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EXAMINING THE EFFECT OF PRODUCTION CONDITIONS AT TERRITORIAL LOGISTIC SYSTEMS OF MILK HARVESTING ON THE PARAMETERS OF A FLEET OF SPECIALIZED ROAD TANKS

A. Tryhuba
Doctor of Technical Sciences, Professor, Head of Department
Department of Information Systems and Technologies
Lviv National Agrarian University
V. Velykoho str., 1, Dublyany, Zhovkva district, Lviv region, Ukraine, 80381
E-mail: trianamik@gmail.com

O. Zachko
Doctor of Technical Sciences, Professor
Department of law and management in the field of civil protection
Lviv State University of Life Safety
Kleparivska str., 35, Lviv, Ukraine, 79007
E-mail: zachko@ukr.net

V. Grabovets
PhD, Associate Professor*
E-mail: vgrabovets@ukr.net

O. Berladyn
PhD*
E-mail: ola.lutzk@hotmail.co.uk

I. Pavlova
PhD, Associate Professor*
E-mail: Iruna_Pavlova@ukr.net

M. Rudynets
PhD, Associate Professor
Department of Tourism and Civil Security**
E-mail: rudinetc@meta.ua

*Department of cars and transportation technologies**
**Lutsk National Technical University
Lvivska str., 75, Lutsk, Ukraine, 43018

Проведено дослідження впливу мінливих виробничих умов та складових транспортних процесів на потребу у спеціалізованих автомобілях для систем заготівлі молока. На підставі прогнозування добових обсягів заготівлі молока від сімейних молочних ферм встановлено, що існує два періоди надходження молока впродовж календарного року – інтенсивний (з травня до вересня) та неінтенсивний (інші місяці). На підставі хронометрування транспортних процесів із використанням автоцистерн Hyundai HD-65 STD+Г6-ОТА-3,9 виконані виробничі експерименти. Встановлено, що тривалості транспортних операцій описуються законом розподілу Вейбулла. Питомі тривалості завантаження автоцистерн Hyundai HD-65 STD+Г6-ОТА-3,9 у сімейних молочних фермах та їх розвантаження у переробному цеху мають математичне сподівання відповідно 0,92 та 0,52 год/тону молока, а їх середньоквадратичне відхилення – 0,018 та 0,008 год/тону молока.

На прикладі виробничих умов Бродівського району Львівської області проведено імітаційне моделювання транспортних процесів доставки молока від виробників до переробного цеху із врахуванням мінливих виробничих умов та складових транспортних процесів. Встановлено, що зі зростанням добового обсягу заготівлі молока від 6 до 66 тонн/добу, зростають оцінки математичного сподівання сумарної добової кількості виконаних маршрутів автоцистернами Hyundai HD-65 STD+Г6-ОТА-3,9 за лінійною залежністю. Пробіг цих автоцистерн та тривалість їх використання, зі зростання добового обсягу заготівлі молока, зростають за поліноміальними залежностями другого ступеня. Вантажообіг змінюється частково дискретно від 820 до 4610 т·км, що зумовлено зміною технологічно потребої кількості автоцистерн.

Встановлено, що потреба у спеціалізованих автомобілях Hyundai Hyundai HD-65 STD+Г6-ОТА-3,9 впродовж календарного року змінюється від 1 до 4 одиниць. Із січня по березень та із жовтня по грудень окремого календарного року слід організовувати виконання транспортних процесів у одну зміну, а із квітня по вересень у дві зміни. Отримані розподіли мінливих складових виробничих умов і транспортних процесів, а також залежності показників використання автоцистерн від обсягів заготівлі молока, лежать в основі створення інформаційної системи підтримки прийняття рішень у логістичних системах заготівлі молока. Також вони є основою планування роботи парку спеціалізованих автомобілів та проектування логістичних систем заготівлі молока

Ключові слова: ефективні управлінські рішення, оптимальне управління, логістичні системи, заготівля молока, парк автомобілів

1. Introduction

At present, Ukraine faces the unresolved problem of food security. When this country joined the World Trade Organization, the problem has become more pressing because the produced raw materials mostly fail to meet the requirements of EU legislation. Specifically, this concerns the production and procurement of milk, which belongs to perishable products and has specific requirements to its harvesting. At the same time, these requirements lead to a change in the systems of milk production. Small-scale privately-owned farms that produce more than 80 % of the total milk production in Ukraine do not ensure the quality regulated by the EU standards. They are forced to cooperate in order to form family dairy farms. To this end, the State has developed a number of programs that promote such efforts of milk producers. At the same time, neglected are the logistic systems of milk harvesting at the territory of separate administrative districts, whose parameters greatly affect quality of the raw milk for the production of dairy products.

To create efficient logistics systems for milk harvesting at the territory of separate administrative districts, it is necessary to apply specific methods and models. Such methods and models must take into consideration both the features of production conditions for milk harvesting (the presence of family dairy farms, geographical location, condition of the road network, etc.) and its seasonality. This largely defines the parameters for the fleet of specialized vehicles (SV) milk harvesting, as well as the modes of their operation over a calendar year.

2. Literature review and problem statement

Paper [1] proposed an approach for planning the operation of a fleet of vehicles when servicing sea ports. Studies [2–5] address the improvement of efficiency of a fleet of vehicles based on different criteria (cost, impact on the environment, etc.). Works [6–8] take into consideration special features of using freight vehicles during cargo transportation. However, applying the reported research results in order to define parameters for a fleet of specialized vehicles employed in logistics systems of milk harvesting (LSMH) is impossible, because they do not imply the use of quality criteria for the delivered cargo, as well as the time, which are characteristic of perishable cargoes that include milk.

It is proposed in papers [9–11], in order to define the indicators of employing freight vehicles, to model the use of these vehicles. The above methods and models imply specifying the deterministic indicators for the use of vehicles. It is not possible to apply the obtained research results for LSMH as they fail to take into consideration the changing volumes of milk harvesting over a calendar year, as well as conditions and peculiarities in the execution of transport operations.

Papers [12–14] propose to substantiate the need for vehicles taking into consideration the changing volumes of cargo transportation, and, as suggested in articles [15–17], taking into consideration the associated risk. However, the application of results, reported in these works, in order to substantiate the SV parameters for LSMH is impossible, due to the fact that they do not take into consideration the specific operational conditions for transportation processes in these systems. Specifically, they do not account for the peculiarities in the production conditions of milk harvesting that are specific for each administrative district of the state. In addition, they do not consider the seasonality of milk production and, accordingly, its harvesting, which greatly affect the efficiency of transportation processes [18, 19] and the quality of the delivered milk [20].

The adequate forecasting of production conditions and the representation of transportation processes in LSMH is only possible based on modeling [21, 22]. That requires undertaking a special research [20]. It is impossible, in the case of underestimation of production conditions that are specific for each administrative territory, and without forecasting the seasonality of milk harvesting and the indicators of transportation processes, to adequately substantiate the effective parameters for a fleet of specialized vehicles (SV) in the respective logistics systems.

Scientific papers [23–25] partially consider production conditions of milk harvesting and prediction of its volumes. However, they address the procurement of milk from small-scale individual households [26, 27], which does not adequately represent conditions for milk harvesting from family dairy farms. In addition, they did not take into consideration the possibility to model transportation processes for each of the periods in the seasonal milk harvesting, which makes it impossible to adequately substantiate the parameters for a fleet of SV in LSMH.

The need in SVs for territorial LSMH is characterized by their number and the predefined brand, in order to ensure the delivery of the total amount of milk to dairy plants. The need ine SV is affected by the production conditions in LSMH and the duration of implementation of transportation operations that change over a calendar year.

It is possible to explore the impact of changing production conditions over a calendar year on the need in SV for LSMH based on forecasting the volume of transportation operations to be performed. To this end, it is required to carry out a simulation modeling of transportation processes for each season in milk harvesting. Based on the simulation modeling, the trends in the change of indicators for using SV are established, and the need in them is determined for each of the periods in the season of milk harvesting [25].

Consider the peculiarities of territorial LSMH. They are characterized by changing production conditions that predetermine the changing need in SV over a calendar year. The characteristics of production conditions include the changing daily volumes of milk harvesting from each family dairy farm and the durations of periods during which these volumes remain constant. They predetermine the changing annual volume of transportation operations within LSMH. There is also a limited duration of transportation operations in LSMH. It depends on the technological requirements for milk harvesting that are regulated by the acting standards [25–27].

There is a set of family dairy farms within separate administrative territories, each of which has a daily output of milk production. The geographical location of these farms and the duration of operations related to loading and issuing forwarding documents affect the need in SV and the organizational modes of their utilization. Specifically, work of SV in LSMH can be performed over a single or several shifts. In this case, for the assigned production conditions and the makes of SV used, there is always the optimal organizational mode for transportation operations [25].

All the above-specified indicates that the efficiency of using SV within LSMH depends on the following components:

$$E_{SV} = f\left(N_o, \xi, \lambda, O, P, Z\right), \qquad (1)$$

where E_{SV} is the efficiency of using SV for LSMH over a particular period during the season of milk harvesting; N_o is the number of family dairy farms within LSMH; ξ is the geographical location of family dairy farms within an administrative territory; λ is the intensity of milk delivery from family dairy farms; O is the organizational mode of transportation operations; P are the acting regulations for harvesting and transportation of milk; Z are the parameters for a fleet of SV.

All components from expression (1) are interconnected; relations between them should be considered in models and methods that are used to substantiate the parameters for a fleet of SV in LSMH. These relationships could be elucidated only based on the simulation modeling of SV operation within LSMH.

The availability and geographical location of family dairy farms within territorial LSMH are substantiated based on known method [27]. The resulting information, as well as the topographic map of LSMH territory, are the basis for determining distances between the family dairy farms and a milk processing plant. The acquired data are entered to symmetrical matrix ξ of the shortest distances between the family dairy farms within a territorial LSMH, of dimensionality $N_o+1 \times N_o+1$:

$$\xi = \begin{bmatrix} 0 & L_{12} & L_{13} & \dots & L_{1n} \\ & 0 & L_{23} & \dots & L_{2n} \\ & & 0 & \dots & L_{3n} \\ & & & \dots & \dots \\ & & & & 0 \end{bmatrix}, \qquad (2)$$

where N_o is number of family dairy farms within a territorial LSMH, units; L_{1n} – is the distance between the first and the n-th family dairy farm, km.

In a given matrix (4), number one is assigned to the processing plant, other numbers – to family dairy farms in the increasing order of distances from them to the processing plant.

The volume Q_{dtn} of milk harvesting within the assigned territory of LSMH on the j-th t-th day during a season is derived from formula:

$$Q_{dtn} = \sum_{x=1}^{N_0} Q_{dxj}, \qquad (3)$$

where Q_{dxj} is the amount of milk harvesting from the x-th family dairy farm on the j-th day, t; N_o is the number of family dairy farms within the territory of LSMH, units.

The volumes Q_{dxj} of milk harvesting from the x-th family dairy farms on the j-day during a season of harvesting are forecast based on known technique [25]. The durations of operations in the transportation processes of LSMH are determined based on the production observation that implies timekeeping [18].

To study the influence of production conditions at territorial LSMH on the parameters of SV fleet taking into consideration the changing volumes of transportation operations over a calendar year, we apply the developed simulation model of milk production management, which includes a set of interrelated technical-technological and organizational-technical subsystems, each of which adds value [26]. The proposed simulation model is composed of the following modules:

1) compilation of initial data for modelling;

2) simulation at the level of specific processes and determining the functional indicators for SV along separate routes;

3) modelling at the generalized level and determining the systemic functional indicators for SV.

The result of simulation modeling of transportation processes is the determined rational delivery routes based on known method [20]. This method provides for the selection of routes to transport milk from family dairy farms to the processing plant based on three major rules that take into consideration effectiveness E_{CA} of using SV within LSMH and the fund of a working SV regulated by the acting standards. That makes it possible to identify such indicators of using SV for LSMH as the distance $L_{\mu j}$ traveled along the μ-th route on the j-th day of milk harvesting, the duration $t_{\mu j}$ taken to travel along μ routes, the freight turnover $W_{\mu j}$ on μ routes.

The specified parameters make it possible to determine the required number N_{rj} of SV of the predefined make for the j-th day during a milk harvesting season:

$$N_{rj} = \frac{\sum_{\mu=1}^{n_\mu} t_{\mu j}}{[t_\partial]}, \text{ units,} \qquad (4)$$

where $t_{\mu j}$ is the time taken by SV to travel the μ-th route on the j-th day during a milk harvesting season, h; $[t_\partial]$ is the regulated duration of SV operation during day j, h; n_μ is the number of routes traveled by SV on the j-th day, pieces.

The results obtained from determining the required number (N_{rj}) of SV of the predefined make for j days during a milk harvesting season underlie the graph demonstrating the need in them (Fig. 1).

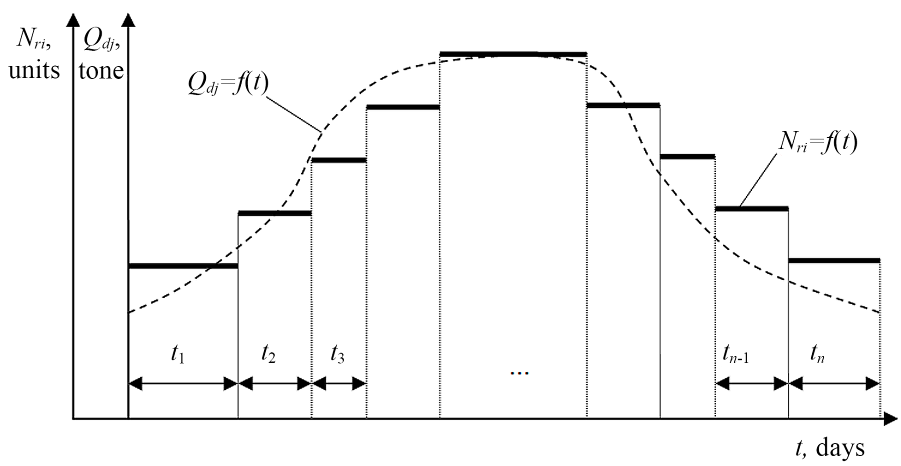

Fig. 1. Trends in a change in the need in SVs (N_{rj}) of the predefined make over a milk harvesting season and the durations (t_n) of periods with a constant need in them: Q_{dj} – daily volume of milk harvesting within a territorial LSMH; t_1, t_2,..., t_n – duration of the 1st, 2nd, and n-th period of milk harvesting

The number of periods (n_n) with a constant need in SV during a separate season of milk harvesting, and their duration (t_n), depend on:

$$t_n(n_n) = f(Q_{dj}, q_r), \qquad (5)$$

where Q_{dj} is the daily volume of milk harvesting within a territorial LSMH, t; q_r is the load capacity of SV, t.

With respect to the stated earlier, one can argue about the possibility to objectively determine the need in CA, as well the modes of their use, based on taking into consideration the changing patterns in production conditions within LSMH. To this end, it is necessary to predict the changing volumes of milk harvesting over a calendar year and to model transportation processes for each period during a milk harvesting season. That would enhance the accuracy of determining the indicators for using SV in LSMH. In order to investigate the influence of changing production conditions on the need in SV, one should use a database that is compiled from different sources. These include: territorial maps (Google maps geodata), volumes of milk production at the territory of LSMH, chronometric data on the duration of transportation operations (speedometers' readings, time taken to perform individual operations, statistical data form forwarding documents), reported data on the availability of freight vehicles in LSMH.

3. The aim and objectives of the study

The aim of this work is to investigate the impact of the changing characteristics of production conditions and the components of transportation processes on the need and the modes of using SV for LSMH.

To accomplish the aim, the following tasks have been set:

– to explore the changing production conditions during milk harvesting and the duration of execution of certain transportation operations;

– to define the indicators for using SV with respect to the changing production conditions during milk harvesting and the duration of execution of transportation operations;

– to substantiate the need in SV and the modes of their utilization over a calendar year.

4. Results of investigating the changing production conditions during milk harvesting and the duration of execution of separate transportation operations

We investigated production conditions during milk harvesting using the example of LSMH, which is limited to the territory of the Brodivskyi Region, Lviv Oblast, Ukraine. The processing plant is in the town of Brody, which is a structural subdivision of PAT "Brodivskyi ZSZM". Based on official documents from PAT "Brodivskyi ZSZM", it was found that the Brodivskyi Region has 24 communities hosting the family dairy farms that produce milk. They are shown in the diagram of the territorial LSMH in Fig. 2.

The family-owned dairy farms, which are located at the territory of separate communities of the territorial LSMH are assigned the numbers, starting with two, in the order of increasing distances from them to the processing plant. Given the data on the existence and territorial location of family dairy farms in Brodivskyi Region, and using the geodata from Google maps for this administrative region, we determined distances between the settlements hosting the family dairy farms.

Based on known procedure [20], we predicted a daily volume of milk harvesting from the family dairy farms at separate communities in Brodivskyi Region over a calendar year. That allowed us to obtain data for each of 24 communities within LSMH about volumes of milk harvesting for specific days over a calendar year (the sample size is v_Q=53·24=1,272) (Table 1).

We verified extreme values for a variation series of the volumes of milk harvesting for their belonging to the sample based on the Irvine criterion, and tested the vicinity of empirical and theoretical distributions based on criterion X^2 (Chi–square, by Pearson) [20]. Based on the mathematical processing of statistical data on the estimated daily volume of milk harvesting from family dairy farms at the territory of separate communities, it was found that there are two periods of milk delivery – intensive (weeks 17–43 over a calendar year) and non-intensive (weeks 1 to 16 and 44 to 53 over a calendar year). It was established for the intensive and non-intensive periods over a calendar year that the distributions of daily volume of milk harvesting from family dairy farms are described by laws of the Weibull distribution (Fig. 3, 4); their respective statistical characteristics are given in Table 2.

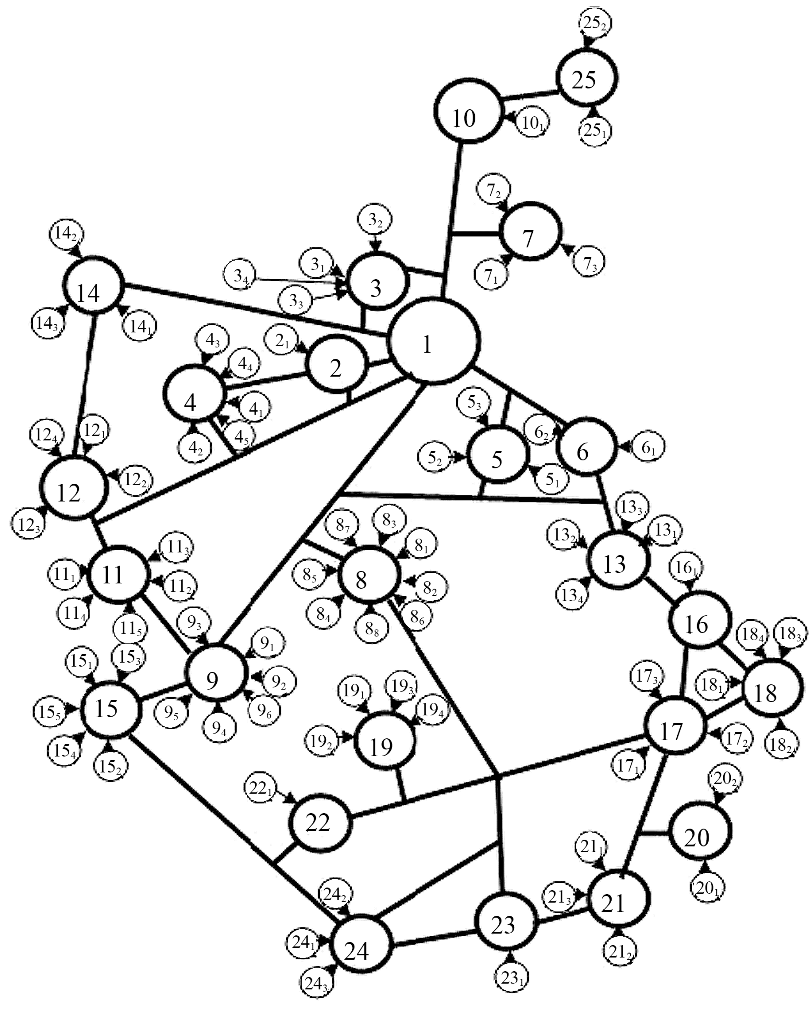

Fig. 2. Graph of territorial LSMH: 1 – processing plant. 2, 3, ..., *n* – the second, third and *p*-th community; 22_i, 3_i,..., n_i – the *i*-th family dairy farm at the territory of the second, third and *n*-th community

Table 1

Results of predicting the daily volumes of milk delivery from the family dairy farms at separate communities in Brodivskyi Region over a calendar year

Week of year	Daily volume of milk delivery to the separate points of its harvesting, liters																							
	Smilnivska	Yazlivchyts-ka	Ponykovyts-ka	Hayivska	Suhovilska	Shnyrivska	Ponykvyans-ka	Yasenivska	Chernytska	Leshnivska	Zabolott-sivska	Razhnivska	Nakvashans-ka	Stan-islavchytska	Pidgoretska	Pidkaminska	Polovetska	Komarivska	Palykoro-vivska	Penyakivska	Golubitska	Markopilska	Batkivska	Verbivchyts-ka
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1	52	381	634	314	174	429	280	365	134	339	411	86	235	290	46	112	235	209	128	239	201	184	312	201
2	102	749	1248	618	343	844	552	719	264	667	639	170	462	570	91	220	461	411	252	470	395	362	613	394
3	119	879	1463	725	402	990	647	843	310	782	750	199	542	669	106	259	541	482	296	551	463	425	719	463
4	125	922	1535	761	422	1038	679	884	325	821	788	209	569	702	112	271	568	505	310	579	486	446	755	485
5	134	986	1641	813	451	1110	725	945	347	877	843	224	608	750	119	290	607	540	331	618	520	476	807	519
6	156	1148	1911	947	525	1293	845	1101	405	1022	982	260	708	874	139	338	707	629	386	720	605	555	940	604
7	169	1245	2072	1027	570	1402	916	1194	439	1108	1065	282	768	947	151	366	766	682	419	781	656	602	1019	655
8	182	1341	2233	1106	614	1510	987	1286	473	1193	1148	304	828	1020	162	395	826	735	451	841	707	648	1098	706
9	195	1438	2394	1186	658	1619	1058	1379	507	1279	1232	326	887	1094	174	423	885	788	483	902	758	695	1176	757
10	208	1534	2554	1266	702	1728	1129	1472	541	1365	1315	348	947	1167	186	451	945	841	516	963	809	742	1255	808
11	203	1499	2495	1236	686	1688	1103	1438	528	1334	1285	340	925	1140	181	441	923	821	504	940	790	724	1226	789
12	212	1562	2601	1289	715	1759	1150	1498	551	1390	1340	354	964	1189	189	460	962	856	525	980	823	755	1278	822
13	210	1550	2580	1278	709	1745	1141	1486	546	1379	1331	351	956	1179	188	456	954	849	521	972	817	749	1268	816
14	234	1727	2876	1425	790	1945	1271	1657	609	1537	1483	392	1066	1314	209	508	1064	946	581	1084	911	835	1413	909
15	290	2134	3552	1760	976	2403	1571	2047	752	1899	1829	484	1317	1623	258	628	1314	1169	717	1339	1125	1031	1746	1123
16	333	2454	4085	2024	1123	2763	1806	2354	865	2184	2103	557	1514	1867	297	722	1511	1345	825	1540	1293	1186	2008	1292
17	397	2926	4872	2414	1339	3295	2154	2807	1032	2604	2505	664	1806	2226	354	861	1802	1603	984	1836	1543	1414	2395	1540
18	461	3399	5658	2804	1555	3827	2502	3260	1198	3024	2908	771	2097	2586	411	1000	2093	1862	1143	2132	1792	1643	2781	1789
19	525	3871	6445	3194	1771	4359	2850	3713	1365	3445	3311	878	2389	2945	469	1139	2384	2121	1302	2429	2041	1871	3168	2038
20	554	4085	6800	3370	1869	4599	3007	3918	1440	3635	3493	926	2520	3108	495	1201	2515	2238	1373	2563	2153	1974	3342	2150
21	563	4148	6906	3422	1898	4671	3053	3979	1463	3691	3548	941	2559	3156	502	1220	2554	2273	1395	2603	2187	2005	3394	2183
22	570	4202	6995	3466	1922	4731	3093	4030	1481	3739	3595	953	2592	3197	509	1236	2587	2302	1413	2636	2215	2031	3438	2212
23	560	4128	6872	3405	1889	4648	3038	3959	1455	3673	3533	936	2547	3141	500	1214	2542	2262	1388	2590	2176	1995	3378	2173
24	545	4014	6682	3311	1836	4519	2954	3850	1415	3571	3437	910	2476	3054	486	1181	2471	2199	1349	2518	2116	1940	3284	2113
25	519	3826	6369	3156	1750	4308	2816	3669	1349	3404	3278	868	2360	2911	463	1125	2356	2096	1286	2400	2017	1849	3130	2014
26	511	3765	6267	3106	1722	4239	2771	3611	1327	3350	3227	854	2323	2864	456	1107	2318	2063	1266	2362	1984	1819	3081	1982
27	503	3704	6166	3055	1695	4170	2726	3552	1306	3296	3176	840	2285	2818	448	1089	2281	2029	1245	2324	1952	1790	3031	1950
28	515	3795	6318	3131	1736	4273	2793	3640	1338	3377	3255	861	2342	2887	459	1116	2337	2079	1276	2381	2000	1834	3105	1998
29	501	3696	6153	3049	1691	4162	2721	3545	1303	3289	3172	838	2280	2812	447	1087	2276	2025	1243	2319	1948	1786	3024	1945
30	531	3912	6513	3227	1790	4405	2880	3752	1379	3481	3356	887	2414	2976	474	1151	2409	2143	1315	2454	2062	1891	3201	2059
31	539	3975	6618	3280	1819	4476	2926	3813	1402	3537	3411	902	2453	3025	481	1169	2448	2178	1337	2494	2096	1921	3253	2093
32	548	4039	6724	3332	1848	4548	2973	3874	1424	3594	3466	916	2492	3073	489	1188	2487	2213	1358	2534	2129	1952	3305	2126
33	546	4024	6699	3319	1841	4531	2962	3859	1419	3580	3454	913	2483	3061	487	1184	2478	2205	1353	2524	2121	1945	3293	2118
34	536	3953	6580	3261	1808	4451	2909	3791	1394	3517	3395	896	2439	3007	479	1163	2434	2166	1329	2480	2083	1910	3234	2081
35	527	3882	6462	3202	1776	4371	2857	3723	1368	3454	3335	880	2395	2953	470	1142	2390	2127	1305	2435	2046	1876	3176	2043
36	517	3810	6343	3143	1743	4291	2805	3655	1343	3391	3276	864	2351	2899	461	1121	2346	2088	1281	2391	2008	1842	3118	2006
37	487	3587	5971	2959	1641	4039	2640	3440	1265	3192	3087	813	2213	2729	434	1055	2209	1965	1206	2250	1891	1733	2935	1888
38	486	3582	5963	2955	1639	4033	2636	3435	1263	3187	3084	812	2210	2725	434	1054	2205	1962	1204	2247	1888	1731	2931	1885
53	76	559	930	461	256	629	411	536	197	497	421	127	345	425	68	164	344	306	188	351	295	270	457	294

Continuation of Table 1

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
39	454	3343	5565	2758	1530	3764	2461	3206	1179	2975	2882	758	2063	2543	405	983	2058	1832	1124	2097	1762	1616	2735	1760
40	442	3254	5417	2684	1489	3664	2395	3121	1147	2896	2807	738	2008	2476	394	957	2004	1783	1094	2042	1715	1573	2663	1713
41	429	3165	5269	2611	1448	3564	2330	3036	1116	2816	2732	718	1953	2408	383	931	1949	1734	1064	1986	1668	1530	2590	1666
42	414	3053	5083	2519	1397	3438	2248	2929	1077	2717	2638	692	1884	2323	370	898	1880	1673	1027	1916	1609	1476	2498	1607
43	378	2789	4643	2301	1276	3141	2053	2675	983	2482	2415	633	1721	2122	338	820	1717	1528	938	1750	1470	1348	2282	1468
44	343	2525	4204	2083	1155	2843	1859	2422	890	2247	2191	573	1558	1921	306	743	1555	1383	849	1584	1331	1220	2066	1329
45	307	2261	3764	1865	1034	2546	1664	2168	797	2012	1967	513	1395	1720	274	665	1392	1239	760	1418	1192	1093	1850	1190
46	271	1997	3324	1647	914	2248	1470	1915	704	1777	1744	453	1232	1519	242	587	1229	1094	671	1253	1052	965	1634	1051
47	250	1844	3070	1521	844	2077	1357	1769	650	1641	1615	418	1138	1403	223	542	1136	1010	620	1157	972	891	1509	971
48	218	1608	2677	1327	736	1811	1184	1542	567	1431	1415	365	992	1223	195	473	990	881	541	1009	848	777	1316	846
49	184	1356	2258	1119	621	1527	998	1301	478	1207	1202	308	837	1032	164	399	835	743	456	851	715	656	1110	714
50	133	978	1628	807	447	1101	720	938	345	870	882	222	603	744	118	288	602	536	329	614	516	473	800	515
51	102	754	1256	622	345	850	555	724	266	671	693	171	465	574	91	222	465	413	254	473	398	365	617	397
52	77	569	947	469	260	641	419	546	201	506	536	129	351	433	69	167	350	312	191	357	300	275	466	300

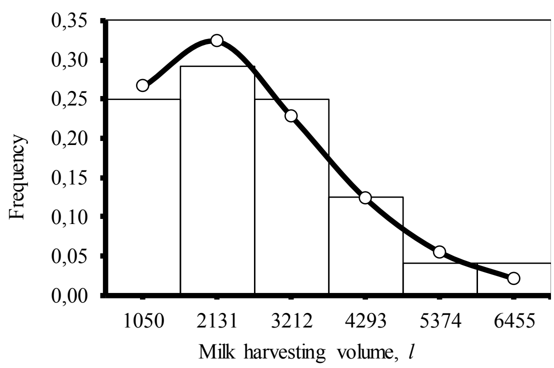

Fig. 3. Distribution of the estimated daily volume of milk harvesting from family dairy farms over an intensive period of using SV

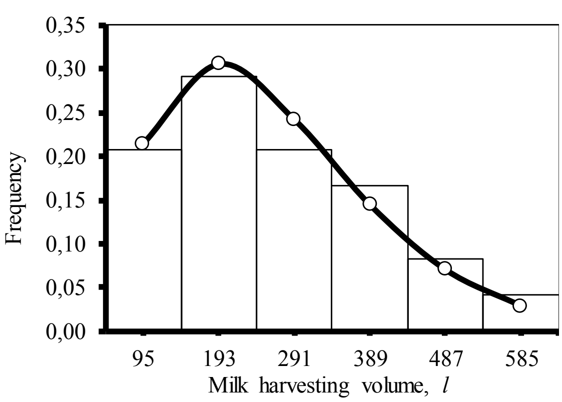

Fig. 4. Distribution of the estimated daily volume of milk harvesting from family dairy farms over a non-intensive period of using SV

The main statistical characteristics for distributions of the estimated daily volume of milk harvesting from family dairy farms at the territory of separate communities in Brodivskyi Region for the intensive (Fig. 3) and non-intensive (Fig. 4) periods of using SV are as follows: the coefficient of variation is 0.65 and 0.62; a shape parameter is 1.56 and 1.64. The confidence interval is, respectively, 509...6,995 and 46...634 l. We have derived the estimated values for criteria X^2 compared with the tabular values $(X^*)^2$ for distributions of the estimated daily volume of milk harvesting from family dairy farms at the territory of separate communities during the intense and non-intensive periods of using SV. They are, respectively, $(X^2 = 0{,}71) < ((X^*)^2 = 4{,}6)$ and $(X^2 = 0{,}89) < ((X^*)^2 = 3{,}2)$. That indicates that the theoretical curves in the Weibull distributions adequately reflect empirical data on the estimated daily volume of milk harvesting from family dairy farms at the territory of separate communities during the intensive and non-intensive periods of using SV.

Table 2

Statistical characteristics of distributions of the estimated daily volume of milk harvesting

Indicator	Equation	Statistical characteristics	
		$\bar{M}[Q_i]$	$\bar{\sigma}[Q_i]$
Volume of milk harvesting during intensive period, l	$f(Q_i) = 1 \cdot 10^{-3} \left(\frac{Q_i - 509}{2457} \right)^{0{,}568} \times \exp\left[-\left(\frac{Q_i - 509}{2457} \right)^{1{,}568} \right]$	2,716	266
Volume of milk harvesting during non-intensive period, l	$f(Q_n) = 7 \cdot 10^{-3} \left(\frac{Q_n - 46}{246} \right)^{0{,}648} \times \exp\left[-\left(\frac{Q_n - 46}{246} \right)^{1{,}648} \right]$	1,429	136

Notes: $\bar{M}[Q_i]$, $\bar{\sigma}[Q_i]$ *are, respectively, the mathematical expectation and the standard root mean square deviation in the volume of milk harvesting over the i-th period, l; 509, 46 are, respectively, the minimum value of the estimated daily volume of milk harvesting from family dairy farms at the territory of separate communities for the intensive and non-intensive periods in a calendar year; 2,457, 246 is, respectively, the measure parameter for the intensive and non-intensive periods in a calendar year*

Accordingly, the estimated daily volume of milk harvesting from family dairy farms, as well as the dependence of the total annual duration of SV operation on their load capacity [19], allow us to determine their number for a predefined make. For the further research we selected the SV Hyundai HD-65 STD+G6-OTA-3.9, which are used in the existing LSMH at Brodivskyi Region.

Based on timekeeping (using a stopwatch and by monitoring the SV Hyundai HD-65 STD+G6-OTA-3.9) of certain transportation operations, we determined specific duration of loading milk into SV, including the issuing of forwarding documents at separate family dairy farms. We similarly determined specific duration of unloading milk from SV at a processing plant and the average motion speed between the settlements within LSMH. The data on the duration of separate transportation operations, acquired experimentally, using the SV Hyundai HD-65 STD+G6-OTA-3.9, are given in Table 3.

The result of mathematical processing of the obtained experimental data (Table 2) is the constructed distributions of specific duration of loading and unloading the SV Hyundai HD-65 STD+G6-OTA-3.9. It has been established that they are described by laws of the Weibull distribution (Fig. 5).

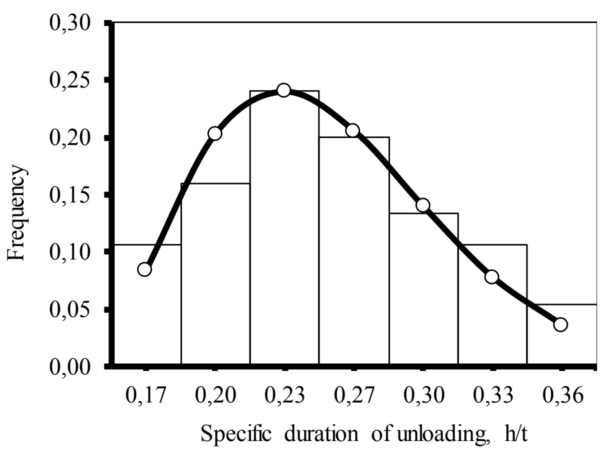

Fig. 6. Distribution of specific duration of unloading the road tanker HD-65 STD+G6-OTA-3.9 at a processing plant

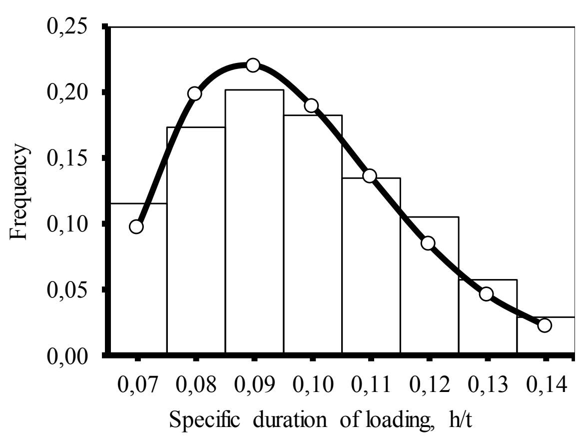

Fig. 5. Distribution of specific duration of loading milk to the road tanker Hyundai HD-65 STD+G6-OTA-3.9

Statistical characteristics for the distributions of specific duration of loading (Fig. 6) the SV Hyundai HD-65 STD+G6-OTA-3.9 at family dairy farms and their unloading (Fig. 6) at a processing plant are given in Table 4.

Table 3

Experimental data on the components of transportation operations using the SV Hyundai HD-65 STD+G6-OTA-3.9

Indicator	Quantitative value									
Specific duration of loading SV, h/t	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
	0.06	0.06	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
	0.08	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09	0.09
	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
	0.1	0.1	0.1	0.1	0.11	0.11	0.11	0.11	0.11	0.11
	0.11	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12	0.12
	0.12	0.13	0.13	0.13						
Specific duration of unloading SV, h/t	0.15	0.15	0.15	0.16	0.16	0.17	0.17	0.17	0.18	0.18
	0.18	0.18	0.19	0.19	0.19	0.2	0.2	0.2	0.21	0.21
	0.22	0.22	0.22	0.22	0.22	0.22	0.23	0.23	0.23	0.23
	0.23	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.25	0.25
	0.25	0.25	0.26	0.26	0.26	0.26	0.26	0.26	0.27	0.27
	0.27	0.27	0.27	0.28	0.28	0.28	0.29	0.29	0.29	0.29
	0.29	0.3	0.3	0.31	0.31	0.31	0.32	0.32	0.32	0.33
	0.33	0.34	0.35	0.36	0.37	0.37				
Technical motion speed of SV, km/h	25,1	25,2	25,6	25,7	25,9	26,2	26,3	26,5	26,7	27
	27,3	27,6	28,1	28,3	28,4	28,4	28,6	28,8	29,2	29
	29,3	29,4	29,5	29,7	30,0	30,1	30,3	30,4	30,6	30
	31,2	31,5	31,6	31,9	32,1	32,4	32,4	32,5	32,6	32
	32,8	32,9	32,9	33,0	33,1	33,3	33,5	33,6	33,6	33
	33,8	34,2	34,2	34,2	34,3	34,3	34,5	34,5	34,5	34
	34,6	34,6	34,6	34,7	34,8	34,8	34,9	34,9	34,9	35
	35,2	35,3	35,8	35,3	36,4	36,5	36,8	36,9	36,9	37
	37,1	37,4	37,6	37,7	38,2	38,3	38,5	38,8	38,9	38
	39,3	39,4	39,9	40,0	40,4	40,5	41,3	41,4	41,6	41
	41,8	42,2	42,6	42,7	43,5	43,9	44,1	44,5	44,6	45
	46,3	47,7								

Table 4

Statistical characteristics for the distributions of specific duration of execution of separate transportation operations

Indicator	Equation	Estimates of statistical characteristics	
		$\bar{M}[t_i]$	$\bar{\sigma}[t_i]$
Specific duration of loading SV, h/t	$f(t_l)=49{,}502\cdot\left(\frac{t_l-0{,}06}{0{,}036}\right)^{0{,}804}\times \times\exp\left[-\left(\frac{t_l-0{,}06}{0{,}036}\right)^{1{,}804}\right]$	0.092	0.018
Specific duration of unloading SV, h/t	$f(t_{unl})=119{,}434\cdot\left(\frac{t_{unl}-0{,}38}{0{,}015}\right)^{0{,}842}\times \times\exp\left[-\left(\frac{t_{unl}-0{,}38}{0{,}015}\right)^{1{,}842}\right]$	0.052	0.008

The basic statistical characteristics for the distributions of specific duration of loading the SV Hyundai HD-65

STD+G6-OTA-3.9 at family dairy farms and their unloading at a processing plant are, respectively, as follows: the coefficient of variation is 1.57 and 1.61; the measure parameters are 0.036 and 0.061; shape parameters are 1.66 and 1.8. Confidence interval is, respectively, 0.006...0.16 and 0.038...0.072 h/t. We have derived the estimated values for criteria X^2compared with the tabular values $(X^*)^2$. For the distributions of specific duration of loading, at family dairy farm and unloading at a processing plant, the SV Hyundai HD-65 STD+G6-OTA-3.9, they are, respectively, $\left(X^2=1{,}92\right)<\left(\left(X^*\right)^2=7{,}78\right)$ and $\left(X^2=0{,}81\right)<\left(\left(X^*\right)^2=6{,}25\right)$. This indicates that the constructed theoretical curves for the Weibull distributions adequately reflect the empirical data on specific duration of loading at family dairy farms, and unloading at a processing plant, the SV Hyundai HD-65 STD+G6-OTA-3.9.

Based on keeping the time of operations in the transportation processes of milk harvesting, which involves using the SV Hyundai HD-65 STD+G6-OTA-3.9, we acquired data on their technical motion speed (V_p). That allowed us to substantiate the theoretical law of the distribution of technical motion speed (V_p) of the SV Hyundai HD-65 STD+G6-OTA-3.9 (Fig. 7).

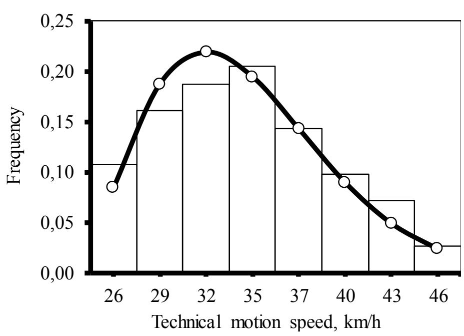

Fig. 7. Distribution of technical motion speed (V_p) of the SV Hyundai HD-65 STD+G6-OTA-3.9

By processing the obtained statistical data in a similar fashion, we have established that the technical motion speed (V_p) of the SV Hyundai HD-65 STD+G6-OTA-3.9 (Fig. 7) is represented by a theoretical law of the Weibull distribution, which is described by the following equation:

$$f(V_p)=0{,}181\left(\frac{V_p-25{,}1}{10{,}315}\right)^{0{,}87}\times\exp\left[-\left(\frac{V_p-25{,}1}{10{,}315}\right)^{1{,}87}\right]. \quad (6)$$

The basic statistical characteristics for the distribution of technical motion speed (V_p) of the SV Hyundai HD-65 STD+G6-OTA-3.9 are as follows: the estimate of mathematical expectation is 34.15 km/h, the estimate of root mean square deviation is 5.05 km/h, the coefficient of variation is 1.55, the measure parameters and a shape parameter are 10.31 and 1.87. The confidence interval is 25.1...46.16 km/h.

We have derived the estimated values for criteria X^2 compared with the tabular values $(X^*)^2$. For the distribution of technical motion speed (V_p) of the SV Hyundai HD-65 STD+G6-OTA-3.9, they are, respectively, $\left(X^2=2{,}96\right)<\left(\left(X^*\right)^2=7{,}78\right)$. This indicates that the obtained theoretical curve for the Weibull distribution adequately reflects the empirical data on technical motion speed (V_p) of the SV Hyundai HD-65 STD+G6-OTA-3.9.

The obtained numerical values for the indicators of using SV to transport milk demonstrate the possibility to employ them in order to model transportation processes for each period of milk harvesting and to establish trends in a change in their functional indicators.

5. Results of determining the indicators of using specialized vehicles

In order to study the impact of production conditions within territorial LSMH on the need in SV over a calendar year, taking into consideration the changing volumes of transportation operations, we performed simulation modeling of the respective processes. The developed simulation model of transportation processes, which was reported in paper [20], was tested for adequacy based on the paired t-criterion. While checking its adequacy, we compared the experimental and simulated values for the duration of separate routes traveled by the road tanks SV Hyundai HD-65 STD+G6-OTA-3.9. It was established that the deviation of the derived quantitative values for the duration of separate routes based on the simulation of transportation processes from their values obtained experimentally does not exceed 3.7 %. This indicates the adequacy of the applied simulation model of transportation processes within LSMH.

That allowed us to determine the following parameters: a total number of completed routes $\left(N_\mu\right)$; total distance $\left(L_r\right)$ traveled by the SV Hyundai HD-65 STD+G6-OTA-3.9; duration $\left(t_r\right)$ of utilizing the SV during milk delivery from family dairy farms to the processing plant; their cargo turnover $\left(W_r\right)$, fuel consumption $\left(\psi_r\right)$; need in SVs $\left(N_r\right)$.

The result of simulation modeling of transportation processes within LSMH is the derived quantitative values for indicators of using the SV Hyundai HD-65 STD+G6-OTA-3.9. Based on these data, and by employing the statistical software Statistica, we built dependences of the estimation of mathematical expectation for the daily number of completed routes $M[N_r]$, traveled distance $M[L_r]$, duration of use $M[t_r]$ and cargo turnover $M[W_r]$ of the SV Hyundai HD-65 STD+G6-OTA-3.9 on the daily volume (Q_d) of milk harvesting. That allowed us to derive equations of the specified dependences, given in Table 5.

Table 5

Dependences of indicators for using the SV Hyundai HD-65 STD+G6-OTA-3.9 on the daily volume (Q_d) of milk harvesting

Indicator	Equation
Estimate of mathematical expectation of the total daily number of completed routes $M[N_r]$, units	$\overline{M}\left[N_r\right]=0{,}254\cdot Q_d+0{,}633$, r=0,98
Estimate of mathematical expectation of the total daily mileage of $M[L_r]$, km	$\overline{M}\left[L_r\right]=754{,}241+21{,}725\cdot Q_d-$ $-156{,}577\cdot q_r-6{,}9\cdot 10^{-3}\cdot Q_d^2-$ $-1{,}51\cdot Q_d\cdot q_r+9{,}365\cdot q_r^2,\ r=0{,}82$
Estimate of mathematical expectation of the total daily duration of using SV $M[t_r]$, h	$\overline{M}\left[t_r\right]=20{,}822+0{,}754\cdot Q_d-$ $-4{,}401\cdot q_r-3\cdot 10^{-4}\cdot Q_d^2-$ $-4{,}19\cdot 10^{-2}\cdot Q_d\cdot q_r+0{,}258\cdot q_r^2,$ $r=0{,}86$

The dependences derived indicate that an increase in the daily volume (Q_d) of milk harvesting within the territorial LSMH leads to an increase in the estimates of mathematical expectation of the total daily number of completed routes $M[N_r]$ in line with a linear dependence. The mileage $M[L_r]$ of road tanks and the duration $M[t_r]$ of their utilization, when a daily volume of milk harvesting grows, increase according to the polynomial dependences of second power. In the obtained dependences, the correlation ratio is within 0.82...0.98, indicating a strong interrelation between the indicators of transportation processes and the daily volume (Q_d) of milk harvesting from family dairy farms within territorial LSMH.

The result of simulation modeling of transportation processes is the derived quantitative values for cargo turnover (W_r) of the SV Hyundai HD-65 STD+G6-OTA-3.9 for different values of daily volumes (Q_d) of milk harvesting from family dairy farms within territorial LSMH. Their respective dependence, constructed by employing the Microsoft Excel software, allowed us to establish that the achieved cargo turnover W_r changes partially discretely at an increase in the daily volume (Q_d) of milk harvesting from family dairy farms within territorial LSMH (Fig. 8).

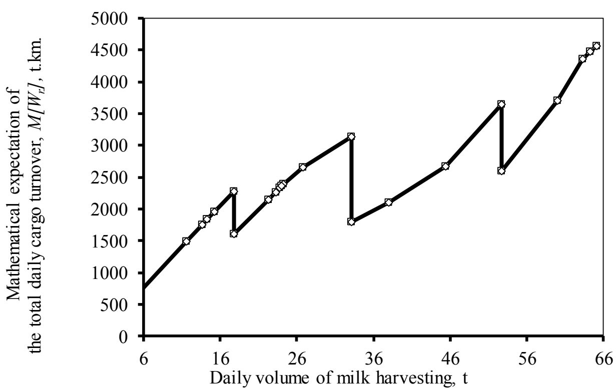

Fig. 8. Dependence of change in the achieved turnover (W_r) by the SV Hyundai HD-65 STD+G6-OTA-3.9 on a change in the daily volume (Q_d) of milk harvesting

Discrete character of the cargo turnover achieved by the road tankers Hyundai HD-65 STD+G6-OTA-3.9 is predetermined by a change in the technological need in their quantity (1 to 4 units) under condition of fulfilling the predefined amount of transportation operations.

6. Results of determining the need in specialized vehicles and the modes of their utilization

Based on the obtained quantitative values for the indicators of using the road tanks, we determined the need in them. Processing the data acquired by employing the Microsoft Excel software has allowed us to build a dependence of the estimates of mathematical expectation of the need $M[N_r]$ in the SV Hyundai HD-65 STD+G6-OTA-3.9 on the specific day during a milk harvesting season (Fig. 9) and the dependence of need in them $M[N_r]$ on the annual volume (Q_p) of milk harvesting (Fig. 10).

The dependences obtained indicate that the need in road tanks discretely changes over a calendar year, depending on a change in the volume of the completed transportation operations. Specifically, the estimate of mathematical expectation of need $M[N_r]$ in road tanks depends on the annual volume (Q_p) of milk harvesting within the territory of LSMH. A growth of the annual volume (Q_p) of milk harvesting from 5 to 65 t leads to a discrete increase in the need in road tanks, from 1 to 4.

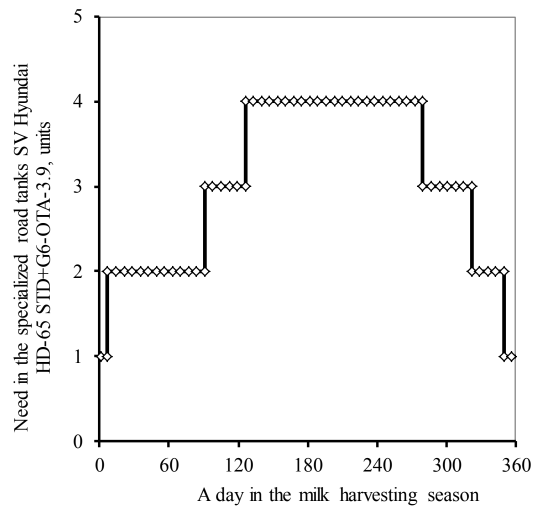

Fig. 9. Dependence of the estimate of mathematical expectation of need M[Nr] in the road tanks Hyundai HD-65 STD+G6-OTA-3.9 on a specific day during a milk harvesting season

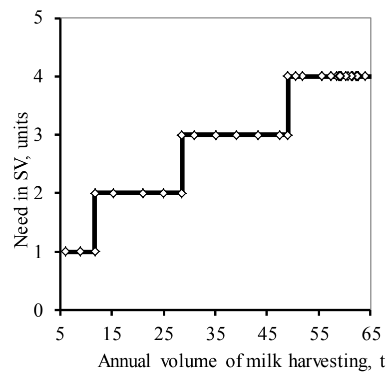

Fig. 10. Dependence of the estimate of mathematical expectation of need M[Nr] in the road tanks Hyundai HD-65 STD+G6-OTA-3.9 on the annual volume of milk harvesting

Based on Fig. 9, 10, one can argue that during the intensive period of transportation operations, which lasts from May to September with a single calendar year, transportation processes should be organized in two working shifts. In this case, the need in SV changes from 1 to 2 units. During the non-intensive period, which lasts from January to March and from October to December within a separate calendar year, transportation processes should be organized in a single working shift. The need in SV during this period varies from 2 to 4 units.

The application of the proposed approach to determining the number of SV for separate LSMH. as well as the modes of their utilization, ensures meeting the acting requirements to transportation processes, which largely affects the quality of the harvested raw materials and, accordingly, the quality of production of dairy products.

7. Discussion of results of studying the impact of production conditions on the need in specialized vehicles

The study that we conducted into the influence of changing production conditions and the components of transportation processes on the need in SVs are based on the approach that eliminates the disadvantages of the existing ones. Specifically, this approach takes into consideration the changing production conditions within LSMH and implies the prediction of changing amounts of milk harvesting over a calendar year. A given approach implies taking into consideration the changing components of duration of transportation operations, as well as the simulation of transportation processes, in order to determine indicators for using road tanks. These indicators underlie our determining the need and modes of road tanks utilization over a calendar year.

The main disadvantage of the proposed approach and the conducted study is that it implies performing specific and labor-consuming experiments to determine the characteristics of production conditions and the components of transportation processes. However, in the future, development of a decision support system for LSMH will facilitate compiling a database and processing the results of experimental research into the changing production conditions and the components of transportation processes. In addition, the availability of such an information system would make it possible to accelerate a decision-making process on determining the need in, as well as the modes of utilization of, road tanks over a calendar year, and would improve their accuracy.

The results obtained when studying the changing volumes of milk harvesting allowed us to establish the existence and the duration of two periods of transportation operations that formed the basis for determining the modes of SV utilization. It was found that the duration of separate transportation operations that are described by laws of the Weibull distribution (Table 4), as well as the experimentally investigated trends of change in the volumes of milk harvesting for each community (Fig. 3, 4), are the initial data for simulating transportation processes within LSMH.

The simulation of transportation processes has made it possible to determine the indicators of SV utilization (Table 5). It was established that the turnover of SV changes discretely from 820 to 4,610 t·km at an increase in the daily volume of milk harvesting from family dairy farms from 6 to 66 tons/day within territorial LSMH. Discrete character of the achieved turnover is predetermined by a change in the technological need in the number (1 to 4 units) of SV Hyundai HD-65 STD+G6-OTA-3.9 to perform the predefined volume of transportation operations.

The established trends in a change in the need in SVs (Fig. 9, 10) are the basis to substantiate the optimal utilization modes of these road tanks within separate territorial LSMH. The established durations of periods with the constant demand for SVs, shown in Fig. 9, allowed us to determine the duration of periods for the one-shift and two-shift organization of transportation processes within a calendar year. For the intensive period of transportation operations, which lasts from May to September within a single calendar year, transportation processes should be organized in two working shifts. For the non-intensive period, which lasts from January to March and from October to December within a separate calendar year, a one-shift work would suffice. The need in the SV Hyundai HD-65 STD+G6-OTA-3.9 over specified periods changes, accordingly, from 1 to 2 units and from 2 to 4 units. The results of our research underlie determining the cost-related indicators for transportation processes. They form the basis for planning the need in resources for the functioning of LSMH and are applied for designing the specified systems.

The study that we performed is useful for managerial staff that plan the operation of LSMH, as well as design them. The substantiated patterns of change in the need in SVs could speed up decision making and improve its accuracy. Further research in this field should be conducted to address the development of a decision support system for LSMH, which would make it possible to substantiate the need in SVs with various cargo capacity under different production conditions (separate regions of different countries). That would make it possible to optimize the SV parameters for separate territorial LSMH and to devise recommendations regarding their design.

8. Conclusions

1. The investigated production conditions of milk harvesting have allowed us to predict the changing volumes of milk harvesting over a calendar year and to establish the existence and duration of two characteristic periods while performing transportation operations. It was established that the intensive period of transportation operations lasts from May to September within a single calendar year, while the non-intensive period has two half-periods, which last, respectively, from January to March and from October to December within a single calendar year. The production experiments that we performed have made it possible to determine the duration of execution of transportation operations and to substantiate their distributions. It was established that specific durations of loading and unloading the road tanks SV Hyundai HD-65 STD+G6-OTA-3.9 are described by laws of the Weibull distribution.

2. Based on the examined changing production conditions for milk harvesting and the duration of execution of transportation operations within the specified administrative territory, we have performed the simulation of transportation processes. That has made it possible to determine the key performance indicators (number of routes traveled, duration of tank utilization, mileage, and cargo turnover) for using road tankers. It was established that they do change. An increase in the daily volume of milk harvesting within territorial LSMH leads to an increase in the estimates of mathematical expectation of the total daily quantity of routes traveled, in line with a linear dependence, while the mileage and duration of using the road tanks SV Hyundai HD-65 STD+G6-OTA-3.9 are described by the polynomial dependences of second power. The cargo turnover changes discretely from 820 to 4,610 t·km at an increase in the daily volume of milk harvesting from family dairy farms from 6 to 66 tons/day within the predefined territorial LSMH. This is due to a change in the technological need in the quantity (1 to 4 units) of the road tanks Hyundai HD-65 STD+G6-OTA-3.9 to fulfill the required volume of transportation operations. In the derived dependences, the correlation ratio varies within 0.82...0.98, indicating a strong interrelation between the indicators for transportation processes and the daily volume of milk harvesting.

3. Based on the derived indicators for using the road tanks Hyundai HD-65 STD+G6-OTA-3.9, we determined the need in them for each period during a milk harvesting season. It was established that the need in the road tanks Hyundai HD-65 STD+G6-OTA-3.9 during the intensive and non-intensive periods of transportation operation varies from 1 to 2 units and from 2 to 4 units. During the intensive period, transportation processes should be organized in two working shifts, and during the non-intensive period, in one shift.

4. Further research should be carried out to address the development of a decision support system for LSMH. That would make it possible to assess the need in road tanks of various cargo capacity for the assigned production conditions (or regions in different countries), which forms the basis for the optimization of parameters for a fleet of road tanks for regions of different countries.

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В дослідженні запропоновано новий критерій оцінки ефективності системи перевезень, який базується на врахуванні коливань рівня завантаження рухомого складу по маршрутах однієї системи перевезення. Критерій оцінює рівень приросту доданої вартості товару внаслідок процесу доставки товарів по рітейл мережі за умови мінімізації собівартості транспортування однієї тонни. Розроблено екстремальний план повного факторного експерименту з варіюванням параметрів на трьох рівнях. Встановлено, що попит на перевезення в рітейл мережі великого міста має дискретний характер. Статистичний аналіз обсягів замовлення на перевезення дозволив зробити висновок про можливість опису даної величини біноміальним законом розподілу. Проведено експеримент над полігоном обслуговування клієнтів рітейл мережі в великому місті. На основі сформованих 9 альтернативних систем логістики останньої милі досліджено вплив варіативності попиту на перевезення на формування рівнів завантаження транспортних засобів по маршрутах. Отримані статистичні дані слугували основою для розрахунку розмірів собівартості транспортування однієї тонни вантажу та оцінки розміру надлишкової доданої вартості товарів.

Проведена оцінка рівня варіативності розміру сумарної та середньої доданої вартості товару. Встановлено, що процес транспортування по роздрібній мережі може формувати приріст в сумарній доданій вартості по всій мережі в розмірі 444,5 відсотків (12 маршрутів в системі перевезення) та середнє значення для одного колового маршруту – 37,03 відсотки. Дана оцінка ефективної області функціонування логістики останньої милі, яка гарантується при умові незначного коливання рівня завантаження транспортних засобів. Це відповідає значенню коефіцієнта варіації завантаження рухомого складу в діапазоні від 0 до 10 відсотків. Поряд з цим встановлено, що найбільш чутливим до коливань обсягів замовлення є рухомий склад малої та середньої вантажності

Ключові слова: логістика останньої милі, маршрут перевезення, собівартість транспортування, додана вартість, варіативність

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ASSESSING THE IMPACT OF PARAMETERS FOR THE LAST MILE LOGISTICS SYSTEM ON CREATION OF THE ADDED VALUE OF GOODS

A. Rossolov
PhD, Associate Professor
Department of Transport Systems and Logistics
O. M. Beketov National University of Urban Economy in Kharkiv
Marshala Bazhanova str., 17, Kharkiv, Ukraine, 61002
E-mail: rossolovalex@gmail.com

N. Popova
Doctor of Economics Science, Associate Professor
Department of Marketing
Kharkiv Institute of Trade and Economics of Kyiv National University of Trade and Economics
Otakara Yarosha lane, 8, Kharkiv, Ukraine, 61045
E-mail: pnv-15@ukr.net

D. Kopytkov
PhD, Associate Professor
Department of Transport Technologies*
E-mail: kopytkov_dm@ukr.net

H. Rossolova
Head of Department
Department of Planning and Control
PJSC "Kharkiv Tile Plant"
Moskovskyi ave., 297, Kharkiv, Ukraine, 61106
E-mail: galina.rossolova@gmail.com

H. Zaporozhtseva
PhD, Associate Professor
Department of Road Traffic Organization and Safety*
E-mail: zhelen77@ukr.net

*Kharkiv National Automobile and Highway University
Yaroslava Mudroho str., 25, Kharkiv, Ukraine, 61002

1. Introduction

Transportation process plays an important role in forming the added value to goods, which necessitates the minimization of the negative impact of this process on the final price of a product. One variant to resolve this issue is to search for a rational mode of transportation or their combination [1, 2], which is an effective measure at the stage of trunk line (long-haul) transportation in the supply chain. Servicing the trunk line (long-haul) transporting flows requires the rational location of terminals with the appropriate handling capabilities [3, 4] and the description of a delivery