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Development and improvement of mobile lifting units for oilfield operations

Rozwój i doskonalenie mobilnych urządzeń dźwigowych do eksploatacji złóż ropy naftowej

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ABSTRACT: Based on the application of the law of progressive evolution to the design of oilfield equipment—specifically mobile hoist units—this paper evaluates the qualitative development of the system under consideration at its current stage of evolution. When assessing the reliability of oilfield equipment, a significant scatter in statistical data on the time between failures of parts and assemblies is often observed, primarily due to variations in operating conditions. This is particularly characteristic of oilfield units whose operation involves periodic relocation from one well to another. Furthermore, routine and major well repairs differ significantly, particularly in terms of the magnitude and nature of the loads acting on the main equipment components. For this reason, when using such data, it is necessary to test statistical hypotheses, including determining whether different samples originate from the same population. The hypothesis being tested is referred to as the null hypothesis. It is tested using statistical criteria to determine whether there are grounds for accepting or rejecting it. Based on the research conducted, the main directions for further development of the units were determined. The development of a specific object of study is presented, from the creation of the initial model through its degradation to the development of a modernized or new design. This includes issues related to improving manufacturability, reducing material consumption, and lowering the labor intensity involved in manufacturing assemblies and individual equipment parts; issues related to increasing the reliability, maintainability, and installation capabilities of mobile hoist unit components; and, overall, enhancing the competitiveness of the units.The results of the research on the service life of mobile oilfield hoist units, conducted within the framework of the law of progressive evolution, made it possible (taking into account the modification already implemented) to identify directions for their further development.

Keywords: mobile lifting unit, stages of technical system development, degradation.

STRESZCZENIE: W niniejszym artykule, w oparciu o prawo progresywnego rozwoju systemów technicznych, dokonano analizy aktualnego poziomu rozwoju mobilnych urządzeń dźwigowych wykorzystywanych w eksploatacji złóż ropy naftowej. Przy ocenie niezawodności tego rodzaju urządzeń często obserwuje się znaczny rozrzut danych statystycznych dotyczących czasu pracy między kolejnymi uszkodzeniami części i zespołów. Wynika on przede wszystkim ze zróżnicowanych warunków eksploatacji. Jest to szczególnie istotne w przypadku urządzeń okresowo przemieszczanych pomiędzy odwiertami. Istotne różnice występują również między remontami bieżącymi a kapitalnymi, zwłaszcza w zakresie wartości i charakteru obciążeń działających na główne zespoły urządzeń. Z tego względu wykorzystanie takich danych wymaga weryfikacji hipotez statystycznych, między innymi w celu ustalenia, czy analizowane próby pochodzą z tej samej populacji. Weryfikowana hipoteza jest określana jako hipoteza zerowa. Do jej sprawdzenia stosuje się odpowiednie kryteria statystyczne, na podstawie których podejmuje się decyzję o jej przyjęciu lub odrzuceniu. Na podstawie przeprowadzonych badań określono główne kierunki dalszego rozwoju analizowanych urządzeń. Przedstawiono kolejne etapy rozwoju badanego rozwiązania technicznego – od opracowania konstrukcji wyjściowej, poprzez etap jej degradacji, aż do stworzenia zmodernizowanej lub nowej konstrukcji. W analizie uwzględniono zagadnienia związane z poprawą możliwości produkcyjnych, zmniejszeniem zużycia materiałów oraz ograniczeniem pracochłonności wytwarzania zespołów i poszczególnych części urządzeń. Rozpatrzono również możliwości zwiększenia niezawodności, łatwości konserwacji oraz usprawnienia montażu elementów mobilnych urządzeń dźwigowych, a w szerszym ujęciu – poprawy ich konkurencyjności. Wyniki badań dotyczących trwałości eksploatacyjnej mobilnych urządzeń dźwigowych, przeprowadzonych z uwzględnieniem założeń prawa progresywnego rozwoju systemów technicznych, umożliwiły (po uwzględnieniu już wprowadzonych modyfikacji) wyznaczenie kierunków ich dalszego doskonalenia.

Słowa kluczowe: mobilne urządzenie dźwigowe, etapy rozwoju systemu technicznego, degradacja.

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Introduction

In the oil fields, mobile lifting units are used to lift and move technical equipment, equipment, etc. to a height, during repair and construction work of wells, and their maintenance. There are various types of mobile lifting units.

The evolution of mobile lifting installations is largely related to the development of research and development institutes; in particular, the Azinmash Institute, the Azerbaijan Scientific Research and Design Institute of Petroleum Engineering, developed the norm (H688-64 “Equipment for the oil industry. A number of lifting capacities for lifting equipment”), according to which the recommended lifting capacities for mobile lifting installations were 16; 32; 50; 80 tons. Later, the norm was replaced by the industry standard (Babaev et al., 2020).

Considering the above, the further evolution of the design developments and research carried out during the period under consideration is most clearly reflected in the lifting units designed by AzINMASH (Figure 1).

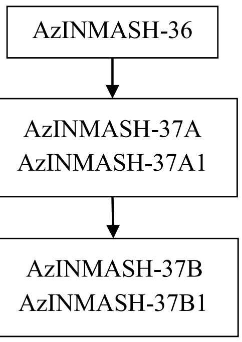

Figure 1. Evolution of lifting units on the chassis of off-road vehicles

Production of mobile lifting units on vehicle chassis was organized based on operational experience. In particular, AzINMASH-36 unit with a lifting capacity of 160 kN (16 t) was mounted on the chassis of a off-country vehicle (ZIL-157 KE) and consisted of the following components: transmission, drum winch, tower with hoisting system, as well as hydraulic, pneumatic and electrical systems. The main disadvantage of this unit was insufficient lifting capacity on the hook, which was associated with the limited capabilities of the vehicle's traction engine.

Considering the above, as well as the analysis of the identified failures of this installation, AzINMASH-37A lifting installation with a lifting capacity of 320 kN (32 t) was designed on the basis of the KrAZ-255B high-off-country vehicle (engine power 176.5 kW; lifting capacity of the mounting base 90 kN). Installations with improved performance were also produced: AzINMASH-37A1 and AzINMASH-37B on the chassis of the KrAZ-260 high-cross-country vehicle (engine power 220 kW; lifting capacity of the mounting base 105 kN (10.5 t).

AzINMASH-37 lifting units were designed for lowering and lifting operations during underground well repairs with laying of tubing and rods on catwalks. AzINMASH-37B lifting unit, unlike the above units (AzINMASH-37A and AzINMASH-37A1), was equipped with a spider and a manipulator for screwing and unscrewing tubing. AzINMASH-37 installation has undergone a certain modernization and is currently in operation. AzINMASH also created installations mounted on a tractor base and equipped with a tower with a hoist system, as well as towerless modifications of them.

”Bakinets” units mounted on a tracked tractor were created to carry out repair work on wells not equipped with fixed towers or masts. The ways of modification of lifting installations were carried out taking into account the improvement of both operational performance and ensuring the economic efficiency of the project (Habibov et al., 2026).

Modifications of this installation, (”Bakinets – 2M” and ”Bakinets – 3M”), were used for a long time in the fields, up to the creation (in accordance with the normal range of lifting capacities) of AzINMASH-43 A installation. This lifting unit with a lifting capacity of 320 kN was a tractor modification of AzINMASH 37A lifting unit and intended for tripping operations during routine and major repairs of wells located in hard-to-reach places. The evolution of these installations is shown in Figure 2.

Along with this, AzINMASH-43P tractor lift was created (based on the T-130 M G-1 tractor) to perform lowering and lifting operations during repair of wells equipped with stationary towers or masts. In fact, this unit was a towerless modification of AzINMASH-43A unit (Babaev et al., 2022). The lifting units AzINMASH-43A, AzINMASH-43P, AzINMASH-37 were in operation for quite a long time, which made it possible to identify both their positive and negative features.

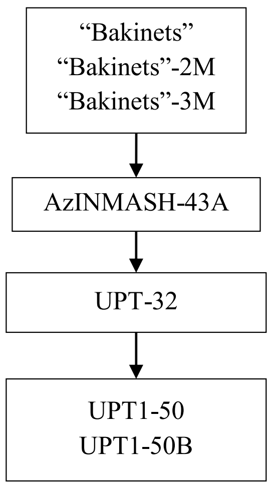

Figure 2. Evolution of tractor-based lifting units

When assessing the reliability of oilfield equipment, there is often a significant dispersion of statistical data on the mean-time between failures of parts and assemblies, which is mainly explained by changes in operating conditions (Mirzoev, 2022). This is especially characteristic of oilfield installations, the operation of which was associated with periodic relocation from one well to another. At the same time, the current and major repairs of wells have significant differences, in particular in the magnitude and nature of the loads acting on the main units of the installations.

For this reason, when using such data, it is necessary to test statistical hypotheses, including determining whether different samples belong to a single general population. The hypothesis being tested is called the null hypothesis. It is tested using statistical criteria in order to identify the grounds for accepting or rejecting the proposed hypothesis. In the case of a normal or log-normal distribution, the problem of belonging of two independent samples to a single general population is solved by comparing the mean values (Student's test) or the variances of two samples (Fisher's test) (Orlov, 2015).

Research methods

The winches of mobile lifting installations (AzINMASH-37A, AzINMASH-43A, AZINMASH-43P) were accepted as the object of the study. An analysis of the causes of failures of the AZINMASH-43P installations showed that of the total number of failures, the majority (about 30%) are failures of the friction clutch of the main winch. By analyzing the failures of the friction clutches (20 winches) taken under observation, it was found that the total time of field tests of lifting installations was T_{av} = 86400 h; the average operating time for failure of the friction clutch of the main winch was T_{av} = 733 h. Experiments were conducted in six oil and gas fields of Azerbaijan, differing in operating conditions. The results of field tests of the main winches of mobile lifting units were taken as the initial data (Babaev et al., 2017).

The results of the study and their discussions

Usually, the Wilcoxon and Mann-Whitney criteria are used to compare two independent samples by the level of a feature when the data does not meet the assumptions about the normality of the distribution and the equality of variances required for the *t*-test. In other words, they are used to determine if there is a statistically significant difference between two groups when the distributions of these groups are not necessarily normal (Kramer, 1999).

The average total operating time of the units was 9551 hours with a standard deviation of 1927 hours. At the same time, the mean time between failures for the units was 221...519 hours, i.e. it varied within a wide range.

The time spent on unscheduled routine repairs also varied significantly (with a mean of 2546 h and a standard deviation of 1464 h). The number of failures associated with unscheduled routine repairs ranged from 20 to 32, which, at a given the above-mentioned time spent on eliminating these failures, resulted in a significant variation in the average recovery time ($\bar{\tau}_n$ = 5.8...243 h).

The time spent on maintenance and scheduled current repairs also varied greatly (from 32 to 1040 hours), which affected the values of the technical utilization coefficient ($C_{\text{t.u.}}$ = 0.499…0.984).

An analysis of the causes of failures of AzINMASH-43P units showed that of the total number of failures, the majority (29%) were the failures of the friction clutch of the main winch.

Table 1 provides statistical information on friction clutch failures for the 20 winches under observation. The total time of field testing of the hoisting units was T_{av} = 86400 h; the average time between failures of the friction clutch of the main winch was T_{av} = 733 h. It is necessary to determine the homogeneity of the samples: with a relatively large volume of statistical data (operating time of friction clutches to the first and second failures) and with a relatively small volume of data (operating time to the fourth and fifth failures).

In addition, it was necessary to test the null hypothesis about the homogeneity of the samples for winches, which contain variation series of operating time for all six failures of friction clutches (Table 1).

First of all, the first two tasks required determining whether it was possible to combine the statistical data of the two samples, not considering the differences in the operating conditions of the lifting units. This required checking whether the two samples belonged to a single general population (Antipina et al., 2021).

As the statistics the largest absolute difference between the accumulated frequencies from the values calculated for each, with a limited volume of tests (or for each interval of values of a random variable when grouping test results) was used:

$$D = \max\left|w_1(x) - w_2(x)\right| \tag{1}$$

The obtained statistics (1) were compared with the critical value depending on the significance level α and sample sizes n_1 and n_2.

In this case, for $n_1 + n_2 > 35$.

$$D_\alpha = \lambda_\alpha \sqrt{\frac{n_1 + n_2}{n_1 \cdot n_2}} \tag{2}$$

Table 1. Results of tests of the main winches of AzINMASH-43P units

Numbers of main winches taken under observation $j = 1, 2, ...N$	Mean time between failures of the main winch friction clutch by the number of failures i = I, II, …					
	I	II	III	IV	V	VI
1	950	110	600	320	560	1800
2	120	890	2100	1600		
3	822	1100	675			
4	1250	640	915	870	610	
5	750	1105	640	895		
6	670	1000	1200			
7	1210	480	900	700	1900	1100
8	1400	280	560	680	2005	440
9	640	400	2150	1150		
10	420	1800	845			
11	1105	2100	735	680		
12	480	600	1805	915	1600	
13	810	1120	1105	440	210	2105
14	975	850	1000	510		
15	856	975	1050			
16	910	1800	280	1900	875	
17	576	1400	905			
18	1800	435	875	700		
19	1900	385	935	800	1100	
20	1100	450	705	945	780	1110

In most cases, 5% or 1% levels are used as significance levels. In this case $\lambda_{0.05} = 1.36$; $\lambda_{0.01} = 1.36$. If the following condition is met:

$$D \leq D_a \tag{3}$$

then the null hypothesis is not rejected. If condition (3) is not met, the hypothesis that the two samples belong to a single general population is rejected.

Table 2, based on the data on the failures of the friction clutch of the AZINMASH-43P lifting unit (see Table 1), shows the compiled variation series, including the operating time to the first (I_v) and second (II_v) failures ($n_1 = 20$; $n_2 = 20$).

Table 2. Variational series of time between failures to the first and second failures

i	I_v	II_v	i	I_v	II_v
1	120	110	11	910	890
2	420	280	12	950	975
3	480	385	13	975	1000
4	576	400	14	1100	1100
5	640	435	15	1105	1105
6	670	450	16	1200	1120
7	750	480	17	1205	1400
8	810	600	18	1400	1800
9	822	640	19	1800	1800
10	856	850	20	1900	2100

The data were grouped beforehand and the accumulated frequencies were calculated. As it can be seen from Table 3, the greatest value of the differences in the accumulated frequencies for the two samples under consideration falls on the interval of 350...600 hours of operation and based on condition (1), is $D = 0.20$.

The value of the critical region boundary is found using formula (2). At $\alpha = 0.05$; $D_{0.05} = 0.316$. That is, condition (3) is satisfied and there are no grounds for rejecting the null hypothesis. This means that the two samples considered belong to the same general combination.

To compare two samples with relatively small volumes, it is effective to use the nonparametric Wilcoxon, Mann, and Whitney rank test, which is based on the distribution of inversions. The method is applicable for a sample volume of $n + m \geq 20$ and $m > 3$ (where is m the volume of the smallest sample). We accept samples corresponding to the IV and V mean time between failures ($n = 15$; $m = 9$) of the friction clutch of the main winch of the AzINMASH-43P unit (Table 1). Using the Wilcoxon, Mann, and Whitney test, we test the null hypothesis that the two samples belong to the same general combination.

Table 3. Results of determining the accumulated frequencies

Components	Sample number	Intervals							
		100–350	350–600	600–850	850–1100	1100–1350	1350–1600	1600–1850	1850–2100
Frequency	I	1	3	5	5	3	1	1	1
	II	2	6	2	4	2	1	2	1
Cumulative frequency	I	1	4	9	14	17	18	19	20
	II	2	8	10	14	16	17	19	20
Cumulative frequency	I	0.05	0.20	0.45	0.70	0.85	0.90	0.95	1.00
	II	0.10	0.40	0.50	0.70	0.80	0.85	0.95	1.00
$\|w_1(x) - w_2(x)\|$		0.05	0.20	0.05	0.00	0.05	0.05	0.00	–

To do this, both samples (IV_v and V_v) are arranged in a single variation series, where each value of the mean time between failures is assigned a rank from one to $n + m$ (Table 4). For equal values of the members of the general variation series belonging to different samples, the same (average) rank is assigned.

Table 4. General variation series of two samples and its ranking

Rank	Mean time between failures [h]	Sample
1	210	V
2	320	IV
3	440	IV
4	510	IV
5	560	V
6	610	V
7.5	680	IV
7.5	680	IV
9.5	700	IV
9.5	700	IV
11	780	V
12	800	IV
13	870	IV
14	875	V
15	895	IV
16	915	IV
17	945	IV
18	1100	V
19	1150	IV
20.5	1600	IV
20.5	1600	V
22.5	1900	IV
22.5	1900	V
24	2005	V

Then the sum of the ranks of the first R_1 and second R_2 samples is calculated. In this case, the sum of the ranks of the first (IV_v) sample is $R_1 = 178$ and the second (V_v) sample is $R_2 = 122$. The correctness of the calculation of the rank sums is checked by the formula (Saleem et al., 2013).

$$R_1 + R_2 = 1/2(n + m)(n + m + 1) \tag{4}$$

In the case under consideration, condition (4) is satisfied:

$$178 + 122 = 0.5(15 + 9)(15 + 9 + 1) = 300.$$

After definition R_1, R_2 the inversions are calculated:

$$u_1 = mn + 1/2n(n + 1) - R_2 \tag{5}$$
$$u_2 = mn + 1/2n(n + 1) - R_1 \tag{6}$$

with their control according to the formula:

$$u_1 + u_2 = mn \tag{7}$$

We define: $u_1 = 58$; $u_2 = 77$; $u_1 + u_2 = m \cdot n = 135$.

The smallest of the inversion values u_1 and u_2 are taken as the statistic when testing the homogeneity of two samples, i.e. $u_1 = 58$.

Testing the null hypothesis involves calculating the normalized value (Stepanov, 2005).

$$Z = \frac{\left|u_1 - \frac{1}{2}\right| - \frac{1}{2}}{\sqrt{\frac{1}{12}mn(m+n+1)}} \tag{8}$$

and inequality estimates:

$$Z \le Z_{1-\frac{\alpha}{2}} \tag{9}$$

where $Z_{1-\alpha/2}$ is the quantile of the level of $P = 1 - \alpha/2$ normalized normally distributed random variable, determined for the selected significance level; $\alpha = 0.05$.

Based on the results of calculations using formula (8) $Z = 0.537$. The values $Z_{1-\alpha/2}$ are tabulated. In this case $Z_{0.975} = 1.960$. As it can be seen, inequality (9) is satisfied. This means that the null hypothesis about the belonging of the two considered samples to a single general combination is not rejected.

Table 5. Variational series of failure times of winch friction clutches

pp	Mean time between failures by winch №				
	1	7	8	13	20
1	110	480	280	210	450
2	320	700	440	440	705
3	560	900	560	810	780
4	600	1100	680	1105	945
5	950	1210	1400	1120	110
6	1800	1900	2005	2105	1110

It is also of interest to check whether several statistical samples obtained as a result of testing a group of objects (Table 5) belong to the same general population.

In the case of a normal or log-normal distribution of the characteristic under consideration, testing the hypothesis about the membership of several samples in a single general population usually comes down to testing the hypotheses about the homogeneity of a series of variances and the homogeneity of a series of mean values using one-way variance analysis.

In the absence of data confirming the validity of using the normal law, the null hypothesis about the belonging of a number of independent samples to a single general population can be tested using the nonparametric rank test of Kruskal and Wallis (Levin and Rubin, 2004).

Table 5 shows the variation series for 6 operating times between failures of friction clutches obtained as a result of testing the main winches of AzINMASH-43P lifting units (No. 1, 7, 8, 13 and 20; Table 5).

Based on the data in Table 5, a single variation series is compiled with ranking of its components.

Based on the data in Table 6, rank sums are calculated. They are:

$R_{\mathrm{I}} = 71.5$; $R_{\mathrm{II}} = 111.5$; $R_{\mathrm{III}} = 85$, $R_{\mathrm{IV}} = 99.5$, $R_{\mathrm{V}} = 97.5$.

In this case R_j, the correctness of the calculation of rank sums is controlled by the formula (Fashiev, 2012):

$$\sum_{j=1}^{m} R_j = \frac{1}{2}\sum_{i=1}^{n} n_i\left(\sum_{i=1}^{n} n_i + 1\right) \tag{10}$$

At $\sum_{i=1}^{6} n_i = 30$ and $m = 5\sum_{i=1}^{5} R_i = 465$.

$$H = \frac{12m}{n^2(n+1)}\left(\sum_{j=1}^{m} R_j^2\right) - 3(n-1) \tag{11}$$

In the case under consideration, $H = 2.00$.

The value of H at $n \geq 5$ and $m \geq 4$ is distributed according to the law χ^2 with the number of degrees of freedom $k = m - 1$. Since the inequality $H < \chi^2_{0.05}$ is satisfied, the null hypothesis about the identity of the samples under consideration is not rejected.

Thus, as a result of the analysis of statistical information of lifting units (AzINMASH-37A, AzINMASH-43A and AzINMASH-43P), the main reasons for their failures were determined.

The tests of the said lifting units carried out revealed a number of shortcomings. In particular, Table 7 shows the final averaged data on the results of testing 14 AzINMASH-43P units. As it can be seen, the average recovery time of these units is significant, which affected the values of the availability C_r and technical use factors $C_{\text{t.u.}}$.

Based on the analysis results of the failures causes of AzINMASH-43A and AzINMASH-43P lifting units, it was found that the greatest number of their failures occurred in the main winch and gearbox. The main design shortcoming was the need for preliminary dismantling of the winch to be able to remove the gearbox from the units in order to eliminate failures. This had a negative impact on the operational and repair technology of the units.

Table 6. Single variation series

t [h]	Rank	№ of refusals (samples)	*t* [h]	Rank	№ of refusals (samples)	*t* [h]	Rank	№ of refusals (samples)
110	1.0	I	600	11.0	I	1100	20.5	V
210	2.0	IV	680	12.0	III	1105	22	IV
280	3.0	III	700	13.0	II	1110	23	V
320	4.0	I	705	14.0	V	1120	24	IV
440	5.5	III	780	15.0	V	1210	25	II
440	5.5	IV	810	16.0	IV	1400	26	III
450	7.0	V	900	17.0	II	1800	27	I
480	8.0	II	945	18.0	V	1900	27	II
560	9.5	I	950	19.0	I	2005	29	III
560	9.5	III	1100	20.5	II	2105	30	IV

Table 7. Results of the assessment of failure-free operation, maintainability and complex reliability indicators of lifting units AzIN-MASH-43P

Total operating time of installations T_{tot} [h]	Number of failures	Mean time between failures, $\overline{T}$ [h]	Average recovery time, $\overline{\tau}_r$ [h]	Coefficients	
				Readiness C_r	Technical use $C_{t.u.}$
9620	26	370	99	0.789	0.759

Based on the identified significant shortcomings, AZINMASH-43A and AzINMASH-43P units were taken out of production and replaced by UPT-32 and LPT-8 units. UPT-32 mobile lifting unit with a lifting capacity of 320 kN is designed to serve wells up to 2400 m deep; it is mounted on a T-170.00-1 (T-130MG-1) crawler tractor and equipped with mechanisms for screwing and unscrewing tubing and pump rods. The unit has high hook lifting speeds due to the use of a more powerful tractor engine.

LPT-8 lift is a modification of UPT-32 unit and also mounted on T-170.00-1 tractor; however, unlike UPT-32, it does not have its own tower. Its nominal lifting capacity is 320 kN.

Based on the statistical information analysis on the reliability of the components of the lifting units, AzINMASH made certain design changes to them. These changes were mainly related to the elimination of the most frequent failures of parts and units, which led to significant downtime of the units and required more time for restoration.

In addition to the above a study of the evolution of mobile lifting units during the period of their intensive development showed the following.

Despite the relatively slow development of the research objects that was noted, their development period was completed quite successfully: an industry standard (IS) was developed defining a range of lifting capacities for the installations; mobile lifting units were created both on tracked tractors and on wheeled chassis.

The period of intensive development of the TS in the initial segment also proceeded at a fairly high rate of intensity criteria growth. The elimination of the main design shortages identified during testing and operation of the TS is noted. This is especially true for the currently used lifting unit AzINMASH-37A (AzINMASH-37BF), certified for the highest quality category.

Thus, it is confirmed that in order to solve the problem of creating mobile lifting units in full compliance with the industry standard, it is advisable to:

- use of serially produced vehicle chassis for low and medium-capacity units and special multi-axle chassis for high load-carrying capacity values.
- use (by agreement) of factory-made vehicle chassis with extended and reinforced side members, as well as non-standard gearboxes and power take-offs.

The recommendations on the advisability of using a "top drive" on lifting units to expand the range of work performed at wells, as well as means of mechanization, automation and computerization of technological operations are also worthy of attention.

Conclusions

1. It is necessary to develop special mobile installations equipped with a sufficiently large assembly platform. This primarily concerns the lifting unit with a lifting capacity of 1250 kN specified by the industry standard (IS), as the equipment cannot be mounted on a standard truck chassis. The development of such a specialized lifting unit will fully ensure compliance with both the operating conditions and the requirements for technical maintenance and repair under industrial conditions.
2. The use of the specified specialized mobile lifting unit will also allow to solve all issues related to the comprehensive mechanization of the main work on well repair when it is used in the conditions of well overhaul. A promising approach is to use a "top drive" in these lifting units to fully combine the operations of lowering and lifting the tubing and pump rods with their screwing and unscrewing.
3. Installation of equipment on specialized self-propelled platforms will also allow to solve issues of increasing manufacturability, reducing material and labor intensity of manufacturing assembly units of equipment; issues of increasing reliability, maintainability and installation suitability of the components of the installations; and, in general, increasing the competitiveness of the installations.

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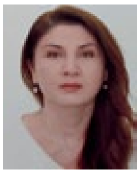

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