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OPTIMIZATION OF THE SERVICE SYSTEM OF TANKERS ON DISTRIBUTION FACILITY

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Abstract. At present, the delivery of oil products to agricultural enterprises and farms of the region is carried out by tank trucks from the distribution tank farm Uzneftegaz AK. At the same time, tank trucks may belong to farms or they may be organized into separate specialized auto detachments and belong to specialized enterprises (centralized delivery).
Key words. tank truck, shipping, oil products, tank farm, formula, waybill, farming.

The region's need for tank trucks is determined by dividing the total volume of oil product delivery by the capacity of one tank truck, which depends on the capacity of the tank truck and the time of its journey.
One of the main components of the flight time is the maintenance of a tanker truck at an oil depot. The longer the service time at an oil depot, the longer the trip time and the lower the productivity of one tanker truck, and, consequently, the more tankers are required to deliver the same volume of oil products to the farms of the area .
Until now, the study of the issue of servicing tankers at oil depots has not been given due attention. There is no data on the idle time of tank trucks at distribution oil depots. Obviously, this is due to the fact that the oil distribution depots belong to the Uzneftegaz AK system, which is not interested in the efficient use of tankers, which belong to the agricultural enterprises of the region. In the conditions of the region, the issue of increasing the efficiency of servicing tankers at oil depots is of great importance, since the uninterrupted supply of oil products to the MTP and the cost of delivering fuels and lubricants depend on its correct solution.
The purpose of this work is to investigate and optimize the process of servicing tank trucks at a distribution tank farm.
The studies were carried out at the Poytug oil depot of the Izbaskan district of the Andijan region by the method of time-based observations.
According to the timing data, the main indicators of the process of servicing tankers were determined [2]:
number of tankers at the oil depot

$$B_n = B_{n-1} + U_n - P_n \quad , \qquad (1)$$

service time per tanker

$$t_{обс} = t_{дов} + t_{оф} + t_{н} + t_{кп} + t_{кв} \, , \qquad (2)$$

time spent 1 - tank trucks at the oil depot

$$t_{оз1} = t_{ух1} - t_{пр1} - t_{обс1} + t_{ож1} \qquad (3)$$

average waiting time for one tank truck queue (start of service)

$$t_{ож} = \frac{\sum_{1=1}^{M} (t_{оз1} - t_{обс1}),}{M} \qquad (4)$$

where B_n , B_{n-1} - number of tankers at the end n-**. . . (**n - 1) - periods ;
U_n ,P_n - the number of tankers coming and going for n-period;
$t_{дов}$ - time to control income from the farm for the processing of petroleum products;
$t_{оф}$ - the time of registration of the consignment note;
$t_{н}$ - time of tanker loading;
t_{kn} - time of density control and calculation of the cost of dispensed oil products;
t_{kb} - time to control the correctness of filling oil products into a tank truck in accordance with the bill of lading;
$t_{ух1}$,$t_{пр1}$ - moments of departure and arrival of the 1-tank truck to the tank farm;
$t_{ож1}$ - waiting time for one 1-tanker queue;
M - average daily number of tank trucks tinned at a given oil depot.
Experienced random input flow of tank trucks to the tank farm is reduced to a conditional group flow;

$$Q_п = m_п (\underline{2 \, t_{ож}} + 1) \qquad (5)$$

$t_п$

where $Q_п$ - the number of tankers in the group;

m_H - the amount of bulk funds at the oil depo

The criterion for optimizing the process of servicing tank trucks at the oil depot was taken to be the minimum of the total reduced costs 3 for the maintenance of bulk liquids and for downtime of tank trucks:

$$3 = C_H \cdot m_H + C_м \cdot T_c, \qquad (6)$$

where C_H– the cost of maintaining one bulk product at the oil depot, soum / year;

$C_м$ - the cost of idle time of one tank truck, soum/h;

T_c - annual loss of time (idle time in the queue) of all tankers at the oil depot, h/year.

The value of Tc was determined by the formula:

$$T_c = t_{ож} \cdot M \cdot D, \qquad (7)$$

where D - the number of working days in a year.

The optimal amount of bulk liquids at the oil depot is equal to (1):

$$m_{H\ опт} = \sqrt{\frac{M \cdot Q_п \cdot D \cdot C_M}{2q_H \cdot c_H}} \qquad (8)$$

where q_H is the productivity of one bulk product at the tank farm, 1/h.

As a result of the research, a certain regularity in the change in the daily number of tank trucks serviced at the distribution tank farm was established.

During the non-busy period (July) 2175 tank trucks were serviced, the smallest daily intake of tank trucks was 28 units, the largest was 105 units, the average was 84 units. During the tense period (November), 1029 tank trucks were serviced for ten days, the smallest intake per day was 88 units, the largest 129 units, the average 103 units.

It has been established that the largest number of vehicles (74% of their daily number) arrive at the oil depot from 9 a.m. to 1 p.m. (Table 1).

The intensity of the arrival gradually fades to zero by the end of the working day: in the interval from 9 to 13 hours it averages 15.5 units, in the interval from 14 to 20 hours - 3.7 units. [4]

The intensity of leaving tank trucks from the tank farm gradually increases in the range of 9...13 hours from 10 to 13 units. , and in the interval from 14 to 20 hours it gradually decreases from 12 to 1 pc.

The uneven inlet and outlet flows of tankers, as well as the low productivity of the service system, are the main reason for the accumulation of large queues of tankers at the distribution tank farm.

Table 1

Average hourly number of tanker trucks at the tank farm

Hours of the day	busy period (november)		relaxed period (July)	
	Coming	Departure	Coming	Departure
8...9	19,8	-	-	-
9...10	24, 4	6,4	17,8	9,7
10...11	9,6	8,6	16,0	11,1
11...12	10,0	10,7	15,0	11,8
12...13	11,3	17,1	13,5	12,5
13...14	-	-	-	-
14...15	14,6	14,4	11,4	11,7
15...16	9,2	13,1	9,7	11,8
16...17	1,4	12,6	7,8	9,3
17...18	1,3	16,4	9	8,1
18...19	1	6,2	2	9,4
19...20	1	3,5	1	7
20...21	1	1	-	-
21...22	1	1	-	-

The most probable intervals between the moments of arrival of tankers are up to 10 minutes (44% of the total number), the least probable intervals are 70 minutes or more (1.1% of the total number), the average interval between the moments of arrival is 18 minutes (Table 2). Between the moments of the departure of tank trucks from the distribution tank farm, the most likely interval is up to 30 minutes (30% of the total). The least likely intervals are 70 minutes or more (1.1% of the total number), the average interval between the moments of departure is 26 minutes. [5]

Of the 2175 tankers examined, during the non-busy period, the largest the number of tank trucks (up to 26% of the total number) were at the tank farm for up to 60 minutes, and the smallest (0.1%) - 230 minutes. During the tense period, the largest number of tank trucks were at the oil depot for 100 ... 190 minutes (40% of the total). There are cases when tank trucks are at the oil distribution depot for 400...560 minutes, on average 179 minutes. Tanker trucks are idle due to poor organization of their maintenance at the oil depot.

Table 2

Distribution of time intervals between the moments of arrival and departure of tank trucks at the distribution oil depot

Time interval, min	Frequency (probability)	
	Coming	Departure
0…10	0,44	0,14
10…20	0,23	0,19
20…30	0,13	0,30
30…40	0,074	0,17
40…50	0,053	0,13
50…60	0,032	0,042
60…70	0,032	0,032
70…80	0,011	0,011

There are nine filling devices at the distribution tank farm for dispensing oil products (Table 3). Pumps (3 pcs.) are used for loading and unloading oil products, including two 5NK-9 pumps and an ASCL-20-24 pump. The performance of one pump 5NK-9 is 60 m3/h, power - 20 kW, book value - 321 thousand soums. The performance of the ASCL-20-24 pump is 30 m3 / h, the power is 7.5 kW, the book value is 174 tk.s.s.m. In addition, there is a pump 5NK-9 (367M) for filling and draining oils with a capacity of 60m3 / h, a power of 20 kW, and a balance sheet value of 491 tks.soum. At the distribution tank farm, three USN-175 bottom discharge units were installed to receive oil products from tanks. [6]

Tank trucks are serviced according to the 5-operational system:
I-control of the transfer of money to receive fuel and lubricants:
II - registration of the consignment note:
III- loading tankers:
IV- density control and fuel cost calculation:
V-control of the correct filling of fuel and lubricants into the tanker in accordance with the consignment note.

Table 3

The number of bulk funds and methods for loading oil products into tank farm

Oil product	**Filling method**	**Number of liquids**	
		Total	**including working**
Diesel fuel	Electric pump Samotech	2	1
Gasoline	hand pump	2	1
	Self-flow	1	
Oils: Motor industrial	Electric pump	1	1
	hand pump	1	
	Self-flow	1	1
Filling is done in three ways:			
Filling method	Average time	Amount of dispensed filling, min fuel, % of the total	
Electric pump	6	62	
hand pump	18	21	
Self-flow	20	17	

Tank truck loading time 2.5 . . .50min, weighted average (taking into account three ways) filling time 11 min. The average time for operations and the performance of the sections are shown in Table 4. [7]

In order to establish a correlation between the group flow of the tanker truck Vn and their daily number serviced at the oil depot Qp, the service time of one tanker truck tobs, the time of filling the oil product into tankers t cash, the annual consumption Qg of the oil product and the minimum reduced costs 3 for the maintenance of bulk vehicles and for a simple tank truck.

The correlation coefficient between these indicators was found from the formula
mule [8]

$$Ч_{xy} = \frac{C_{cy}}{\sigma_x \cdot \sigma_y} \qquad (9)$$

where is the Cxy covariance

σ_x, σ_y - standard deviations of indicators of average values.

The mean square error of the coefficient is equal to the correlation:

$1- ч^2xy$

$$m_{ч} = \frac{\qquad}{n\sqrt{\quad}} \qquad (10)$$

where n is the number of paired values

Table 4
Average tank truck maintenance operations and site productivity

Operation	Average operation time min	Number of operating service channels	Site performance, 1/h
1	0,45	1	134
2	0,8	1	75
3	11	3	16,3
4	0,9	1	67
5	0,5	1	120

The maximum number of cars in the queue reaches 44 units, the average number of them in the queue during the day in a busy period is 17, in an unstressed period - 14 units. (Fig. 1).

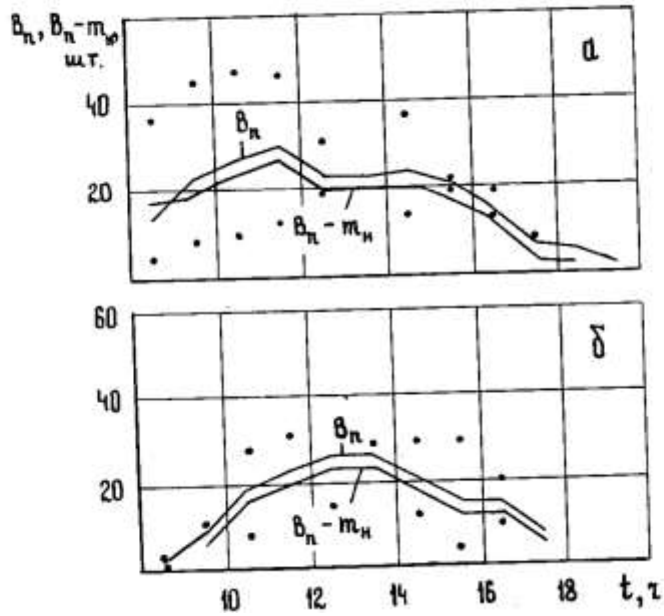

Рис.I. Изменение общего количества автоцистерн $В_п$, находящихся на нефтебазе, и количества автоцистерн $В_п - m_н$, ожидающих очереди в течение рабочего дня: а – ненапряженный период; б – напряженный период

To establish the tightness of the relationship between the group flow of tankers and their daily number served at the oil depot, the coefficient and the correlation direct dependence are determined: [9]

$$r_{Qn,м} = 0{,}774\ ; \quad m_{ч} = 0{,}057; \qquad (11)$$

$$Q_n = 0{,}62M - 1{,}9. \qquad (12)$$

A comparison of the initial and calculated data shows (Table 5) that the average relative error does not exceed 8%, and therefore we can assume that the obtained correlation dependence corresponds to the experimental data.

Under the current system, the average queue waiting time for one autocis
turn in a relaxed period is 66 minutes, the maximum waiting time is 192 minutes, in a busy period - 165 and 417 minutes, respectively.

Optimization of the process of loading tankers at the distribution oil depot was carried out with the following initial: M = 871/day; [10]

tH = 11 min, between the moments of their departure 26 min; the average time spent by tank trucks at the oil depot during the non-stressful period is 80 minutes, during the busy period – 179 minutes.

The analysis of these data showed that the actual service time of the daily number of tankers decreases with an increase in the number of tank trucks. [11]

Table 5

The number of tankers in the group depending on the daily the number of tankers serviced at the distribution tank farm

Daily amount tank trucks		Number of tankers in the group		Absolute mistake, unit	Relative mistake, %
interval	the average meaning	experienced	estimated		
0 . . . 20	10	4,7	4,3	0,4	8,5
20 . . . 40	30	17,4	16,7	0,7	4,0
40 . . . 60	50	30,4	29,1	1,3	4,2
60 . . . 80	70	42,1	41,5	0,6	1,5
80 . . . 100	90	57,1	53,9	3,2	5,6
100…120	110	74,6	66,3	8,3	11,1
120… 140	130	97,0	78,3	18,7	19,2
Average error				4,7	7,7

funds to a lesser extent than estimated. This is explained by the fact that the calculation assumes the simultaneous arrival of the entire daily number of tankers to the tank farm and the operation of all installed bulk vehicles. In reality, the delivery of tank trucks to the oil depot is uneven throughout the working day. Therefore, when determining all indicators of the filling process, only the experimental value of the service time was used. Liquids are loaded unevenly due to the uneven inlet flow of tank trucks. [12]

The number of bulk vehicles significantly affects the total number of tank trucks at the oil depot. in. 1.8 times. At the same time, the maximum number of tankers in the queue decreases from 14 to 1 (14 times) in a relaxed period, and from 17 to 1 (17 times) in a busy period. average time spent by one tank truck waiting in line. At mH= 3, the average waiting time tozh is equal to: when filling with an electric pump 35 min, by gravity 105 min, by a manual pump 94 min.

A queue of tank trucks occurs not only when the average intensity of the input flow is greater than the output, but also when it is less than or equal to. In the latter case, the queue arises due to the random nature of both threads. [13]

According to the results of the analysis of the loading process, the dependencies of the annual loss of time Tcom of the number of loading facilities for various loading methods were revealed. The greatest losses were noted at mH = 1: 66155 h/year (when filling the electron with a pump), 212967 h/year (by gravity), 199665 h/year (with a manual pump). [14]

The optimization of the filling process was carried out with the following initial data: Cm = 1,000 soum/h ;CH equal to 1344, 1248 and 1258 thousand som/year when filling, respectively, with an electric pump, gravity flow and a manual pump: D = 300 days. The minimum total costs for filling with an electric pump were obtained at mH = 7 pcs. , by gravity and by a hand pump - at mH = 13 pieces (Table 6).

Therefore, this number of loading facilities is optimal for loading tankers with fuel at the tank farm.

When installing a smaller number of bulk funds, the total reduced costs increase due to an increase in the idle time of tankers in the queue. When installing a larger than optimal number of liquids, the downtime of tankers is reduced to a minimum, but the total reduced costs increase due to the increase in the cost of maintaining liquids. [15]

Based on the results of the research, a nomogram was developed (Fig. 2), which makes it possible to quickly determine the optimal number of bulk vehicles of a control distribution tank farm. The initial scale on the nomogram is the daily number of tank trucks serviced at the oil depot. The order of calculation is shown by a dashed line.

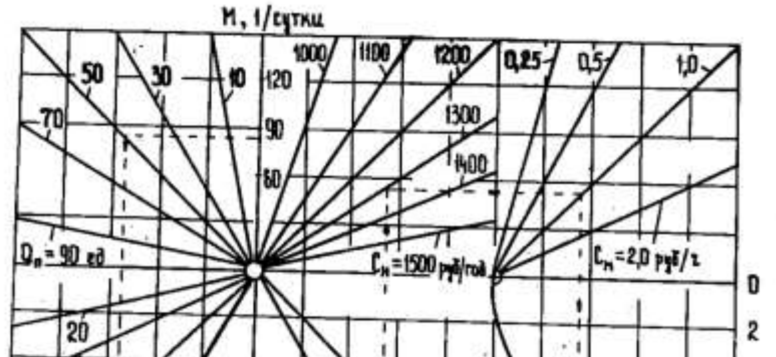

Рис.2. Номограмма для определения оптимального числа наливных средств на нефтебазе

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Table -6

Change in time losses and costs for maintenance of tank trucks depending on the number of cash

Indicator	**Number of liquid funds, pcs**														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Filling with an electric pump															
Waiting time, min	153	75	48,9	36	28,2	22,9	19,3	16,5	14,3	12,6	11	9,9	9	8,1	7,2
Annual loss of time, thousand h/year:	66,5	33,9	20,9	15,7	11,7	10,0	8,4	7,2	6,2	5,5	4,9	4,3	3,9	3,5	3,1
Reduced costs, thousand soums/year:															
on a simple tank truck	6650	3390	2090	1570	1170	1000	840	720	620	505	490	430	390	350	310
for the maintenance of liquid funds	1300	2700	400	540	670	810	940	1070	1210	1304	1480	1610	1740	1880	2010
total	678	3660	2490	2010	1840	1810	1780	1740	1830	1890	1970	2040	2130	2230	2320
Filling with a hand pump															
Waiting time, min	459	225	147	108	85	69	58	49	43	38	33	30	27	24	22
Annual loss of time, thousand h/year:	199,7	97,9	63,9	47,0	36,8	30,1	25,2	21,5	18,7	16,4	14,6	13,0	11,7	10,6	9,6
Reduced costs, thousand soums/year:															
on a simple tank truck	1970	9790	6390	470	3680	3010	2520	2120	1870	1640	1460	1300	1170	1060	960
for the maintenance of liquid funds	120	105	380	500	630	750	880	1001	1130	1260	1380	1510	1630	1760	1890
total	2009	10040	6770	520	4310	3,60	3400	3160	3000	2900	2840	2810	2800	2820	2850
Filling with a hand pump															
Waiting time, min	510	250	163	120	94	77,6	64,3	55	48	42	37	33	30	27	25
Annual loss of time, thousand h/year:	213,0	104,4	68,2	50,1	39,2	32,0	26,8	23,0	20,0	17,5	15,6	13,9	12,5	11,3	10,3
Reduced costs, thousand soums/year:															
on a simple tank truck	2130	1044	6820	5010	3920	3200	2680	2300	2000	1750	1560	1390	1250	1130	1030
for the maintenance of liquid funds	120	250	370	500	620	750	870	1000	1120	1240	1370	1500	1620	1750	1870
total	2142	1069	7190	5510	4540	3950	3550	3300	3120	2990	2930	2890	2870	2808	2900

The production check showed the high efficiency of using the conditional group flow of tankers to optimize the process of their maintenance at the oil depot.

Optimization of the number of liquids makes it possible to reduce the waiting time for tankers in the queue by 2.2. . . 6.7 times, time loss of tanker trucks - 1.3 times. . . 3.5 times, reduce the amount of losses from downtime of tankers and the cost of maintaining liquid funds by 1.6. . . 2.7 times compared to the values of these indicators that exist in practice.

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