, wheat and barley), which last much less — 4.6...9.1 minutes, moreover, twice as much time is spent on wheat (9.1 minutes) than on corn and barley (4.6...4.8 minutes).

It is known that the determination of grain quality indicators can take different times — it all depends on the culture, its quality, the methods used to equip the laboratory with instruments, and the human factor etc. If, for example, a grain sample has an increased moisture content that does not meet the requirements of the standard, then the moisture content must be determined by the standard method using an oven, not an express analyzer, which significantly prolongs the analysis time. When the grain will have a high content of weed impurities, then, for example, for rapeseed, the duration of determining the clogging will be much longer. Crops such as corn and soybeans can have an increased amount of damaged or spoiled grains, and then you need to have extra time to cut a significant amount of grains for analysis. When taking wheat grains, it is necessary to determine the quantity and quality of gluten. This is usually done using express analysis, but if necessary, more accurate results are done according to GOST 13586.1-68 "Grain. Meth-

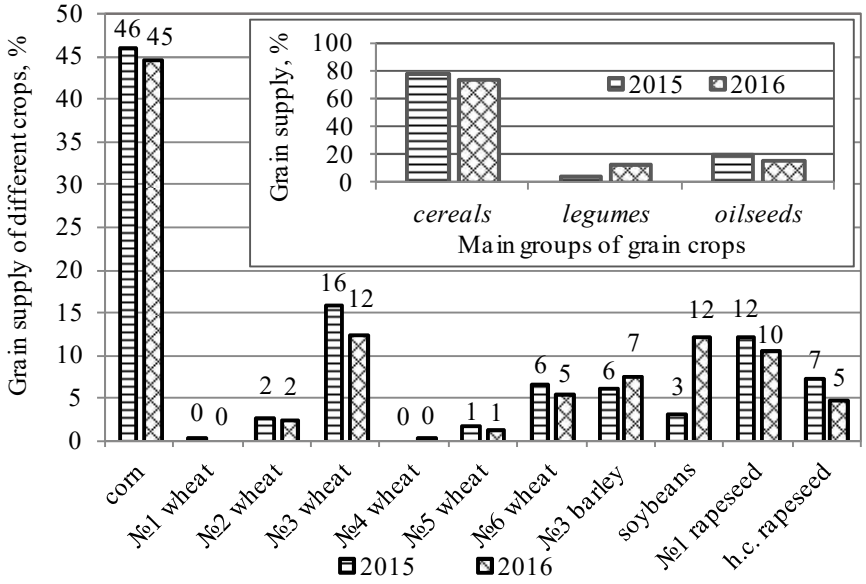

Fig. 1 – Histograms of the distribution of the crops supply by railway and their ratio by crop groups

ods for determining the quantity and quality of gluten in wheat", it is much longer by the manual method. Some crops (rapeseed, soybeans) in addition to the main quality indicators require checking for the presence of GMOs, it can take more than 20 minutes.

The second-longest operation is the grain unloading from wagons, which lasts 16...21 minutes depending on the crop, with rapeseed falling faster and corn lasting longer, due to their physicomechanical properties, primarily flowability.

Third in duration is sampling to determine grain quality indicators, which takes 6.4...7.2 minutes. The initial operation (installation of the wagon) and the final (cleaning grain from the unloading point) take 3.2...5.0 minutes. It takes a little time to open the gate valves — 1.5...3.7 minutes, and the short operation is to remove the seals — 0.7...1.1 minutes.

Thus, the timing showed that to increase the volume of grain acceptance, the most bottleneck is the duration of determining the grain quality. Despite a significant portion of the wheat grain supply, it is also advisable to reduce almost twice the duration of the analysis of its quality indicators — by improving the organization of analysis and the use of modern express devices.

Despite the considerable duration of the unloading of grain from the wagon, it is practically impossible to significantly reduce it, because it is determined by the flowability of the grain, which in turn depends on many factors — crop, its moisture content, shape and condition of the grain surface, and others that cannot be influenced.

There is little potential in reducing the operations of installing and cleaning hopper cars (wagons), removing seals and opening hatches, the duration of which is determined primarily by the human factor and weather conditions, but their share in the total duration of unloading hopper wagons is very small.

Using the results of the timing, it is possible to determine the total duration of unloading of the one wagon with grain of different crops entering the enterprise. Considering that the enterprise has 2 receiving streams of grain recepion from the railway, then 4 hopper wagons can be unloaded on them at the same time. Then, it is possible to assess the potential of the enterprise to receive grain of various crops by railway. The results of the calculations are shown in table 1.

The actual monthly number of grain hopper cars (hopper wagons) unloaded in 2015-2016 during the above-mentioned months of maximum grain intake was respectively 3422… 3491 and 2744… 3016 items.

Thus, the enterprise has the potential to receive and unload significantly more carloads and, accordingly, increase grain exports by about 30 %.

Table 1 – Summary calculations from the timing of unloading hopper wagons with different crops

Crops	Duration of unloading of the one hopper wagon, minutes			The number of hopper wagons that can be unloaded, items	
	minimum	maximum	average	for day	for month
Corn	35.6	39.5	37.5	154	4608
Wheat	40.7	45.6	43.1	134	4009
Barley	37.1	38.5	37.8	152	4571
Rapeseed	56.8	61.9	58.9	98	2934

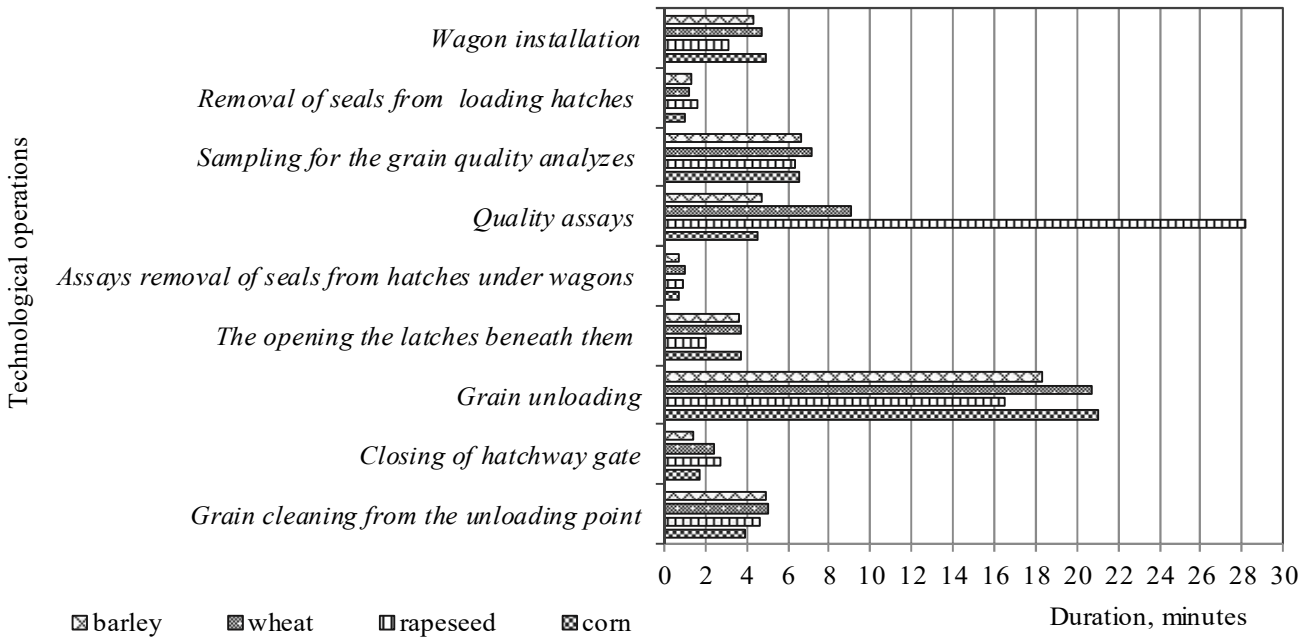

Fig. 2 – Histograms of the duration of individual technological operations when unloading wagons with grain of different crops

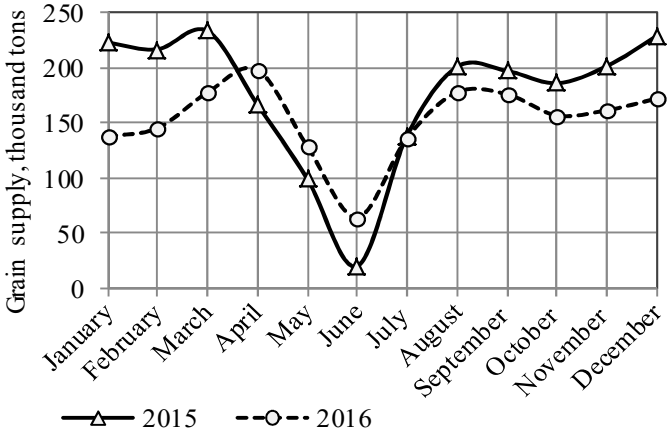

Fig. 3 – Grain volumes supplied to the enterprise by rail in 2015-2016

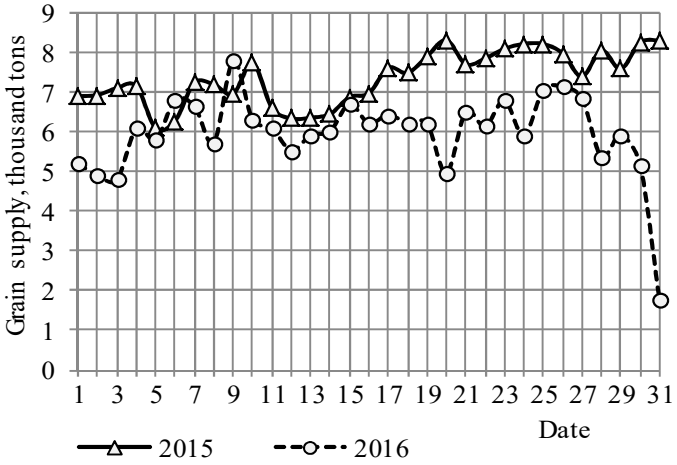

Fig. 4 – Dynamics of the averaged (for the busiest 3 months of work) daily grain supply by railway

Next, studies were carried out on the total grain volumes that arrived at Section 1 by railway during 2015-2016, the results of which are shown in Fig. 3, it clearly shows the monthly distribution of grain volumes over the years studied. From the graphs it can be seen that the volume of grain receipts by railway in 2015 was more than in 2016.

Further, for each year studied, based on the analysis of monthly grain receipts, the 3 most intense months of grain intake were determined.

The analysis of these graphs showed the following: January, March and December were the busiest months of grain receiving, with the largest volumes of its arrival at the railway company in 2015 and April, August and September in 2016; the smallest volumes of grain inflow were observed in 2015 — in May, June and July, and in 2016 — in January, May and June.

Studies also showed that the pattern of the monthly distribution of hopper wagons that delivered grain in the 2015-2016 study fully coincides with the pattern of the receipt of grain volumes, which is shown in Fig. 3, because the volume of grain is directly proportional to the number of hopper cars, if you do not take into account minor fluctuations in their carrying capacity.

So, the largest number of hopper cars (wagons) arrived at the enterprise in 2015, in particular, the busiest months of their reception were (items): in January 3422, March — 3491 and December —3460. In 2016, more hopper cars arrived (items): in April — 3016, August — 2744 and September — 2744 items.

Based on the above data of the 3 months of the most intense grain supply, the average daily maximum grain inflows for both years studied were determined. Using the data obtained, graphs were constructed (Fig. 4), they give a visual representation of the flow dynamics of the average daily intake of grain by railway over the months of 2015-2016. From the above graphs, it is seen that in the month of maximum volumes of supply, the grain was received quite unevenly. Fluctuations in the volumes of grain supply on the most stressful 3 days in 2015 were in the range of 6099...8317 tons, and in 2016 it amounted to 4802...7795 tons (excluding the anomalous August 31, when only 1758 tons of grain arrived).

A characteristic of fluctuations in the volume of grain supply both daily and monthly is usually the unevenness coefficient. Their actual values should be taken into account when analyzing the work, designing or reconstructing the enterprise, in particular, when substantiating the necessary performance of the transport and technological equipment for grain receiving lines, ensuring uninterrupted reception and processing of grain arriving at the terminal.

Using the method described above, we determined the coefficients of daily and monthly unevenness of the grain supply to the grain terminal in 2015-2016. The obtained calculation results are given in table. 2.

As can be seen from the data obtained, the coefficients of the daily and monthly irregularities in the flow of grain to the grain terminal do not exceed the normative (literary) values.

At the final stage, the average daily actual productivity of the receiving station from the railway in the busiest months of grain inflow was calculated, which amounted to 301 t/h in 2015 and 247 t/h in 2016, in contrast to the passport capacity of 500 t/h. Thus, the company has the technical capabilities to increase the volume of the grain reception from the railway and, accordingly, the grain export.

Conclusions

1. Analysis of the structure of grain crops supplied by LLC "Ukrelevatorprom" for 2015-2016 by railway and their ratio have showed that the main share was occupied by cereals (78.0 % and 73.1 %, respectively), which were represented in mainly corn, whose share was significantly dominated by other crops (wheat of the different classes and barley) and amounted to 45.8 % and 44.5 % in 2015 and 2016, respectively, which can be explained by its high demand in the international grain market, in which Ukraine occupies a leading position. Oilseeds (rapeseed 1 and highest classes) were received 19.1 % and 14.9 %, and legumes (soybeans) — 2.9 % and 12.0 % respectively.

2. An analysis of the timing of the unloading of grain wagons (hoppers cars) showed that the total duration of this process, depending on the crops, averages 37...59 minutes. The longest stages of unloaded wagons are the determination of grain quality indicators, especially rapeseed, and the precipitation of grain from wagons, therefore, to reduce their duration, it is necessary to

Table2 – The results of the study of the grain supplyby railway to the grain terminal

Name of indicators	Experimental data		Regulatory data [8]
	2015 year	2016 year	
The annual period of the grain supply, P_r, days	349	353	–
The total amount of the annual grain supply, $A_{total.annual}$, t	2066116	1821567	
The average daily grain supply, $A_{average.day}$, t/day	5920	5160	
Maximum daily average grain supply, $A_{aver.day}^{3\,max}$, t/day	8699	7864	
Average monthly amount of grain supply, $A_{aver.month}$, t/month	172176	151797	
Maximum average monthly grain supply, $A_{aver.month}^{3\,max}$, t/month.	228304	183878	
Coefficient of daily irregularity, K_{daily}	1.47	1.52	2.5
Coefficient of monthly irregularity, K_{month}	1.33	1.21	2.0

pre-form the supply of wagons with identical grain batches and use more advanced express analyzers to determine the grain quality indicators, this will increase the productivity of the grain receiving line from the railway. Now the enterprise has the potential to take and unload significantly more wagons and, accordingly, to increase grain exports by about 30 %.

3. It was established that the periods of grain receipt at the enterprise in 2015-2016 were 349 and 353 days, respectively, the actual coefficients of daily irregularity K_{daily} for the receipt of the grain by railway transport was 1.47 and 1.52 in these years, respectively, and the monthly irregularity K_{month}, respectively was 1.33 and 1.21, it does not exceed the standard values K_{daily}= 2.5 and K_{month}= 2.0. This made it possible to clarify the database from the actual characteristics of the process of the grain receiving by railway, and perhaps the design and verification calculations of the equipment in the technological lines for the receiving grain from railway transport will contribute to increasing the efficiency of the grain transshipment terminals.

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ДОСЛІДЖЕННЯ ХАРАКТЕРИСТИК ПРИЙМАННЯ ЗЕРНА ІЗ ЗАЛІЗНИЧНОГО ТРАНСПОРТУ НА ЗЕРНОВИЙ ПЕРЕВАНТАЖУВАЛЬНИЙ ТЕРМІНАЛ

Анотація

У перспективі в Україні планується збільшити посівні площі під злаковими, бобовими і олійними культурами, збільшити валовий збір зерна до 80 млн. тонн, а його експорт за кордон — удвічі. Інтенсивне будівництво в південних портах України зернових перевантажувальних терміналів з металевими силосами великої місткості дозволить вирішити завдання збільшення у перспективі експорту зерна. На ці потужні термінали основна маса зерна надходить переважно залізничним транспортом, а відвантажується на водний.

Метою роботи було дослідження характеристик приймання зерна із залізничного транспорту на зерновий перевантажувальний термінал ТОВ «Укрелеваторпром», що дозволить підвищити ефективність його роботи. Об'єктом дослідження була технологія приймання зерна на зерновому перевантажувальному терміналі; предметом досліджень – злакові, бобові та олійні культури, а також дані з добових об'ємів приймально-відпускних операцій на зерновому перевантажувальному терміналі ТОВ «Укрелеваторпром» за 2015–2016 рр.

Дослідження проводили на підставі обробки даних журналів накладних за 2015–2016 рр., за якими була підсумована кількість щодобово перевезеного залізницею зерна (нетто). Подальшу обробку отриманих даних проводили комбінованим графоаналітичним методом, для чого на основі табличних значень для кожного дослідженого року будували відповідні гістограми і графіки та визначали необхідні показники.

Аналіз структури зернових культур, що надходили залізничним транспортом на ТОВ «Укрелеваторпром» за 2015 і 2016 роки та їх співвідношення показали, що основну частку займали злакові культури (78,0 % та 73,1 % відповідно), які були представлені в основному зерном кукурудзи, частка якої значно переважала інші зернові культури (пшеницю різних класів та ячмінь) та складала відповідно 45,8 % і 44,5 %, що можна пояснити її високим попитом на міжнародному ринку зернових, у якому Україна займає провідні позиції. Олійних культур (ріпаку) було прийнято відповідно 19,1 % та 14,9 %, а бобових (сої) — 2,9 % та 12,0 %.

Аналіз результатів хронометражу вивантаження вагонів-зерновозів показав, що загальна тривалість цього процесу залежності від культур складає в середньому 37…59 хв. Найбільш тривалими етапами при вивантажені вагонів є визначення показників якості зерна, особливо ріпаку, та висипання зерна з вагонів, тому для зменшення їх тривалості необхідно попередньо формувати подачі вагонів з однаковими за якістю партіями зерна та використовувати більш сучасні експрес-аналізатори для визначення показників якості зерна, що дозволить збільшити продуктивність лінії приймання зерна із залізниці. За результатами досліджень у підприємства є потенційна можливість збільшення приблизно на 30 % обсягів приймання зерна.

Встановлено, що періоди надходження зерна на підприємство у 2015–2016 рр. склали відповідно349 та 353 діб, фактичні коефіцієнти добової нерівномірності $K_{доб}$ надходження зерна із залізниці у ці роки дорівнюють відповідно1,47 та 1,52, а місячної нерівномірності $K_{міс}$ відповідно 1,33 та 1,21, що не перевищує нормативних значень $K_{доб}$ = 2,5 та $K_{міс}$ = 2,0. Це дозволило уточнити базу даних з фактичних характеристик процесу приймання зерна залізницею та може бути використано при проектних і перевірочних розрахунках обладнання у технологічних лініях приймання зерна з залізничного транспорту, що сприятиме підвищенню ефективності роботи зернових перевантажувальних терміналів.

Ключові слова: *зернові культури, надходження зерна залізницею, вагони-зерновози, вагони-хопера, хронометраж, коефіцієнти нерівномірності.*

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