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Contents

THE INFLUENCE OF GLOBAL CLIMATIC CHANGES ON FORMULATION OF MUDSTREAM IN THE RIVER OF MAJOR CAUCAUSUS AT PRESENT.

The leading research officer, J.H Mammadov, the candidate of the Geographical science.
Institute of Geography after acad. G. A Aliyev of The National Academy of Science of Azerbaijan, H.Javid ave, 31, Baku, Az 1143, Azerbaijan
E-mail address: jumamamedov@yahoo.com, tel.: +994 124313251, +994125183821

Abstracts

Article is devoted to the change of global climate influencing to forming of the streams.

It has been defined that in comparison with expenditures of middle perennial water till the year 1977, from the year 1977 to nowadays in the expenditure norm in the direction of decreasing changes happened. So, low norm of the expenditures of middle perennial water has increased at 2.6, but the upper norm decreased 1.7 times. The reason of the increasment of low norm expenditure since the year 1976 ,the increasing the number of water basins in the lowland of Kur- Aras and their capability of soft influence to local climate circumstances but decreasment of the upper norm mentioned before in the comparison of global warming can be explained by being weak. Such scenery has been observed in the features of alluvium. So till the period of 1977 year the alluvium of middle many yearly expenditure of water changed between 0.23-120 kg/s but from year 1977 till nowadays it decreased between 0,23-86 kg/s.

The use of mountainous areas for accumulation of purposes of economy and great number causes weathering materials on the surface of river basins. The intensive downpour taking place during the period of strong droughts cause weathering materials accumulated on the surface of river basin to run into the river and this forms the mud stream. This damages greatly natural and anthropogenic landscapes. Lately, the influence to the flowing of rivers the change of climate in global scale reflects on our republic. [1;5;7; etc]. The influence of global climate changes to the torrent materials is defined by the intensity of weathering [2;3;4;6;]. According to the climate investigators the longstanding temperature of weather norm 0,6 Cº and above it warming is connected with global changes.

Nowadays, the flowing of torrents transported alluvium also proves it.

So, in the river Shin flowing through the territory of Major Caucasus the capacity of alluvium was in 1962 197000 t, in 1992 609000 t, but in 2008 was 5000 000 t.

If in Talachay the capacity of alluvium in 1964 was 282 000 t, in 2003 it was equal to 5 918 800 tones.

The harm that caused such torrents stands on the same level as natural disasters, sometimes overcomes them.

Through the United Nations Organization announced the 1990-2000 years to struggle against the natural disaster, but in not fluttered countries haven't paid any strict attention to the study of torrents.

Firstly, it explained by lack of financial equipments.

The study of torrents on a large scale, gives an opportunity to continue the scientific researches on international level.

And it helps to study the mechanism of happening torrents in regions.

Scientific side of study torrents is to discover the processes that take place on the surface of river basins and to display in the environment mutually and struggle against it.

The complication and solution of the problem demands a deep scientific relation to it.

Taking into consideration upper mentioned our duty is to study some characteristics in the rivers flowing through Major Caucasus.

Such features formed with influence of climate change on global level, water and changes that take place, longstanding observation over the raise of alluvium.

To solve the problem in details the National Hydrometrological Department at the Ministry of Ecology and Natural Resources gathered the materials of water and raise of alluvium observation facts till the year 2007 and generalized.

Taking into consideration the global climate changes and since the year 1976 had made water reservoirs, increase, the water measuring 38 observation posts and till the year 1977 and from that year up to now is divided into 2 parts and compared.

The analyses of generalized quantities show that according to the territory the many yearly norm of expenditure till the year 1977 the norm changed from 0,13 m^3/s- 105 m^3/s, from the year 1977 up to now middle longstanding norms expenditure of water degreasing (0,34 m^3/s- 66,9 m^3/s) changed.

The lower level of norm of longstanding expenditure of water increased 2,6 times, but upper norm is 1,7 times reduced.

We suppose that it is because of global warming of climate.

We must note that since the year 1977 up to now the references middle longstanding expenditure till the year 1977 middle longstanding expenditure of water changes between 0.76-1.13 times.

From the year 1977 up to now the references of the expenditure of water to the year of 1977 the middle longstanding expenditure of water from 38 water measuring posts in 20 large, in 1 unchangeable, and in the rest was less as well.

As it is seen though the global warming of climate the number of expenditure of water is the largest.

But the largest expenditure of waters had to be reduced in comparison of previous times.

The solve problem we consider to analyze upper mentioned references, the two characteristic of the rivers of Major Caucasus.

So, as the river flowing in the north-eastern slope of Major Caucasus the noted references changed 0.76- 1.57 times, in the South slope increases between 0.86-2.36.

In the rivers flowing in the South slope the values of upper and low borders increased.

The reason is that since the year 1976 in our republic in the South slope of Major Caucasus and in North –Eastern slope of Minor Caucasus including, and in South-East slope built in Kura Hollow rising evaporation basins together with convective cloudiness was condensed.

One of the features confirming these values of references in the rivers flowing through Northeast slope in 21 water measuring posts in 7 large, in 1 unchangeable and in the rest posts was little.

But in the rivers flowing through the South slope the values of references in 17 water measuring posts in 13 large and in 4 was little.

The analysis show that the alluvium raise till the year 1977 longstanding expenditure changes between 0.23 kg/s- 120 kg/s, from the beginning of the year 1977, nowadays it changes between 0.22 kg/s- 86 kg/s.

Probably the reason for it is since 1976 the feculence of the rivers was reduced and washable constant breeds and in comparison of the previous periods, is explained the flowing to the surface.

The references of the flowing water values compared in the raise of alluvium reference in 12 water measuring posts in 5 large, in 6 little and in 1 remained unchangeable.

Depending on the height of basin the alluvium is formed longstanding period the largest raise of alluvium flowing through the rivers was different.

The largest expenditure of raise of alluvium is flowed till the year of 1977 in May 1300m- 2646 in June 800-2630 mm in July it was between 1000-1600 in height.

But in period from 1977 up to now the largest expenditure of alluvium rise in May 1000-2300m, in June 2630m it flowed in the middle height.

It is interesting that in the period till 1977 year the largest expenditure of alluvium raise of the least border passed from 890m for June, but from 1977 till nowadays the boarders increased to 1560 meters.

Similar position was observed in the period till the year 1977.

The same position was observed in longstanding period of alluvium raise the largest expenditure of the flowing in May till the year of 1977(1300-2640m.)

The analysis show that in May the alluvium raise of upper flowing boarder was reduced down 340 m.

The largest expenditure alluvium raise in June till the year 1977 passing border was 890-2630m, from the year 1977 up to now that limit raised 1560-2636 meters.

So, the largest expenditure of alluvium raise of the least passing border rose from 890m to 1560m in the latest period.

The analyzed all the features can be considered as the features of the changes that take place in the climate.

The influence of the global climate changes to the formulation of torrents in the basins of Major Caucasus, the greatest expenditure of water and the alluvium raise can be explained by the factors of their changes.

So, for the calculation of the expenditure of water forming torrents the relation

$Q_{\max.} = k\left(\overline{X}\frac{\sqrt{F}}{\overline{H}}\right)^{n}$ was investigated.

The general picture of relation is as following: here $Q_{max.}$ norm of longstanding of the largest expenditure of water, m³/s; X-maximum daily precipitations mm', F—the basin area of river km²; H- the middle height of river basins with m-, n and k – possesses different values in the group forming rivers.

The connection with the upper mentioned features reflecting complex between the largest expenditure of water gained connection formula was differential in 5 groups. The parameters of relationship was given below in the first table.

Table 1.

Parameters of equation for calculation of greatest expenditure of water.

Territory the area using the relationship	The upper degree of formula N	Coefficient of proportionate K	The middle high of basin m-s	From factor with % per
The north-eastern slope of Major Caucasus	1,01	182,2	Larger then 2400 m	as ± 19
The north-eastern slope of Major Caucasus	1,01	99,42	Less than 2400 m	as ± 22
The southern slope of Major Caucasus	1,11	27,7	1000 m lower	as ± 17
The southern slope of Major Caucasus	1,11	60,8	1000-1860	as ± 23
The southern slope of Major Caucasus	1,45	149	higher than 1860	as ± 19

The global climate changes influenced to the largest expenditure of river waters.

The calculation show that in the investigated territory the largest expenditure changes of rivers change between 0.10-2.99. It caused because of daily precipitations.

So, for studied territory rivers in the maximum precipitations the connection between

$C_{V_{Q\max}}$ was invented.

The influence of global warming of climate to the largest expenditure of alluvium raise...

For this $R_{\max .} = k\left(\overline{Q}_{\max .}\sqrt{\frac{F}{F_{mese}}}\right)^{n}$ relation was learned.

R-the longstanding norm of the largest expenditure of allivium raise: kq/s, Qmax- the largest expenditure of water 1 longstanding norm of m^3/s, Pm- the formula of basins in the area of forest km^2, n-the degree of formula.

The connection formula was differentialized in 7 groups. Each group is divide into the smaller groups.

The parameters of connection was given in table 3.

The analytic picture of relationship is a following: $C_{V_{Q\max.}} = k\overline{X}^{n}$ -the largest change of expenditure of water; X-daily maximum

Precipitations in mm-s, k-changes coefficient, n- the upper formula degree.

The connection formula was differential in 4 groups. The formula parameters is given in the 2^{nd} table.

Table 2

Parameters of equation for calculation of changeability expenditure of water.

The territory using the relation	The upper degree of preciptal n	Changeable coefficient	Calculated $C_{V_{Q\max}}$ with %
Between Gussarchay-Agchay	3,51	0,00114 or 0,114x10^2	as ± 28
Garachay-Derkchay	3,51	0,000326 or 0,0326x10^2	as ± 32
Between Derkchay-Sungoutchay	3,51	0,000342 or 0,0342x10^2	as ± 14
Balakanchay-Pirsaat	3,51	0,1222	as ± 31

Table 3

Parameters of equation for calculation of greatest expenditure of raise of alluvium.

The territory using the connection	The upper degree of formula	The hight K	Calculated expenditure of water from factors per-sent %
Samurchay-Luchek, Akhti-Usukhchay	2,2	10,39	as ±24
Gudyalchay-Kupchal, Valvalachay-Tangialti; Agchay-Sukhtagala	1,246	1,765	as ±18
Sabranchay-Zeyne	1,246	0,115	0
Kharmidorchay-Khaltan	1,246	0,2	0

Atachay-Altiagage	1,246	0,0333	0
Balakanchay-Balakan	2,21	34,54	0
Katekhchay-Gabizdara	2,21	7,2	0
Talachay-Zakatala	2.21	302,9	0
The basin of Kurmukhchay	2,21	1,878	as ±20
Between Ayrichay-Kischay	1,797	305,65	as ±28
Gaynarchay	1,797	5	0
Damiraparanchay-Vandamchay	1,173	0,316	as ±21
Goychay- Goychay	1,115	9,813	0
Bumchay-Bumchay	1,115	2,93	as -13
Goychay-Buynuz	1,115	6,433	as -25
Aghsu- Aghsu	1,115	28,1	as +17
Pirsaatchay- Shamakhi	1,91	0,85	0
Pirsaatchay-Poladli	1,91	1,49	as ±15
Sumgaitchay-Pirikushkul	1,91	1,49	as ±15

In the changeable coeffcent of allivium raise was the influence of global changes of climate too. It proves the $C_{V_{R\max.}} = a\overline{X}^n$ relation (connection).

$C_{V_{R\max}}$ changeable coefficient of the largers expenditure of allivium raise, x- daily maximum precipiatation mm-s, n- the degree of formula.

The relation formula was differencialized in 5 groups. The parameters were given below in 4th table.

Table 4.

Parameters of equation for calculation of greatest expenditure of raise of alluvium.

The territory using the relation.	The upper degree of formula N	Coefficient of proportionate k	The middle heigh of basin in m-s	Calculated $C_{V_{R\max}}$ from factory
The north-eastern slope of Major Caucausus	0,855	0,0892	1380-2400	as ±17
The north-eastern slope of Major Caucausus	0,855	0,1707	2400-2590	as ±18
The north-eastern slope of Major Caucausus	0,855	0,0512	2590-2930	as ±14
The south slope of Major Caucausus	0,55	0,079	-	as ±18

The generalize the influence of global climate changes in the river basins to the formulation of torrents to the coefficient of the largest expenditure of allivium raise the investigated territory carried out regioning.

According to the coefficent of the largest expenditure of raise of alluvium change carried out regionaliioning is 2 hight zone and 8 local region. There are given in the 5th table.

Table 5.

Change of greatest expenditutr raise of alluvium in high zones and azonal regions.

According to the changing coefficient hight zones and local regions	High zones and territory of local regions in km²	The hight zones and the midhight of local regions in m-s	The hight zones and the borders of change coefficient according local regions
1.Hight mountains and partially middle mount	13950	Higher than 2000 m	1,1-4,3
1.1 SamurMishlesh aronal region	563	2800	0,17
1.2 Usukhchay- Usukhchay region	272	2640	0,96
1.3 Gusarchay-Gudiyakchay territory aronal region	670	1400-2960	0,67-0,92
1.4 Tikanlichay-Tikanli aronal region	120	1380	0,53
1.5 Kurmukhchay local region	166	1990-2440	0,67-0,98
2. Mainly middle low,in mountainous surrounding zone	23630	2000 m low	0,1-1,1
2.1 Atachay-Kharmidorchay local region	64,8	1360-1386	2,7
2.2 Ayrichay-Ismayilli local region	88,2	940	2
2.3 Damargiq near the local region	35	1860	2,6

The analysis of the 5th table shows that the 3 of local regions high were separeted mountaneous and partly middle montainous but 3 of them in the middle of low mountainous.

It is because of in high mountains spreading there are centers of torrents in middle and low mountainous beside the many yearly actions, change of climate and the influence of antropogen factors.

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The Definition of the Boundary Stress in Wedge-Shaped Wells.

Professor Oleg Terentiev, Dr.Eng. Sc.,
E-mail: OLTR_1@ukr.net, Phone: +380 980819192
Igor Semenukha, Student,
E-mail: semenukha.i@gmail.com, Phone: +380977929215
National Technical University of Ukraine "Kyiv Polytechnic Institute",
115/3 Borshagivs'ka str., Kyiv, 03056, Ukraine.

Abstract

The subject of the article is the definition of the existing mathematical models used for calculating some operation factors during wells drilling process; the problem of the article is the detection of the influence of load concentrators' presence in a wedge-shaped well on a destruction process; the aim is the definition of the stress intensity in concentrators using the base mathematical model for detection of SIF. In this article we analyze the advantages and disadvantages of represented mathematical models in order to conduct the systematic foundation of scientific results.

Setting of the problem and its relationship with the important scientific tasks. The main problem during the solid rocks destruction is to ensure minimum of the specific power inputs. The solution of the mentioned problem is provided for creation of energy-saving technology of competent rock drilling using wedge-shaped wells. The importance of the problem is confirmed by the Decree of the Presidium of the National Academy of Sciences of Ukraine № 55 from 25.02.09, entitled: «The basic scientific directions and chief problems of fundamental research in the field of natural sciences, technics and humanities from 2009-2013».

Analysis of the latest research and publications, where the solution of given problem was initiated. In accordance with [1] the fundamental mechanics the destruction is the energetical theory of Griffiths, which allows to neglect the detailed analysis of the mechanism of the interatomic bond rupture at the end of the opening crack and to record the relationship between internal (RADIUS, the length of the crack) and external parameters (stretching force and it's pressure angle). The advantages of Griffiths' model; the explanation of the stuff's rigidity decreasing in regard to the theoretical; capability of the debris' hardness testing through the physical and stress-strain properties of the material; it was reported that maximum destructive stress is achieved after reaching a critical crack dimension (that is individual for each separate task). Disadvantages: it disregards the quasi-brittle fracture, notably the ability of the material to resist the crack growth, geometry of massif (length, width), in which the crack was discussed also the crack's geometry (form, large and small radius).

In mathematical model of Orovan - Irwin [2] was defined with the help of the test that: 1) the plastic deformation concentrates in a seam near the surface of a crack (a fracture with the plastic deformation has been called quasi-brittle), 2) energy consumption during the creation of new surfaces been destructed, is connected with the functioning of the plastic deformation stuff size located on the crack path, 3) flux of energy concentrated in the crack tip is determined by the cohesive force work. **Advantages**: the decision of Orovan-Irwin allowed making a conversion from the ideal material in Griffith's model to real materials. The established quasi-brittle destruction scheme takes into consideration that the zone of nonlinear effects in comparison with the crack length is small and gives a possibility to control the deformation by means of stress intensity factor (SIF), liquid limits, compression ratio and characterize stress field around the plastic zone through asymptotic equations; determined the radius of the plastic zone around the apex of crack ; calculated plastic correction data for estimation of the plastic zone**. Disadvantages**: The mathematical model does not consider the massif geometry (length, width) as an accountable factor, in which crack was examined, its shape and geometry (radius, vertex angle); does not determine the influence on the destruction of such factors as: the cross-section of well with concentrators, frequency in location of wells and their interaction during the destruction.

Barenblatt in his research [3] defines the geometry of the crack apex its growth start and further development as opposed to Griffiths' energy principle. Adhesion forces between surfaces at the apex of crack, allocated so that the opening geometry of the apex of crack into a wedge with the lips as falling exponential form, and the total load of field is considered generically. **Advantages**: The mathematical model accounts that crack lips are not free of loads, and they locate under the force of cohesion; the lips of crack are considered in falling exponential form, which increases the accuracy of calculations, the load directed to the crack lips is closed because crack tip stress intensity factor is zero; mathematical model with the help of singular equations confirms unlimited intensification at the tip of cracks. **Disadvantages:** The mathematical model of Barenblatt ignores composite material structure, since the vast zone under load stress and flaw shape form comparative with environment destruction, does not consider the massif geometry (length, width) in which crack was studied, its shape and geometry (radius, apex angle); does not determine the effect on the destruction of such factors as: the well's overcut with the concentrators, the frequency of wells' location and their interaction during the destruction.

Mathematical model of Dahdeyl – Leonov – Panasyuk [3] differentiates in following: 1) calculates a cohesion force of the crack lips through the material constant, 2) crack growth occurs when the discrepancy comes to the boil $\sigma 0$, *MPa*. **Advantages**: The mathematical model of growth limits the load increasing p at $l \rightarrow 0$. For short duration crack $p \rightarrow \sigma 0$; takes into account SIF change in the calculation of short-length cracks. **Disadvantages**: does not consider the massif geometry (length, width) in which crack was considered, its shape and geometry (radius, apex angle); does not determine the influence on the destruction of such factors as: : the cross-section of well with concentrators, frequency in location of wells and their interaction during the destruction.

In the paper of Eloev - Dzahoev [4] was determined the massif with the blast holes under the static stress (tension) was considered, in which fracture initiation appears after reaching **the boundary value of critical voltage,** setting the destruction of the massif in the specified course; dynamic of initiation and motion of cracks around the blast holes in mine workings with a glance of the depth of excavation, the mode number of tectonic and gravitational forces**. Advantages**: The mathematical model takes into consideration the dependence of SIF from the radius of the range of stress, mode number, depth of excavation, tectonic and gravitational forces, and its influence on the crack size, spreading rate relative to their initiation, taking into account the geometry of the blast hole (radius, length of concentrators), and the distance between blast holes. **Disadvantages:** this model simulates only the strategy of cracks under the squeezing, does not include the massif size (length, width), does not discount the form of stress concentrator.

The delimitation of unsolved parts of the general problem. Making a review of mathematical models of the destruction of the rock massif using the stress concentrator demonstrates that there is no method that takes into account both the width, block length, interposition of wells, form and stress concentrators' length.

The aim of this work is to review existing mathematical models, to choice of the base mathematical model, and a mathematical model for detection of SIF, which depends on the width, block length, interposition of wells, form and stress concentrators' length.

Exposition of the basic material of the article. The selection of the basic model is conducted by means of the hierarchical analysis. As critical parameters it was chosen: the accuracy of the model (equivalence between the theoretical calculations and the experimental ones), the quantity of variables that model takes into account (length, width of the block, the length of concentrators, well's diameter, etc...), structure of the material, where the well concentrators exist. According to the sum of integral criterions the mathematical models are organized in following order: model of Eloev-Dzahoev - 25.12; Dahdeyl-Leonov-Panasyuk - 22.54; Orovan-Irwin - 21.32, Barenblatt - 20.89; Griffith's - 19.08. Using a paired-comparison method the model of Dzahoev-Eloev is considered to be a constitutive one.

SIF is a measure of stress and deflection, which takes into account the cracks formation processes that take place within the plasticity zone. The total SIF system defined by the superposition theorem that is separately analyzed three cases of rock massif destruction: 1) it does not account the geometry of the block and concentrators form, 2) it takes into account the geometry of the block, 3) its considered geometry of concentrator. The crack expansion starts when the SIF reaches the critical value or when the stress in the well reaches the critical value $\sigma > \sigma_c$. For wells centers are located in a line which crosses the apex of the concentrators:

$$\sigma_C = (K_I^1 \cdot f_1 \cdot f_2)/Y(\lambda) \cdot \sqrt{\pi a}, \text{ Pa} \quad (1)$$

where: K_I^1 - *SIF* first kind, Pa·м$^{1/2}$ from [4];

f_1- corrective factors in [2], that takes into account the distance between the well center the acting;

f_2- corrective factors in [5], that takes into account the thickness of the block, the acting;

Y (λ) – the dependence function of crack length from the thickness of the block, acting;

a – the distance from center of the well to the well's crack, c.

Depending on (1) f_1- corrective factors take into account a distance from concentrator's border, to the point of application of destructive force, the total length of the concentrator (with a radius of well). And in the corrective factor f_2- was entered the rearrangement of the material and durability to breakdown a mountain mass to determine the thickness of the block. The function *Y (λ)* determines the effect of thickness of the block on the value of SIF, adjusting limit stress value σ_c.

For wedge-shaped wells located in the close drilling of equation (1) according to [6] takes the form:

$$\sigma'_C = (K_I^1 \cdot f_1 \cdot f_2 \cdot f_3)/Y(\lambda) \cdot \sqrt{\pi a}, \text{ Pa} \quad (2)$$

where: f_3 – coefficient of well survey, acting.

In the coefficient of well survey f_3 – wells variables are included that take into account the distance between wells in one row, the distance between rows, and length of concentrators with a borehole diameter. Factor f_3 – is adapting the mathematical model (1) for drilling wells using net.

Finding dependences (1, 2) define the terminal pressure when cracking begins. The formulas differ from legacy ones, taking into account the geometry of the depleted unit (corrective factors f_2*, the function Y (λ)),* the distance between the centers of wells (corrective factors f_1*),* form and length of stress concentrators *(*K_I^1*),* the distance between rows of wells f_3 – (for wells located in the drilling net).

Conclusions

1. To select of the base mathematical model for detection of SIF during the destruction of the rock massif by means of the wedge-shaped wells method of paired comparisons is used, that gave us an opportunity to conduct the systematic foundation of scientific results.

2. According to the sum of integral criterions the mathematical models are organized in following order: model of Eloev-Dzahoeva - 25.12; Dahdeyl-Leonov-Panasyuk - 22.54; Orovan-Irwin - 21.32, Barenblatt - 20.89; Griffiths - 19.08. As a basic mathematical model the model with the largest integrated assessment was selected (25.12).

3. It was obtained mathematical models that define the terminal pressure when cracking begins: 1) for wells in one raw, when their centers are located in a line which crosses the apex of the concentrators 2) for wells located in the drilling net. The formulas differ from legacy ones, taking into account the geometry of the depleted unit (corrective factors f_2, the function $Y(\lambda)$) the distance between the centers of wells (corrective factors f_1), form and length of stress concentrators (K_I^1), the distance between rows of wells f_3 (for wells located in the drilling net).

4. Proposed mathematical models differ from legacy ones, taking into account the geometry of the depleted unit (corrective factors f_2, the function Y (λ)), the distance between the centers of wedge-shaped wells (corrective factorsf_1), form and length of stress concentrators (K_I^1), the magnitude of a force of the destruction that appears in the well during the explosion - K_I^1, the distance between rows of wells f_3 (for wells located in the drilling net).

5. Mathematical models that define the terminal pressure when cracking begins: 1) for wells in one raw, when their centers are located in a line which crosses the apex of the concentrators 2) for wells located in the drilling net.

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Without review

MODERN STATE OF PRODUCTION of the ECOLOGICAL CLEAN and HIGH-ANTIKNOCK MOTOR-CAR PETROLS

R.A. Ashrafov
E-mail: ashrafov@yahoo.com, Tel.: +99 450 3232776
Institute of Petrochemical Processes, National Academy of Sciences of Azerbaijan, Baku, Azerbaijan

Abstract

The article is devoted one of basic tasks of modern oil-processing industry to development and mastering of production of motor-car petrols, satisfying modern ecological requirements. One of ways of improvement of ecological indexes of motor-car petrols consists in the decline of maintenance in them.

СОВРЕМЕННОЕ СОСТОЯНИЕ ПРОИЗВОДСТВА ЭКОЛОГИЧЕСКИ ЧИСТЫХ ВЫСОКООКТАНОВЫХ АВТОМОБИЛЬНЫХ БЕНЗИНОВ

АШРАФОВ Р. А.
E-mail: ashrafov@yahoo.com, Tel.: +99 450 3232776
Институт Нефтехимических процессов НАН Азербайджана, г.Баку, Азербайджан

Одной из основных задач в улучшении экологических характеристик автомобильных бензинов является отказ от применения бензинов, содержащих ТЭС в качестве антидетонатора. Эта задача решена в Японии, США и Канаде. В некоторых странах: Голландии, Австрии, Дании, Бельгии, Швейцарии, Швеции, Финляндии, Норвегии и Германии разрешено вводить этиловую жидкость только в специальные высокооктановые сорта[1;2].

Переход на неэтилированные топлива не только предотвращает эмиссию свинца с продуктами сгорания, но и сокращает на 60-90% другие вредные выбросы путем использования каталитических нейтрализаторов, для которых свинец является ядом. Кроме того, в этом случае возможно поддержание состава топливно-воздушной смеси, близкое к стехиометрическому, что обеспечивает такие оптимальные характеристики бензина, как плотность, вязкость, испаряемость, углеводородный состав, которые практически не влияют на токсичность отходящих газов. Но отказ от этилирования влечет за собой проблемы, связанные с обеспечением требуемого октанового числа бензина.

Первоначально этилированные сорта заменялись регулярными бензинами с относительно низким октановым числом (82-86 м.м.). Это было связано с отставанием темпов наращивания мощностей производства высокооктановых компонентов от требований по снижению норм этилирования. Однако дефицит высокооктановых неэтилированных бензинов был временным. Доля этилированных бензинов на протяжении 80-х годов ежегодно снижалась в среднем на 5-6%. В 1995 г. доля неэтилированных бензинов достигла 65% от общего потребления, а к 2000 г. - более 90%. Основным видом неэтилированных бензинов должен стать премиальный бензин „европремиум“.

Известно, что США - признанный лидер в области требований к экологической чистоте топлив. Рост числа автомобилей предопределяет ужесточение национальных стандартов, ограничивающих вредное воздействие отработавших газов. В соответствии с новыми дополнениями к Закону о чистоте воздушного бассейна основными отличиями качества автомобильных бензинов с улучшенными экологическими характеристиками, называемыми также реформулированными, модифицированными, „зелеными“, экологически чистыми и т.п., являются:

- низкая летучесть (давление насыщенных паров);
- пониженное содержание ароматических (особенно бензола) и олефиновых углеводородов, участвующих в образовании смога;
- обязательное использование кислородсодержащих компонентов и моющих присадок для предотвращения образования отложений в системах подачи топлива в двигателе;
- отсутствие свинца, марганца и других тяжелых металлов.

Испарение бензинов - основная причина естественных потерь и выбросов в окружающую среду токсичных углеводородов. При транспортировке, хранении и заправке автомобилей бензином потери от испарения достигают 1,5-2%. Снижение содержания свинца и изменение состава автомобильных бензинов привели к другой проблеме - увеличению показателя летучести товарных бензинов. Показатели летучести автомобильных бензинов (упругость паров по Рейду) для легких сортов бензинов повысились с 609 до 714, для зимних - с 798 до 931 г/см^2. Углеводороды, содержащиеся в парах бензинов, представляют опасность не только как токсичные вещества, но, участвуя в фотохимических реакциях под действием солнечного света, приводят к образованию смога. Все это вызывает необходимость снижения давления насыщенных паров бензинов, что, в свою очередь, понижает их ресурсы и детонационную стойкость. Максимальное давление насыщенных паров для бензинов с улучшенными экологическими свойствами - не выше 79,9 кПа.

В нефтеперерабатывающей промышленности принят ряд изменений в технологии производства бензинов. Так, большинство нефтеперерабатывающих компаний пошло по пути снижения содержания в бензинах компонентов с высоким показателем летучести. К последним относятся *н*-бутан, кислородсодержащие соединения, легкий прямогонный бензин и легкие продукты различных процессов, доля которых возрастает с ростом жесткости режимов работы установок. Суммарная доля таких компонентов может достигать 40% от общего объема товарных бензинов. Успешному решению проблемы способствовал ввод в эксплуатацию дополнительных мощностей процессов, таких, как алкилирование, каталитическая полимеризация и димеризация, а также снижение давления на установках процесса риформинга, переход к процессам с непрерывной регенерацией катализатора. Изменения в компонентном составе продукции в структуре технологического парка нефтепереработки сопровождались также увеличением содержания в бензинах ароматических углеводородов и изопарафинов, снижением доли низкооктановых *н*-парафинов[3].

Европейским комитетом стандартов также разрабатываются новые нормативы на предельно допустимые значения плотности бензинов и упругости паров. Следует отметить, что в целом по странам Западной Европы и в Японии этот показатель несколько ниже, чем в американских стандартах. С целью снижения потерь бензина от испарения новые машины в европейских странах снабжаются специальным конденсационным баком с поглотителем. Предусмотрены также защитные меры по уменьшению потерь в системе распределения бензина. Рассматривается вопрос о снижении предельно допустимой концентрации бензола в неэтилированном бензине, составляющей около 5% об., а в будущем ниже 1%. Однако использование катализаторов дожига и специальных баков приводит к резкому сокращению выбросов бензола в атмосферу[3]. Из рисунков 1, 2 и 3 видно, что доля бензола, серы и суммы ароматических углеводородов в составе товарных автомобильных бензинов согласно европейским нормам в последние годы существенно снижается[4].

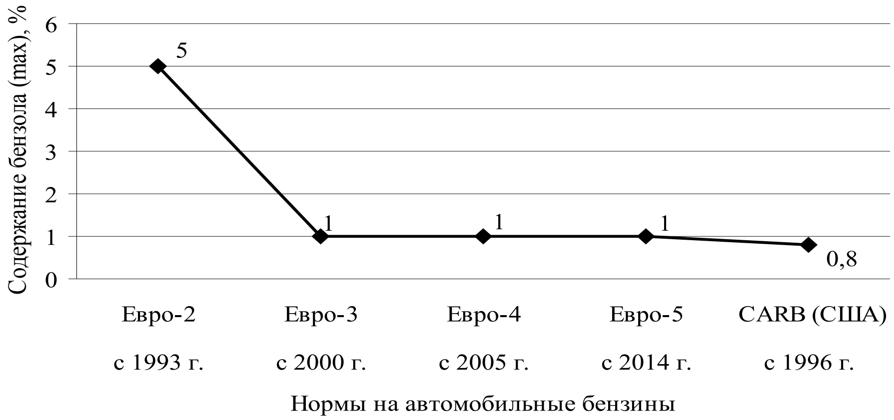

Рис. 1. - Максимально допустимое содержание бензола в товарных автомобильных бензинах

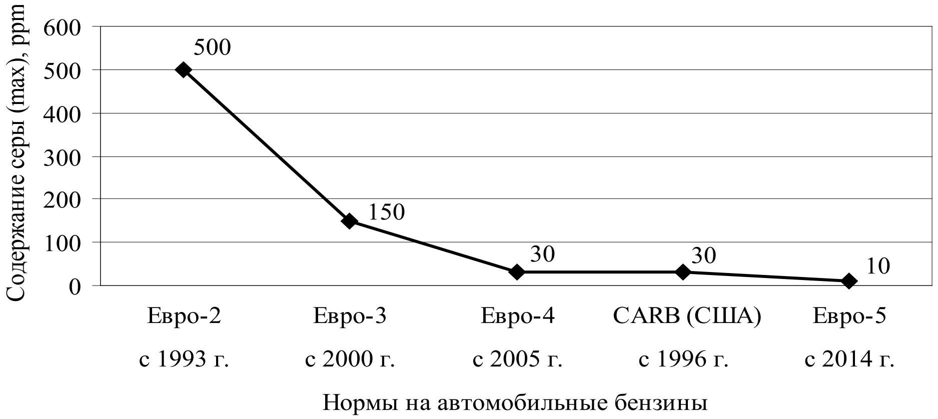

Рис. 2. - Максимально допустимое содержание серы в товарных автомобильных бензинах

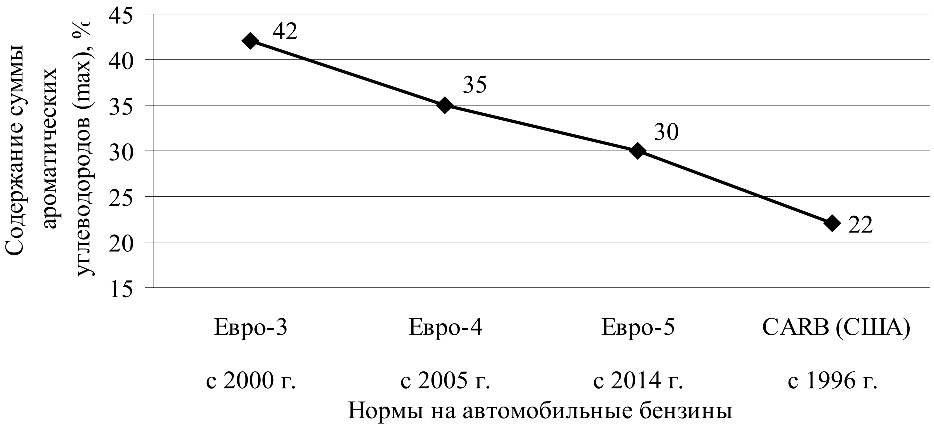

Рис. 3. - Максимально допустимое содержание суммы ароматических углеводородов в товарных автомобильных бензинах

С целью повышения октановых характеристик товарных бензинов используются спирты и простые эфиры в качестве компонентов. Следовательно углеводородный состав бензина с улучшенными экологическими характеристиками нормируется по содержанию ароматических соединений, бензола и олефинов. Содержание бензола в бензине США составляет не более 3%, в новых спецификациях на экологически чистые бензины - не более 1%. Ограничение содержания ароматических соединений до 20-25% (вместо ранее принятых 35-50%) приводит к удорожанию бензина. Выбор экономичной схемы снижения содержания бензола в бензине зависит от многих факторов, среди которых преобладает модернизация установок каталитического риформинга[4].

Одним из наилучших вариантов является использование процесса трансалкилирования бензола фракции C_7+ бензина риформинга, при котором полученный бензин даже без разбавления неароматическими компонентами, удовлетворяет требованиям ГОСТ Р-51105-97 по содержанию бензола. Кроме того, в полученном бензине на 31,4% меньше ароматических углеводородов C_9+, вызывающих повышенное нагарообразование в цилиндрах двигателей внутреннего сгорания и увеличение выбросов сажи в атмосферу с отработавшими газами. Снижение содержания бензола и увеличение октанового числа получаемого бензина позволяют снизить требования к неароматической составляющей, используемой при составлении композиций товарных высокооктановых бензинов.

На основе бензина трансалкилирования предлагается вариант производства товарного бензина АИ-95, удовлетворяющего следующим требованиям – содержание бензола не более 3% об., суммарное содержание ароматических углеводородов не более 45% об. Такой бензин может быть получен путем смешения 80% бензина трансалкилирования и 20% алкилата, он имеет октановое число 96 ИМ и 87,1 ММ, содержание бензола и суммы ароматических углеводородов 2,5 и 44,1% об. соответственно.

В табл.1 представлена сравнительная характеристика бензина риформинга и бензина, получаемогов процессе трансалкилирования фракции C_6 бензина риформинга с фракцией C_7+, и которой видно что, полученный по предлагаемой технологии бензин имеет октановое число 97,1 ИМ, что на 1,1 пункта больше, чем у бензина каталитического риформинга. При этом содержание бензола в нем составляет 3,3% мас., или 3,2% об., то есть на 37,7% относ. ниже, чем в бензине риформинга.

Таблица 1

Сравнительные характеристики бензина каталитического риформинга и бензина, полученного с использованием процесса трансалкилирования.

Показатели	Бензин риформинга	Бензин трансалкилирования
Октановое число, ИМ	96,0	97,1
Плотность при 20°С, кг/м^3	776	773
Выход на риформат, % мас	100	95,1
Углеводородный состав, % мас.: Парафинонафтеновые	34,6	35,3

Ароматические	65,4	64,7
В т. ч.: бензол	5,3	3,3
Толуол	17,2	20,1
C_8	23,5	28,0
C_9^+	19,4	13,3

При добавлении бензина трансалкилирования в состав высокооктанового экологически чистого товарного позволяет снизить содержание бензола в его составе ниже 1%.

Использование предложенной технологии позволяет улучшить экологию окружающей среды, уменьшить расход неароматических высокооктановых компонентов бензина. Необходимо отметить, что применение процесса трансалкилирования позволяет вовлекать в состав таких бензинов практически весь риформат и установленные новым стандартом требования должны быть включены во все виды нормативных документов на бензины.

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ON SCALAR CALIBRATION OF AN INERTIAL INSTRUMENT CLUSTER

Ass professor Vadym Avrutov,
e-mail: vyshgorod@gmail.com, phone: +380 674669584
National Technical University of Ukraine (Kiev Polytechnic Institute),
Peremogy Ave 37, Kiev, Ukraine

Abstract

Main features of a scalar calibration method for an inertial instrument cluster consisting of gyroscopes and accelerometers unit are viewed. The method allows to determine of biases, scale factor errors and mounting misalignments of the sensors without applying special requirements for alignment of test equipment and sensors alignment on the test equipment. But it requires sufficiently high accuracy of measurement of the output signals of sensors: the algorithm works fine when the number of digits is at least eight decimal places in normalized output signals of accelerometers.

Introduction

Usually gyroscopes and accelerometers making up an inertial instrument cluster are calibrated by the rate transfer test [1], where the output signals from gyroscopes and accelerometers are compared with the given reference input motion. For a reference input motion, the rotation rate of the rate table $\vec{\omega}$ for gyroscopes and gravity acceleration $\vec{g}$ for accelerometers can be used. The major disadvantage of this method is its stringent requirements to angular alignment of testing equipment.

There is also a scalar method of unit calibration used for gyroscopes and accelerometers [2] based on a scalar reference input motion. For the gyroscopes in the Earth's gravitational field such scalar value is the Earth's rotation rate Ω, and for accelerometers – the value of gravity vector g.

Scalar calibration method

Normally an inertial instrument cluster consists of a triad of single degree-of-freedom gyroscopes $\mathrm{G_X, G_Y, G_Z}$ and a triad of accelerometers $\mathrm{A_X, A_Y, A_Z}$ that are mounted to a vehicle with body frame $Oxyz$ with orthogonal sensitivity axes, as shown on Figure 1.

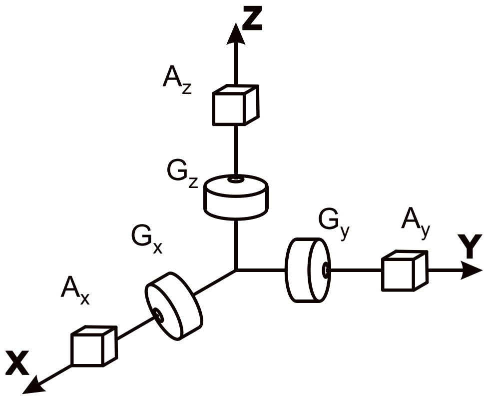

Figure 1. *Inertial instrument cluster*

Taking into consideration the errors of instruments (biases, scale-factor errors), mounting misalignments of the gyroscopes and accelerometers, which cause cross-coupling terms, and in-run random bias errors, the output signals may be expressed as shown below:

$$\begin{bmatrix} \mathbf{U_G} \\ \cdots \\ \mathbf{U_A} \end{bmatrix} = \begin{bmatrix} \mathbf{B_G} \\ \cdots \\ \mathbf{B_A} \end{bmatrix} + \begin{bmatrix} \mathbf{S_G} + \mathbf{E_G} + \mathbf{M_G} & \vdots & \mathbf{0} \\ \dots\dots\dots\dots & \vdots & \dots\dots\dots\dots \\ \mathbf{0} & \vdots & \mathbf{S_A} + \mathbf{E_A} + \mathbf{M_A} \end{bmatrix} \begin{bmatrix} \boldsymbol{\omega} \\ \cdots \\ \mathbf{a} \end{bmatrix} + \begin{bmatrix} \mathbf{w_G} \\ \cdots \\ \mathbf{w_A} \end{bmatrix} \quad (1)$$

where $\mathbf{U_{G(A)}}$ - is a set of output signals of gyroscopes (accelerometers), $\boldsymbol{\omega} = [\omega_x, \omega_y, \omega_z]^T$ - are applied turn rates acting along the principle axes of the vehicle, $\mathbf{a} = [a_x, a_y, a_z]^T$ - are the accelerations acting about these same axes, $\mathbf{S_G}, \mathbf{S_A}$ - is a diagonal matrix representing the scale factor of gyroscopes and accelerometers:

$$\mathbf{S_G} = \begin{bmatrix} S_{x_G} & 0 & 0 \\ 0 & S_{y_G} & 0 \\ 0 & 0 & S_{z_G} \end{bmatrix}; \; \mathbf{S_A} = \begin{bmatrix} S_{x_A} & 0 & 0 \\ 0 & S_{y_A} & 0 \\ 0 & 0 & S_{z_A} \end{bmatrix}$$

$\mathbf{B}_{\mathbf{G(A)}}$ - is a three element vector representing the residual fixed biases,

$\mathbf{w}_{\mathbf{G(A)}}$ - is a three element vector representing the in-run random bias errors,

$\mathbf{E}_{\mathbf{G(A)}}$ - is a diagonal matrix representing the scale-factor errors of gyroscopes and accelerometers the same like $\mathbf{S_G}, \mathbf{S_A}$, which elements are scale-factor errors, $\mathbf{M}_{\mathbf{G(A)}}$ -is a skew symmetric matrix representing the mounting misalignments and cross-coupling terms [3]:

$$\mathbf{M_G} = \begin{bmatrix} 0 & \Delta_{xz_G} & -\Delta_{xy_G} \\ -\Delta_{yz_G} & 0 & \Delta_{yx_G} \\ \Delta_{zy_G} & -\Delta_{zx_G} & 0 \end{bmatrix}, \ \mathbf{M_A} = \begin{bmatrix} 0 & \Delta_{xz_A} & -\Delta_{xy_A} \\ -\Delta_{yz_A} & 0 & \Delta_{yx_A} \\ \Delta_{zy_A} & -\Delta_{zx_A} & 0 \end{bmatrix}.$$

Here in notification of Δ_{xz} angle, the first index is shown that the unit is mounted on ox axes and has been rotated about oz axes on Δ_{xz} angle.

Be noted that listed above linearized model (1) are present to closer for optical sensors like ring laser and fiber optic gyroscopes. For the conventional gyroscopes and dynamical tuned gyro, the above equations should be added to 3×3 matrixes representing the g-dependent bias coefficients and anis elastic coefficients.

Calibration is done on fixed foundation in the gravity field of Earth, hence will pass from a special forces $\vec{a}$ to the projections of gravity vector $\vec{g}$ and from the body turn rate $\vec{\omega}$ to Earth's rate $\vec{\Omega}$. Let's divide every expression of output signal of accelerometer on corresponding scale factor and vector's module $\vec{g}$ ($g = \sqrt{g_x^2 + g_y^2 + g_z^2}$) and every expression of output gyro signal on corresponding scale factor and vector's module $\vec{\Omega}$ ($\Omega = \sqrt{\Omega_x^2 + \Omega_y^2 + \Omega_z^2}$).

New denotations of dimensionless output signals and values of right parts will be as follows:

$$u_{ja}=\frac{U_{j_A}}{S_{j_A}g};\overline{g}_j=\frac{g_j}{g};\ b_{ja}=\frac{B_{j_A}}{S_{j_A}g};e_{ja}=\frac{E_{j_A}}{S_{j_A}};n_{ja}=\frac{n_{j_A}}{S_{j_A}g};$$

$$u_{jg}=\frac{U_{j_G}}{S_{j_G}\Omega};\overline{\Omega}_j=\frac{\Omega_j}{\Omega};b_{jg}=\frac{B_{j_G}}{S_{j_G}\Omega};e_{jg}=\frac{E_{j_G}}{S_{j_G}};n_{jg}=\frac{n_{j_G}}{S_{j_G}\Omega}.$$

Here $j=x,y,z$, and also

$$\delta_{xz_{a(g)}}=\frac{\Delta_{xz_{A(G)}}}{S_{x_{A(G)}}};\delta_{xy_{a(g)}}=\frac{\Delta_{xy_{A(G)}}}{S_{x_{A(G)}}};\delta_{yz_{a(g)}}=\frac{\Delta_{yz_{A(G)}}}{S_{y_{A(G)}}};$$

$$\delta_{yx_{a(g)}}=\frac{\Delta_{yx_{A(G)}}}{S_{y_{A(G)}}};\delta_{zy_{a(g)}}=\frac{\Delta_{zy_{A(G)}}}{S_{z_{A(G)}}};\delta_{zx_{a(g)}}=\frac{\Delta_{zx_{A(G)}}}{S_{z_{A(G)}}}.$$

According to the scalar method of calibration, it is necessary to calculate the scalar value of measuring vector and compare it to the known scalar value of measurable vector.

As far as $\overline{g}_x^2+\overline{g}_y^2+\overline{g}_z^2=1$, and also ignoring values of the second order to the trifle, for the triad of accelerometers will get

$$\begin{aligned}
&\frac{1}{2}(u_{xa}^2+u_{ya}^2+u_{za}^2-1)=\\
&=(b_{xa}+n_{xa})\overline{g}_x+(b_{ya}+n_{ya})\overline{g}_y+(b_{za}+n_{za})\overline{g}_z+\\
&+e_{xa}\overline{g}_x^2+e_{ya}\overline{g}_y^2+e_{za}\overline{g}_z^2+\\
&+(\delta_{xz_a}-\delta_{yz_a})\overline{g}_x\overline{g}_y+(\delta_{zy_a}-\delta_{xy_a})\overline{g}_x\overline{g}_z+(\delta_{yx_a}-\delta_{zx_a})\overline{g}_y\overline{g}_z.
\end{aligned}\tag{2}$$

For the triad of gyros analogically will get

$$\frac{1}{2}(u_{xg}^2+u_{yg}^2+u_{zg}^2-1)=$$
$$=(b_{xg}+n_{xg})\overline{\Omega}_x+(b_{yg}+n_{yg})\overline{\Omega}_y+(b_{zg}+n_{zg})\overline{\Omega}_z+$$
$$+e_{xg}\overline{\Omega}_x^2+e_{yg}\overline{\Omega}_y^2+e_{zg}\overline{\Omega}_z^2+ \qquad (3)$$
$$+(\delta_{xz_g}-\delta_{yz_g})\overline{\Omega}_x\overline{\Omega}_y+(\delta_{zy_g}-\delta_{xy_g})\overline{\Omega}_x\overline{\Omega}_z+(\delta_{yx_g}-\delta_{zx_g})\overline{\Omega}_y\overline{\Omega}_z.$$

Hence, the difference between the scalar value of the normalized measurable vector and his actual value that is equal to one, proportional to the errors of the inertial instrument cluster. Coefficients in this dependence are the normalized values of measurable acceleration $\overline{g}_x, \overline{g}_y, \overline{g}_z$ for accelerometers and angular rate $\overline{\Omega}_x, \overline{\Omega}_y, \overline{\Omega}_z$ for gyros, their exponential orders and compositions.

18 unknown parameters should be found in equations (2) and (3). These 18 parameters are distorted of the inertial instrument cluster output signals. Six of them are differences of mounting misalignments angles of the devices.

To calibrate the inertial instrument cluster we should in the gravity field to turn around the certain direction at fixed angles and in every position get the normalized output signals. To solve the equations (2) and (3) it requires at least nine of the inertial instrument cluster position, so number of tests should be more or equal of nine. The fact is that in each one position of the inertial instrument cluster its output signals simultaneously have been measuring either gyroscopes or accelerometers, so the minimum number of positions in the two times less than the total number of required parameters.

Consider the equation (2) and (3) in matrix-block form:

$$\begin{bmatrix}\mathbf{u_a}\\ \cdots \\ \mathbf{u_g}\end{bmatrix}=\begin{bmatrix}\mathbf{G} & \vdots & \mathbf{0}\\ \cdots & \vdots & \cdots \\ \mathbf{0} & \vdots & \mathbf{\Omega}\end{bmatrix}\begin{bmatrix}\mathbf{e_a}\\ \cdots \\ \mathbf{e_g}\end{bmatrix}, \qquad (4)$$

where $\mathbf{u_a}$, $\mathbf{u_g}$ is a $n\times 1$ column vectors of the normalized inertial instrument cluster output signals:

$$\mathbf{u_a} = \begin{bmatrix} \frac{1}{2}(u_{xa1}^2 + u_{ya1}^2 + u_{za1}^2 - 1) \\ \frac{1}{2}(u_{xa2}^2 + u_{ya2}^2 + u_{za2}^2 - 1) \\ \cdots\cdots\cdots \\ \frac{1}{2}(u_{xan}^2 + u_{yan}^2 + u_{zan}^2 - 1) \end{bmatrix}, \quad \mathbf{u_g} = \begin{bmatrix} \frac{1}{2}(u_{xg1}^2 + u_{yg1}^2 + u_{zg1}^2 - 1) \\ \frac{1}{2}(u_{xg2}^2 + u_{yg2}^2 + u_{zg2}^2 - 1) \\ \cdots\cdots\cdots \\ \frac{1}{2}(u_{xgn}^2 + u_{ygn}^2 + u_{zgn}^2 - 1) \end{bmatrix}$$

$\mathbf{G}$, $\mathbf{\Omega}$ - is a $n \times 9$ matrixes of normalized projections of the acceleration $\vec{g}$ and turn rate $\vec{\Omega}$ of dimension:

$$\mathbf{G} = \begin{bmatrix} \bar{g}_{x1} & \bar{g}_{y1} & \bar{g}_{z1} & \bar{g}_{x1}^2 & \bar{g}_{y1}^2 & \bar{g}_{z1}^2 & \bar{g}_{x1}\bar{g}_{y1} & \bar{g}_{x1}\bar{g}_{z1} & \bar{g}_{y1}\bar{g}_{z1} \\ \bar{g}_{x2} & \bar{g}_{y2} & \bar{g}_{z2} & \bar{g}_{x2}^2 & \bar{g}_{y2}^2 & \bar{g}_{z2}^2 & \bar{g}_{x2}\bar{g}_{y2} & \bar{g}_{x2}\bar{g}_{z2} & \bar{g}_{y2}\bar{g}_{z2} \\ . & . & . & . & . & . & . & . & . \\ \bar{g}_{xn} & \bar{g}_{yn} & \bar{g}_{zn} & \bar{g}_{xn}^2 & \bar{g}_{yn}^2 & \bar{g}_{zn}^2 & \bar{g}_{xn}\bar{g}_{yn} & \bar{g}_{xn}\bar{g}_{zn} & \bar{g}_{yn}\bar{g}_{zn} \end{bmatrix};$$

$$\mathbf{\Omega} = \begin{bmatrix} \bar{\Omega}_{x1} & \bar{\Omega}_{y1} & \bar{\Omega}_{z1} & \bar{\Omega}_{x1}^2 & \bar{\Omega}_{y1}^2 & \bar{\Omega}_{z1}^2 & \bar{\Omega}_{x1}\bar{\Omega}_{y1} & \bar{\Omega}_{x1}\bar{\Omega}_{z1} & \bar{\Omega}_{y1}\bar{\Omega}_{z1} \\ \bar{\Omega}_{x2} & \bar{\Omega}_{y2} & \bar{\Omega}_{z2} & \bar{\Omega}_{x2}^2 & \bar{\Omega}_{y2}^2 & \bar{\Omega}_{z2}^2 & \bar{\Omega}_{x2}\bar{\Omega}_{y2} & \bar{\Omega}_{x2}\bar{\Omega}_{z2} & \bar{\Omega}_{y2}\bar{\Omega}_{z2} \\ . & . & . & . & . & . & . & . & . \\ \bar{\Omega}_{xn} & \bar{\Omega}_{yn} & \bar{\Omega}_{zn} & \bar{\Omega}_{xn}^2 & \bar{\Omega}_{yn}^2 & \bar{\Omega}_{zn}^2 & \bar{\Omega}_{xn}\bar{\Omega}_{yn} & \bar{\Omega}_{xn}\bar{\Omega}_{zn} & \bar{\Omega}_{yn}\bar{\Omega}_{zn} \end{bmatrix};$$

$\mathbf{e_a}, \mathbf{e_g}$ - is a 9×1 column vectors of unknown parameters

$$\mathbf{e_a} = \left[b_{xa} + n_{xa}, b_{ya} + n_{ya}, b_{za} + n_{za}, e_{xa}, e_{ya}, e_{za}, \delta_{xz_a} - \delta_{yz_a}, \delta_{zy_a} - \delta_{xy_a}, \delta_{yx_a} - \delta_{zx_a}\right]^T$$
$$\mathbf{e_g} = \left[b_{xg} + n_{xg}, b_{yg} + n_{yg}, b_{zg} + n_{zg}, e_{xg}, e_{yg}, e_{zg}, \delta_{xz_g} - \delta_{yz_g}, \delta_{zy_g} - \delta_{xy_g}, \delta_{yx_g} - \delta_{zx_g}\right]^T$$

Solving the matrix equation (4) by least-squares method, we obtain:

$$\begin{bmatrix} \hat{\mathbf{e}}_\mathbf{a} \\ \cdots \\ \hat{\mathbf{e}}_\mathbf{g} \end{bmatrix} = \left(\begin{bmatrix} \mathbf{G} & \vdots & \mathbf{0} \\ \cdots & \vdots & \cdots \\ \mathbf{0} & \vdots & \mathbf{\Omega} \end{bmatrix}^\mathbf{T} \begin{bmatrix} \mathbf{G} & \vdots & \mathbf{0} \\ \cdots & \vdots & \cdots \\ \mathbf{0} & \vdots & \mathbf{\Omega} \end{bmatrix} \right)^{\mathbf{-1}} \begin{bmatrix} \mathbf{G} & \vdots & \mathbf{0} \\ \cdots & \vdots & \cdots \\ \mathbf{0} & \vdots & \mathbf{\Omega} \end{bmatrix}^\mathbf{T} \begin{bmatrix} \hat{\mathbf{u}}_\mathbf{a} \\ \cdots \\ \hat{\mathbf{u}}_\mathbf{g} \end{bmatrix} \quad (5)$$
,

where $\widehat{\mathbf{u}}$ - is an estimating values of $\mathbf{u}$, $\widehat{\mathbf{e}}_\mathbf{a}$, $\widehat{\mathbf{e}}_\mathbf{g}$ - is an estimating values of the unknown parameters of inertial instrument cluster.

Thanks to the least squares method the results are smoothing, and as long as average of distribution is equal to zero

$$M\{n_x\} = M\{n_y\} = M\{n_z\} = 0,$$

then estimated values $\widehat{\mathbf{e}}_\mathbf{a}$, $\widehat{\mathbf{e}}_\mathbf{g}$ will not have a random noise.

Let us consider the matrix elements of the normalized projections of the acceleration $\vec{g}$ and turn rate $\vec{\Omega}$. We shall define the orientation of the inertial instrument cluster on the local geographic navigation axes $o\xi\eta\zeta$ by Euler-Krylov angles α, β, γ.

The transition from the coordinate system $o\xi\eta\zeta$ to $oxyz$ is determined by the direction cosine matrix

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}. \tag{6}$$

For the stationary base, the components $\vec{g}$ and $\vec{\Omega}$ on axis $oxyz$ in matrix form appears as follows:

$$\begin{bmatrix} g_x \\ g_y \\ g_z \end{bmatrix} = \mathbf{A} \begin{bmatrix} 0 \\ 0 \\ -g \end{bmatrix}, \quad \begin{bmatrix} \Omega_x \\ \Omega_y \\ \Omega_z \end{bmatrix} = \mathbf{A} \begin{bmatrix} 0 \\ \Omega\cos\varphi \\ \Omega\sin\varphi \end{bmatrix}, \tag{7}$$

here φ - is a latitude.

Using the matrix equations (7), we can obtain normalized projections of acceleration $\vec{g}$ and angular speed $\vec{\Omega}$:

$$\begin{aligned} \bar{g}_x &= -a_{13}; & \bar{\Omega}_x &= a_{12}\cos\varphi + a_{13}\sin\varphi; \\ \bar{g}_y &= -a_{23}; & \bar{\Omega}_y &= a_{22}\cos\varphi + a_{23}\sin\varphi; \\ \bar{g}_z &= -a_{33}; & \bar{\Omega}_z &= a_{32}\cos\varphi + a_{33}\sin\varphi. \end{aligned} \tag{8}$$

Consequently, the solution of equation (5) - implementation of computational procedures with matrices, as transposition, multiplication and inversion is mainly with the elements of the direction cosines matrix $\mathbf{A}$. Moreover, if for accelerometers latitude location does not affect the calculation of their errors, then for gyroscope, this effect is important.

Since, changing angles of rotation $\alpha_i, \beta_i, \gamma_i (i = \overline{1,n})$ inertial instrument cluster respectively to the local geographic navigation axes $o\xi\eta\zeta$, measuring and normalizing the output signals of the inertial instrument cluster, a pre-computed elements of the direction cosines matrix, you can determine the inertial instrument cluster errors with help of the direction cosines matrix. Note that with increasing number of tests $n(n_{\min} = 9)$ there are smoothed results.

Simulations results

To test the algorithm of scalar calibration the output signals of accelerometers triad were simulated with the following normalized values:

$$b_{xa} = b_{ya} = b_{za} = 2 \cdot 10^{-4}; e_{xa} = 2 \cdot 10^{-4}; e_{ya} = e_{za} = 4 \cdot 10^{-4};$$
$$\delta_{xz_a} = 2 \cdot 10^{-4}; \delta_{yz_a} = -2 \cdot 10^{-4}; \delta_{zy_a} = 2 \cdot 10^{-4}; \delta_{xy_a} = -2 \cdot 10^{-4};$$
$$\delta_{yx_a} = 2 \cdot 10^{-4}; \delta_{zx_a} = -2 \cdot 10^{-4}.$$

Figures 2 are shown the absolute value of relative error of the biases depending from the number of digits after the decimal point in the output signals of accelerometers.

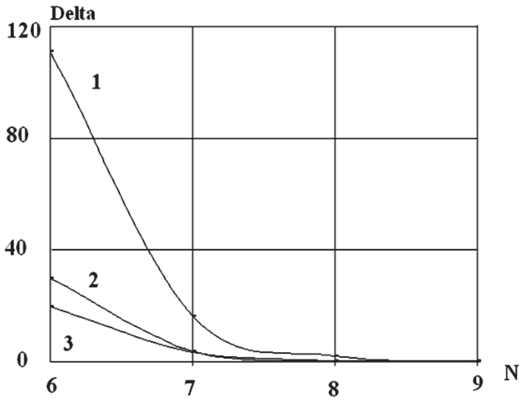

Figure 2. The dependence of the absolute value of the relative error of the biases from the number of digits after the decimal point in the output signals of accelerometers. Here curves 1,2,3 correspond to the relative determining error b_{ya} , b_{xa} , b_{za} *in percents.*

Note that the plots of the absolute value of relative error in determining the scale factors e_{ya} , e_{xa} , e_{za} and differences of the angles of nonorthogonality from the $\delta_{xz_a} - \delta_{yz_a}$, $\delta_{yx_a} - \delta_{zx_a}$, $\delta_{yx_a} - \delta_{xy_a}$ number of digits after the decimal point in the output signals of accelerometers are qualitatively similar form to Figure 2.

It is obvious that the algorithm works fine when the number of digits is at least eight decimal places in output signals of accelerometers.

In addition, it should be noted that in dealing with the matrix equation (5) it could be singular matrix. To solve this problem, the angles of rotation of the triad of accelerometers should be different, such angles α could change from 0° to 360° by step of 40°, angles β - from 0° to 80° by step of 10°, and angles γ also could change from 0° to 360° by step of 40°.

Conclusions

Thus, the scalar method of calibration for gyroscopes and accelerometers has both positive and negative features:

- it does not require to firmly “tie” the rate table axes to the inertial instrument cluster axes;
- one set of rotations in principle allows to calibrate a triad of accelerometers and a triad of gyroscopes;
- alignment errors of the gyroscopes and accelerometers (nonorthogonality angles) are linked in pairs, although the customers are interested in their individual values;
- it requires sufficiently high accuracy of measurement of the normalized output signals of sensors;
- the singular matrix problem may arise in the calculations.

However, as practical experience shows, these problems in principle can be resolved.

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USAGE OF CASTING ALUMINIUM ALLOYS FOR HYDROGEN-STORING VESSELS

Professor D. Chernega, doctor of tech. sciences, corr-member NAS of Ukraine, chief of department, Ukraine, Kiev, National technical university of Ukraine «KPI», tel. +044 4068219, e-mail: admin@fhotm.kpi.ua
V. Sorochenko, senior researcher, Ukraine, Kiev, National technical university of Ukraine «KPI», tel. +044 2387367, e-mail: admin@fhotm.kpi.ua
P. Kud, senior researcher, Ukraine, Kiev, National technical university of Ukraine «KPI», tel. +044 2387367, e-mail: admin@fhotm.kpi.ua

Abstract

Influence of alloying, modifying, complex treatment of fusion and a set of technological operations on tensile strength, corrosive resistance and weldability of AK9 type and AK8M3 type aluminium alloys was investigated. It was stated that application of the above mentioned operations positively affects on tensile strength, corrosive resistance and weldability of these alloys. This conclusion allows recommending these alloys to be used as a construction material for the production of bimetallic and combined vessels for storing hydrogen.

It is known that vessels of storing hydrogen that made of steel are exposed to «hydrogen degradation» that is revealed as an influence of hydrogen on durability and constructive integrity, leads to environmental leaks of hydrogen and reduced reliability of vessels.

Aluminium alloys are not subject to «Hydrogen degradation», because they are characterized by minimal diffusion rate at usual temperature, sufficient leaktightness and corrosive resistance in moderately acidic environment.

However durability of castings aluminium alloys is worse than durability of austenitic class steel that, eventually, limits their applicability for hydrogen storing vessels at high pressure.

The task to reveal the applicability of casting aluminium alloys as a construction material for hydrogen-storing vessels at the pressure of 10-15 MPa was formulated in this paper. To this end influence of alloying and modifying of the Al-Si-Mg system casting aluminium alloys, their hydrogen, out-of-furnace and the special treatments to improve mechanical durability, corrosive resistance and weldability of tested specimens were investigated.

AK9 type and AK8M3 type experimental alloys were selected as an object for the investigation. AK9 type alloy has such chemical composition (%): 8,1 of Si; 1,4 of Mg; 0,25 of Mn; 0,15 of Ti; 0,1 of Zr; 0,1 of Be; <0,6 of Fe and the rest is aluminium. Unlike AK9 type alloy, AK8M3 type is characterized by higher content of copper and beryllium and has such chemical composition (%): 8,1 of Si; 3,5 of Cu; 1,5 of Mg; 0,25 of Mn; 0,12 0f Ti; 0,12 of Zr; 0,15 0f Be; <0,6 of Fe and the rest is aluminium. Alloys were smelted in a resistance-heated furnace SShOL-1,6/12-M3 using of raw primary materials. Alloying additives of copper, manganese and titan were added into fusion of aluminium and silumin at the temperature 1003 ±10 K as twin ligatures, whilst magnesium – by the additive of metallic magnesium of type Mg90. After dissolution of the above listed alloying additions the fusion at the temperature of 1013 ± 10 K was exposed to hydrogen treatment during 3-5 minutes by water steam and the $LaAlH_4$ compound in an amount of 0,25 % of the total mass of fusion. After 10 minutes delay, a ceramic crucible placed into a thermostat was filled up with the fusion. Then, the fusion was exposed to out-of-furnace treatment with the combined modifier (2,4 %) with such chemical composition (%): 16-18 of fluoride-zirconium potassium, 2,0-2,2 of metallic boron and 80-82 of powdered aluminium-beryllium ligatures [1]. After this, the fusion at the temperature of 1003 ± 10 K was placed in a metallic casting mold produce experimental specimens in accordance with GOST 1583-89 in order to determine their tensile strength and explore corrosive resistance of these alloys.

Chemical composition of the alloys was determined by the MFS-8 emission spectrum analysis system in accordance with GOST 7727-81. Mechanical tests of regular specimens of the alloys were conducted by the FP 100/1 tensile tester.

Exploration of corrosive resistance was conducted on specimens of 18 mm of diameter and 4 mm of thickness, which were mechanically preprocessed, polished and finished. Experimental specimens were explored on corrosive resistance following the standard method (GOST 9. 021-74) during 24 hours at the temperature of 298 K in moderately acidic environment: 3 % NaCl + 1 % HCl.

Weldability of the alloys was researched at five times zooming of specimens intended for mechanical tests after their destruction and subsequent connection by means of argon-are welding.

AK9 type and AK8M3 type aluminium alloys were not occasionally selected. The selection was made because they belong to a set of impermeable castings silumins with good casting abilities. That's because they content a plenty of eutectics and has a short crystallization interval [2]. Taking into account the results of previous research [3], where was indicated insufficient durability and, especially, weldability of the Al-Si-Mg system alloys, AK9 type and AK8M3 type have already contained greater amount of alloying elements. This fact allows improving their machineability. With increasing of alloying elements content, especially Cu, Mn, Ti and other additions, in complex-alloying aluminium alloys, the diffusive mobility of hydrogen, which is accompanied by decreasing of diffusion rate, is slowing [4]. On the one hand, it's important for usage of these alloys as a construction material for hydrogen-storing vessels, of the other hand, greater content of copper in AK8M3 type alloy follows to worse corrosive resistance capability of cast blanks and extension of crystalline connectivity. Active treatment methods and a set of technological operations were applied on liquid metal in order to improve corrosive resistance and machineability of the alloys.

Influence of complex treatment and a set of technological operations on durability and corrosive resistance of these alloys are presented in table 1.

Applying of complex treatments, including hydrogen and out-of-furnace ones, on the fusion by the combined modifier follow to improvement of durability of these alloys up to 22-26 %. It is explained by the fact that in the process of hydrogen treatment with the $LaAlH_4$ compound that dissociates with formation of lanthanum and atomic hydrogen [5], which can execute both refining and modifying function [6]. Lanthanum, as an alloying element, consolidates α-solid solution [1]. Zirconium and metal boron, introduced into the fusion as effective modifiers, and beryllium, introduced at out-of-furnace treatment stage of liquid metal, lead to further alloying of α-solid solution, grinding down of structural components and even distributing of eutectic and intermetallic compounds in an aluminium matrix [1]. Applying of heat treatment with T5 mode increases the manner of durability of these alloys.

Table 1.

Influence of complex treatment and a set of technological operations on durability and corrosive resistance of AK9 type and AK8M3 type alloys.

Alloy type	Treatment type	Tensile strength, σ_B, MPa	Corrosive resistance, Δm, $g/m^2 \cdot h$
AK9 type	baseline	215	5,2
AK8M3 type	baseline	245	6,2
AK9 type	hydrogen + out-of-furnace	270	2,6
AK8M3 type	hydrogen + out-of-furnace	298	4,5
AK9 type	hydrogen + out-of-furnace + heat treatment T5	318	2,4
AK8M3 type	hydrogen + out-of-furnace + heat treatment T5	350	3,8
AK8M3 type	hydrogen + out-of-furnace + graded hardening + plastic deformation (5 %) + artificial graded ageing	-	3,2
AK8M3 type	the above + surface of specimen polishing	-	2,75

Corrosive resistance of these alloys, with the conduction of a set of technological operations, is being increased all time that is proven by decreasing of loss of the mass of specimens after they have been tested. Increased dispersion of structure and the presence of beryllium as a surface-active element, which forms protective skin around silicium-phase and intermetallic inclusions, are ending to this feature. The presence of stable cathode θ-phase ($CuAl_2$) in AK8M3 type alloy is reducing its corrosive resistance to some extent as compared with AK9 type alloy where this phase is absent. The combination of dispersion hardening and plastic deformation, which is accompanied with the compression of specimens and formation of dispersion θ'-phase (metastable phase) with less electronegative potential than for stable θ-phase, results in reducing of potential difference between dendrite of α-solid solution and the given phase. This prevents rising of intercrystalline corrosion of AK8M3 type alloy [2]. Usage AK8M3 type alloy for hydrogen-storing vessels as a constructive material without increase.

Polishing of specimens by water emulsion of chrome oxide decreases their surface roughness. This leads to the reduction of the probability of «corrosive ditches» formation and increasing of their corrosive resistance.

The results of weldability investigation of specimens made of AK9 type and AK8M3 type alloys are presented in table 2.

It's possible to see that durability of welded connections of experimental specimens, made of AK9 type and AK8M3 type alloys, where 1201 type alloy welding wire was used as an electrode, is featured by significant reduction of (by 20-25 %) as compared with baseline alloys with appearance of crystallization cracks in AK9 alloy.

Table 2.

Characteristics of the welded connections of AK9 type and AK8M3 type alloys.

Material	Type of electrode	State of core metal	Tensile strength, σ_B, MPa	Relative elongation, δ, %	Quality of the welded connections
AK8M3 type	-	T5	352	4,5	-
AK9 type	-	T5	300	1,8	-
welded connection of AK8M3 type alloy	welding wire 1201	T5	287	5,5	cracks absent
welded connection of AK9 type alloy	welding wire 1201	T5	230	2,4	cracks in 50 % of specimens
welded connection of AK8M3 type alloy	made of AK8M3 type alloy	tempering-573 K, self-control is 1 hour	290	5,6	cracks absent
welded connection of AK8M3 type alloy	made of AK9 type alloy	tempering-573 K, self-control is 1 hour	242	2,0	cracks in 15 % of specimens

Usage of welding electrodes, made baseline alloys, and preliminary tempering at the temperature of 573 K with self-control within approximately 60 minutes promotes the quality of welded connections. Slow cooling of the welded connections in asbestos fabric reduces the appearance of hot crystallization cracks in AK9 type alloy in 3 times, while in AK8M3 type alloy cracks do not appear at all.

Consequently, the improvement of characteristics of these alloys makes it possible to use them as construction material for making hydrogen-storing vessels, which work at the pressure of 10-15 MPa.

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ESTIMATION OF RELIABILITY OF CONDENSATION UNITS IN PLUNGER OF PUMPS ON THE BASIS OF THE PROBABILITY-PHYSICAL APPROACH TO OF WEAR PROCESS

Professor I.A.Habibov, Doctor of sciences, V.Sh.Huseynova, engineer
Azerbaijan State Oil Academy, Baku, Azadliq str. 20, Az1010, Azerbaijan
E-mail: h.ibo@mail.ru, vh74@mail.ru, tel.: +994502164887, +994124986539

Abstract

Wear process of condensation units in plunger oil-field pumps is considered as continuous Markof process with monotonous realizations to which there corresponds diffusion monotonous (DM) distribution. For an estimation of parameters of it distribution iterative procedure which rather quickly converges to exact values of parameters is offered.

Introduction

One of peculiarities in operation of oil-field pumps is rather low level of service life of their hydraulic part. Plunger pair and sealing cuff while in service are exposed to intensive deterioration that promotes a premature stop of pump installation with the subsequent replacement of these details and units and to increase in expenses of time at repair.

Piston and plunger pumps of a high pressure are applied in drilling wells, at various influences on borehole zone of layers, clearing of wells and some other works. In the majority of the listed technological operations a details of a hydraulic part of pumps are exposed to wear process by an abrasive layer (pistons, plungers, cylinder cartridges, rods) and to percussion - abrasive wear process (breech blocks and saddles of the valve). In this connection important value is given to selection of condensation units' construction in pumps [1].

Usually at research of reliability of separate details of pumps for refusal of a detail the size of its deterioration is accepted and the elementary model of linear deterioration [2] is used

$$\eta(t) = \alpha t + \beta,$$

where $\alpha -$ speed of wear process, β - initial value of deterioration: $\beta = \eta(0)$. Random variations of value α reflect distinction of initial properties of the object providing various speeds of deterioration.

In the assumption, as α and β - the independent random variables, submitting to normal distribution (and therefore, $\eta(t)$ has normal distribution), receive distribution of operating time τ as Bernshtein's well-known dispersive distribution [3]. So, in work [4] with the help of Bernshtein's distribution it is received wear resistance of the piston pump's rods by results of their bench tests. At this time presence (before infringement of tightness in interfaces and transition in a state of catastrophic wear process) the established rectilinear site of a curve of wear process of a detail in time with differing speeds of wear process of the samples, dependent on initial quality of their manufacturing and assembly is supposed.

Suppose, that distribution of random values α also β submit to the normal law, proceed from the following habitual reasons. Values α also β are the sum of the big number N items, each of which is a component of the speed, arising under influence of any one physical process (abrasive, fatigue, oxidizing and others wears). If all items have the identical order it is possible to accept, that their sum it will be good to follow the normal law. Thus central limiting theorem (ЦПТ) of the theory of probability which is validity at enough large number $N \to \infty$ of items, in essence, is used. For final *N* the statement of this theorem can and not be carried out.

The analysis of works under the theory of reliability [5] shows, that use of normal distribution in theoretical models of distribution of an operating time is one of the reasons of the unsatisfactory decision of reliability's tasks for mechanical objects (details of machines and systems). However investigators use in the given appendix normal distribution from considerations of calculation convenience (simplicity of formular expressions) with the subsequent essential methodical errors in an estimation of reliability's required parameters.

In case of small values of sizes asymmetry and an excess of statistical density of distribution, i.e. at small deviations of a statistical curve of distribution from normal type, enough effective estimations of non-failure operation and reliability of condensation units oil-field pumps can be received (see [6, 7]) with use of a perturbation function method offered by S.N.Bernshtejn [3].

For increase in service life of a hydraulic part in pumps we had been carried out researches at the choice of a material for sealing cuffs and circuits of their accommodation. As one of kinds of a material the composition on a basis ftoroplast marks FT4A (TNAT 6-05-1995-85) and graphite ГК-1 (GOST 17022-81), made according to the recommendation [8], and also configuration sealing cuffs from ftoroplast FT4A with composite material (SKN4O+SKEPT60+PVCH10) was used. Materials of used compositions, circuits of accommodation of sealing cuffs and corresponding values of a time between failures are resulted in tab. 1 of the given work.

Research of reliability of considered kinds of sealing units is lead in the present work on a basis diffusion monotonous distribution (DM - distributions) the refusals, recommended by standards [9-11] as theoretical model of distribution of an operating time to refusal. The given model represents a probability-physical method of the description continuous Markof process of deterioration with monotonous realizations. As shown in [5], mathematical models of processes of degradation as continuous Markof processes with monotonous and no monotonic realizations to which correspond diffusion monotonous distribution (DM - distribution) and diffusion no monotonic distribution (DN - distribution), are more adequate for random processes of destruction, than used in [2] as model of refusals idealized linear fan process. Diffusion distributions in a new technology of research of reliability for technical systems, independ of type of products (electronic or mechanical) [12].

A probability-physical research method of reliability of machines and equipments on a basis diffusion distributions.

The probability-physical approach to research of reliability of machines and equipments is based on use of distribution laws for refusals (models of reliability), following from the analysis of physical processes of degradation and bringing to refusal. Thus physical processes of degradation are considered as random processes. This approach directly establishes connection of probability for achievement of a marginal level by physical determining parameter, i.e. connects value of probability of refusal and the physical parameter causing refusal. Distribution of refusals (distribution of an operating time to refusals) which parameters have concrete physical interpretation, as against strict probability distributions (models) of refusals (exponential, Veybulla, logarifmic normal, etc.), it is accepted to name distribution of refusals by probability -physical distribution (model) of refusals [13, 14].

In [9, 12] the detailed comparative analysis of existing circuits of formalization of probability-physical models of refusals is given. Thus four circuits of formalization are considered: 1) fan random process to which there corresponds alpha - distribution; 2) “strongly hashed” Gauss process to which there corresponds normal parametrical distribution; 3) continuous markof process with monotonous realizations to which corresponds diffusion monotonous distribution (DM - distribution); 4) continuous markof process with nonmonotonic realizations to which corresponds diffusion nonmonotonic distribution (DN - distribution).

In [9, 13] also it is shown, that diffusion distributions (DM and DN) are more flexible functions better leveling the skilled data in comparison with known two-parametrical is strict probability models (Veybulla, logarifmic normal, gamma - distribution, etc.), and also in comparison with normal parametrical and alpha - distribution. Besides diffusion distributions are represented by rather simple functions having simple expressions for various estimations of the parameters, and also for all basic parameters of reliability.

Diffusion distributions as probability -physical models of reliability have the big advantage before strict probability models that their parameters can be estimated as on the basis of refusals statistics (in this case they are considered as strictly probability models), and on the basis of the analysis of statistical characteristics of the physical process bringing to refusal, and also at jointly use of statistical information on both types. The major factor promoting the decision of various of reliability's tasks at use diffusion distributions is that the form parameter of these distributions represents the generalized characteristic of investigated mutually reversible processes (process of destruction and distribution of an ope∂ung time) - factor of a variation. And the factor of a variation as the generalized characteristic with sufficient accuracy for engineering practice can be estimated a priori on the basis of numerous researches as processes of destructions (durability, weariness, wear process, etc.), and the statistical data on refusals under tests and exploits of products - analogues.

An estimation of reliability of units of plunger pumps condensation units with use diffusion monotonous distribution.

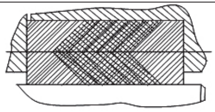
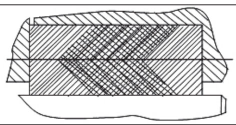
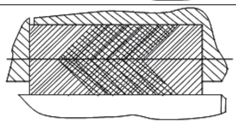
Among the reasons of refusals of condensation units in pump installations the important place occupies ageing of system. In the course of time materials of which elements and connections of condensation system are made, undergo irreversible changes. These changes are generated by corrosion, deterioration, accumulation of deformations and weariness, diffusion of one material in another, etc. These processes are imposed, cooperate and finally cause change of work characters.

That system as a whole and her elements were efficient, work characters of them should lay in some limits determined by a system's kind and designated purpose. When the work characters leave for the set limits, the element (system) starts to work unsatisfactorily, and it is qualified as refusal. Generally the work characters under influence of ageing can change nonmonotonicly, however in most cases it varies monotonously. The further reasonings will be based on the assumption of monotonous character of change of work characters of pump installation's condensation unit. This assumption is much wider accepted in [2] assumptions about linear fan character of change of work characters $\eta(t)$ and enables to use as model of refusals diffusion monotonous (DM) distribution.

For test of samples condensation unit we shall accept 3 circuits: 1) the unit of condensation will consist only from FT4A, and each package will consist of 4 cuffs V - figurative type; 2) the unit of condensation is made from FT4 and rubbers of mark IRP- 1293; 3) the unit of condensation will consist of configuration FT4 and SKN40+SKEPT60+PVC10.

For each chosen circuit 10 complete sets were exposed to test. The statistics of refusals of pump installations under each chosen circuit of units of condensation is resulted in tab. 1.

Table 1.

The circuits of condensation	A material of condensation cuffs	Value of operating tike for group of condensations									
		1	2	3	4	5	6	7	8	9	10
	Ftoroplast FT4A with the maintenance of 10% of graphite	340	352	310	361	340	370	372	350	366	371
	Ftoroplast and rubber	290	295	270	301	295	293	300	260	280	277
	Ftoroplast FT4A and SKN40+SKEPT 60+PVC10	326	374	380	350	380	379	385	401	392	400

Methodology of an establishment of quantity indicators of objects' reliability on the basis of the statistical data on refusals at tests or while in exploit provide acceptance of this or that theoretical model of refusals (function of distribution of an operating time to refusal or on refusal) and definition of parameters of this of distribution function.

Let's accept as theoretical function for distribution of an operating time to refusal of pump installation's condensation unit diffusion monotonous (DM) distribution. Integral function of this distribution has the following simple expression

$$F(t) = DM(t, \mu, \nu) = \hat{O}\left(\frac{t-\mu}{\nu\sqrt{\mu t}}\right), \tag{1}$$

where $\hat{O}(z) = \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{z} \exp\left(-\frac{x^2}{2}\right)dx$ - the normalized normal distribution; $\mu -$ the parameter of scale consider us to a distribution's median of a random variable t; $\nu -$

parameter of the distribution's form for a random variable t, the representing factor of a variation; t - an operating time to refusal.

We shall estimate parameters DM - distributions separately for each of three circuits of condensation on the basis of the statistical data on its refusals at the plan of full tests (the plan [NUN]) (N=10 tests), submitted in the corresponding line of tab. 1. The most widespread and effective from the theoretical point of view a method of definition of a sample estimation of parameters distribution's parameters is the method of maximal plausibility (MP).

The given method, as is known, possesses the important advantages: it always results in well – off estimations (which efficiency grows with increase in volume of sample), having the least possible dispersion and in the best way using the information on the unknown parameter, contained in sample.

MP- estimations for distribution's parameters are received from function of the maximal plausibility

$$L = \prod_{i=1}^{N} f_M\left(t_i; \mu, \nu\right), \qquad (2)$$

where $t_1, t_2, ..., t_N$ - operating time to refusal (N -number of the samples put on test);

$f_M\left(t_i; \mu, \nu\right)$ - density of probabilities of DM - distributions:

$$f_M(t; \mu, \nu) = \frac{(\mu + t)}{2\nu t\sqrt{2\pi\mu t}} exp\left[-\frac{(\mu - t)^2}{2\nu^2 \mu t}\right]. \qquad (3)$$

Taking the logarithm equality (2), with the account (3), we shall receive

$$ln L = \sum_{i=1}^{N} ln\left(\mu + t_i\right) - N\, ln\, \nu - \frac{N}{2} ln\, \mu - \sum_{i=1}^{N}\left(2t_i\sqrt{2\pi t_i}\right) - \sum_{i=1}^{N}\frac{\left(\mu - t_i\right)^2}{2\nu^2 \mu t_i}. \qquad (4)$$

The maximum of function (4) is finded from the decision of system of the equations

$$\begin{cases} \dfrac{\partial \ln L}{\partial \mu} = 0, \\ \dfrac{\partial \ln L}{\partial \nu} = 0. \end{cases} \quad (5)$$

In designations

$$\theta = N\left[2\sum_{i=1}^{N}\left(\mu + t_i\right)^{-1}\right]^{-1}, G = N\left(\sum_{i=1}^{N} t_i^{-1}\right)^{-1}, S = \frac{1}{N}\sum_{i=1}^{N} t_i \quad (6)$$

the first equation of system (5) will be written down as

$$\nu^2\mu^2\theta^{-1} - \mu^2 G^{-1} - \mu\nu^2 + S = 0, \quad (7)$$

And the second - as

$$2 + \nu^2 - \mu G^{-1} - \frac{S}{\mu} = 0. \quad (8)$$

Thus, MP - estimations $\tilde{\mu}, \tilde{\nu}$ of parameters μ, ν are determined from the decision of the following system of the equations

$$\begin{cases} \tilde{\nu}^2\tilde{\mu}^2\theta^{-1} - \tilde{\mu}^2 G^{-1} - \tilde{\mu}\tilde{\nu}^2 + S = 0, \\ 2 + \tilde{\nu}^2 - \tilde{\mu} G^{-1} - \tilde{\mu}^{-1} \cdot S = 0. \end{cases} \quad (9)$$

From the second equation of system (9) we find

$$\tilde{\nu}^2 = \tilde{\mu} G^{-1} + \tilde{\mu}^{-1} S - 2. \quad (10)$$

Having made replacement $\tilde{\nu}^2$ in the first equation, we shall receive a quadratic concerning parameter $\tilde{\mu}$:

$$\tilde{\mu}^2 - 2\tilde{\mu}(G + \theta) + 2\theta G + GS = 0.$$

The unique decision of last equation under condition of $G < \tilde{\mu} < S$ results in expression of MP - estimations $\tilde{\mu}$ of parameter μ.

Thus, MP - estimations of DM – distribution's parameters following from the decision of system (9) have the following kind [15]:

$$\tilde{\mu} = G + \theta - \left(G^2 - SG + \theta^2\right)^{1/2}, \tag{11}$$

$$\tilde{\nu} = \left(\tilde{\mu}G^{-1} + \tilde{\mu}^{-1}S - 2\right)^{1/2}. \tag{12}$$

In work [16] the simplified well-off estimation for scall's parameter of DM - distributions

$$\tilde{\mu} = (SG)^{1/2} \tag{13}$$

Is offered.

Also it is marked, that at enough large N (more than 100) estimations (11) and (13) practically coincide.

We shall notice, that by virtue of first of designations (6) $\theta \approx \theta(\mu)$ and at substitution in the equation (11) instead of θ a corresponding estimation

$$\tilde{\theta} = \theta(\tilde{\mu}) \equiv N\left[2\sum_{i=1}^{N}\left(\mu^2 + t_i\right)^{-1}\right]^{-1} \tag{14}$$

the system of the nonlinear equations concerning unknown persons $\tilde{\mu}, \tilde{\nu}$ will turn out:

$$\begin{cases} \tilde{\mu} = G + \theta(\tilde{\mu}) - \left(G^2 - SG + \theta^2(\tilde{\mu})\right)^{1/2}, \\ \tilde{\nu} = \left(\tilde{\mu}G^{-1} + \tilde{\mu}^{-1}S - 2\right)^{1/2}. \end{cases} \tag{15}$$

For solving the system (15) it is possible to apply iterative procedure

$$\begin{cases} \tilde{\mu}_n = G + \theta(\tilde{\mu}_{n-1}) - \left(G^2 - SG + \theta^2(\tilde{\mu}_{n-1})\right)^{1/2}, \\ \tilde{\nu}_n = \left(\tilde{\mu}_n G^{-1} + \tilde{\mu}_n^{-1}S - 2\right)^{1/2}, (n = 1,2,\ldots) \end{cases} \tag{16}$$

having taken for initial values of calculated parameters

$$\tilde{\mu}_0 = (SG)^{1/2}, \tilde{\nu}_0 = \left(\tilde{\mu}_0 G^{-1} + \tilde{\mu}_0^{-1}S - 2\right)^{1/2}. \tag{17}$$

Let's make calculation of parameters $\tilde{\mu}, \tilde{\nu}$ for the first circuit of condensation, sample of values of an operating time to which refusal is submitted by a variational series (see to tab. 1):

310, 340, 350, 352, 361, 366, 370, 371, 372.

From two last formulas (6) we find $G = 352{,}48.\ S = 353{,}2$

From formulas (17) we find $\tilde{\mu}_0 = 352{,}8.\ \tilde{\nu}_0 = 0{,}043$

Let's calculate $\tilde{\theta}_0 = \theta(\tilde{\mu}_0)$: $\tilde{\theta}_0 = 354{,}56$

From formulas (16) at $n = 1$ we find $\tilde{\mu}_1 = 352{,}798.\ \tilde{\nu}_1 = 0{,}044$

So, after the first iteration of procedure (16) we have $\tilde{\mu}_1 \approx 352{,}8,\ \tilde{\nu}_1 = 0{,}044$ to within the second and third sign accordingly. More exact values can be received, applying this procedure for $n = 2,3,...$

Estimations $\tilde{\mu}, \tilde{\nu}$ for the second and third circuit of condensation are finded similarly.

So, for the second circuit we have a variational series of an operating time to refusal (tab.1):

260, 270, 277, 280, 285, 290, 293, 295, 300, 301

Then $G = 284{,}52$, $S = 285{,}1$, $\tilde{\mu}_0 = 284{,}81$, $\tilde{\nu}_0 = 0{,}0448$, $\tilde{\theta}_0 = 284{,}82$,

$\tilde{\mu}_1 = 284{,}809$, $\tilde{\nu}_1 = 0{,}0447$.

So, after the first iteration we have $\tilde{\mu} = 284{,}81$ and $\tilde{\nu} = 0{,}045$ to within the second and third sign accordingly.

For the third circuit of condensation a variational series of operating time to refusal looks like:

326, 350, 374, 379, 380, 380, 385,392, 400, 401

Parameters G and S in this case have the following values $G = 375{,}35$, $S = 367{,}7$

, $\tilde{\mu}_0 = 376{,}02$, $\tilde{\nu}_0 = 0{,}059$, $\tilde{\theta}_0 = 376{,}047$, $\tilde{\mu}_1 = 376{,}02$.

So here it is possible to accept $\tilde{\mu} = 376{,}02$ and $\tilde{\nu} = 0{,}059$ to within the second and third sign accordingly.

Thus, for considered three circuits of condensation integral functions of distribution will be written down accordingly as:

$$F(t) = \Phi\left(\frac{t - 352{,}80}{0{,}044\sqrt{352{,}80 \cdot t}}\right), \qquad (18_1)$$

$$F(t) = \Phi\left(\frac{t - 284{,}81}{0{,}045\sqrt{284{,}81 \cdot t}}\right), \tag{18$_2$}$$

$$F(t) = \Phi\left(\frac{t - 376{,}02}{0{,}059\sqrt{376{,}02 \cdot t}}\right), \tag{18$_3$}$$

As the maximal operating time to refusal under the second circuit is equal 301 h., it is natural to compare values of function of reliability $1 - F(t)$ of considered three circuits at $t = 300$h.

For the first circuit we shall have:

$$1 - F(300) = 1 - \Phi\left(\frac{300 - 352{,}8}{0{,}044\sqrt{352{,}8 \cdot 300}}\right) = 1 - \Phi(-3{,}69) = \Phi(3{,}69) = 0{,}99989;$$

for the second circuit:

$$1 - F(300) = 1 - \Phi\left(\frac{300 - 284{,}81}{0{,}045\sqrt{284{,}81 \cdot 300}}\right) = 1 - \Phi(1{,}15) = 0{,}12507;$$

and at last, for the third circuit:

$$1 - F(300) = 1 - \Phi\left(\frac{300 - 376{,}02}{0{,}059 \cdot \sqrt{376{,}02 \cdot 300}}\right) = 1 - \Phi(-5{,}03) = \Phi(5{,}03) \succ 0{,}99997.$$

From here follows, that more reliable is the third circuit of condensation. At calculation of function of standard normal distribution $\Phi(x)$ the table A.1 from Appendices [17] was used.

The conclusion

1. For work characters of serviceability of machines details and equipments speed of wear process usually is accepted and the elementary model with linear dependence of speed of deterioration on time $\eta(t) = \alpha t + \beta$ is used. Besides believe, that factors α and β this model are independent normal random variables. Such assumptions are made for convenience of calculation and can lead to essential methodical errors in an estimation of reliability's parameters.
2. In the assumption monotonous (not necessarily linear) character of change of work characters with use as model of refusals diffusion monotonous (DM) distributions it is possible to estimate reliability's function of each separate circuit of pump installation's condensation and to choose the best circuit on the greatest value of reliability's function for the considered period of time.
3. Diffusion monotonous distribution is represented by rather simple function (standard normal distribution), having simple expressions for estimations of the parameters. The offered in this work iterative procedure for estimation of the given distribution's parameters is rather fast (practically for 2-3 steps) convergence to limiting values.
4. DM - distribution is more flexible function better leveling the skilled data, in comparison with known two-parametrical is strict probability models (Veybulla, logarithmic normal, gamma-distribution and etc), and also in comparison with normal parametrical and the alpha - distribution corresponding to linear fun process, determined by linear model of deterioration.
5. Continuous markof process with monotonous realizations to which corresponds DM - distribution, is one of circuits of formalization of probability-physical models of the refusals resulting in increase of accuracy of estimations of reliability's parameters and decrease of expenses for reability's research irrespective of type of products (mechanical or electronic).

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Agriculture

Influence of long-term increase of air temperature onto a photosynthetic apparatus capacity and yield of contrasting winter wheat varieties, Galina A. Priadkina , PhD, Institute of Plant Physiology and Genetics, National Academy of Sciences of Ukraine, Vasilkivs'ka str., 31/17, 03022 Kyiv-022, Ukraine, e-mail: pryadk@yandex.ru

The changes of photosynthetic parameters - chlorophyll content in leaves, leaf area index (LAI) and chlorophyll index (Chl I) - and grain productivity of 2 contrasting varieties of winter wheat (high-yielding variety Favoritka and low-yielding one Mironovskaya 808) were investigated. The studied photosynthetic apparatus components differently respond to prolonged elevated temperatures. LAI was more determined from the temperature increase, chlorophyll content and yield greatly dependent from genotypic features of varieties. The greater size of assimilating surface during grain maturation of high-yielding cultivar allowed to higher, compared with low-yielding one, grain productivity in conditions heightened air temperature.

Innovations and Technologies News, Nr.1(10), 2011, Latvia

Biological Sciences

The investigation of free-radical oxidative reactions participation in development of phytotoxic action of graminicides, Yevgen Morderer, Mariya Palanytsya, Olena Rodzewich, Institute of Plant Physiology and Genetics (IPPG), Ukraine National Academy of Sciences (NASU), Department of Physiological Action of Herbicides, Vasylkivska street 31/17, 03022, Kiev, Ukraine, corresponding author's E-mail: emorderer@mail.ru

Herbicides that inhibit acetyl-CoA-carboxylase (ACC) form a group of so called graminicides due to their ability to selectively control weeds from *Gramineae* family and are commercially the most promising in group of herbicides. However, essential disadvantage of graminicides is reduction in effectiveness at unfavourable weather conditions, as well as antagonistic interaction with herbicides, effective against dicot weeds. It should be noted that antagonistic reduction in graminicide phytotoxicity is not caused by alterations in their uptake, translocations, metabolism or ACC inhibition. Therefore, final graminicide phytotoxicity is not exclusively determined by inhibiting action in the site of action, but depends upon subsequent course of herbicide-induced pathogenesis. Effect of haloxyfop-*R*-metyl (HF) on reaction of lipids peroxidation (LP) meristems of maize (*Zea mays L.)* roots was investigated. The effect of well-known antagonist for graminicides 2,4-D and free radical scavenger tocopherol - in development of phytotoxic

action of graminicides was studied. It was established that primary products of LP - lipid hydroperoxides (LOOHs) and the end products of these reactions – TBA-active substances (TBA-RS) did not increase under HF action. In contrast to leaves of old plants, meristems have showed increase of unsaturated fatty acids in integral lipids. Thus, the necrosis of maize meristems was not accompanied with intensification of peroxidation reactions of integral lipids. When tocopherol and 2,4-D were used with HF, they decreased the appearance of necrosis. On the basis of aggregate data, we offer the hypothesis about the participate of oxidative stress in the development of phytotoxic action of graminicides. In our opinion, the changes in unsaturated fatty acids can be a signal that activates the secondary signal system of the plants, and, in turn, leads to the induction of programmed cell death. In this context the possible role of plants NADPH-oxidase and lipoxygenase signal systems in development of pathogenesis, induced by graminicides, is discussed.

Ukrainian Journal «Physiology and Biochemistry of cultivated plants», Nr.1, 2008, Institute of Plant Physiology and Genetics, Ukraine.

The generation of reactive oxygen species under the action of graminicides and modifiers of their phytotoxicity, **Mariya Palanytsya, Yevgen Morderer, Valentina Trach, Olena Rodzewich,** Institute of Plant Physiology and Genetics (IPPG), Ukraine National Academy of Sciences (NASU), Department of Physiological Action of Herbicides, Vasylkivska street 31/17, 03022, Kiev, Ukraine, corresponding author's E-mail: emorderer@mail.ru

Effect of haloxyfop-R-metyl (HF) and their modifiers on induction of necrosis and generation of reactive oxygen species (ROS) in meristems of maize (*Zea mays* L.) roots was investigated. Antioxidants tocopherol and ionol decreased and hydrogen peroxide (HP) increased necrosis in meristems, induced by herbicide HF. During HF action the short-term generation of HP and prolonged production of superoxide radical (SOR) was observed. ROS generation increased under exogenous effect of HP and decreased under the effect of antioxidants. When ionol was used with HF, the generation of ROS decreased. In contrast, under the effect of HF with HP the generation of SOR and endogenous HP increased. The conclusion about participation of ROS in the development of the pathogenesis induced by graminicides was made.

Ukrainian Journal «Physiology and Biochemistry of cultivated plants», Nr.4, 2009, Institute of Plant Physiology and Genetics, Ukraine.

The possible participation of reactive oxygen species in the development of graminicides phytotoxic action, Mariya Palanytsya, Yevgen Morderer, Valentina Trach, Olena Rodzewich, Institute of Plant Physiology and Genetics (IPPG), Ukraine National Academy of Sciences (NASU), Department of Physiological Action of Herbicides, Vasylkivska street 31/17, 03022, Kiev, Ukraine, corresponding author's E-mail: emorderer@mail.ru

It was established, that the appearance of necrosis, induced under the effect of haloxyfop-*R*-metyl (HF) in meristems of maize (*Zea mays L.)* roots, increased with the adding of unphytotoxic concentration of hydrogen peroxide (HP). Under the effect of HF in maize meristems roots were observed changes in activities of enzymes, that participate in transformation of reactive oxygen species (ROS), such as superoxiddismutase, catalase and peroxidase. Dynamics of these changes had a complicated character, but it was established that HP intensified HF-induced changes in enzyme activities, while antioxidant tocopherol inhibited corresponding effect. The possible role of ROS in the development of the phytotoxic action of graminicides is discussed.

Ukrainian Journal «Physiology and Biochemistry of cultivated plants», Nr.4, 2008, Institute of Plant Physiology and Genetics, Ukraine.

Energy

Lifetime extension of K-200-130 steam turbine housings over park resource, Chernousenko O.Y., Nikulenkova T.V., The National Technical University of Ukraine «Kyiv Polytechnical Institute», Kiev, Ukraine, E-mail: cher_olya@2c.kiev.ua, a-Nikulenkov@yandex.ru

On the basis of the developed comprehensive approach to the operation time extension of the steam turbine power equipment with an allowance for the existing damages and repair-and- renewable changes of the elements design constructions in the process of operation is proposed a technique of the further life cycle prediction for CHP and CMP rotors, valves and bodies of 200MW steam turbines. On the real object there were obtained new data and substantiated the recommendations for the operation time extension of 200 MW steam turbine high-temperature rotors and housing details. The results of the investigations of K-200-130 turbine operation time extension can be used for the TPP power units.

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Use of low-enriched uranium in nuclear fuel cycle in Ukraine, Kuzmenko I.M.,
NTUU "Kyiv polytechnic institute", Peremogy av. 37, Kyiv, Ukraine, e-mail kin@aprodos.kpi.ua

The paper describes the status of nuclear power in Ukraine, problems and prospects. Analyzed the contribution of nuclear energy in the country, prolongation of operating period and replacement old nuclear reactors. Perspectives mining uranium ore in Ukraine and its enrichment. Described the operation of waste fuel storage Analysis the way to create nuclear-fuel cycle in the country. Is recommended develop production of low-enriched uranium using the heavy water rectors.

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Mechanics

Exploitation of surface layer of re-construction details under dynamic loading,
R.J.Bashirov, Azerbaijan State Marine Academy, AZ1000, Baku, Zarifa Aliyeva str. 18,
E-mail: bagirovag@rambler.ru

The joint vibration of reconstructed detail with surface coat on it is considered in this article. Assuming that the considered construction is elastic and thin-walled, the behaviour of this construction is modeled by the behaviour of the two-layered elastic thin-walled beam. It was shown that at the largest values of frequencies of driving normal loading, the profile of deflection may have some stationary points, which correspond to possible exfoliation in this places.

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THE EXPRESS TRAIN-DIAGNOSTICS OF POWER SEMI-CONDUCTOR DEVICES AND CONVERTERS FOR THE RAILWAY TRANSPORT. **Kurmashev S.M., Zazybina E.B.,** The Petersburg state university of means of communication, 190031, St.-Petersburg, Moscow pr., 9, Russia, KSMspp@rambler.ru, Elzazybina@yandex.ru.

In this article a number of the devices of the express train-diagnosing of semi-conductor converters is considered. The given devices allow to reveal the fault and potentially-unreliable power semi-conductor devices in converting plants of the electric municipal and railway transport.

We developed the set of the express-heating devices to test power semi-conductor devices.

We suggest to use the pyrometric checking to reveal the potentially-unreliable power semi-conductor devices in the converter under load. Then the measurement data are processed automatically by the developed method.

Kurmashev S.M., Zazybina E.B.express train of power semi-conductor devices and converters for a railway transportation. Sci. Works ZabIIZT. – Chita, 2009г. p.101-107.

STATE FILTERING OF discrete-time CONTROL SYSTEM, **V. Kolodyazhny, A. Gurko,** Kharkov National Automobile and Highway University, 25, Petrovskogo Str., Kharkov, 61002, Ukraine, E-mail: kolodyazhny@mail.ru, gurko@khadi.kharkov.ua.

We consider the problem of optimal feedback control of the discrete-time dynamic systems on the basis of the analysis of possible state sets where the uncertain quantities are known to belong to given sets. For describing of the system states set the mathematical tools of theories of the atomic functions, *R*-functions and fuzzy sets are used. The proposed procedure is intended for the design of optimal control of complex discrete devices at the uncertain external perturbations.

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