UDC – 528.541: 681.2

PROJECT FOR CREATING A NEW IMPROVED SYSTEM OF HYDRODYNAMIC LEVELING

Hovsep S. Petrosyan
National University of Architecture and
Construction of Armenia
105 Teryan st., 0009, Yerevan
e-mail: Hovsep-petrosyan@mail.ru
ORCID iD: 0000-0002-3090-2983
Republic of Armenia

Frunzik H. Palikyan
Institute of Water Problems and Hydro-Engineering
Named After I.V. Yeghiazarov
125/3 Armenakyan st., 0011, Yerevan
e-mail: vertuvertu111@icloud.com
ORCID iD: 0009-0009-3276-1115
Republic of Armenia

Manuk R. Vardanyan
National University of Architecture and
Construction of Armenia
105 Teryan st., 0009, Yerevan
e-mail: m.vard1@yahoo.com
ORCID iD: 0009-0004-6589-9616
Republic of Armenia

Mher V. Markosyan
Institute of Water Problems and Hydro-Engineering
Named After I.V. Yeghiazarov
125/3 Armenakyan st., 0011, Yerevan
e-mail: mark@yetri.am
ORCID iD: 0000-0003-1972-5266
Republic of Armenia

https://doi.org/10.56243/18294898-2024.4-49

Abstract

They were studied and analyzed by the National Polytechnic University of Armenia and created by HDLS – 10D and by the National University of Architecture and Construction of Armenia of Geodesy of Problematic Laboratory, improved with Practical and laboratory test works performed three samples of DHLS respectively. Based on the methods of their measurement and calculation of vertical movements, the authors proposed a project of a new

improved system of the HDLS in which the following changes were made to the previous systems: a mobile tank was installed in the working fluid tank, which is half immersed in the working fluid. The movements of the mobile tank are regulated at a constant speed by a micromotor installed above the working tank. Three electrode needles were installed in the reference sensor, the lowermost of which is for the comparative damping of the movement of the faster-moving line of curvature of the initial part of the piezometric movement line of the liquid, the second as a reference for the measurement of the reference sensor to take, and the third to stop the movement of the working fluid after the end of the first cycle of measurements, which equalizes the surface of the working fluid in all sensors, after which the reverse measurement process is performed from the still surface of the liquid with uniform movement by the motor. Due to the same speed of movement of the working fluid, the measurement process from the still surface of the liquid, and the same cross-section of the sensor connections and polyethylene pipes, the resistance to fluid movement decreases, as a result of which the degree of measurement accuracy of the system increases.

Keywords: Working fluid, tank, sensor, electrode needle, degree of measurement accuracy, resistance to fluid movement, re-sensitivity.

Introduction

The work on the creation of high-precision geodetic instruments and equipment and the calculation and accuracy assessment of data measured by them has always been and remains relevant.

The hydrodynamic leveling method was developed by Armenian scientists at the National University of Architecture and Construction of Armenia (NUAC) in the 1970s-1980s. In Armenia, such devices were installed on the Akhuryan reservoir dam (in the poternas), in the Joghaz reservoir, at the Armenian Nuclear Power Plant, on the accelerator of the Institute of Physics, etc. In Georgia, at the Riomni hydroelectric power plant, in Ukraine, at the Rovno and Zaporozhye nuclear power plants, in Russia, at the Leningradskaya, Kalininskaya nuclear power plants, at the Zaraysk elevator, in Kamchatka (on "Cone D" near the Klyuchevskaya Sopka volcano), etc. Some higher educational institutions have acquired these devices and included them in their curricula, including Tbilisi Technical University, Rudny Engineering Institute in Kazakhstan, Moscow University of Geodesy, Aerial Photography and Cartography, etc. [1-4].

After the declaration of independence of the Republic of Armenia, due to various geopolitical conditions and a lack of financial resources, scientific activities in this field were temporarily suspended. In 2012, in NUAC the Geodesy Problem Laboratory named after academician R. H. Movsisyan of the RA Academy of Geodesy began work on automating the hydrodynamic leveling system (HDLS) using modern technical means and electronic technologies.

In the first stage, the electronic circuit of the GNSS, the control and recording unit (MRB) was modified, as a result of which the weight of the MRB was reduced by about 5 kg. It became possible to record 30 days of observation data in a memory device in digital form and transfer them to a computer for further processing [5]. Then an algorithm was developed

for processing measured data. The developed algorithm made it possible to automatically perform observations within the required period using the hydrodynamic leveling system, process the measured data, and use it to create graphs of the re-crossings of the remaining points relative to the baseline. The average arithmetic error of the pulse values of each sensor was determined, and the value of one pulse was calculated, which was 0.0480 mm [6].

Then a second prototype of HDLS was created, which was installed in the laboratory of the Engineering Geodesy Department of the Academy of Sciences of the Republic of Armenia, where hydrodynamic measurements and laboratory tests of the leveling system were carried out. As a result of the analysis, it was found that the test data for determining vertical deformations carried out with two test samples installed in different environments, practically coincide and are within +- 0.05 mm [7].

To receive the observed data of the two hydrodynamic leveling systems installed in different objects in real-time in one central office, the system was supplemented with the following modern equipment: a computer was installed next to the management and registration block, an algorithm was developed through which the data recorded in the MRB is entered into the computer, the installed computer was provided with the Internet, an algorithm was developed for the computer installed in the central office, which establishes a connection with computers installed in different objects and creates the opportunity to carry out observation work with commands and receive the observed data for calculating vertical displacements in each object [8, 9].

Conflict Setting

Having analyzed the working principle of the previously created HDLS, it was decided to make some constructive changes to the system. For this purpose, the task was set to equalize the speeds of movement of the working fluid in the forward and reverse directions of the system and to reduce the hydraulic resistances of the sensor connection parts and polyethylene pipes.

Materials and methods: The measurement methodology of the newly designed HDLS and the transmission of measured data via the Internet to a central office are the same as in the three currently operating prototypes of improved HDLS

Research results

In The advantage of hydrodynamic leveling systems is that they have a simple structure, and the accuracy of their measurement depends on the fact that the working fluid encounters minimal resistance on its path.

The proposed new system design, with its structure, can provide a higher accuracy in determining the overshoots between control points than all hydrodynamic leveling systems known to us.

Here, the working fluid does not encounter any resistance during movement, except for frictional resistance, while the working tank filled with liquid remains stationary (Fig. 1).

The essence of the work is as follows: a mobile tank (2) is immersed in a tank (1) filled with working fluid. (2) Some part of the mobile tank (1) remains immersed in the working fluid in the tank, so that there is no impact on the liquid surface of the base of the mobile tank (2).

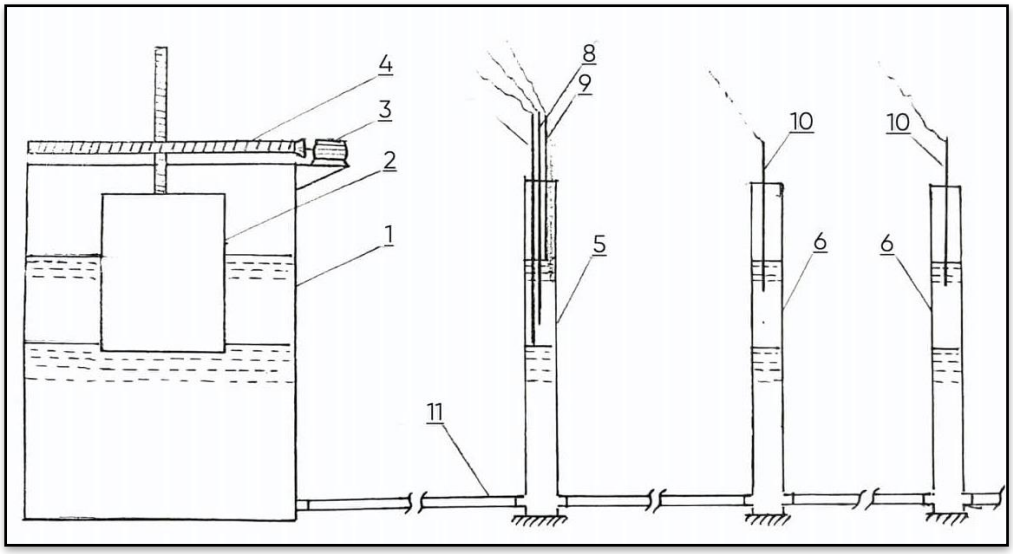

Fig. 1 General view of the new hydrodynamic leveling system
(1) Tank, (2) mobile tank, (3) motor, (4) rotating disk, (5) (6) sensors,
(7) (8) (9) (10) electrode needle, (11) transparent polyethylene pipeline.

With the help of the engine, the disk (4) rotates and the (2) mobile tank begins to slowly immerse itself and is immersed in the working fluid in the tank. The fluid begins to rise in the tank (1), from where it is distributed to the sensors (5) (6), and while rising, touches the electrode needle (9) and stops. Each sensor has its own measuring electrode needle (10), which is recorded at the moment of contact and the deviation between the control points is calculated.

After touching the electrode needle at the highest point (9), the engine stops for a while so that the fluctuations of the working fluid surface in the working tank and sensors calm down. Then (3) the engine (2) starts to move the movable tank in the opposite direction, that is, it starts to rise at the same speed as it was immersed in the tank (1). The liquid in the sensors starts to return to the tank (1). The engine stops when the liquid is separated from the electrode needle (7).

Thus, the first measurement cycle is completed.

One of the sensors installed at the control points is taken as the baseline and the overshoots between the control points are calculated against it using the readings of the sensors installed at the remaining control points. The differences in the overshoots of the control points with respect to the baseline control point are determined through measurements of successive cycles. When the mobile tank (2) is immersed in the tank, the working fluid level rises, and (11) is filled into the sensors through polyethylene pipes (Fig. 2).

First, the liquid begins to rise and fill the sensor (1) located closest to the tank (2), then the sensor (3), and, finally, the sensor located furthest. At the beginning of the movement of the working liquid, when the flow of liquid from the tank (1) reaches the last sensor, which the reverse movement of the liquid flow to the tank occurs. At this time, the surface of the liquid in the sensors begins to rotate up and down. But since this liquid is in motion, the oscillations quickly fade and after some time (up to the size (10) of the electrode needles) (i.e.), contact) the working liquid rises between two adjacent sensors at a constant speed and with the same

slope, which can be considered a linear movement. The movement of this line is carried out along the piezometric line. The same thing happens during the reverse process when the working liquid begins to move downwards. For more convenient and accurate obtaining (5) of measurement data, needle-electrodes (7 and (9) are installed in the reference sensor (Fig. 1), regulating the parameters and maximum ranges of movement of the working liquid.

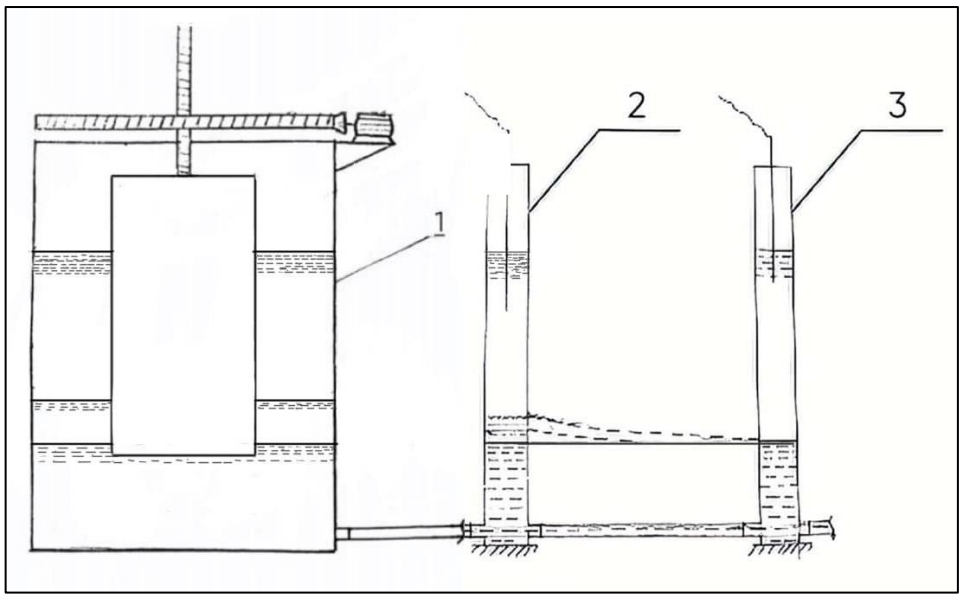

Fig. 2 The process of fluid movement in the sensors

The working fluid begins to rise from the tip of the electrode needle (7) until it touches the electrode needle of the sensor installed at the reference control point (8), after the electrode needle (8), measurements begin in all sensors until it touches the electrode needle of the given sensor, but the liquid continues to rise until it touches the last electrode needle (9). At that time, the engine is turned off and after the liquid surface calms down, the reverse flow measurements are performed.

From the above-mentioned, is obvious that the position of the reference electrode needle (8) is at the lowest position than the electrode needles of the sensors installed at the remaining control points.

During reverse flow measurements, the engine drives the fluid in the opposite direction and pushes the moving tank out of the working fluid tank at the same speed as during immersion, due to which the working fluid moves from the sensors to the tank (1). After the electrode needles of the sensors are detached from the needle of the reference sensor, measurements begin until they are detached from the needle of the reference sensor, and having reached the lowest electrode needle, the engine stops.

By the arithmetic average of the direct and reverse measured data, we obtain the deviations of the control points relative to the sensor installed at the reference control point.

In this system, the value of one unit of the measurement report division is determined as follows: during measurements, a glass etalon sample is placed under one of the sensors, the factory thickness of which is determined to an accuracy of 10 micrometers, and the amount of difference between the measured reports in the height range of the given sample is calculated using this data.

With these data, the calibration of the HDLS system is determined. The linear value of K per unit of the report reading is calculated using the following formula:

$$K = \frac{C}{N_i - N_0}, \quad (1)$$

where K is the linear value of one unit of the given HDL system readings expressed in millimeters, C is the thickness of the glass standard sample expressed in millimeters, N_i- is the last reading of the glass test sample sensor, and N_0 is the initial reading.

After making several measurements, their arithmetic mean value is calculated, which is the value of one unit of the division of the measurement report of the given HDL system, which is used for further observations as a constant value for converting to a linear unit.

The overshoots relative to the starting point are calculated by the following formula:

$$h=K\ (N_i - N_0) \quad (2)$$

and the overshoots between the sensors:

$$h_i = K\ (N_i - N_{i-1}) \quad (3)$$

where N_0 is the reading of the sensor at the origin, N_i - I is the reading of the sensor at the i control point, and N_{i-1}) is the reading of the sensor at the previous control point.

The average of the direct and reverse overshoots will be the overshoot between the two control points.

$$h_i = (\ h_i \text{ direct }) + h_i \text{ reverse }\ )/2 \quad (4)$$

Conclusion

The presented new hydrodynamic leveling system will provide higher accuracy in determining the displacements between the sensors installed at the control points compared to the previous three HDLS prototypes, since here the working fluid does not encounter any resistance during movement, except for frictional resistance, while the working tank filled with the fluid remains stationary. This makes it possible to fulfill the requirements for the degree of accuracy of determining the settlements of the foundations of buildings and structures and their individual structures stipulated by the normative technical documents [10, 11].

References

1. Barkhudaryan A.M., Movsesyan R.A. Theoretical foundations of the method of hydrodynamic leveling //Geodesy and aerial photography. - M., 1976 № 1.- c. 9-14.
2. Movsesyan R.A., Babayan G.A. Hydrodynamic leveling during observation of structures //Geodesy and Cartography.- 1975, No. 7.- pp. 24-28.
3. Barkhudaryan A.M., Vardanyan V.N., Mirzabekyan K.D. About the errors of hydrodynamic leveling //Geodesy and Cartography.- 1986, № 10.- pp. 17-20.

4. Barkhudaryan A.M., Beglaryan A.G., Ambartsumyan P.V., Martirosyan V.V. Method of hydrostatic leveling //Geodesy and Aerial Photography.- 1990, No. 4.- pp. 4-8.
5. Petrosyan H.S., Hambardzumyan P.V., Nalbandyan G.P., Tsaturyan A.S. Automated hydrodynamic leveling device, Scientific Papers of the Armenian Academy of Sciences 2017 Volume IV (67) //Yerevan 2017, pp. 133-139.
6. Tsaturyan A.S., Vardanyan M.R., Petrosyan H.S., Hambardzumyan P .V. Nalbandyan G.P. Laboratory studies of a hydrodynamic leveling device, Bulletin of the Armenian State Academy of Civil Engineering, 2018, No. 3, pp. 11-17.
7. Tsaturyan A.S., Hambartzumyan P.V., Petrosyan S.K., Palikyan F.H. Data analysis of two test samples of the hydrodynamic leveling system, Scientific papers of the National Institute of Civil Engineering 2021, Vol. 2 (80), pp. 77-84.
8. Petrosyan H. S., Hambartzumyan P. V., Tsaturyan A. S., Nalbandyan G. P., Petrosyan S. K., Replacing the kinematic mode with the dynamic one during hydrodynamic leveling. Geodesy and Cartography. – 2023. – No. 5. pp.1–11.
9. Petrosyan H.S., Markosyan M.V., Hambardzumyan P.V., Tsaturyan A.S., Petrosyan S.K. Short-term patent for the invention of a hydrodynamic leveling system N 684 Y issued on 01.12.2021. By the Intellectual Property Office of the Ministry of Economy of the Republic of Armenia.
10. ISO 24846-81. Soils. Methods for measuring deformations of the foundations of buildings and structures.- M.: Publishing House of Standards, 1986.- 156 p.
11. ISO 24846-19. « Soils: Methods for measuring deformations of foundations of buildings and structures.

References

1. Бархударян А.М., Мовсесян Р.А. Теоретические основы метода гидродинамического нивелирования // Геодезия и аэрофотосьемка. - М., 1976 № 1.- с. 9-14.
2. Мовсесян Р.А., Бабаян Г.А. Гидродинамическое нивелирование при наблюденияхза сооружениями // Геодезия и картография.- 1975, № 7.- С. 24-28.
3. Бархударян А.М., Варданян В.Н., Мирзабекян К.Д. Об ошибках гидродинамического нивелирования // Геодезия и картография.- 1986, № 10.- С. 17-20.
4. Бархударян А.М., Бегларян А.Г., Амбарцумян П.В., Мартиросян В.В. Способ гид-ростатического нивелирования // Геодезия и аэрофотосъемка.- 1990, № 4.- С. 4-8.
5. Պետրոսյան Հ.Ս., Համբարձումյան Պ.Վ., Նալբանդյան Գ.Պ., Ծատուրյան Ա.Ս. Հիդրոդինամիկ նիվելիրացման ավտոմատացված սարք, ՃԾՀԱՀ Գիտական աշխատություններ 2017 Հատոր IV (67)// Երևան 2017, էջ 133-139:
6. Ծատուրյան Ա.Ս., Վարդանյան Մ.Ռ., Պետրոսյան Հ.Ս., Համբարձումյան Պ.Վ. Նալբանդյան Գ.Պ. Հիդրոդինամիկ նիվելիրացման սարքի լաբորատոր հետազոտություններ, ՃԾՀԱՀ-ի Տեղեկագիր, 2018, N 3, էջ 11-17:
7. Ծատուրյան Ա.Ս., Համբարձումյան Պ.Վ., Պետրոսյան Ս.Կ., Փալիկյան Ֆ.Հ., Հիդրոդինամիկական նիվելիրացման համակարգի երկու փորձանմուշների

տվյալների վերլուծություն, ՃՇՀԱՀ գիտական աշխատություններ 2021, Հ. 2 (80), 77-84 էջ:

8. Петросян О.С., Амбарцумян П.В., Цатурян А.С., Налбандян Г.П., Петросян С.К. Замена кинематического режима на динамический при гидродинамическом нивелировании. Геодезия и картография. – 2023. – № 5. 1–11 с.
9. Պետրոսյան Հ.Ս., Մարկոսյան Մ.Վ., Համբարձումյան Պ.Վ., Ծատուրյան Ա.Ս., Պետրոսյան Ս.Կ. Հիդրոդինամիկական նիվելիրացման համակարգի գյուտի կարճաժամկետ արտոնագիր N 684 Y տրված 01,12,2021 թ. ՀՀ էկոնոմիկայի նախարարության Մտավոր սեփականության գրասենյակի կողմից:
10. ГОСТ 24846-81. Грунты. Методы измерения деформаций основания зданий и сооружений.- М.: Издательство стандартов, 1986.- 156 с.
11. ԳOUS 24846-19. «Գրունտներ. Շենքերի և կառուցվածքների հիմնատակերի ձևախախտումների չափման մեթոդներ» ստանդարտ:

ՀԻԴՐՈԴԻՆԱՄԻԿԱԿԱՆ ՆԻՎԵԼԻՐԱՑՄԱՆ ՆՈՐ ԿԱՏԱՐԵԼԱԳՈՐԾՎԱԾ ՀԱՄԱԿԱՐԳԻ ՍՏԵՂԾՄԱՆ ՆԱԽԱԳԻԾ

Հ.Ս. Պետրոսյան[1], Ֆ.Հ. Փալիկյան[2], Մ.Ռ. Վարդանյան[1], Մ.Վ. Մարկոսյան[2]

[1]Ճարտարապետության և շինարարության Հայաստանի ազգային համալսարան
[2]Ակադեմիկոս Ի.Վ. եղիազարովի անվան ջրային հիմնահարցերի և հիդրոտեխնիկայի ինստիտուտ

Ուսումնասիրվել և վերլուծվել են ԵրՊԻ-ի կողմից ստեղծված **СГДН-10Д** և ՃՇՀԱՀ-ի Գեոդեզիայի պրոբլեմային լաբորատորիայի կողմից կատարելագործված ՀԴՆՀ-ի երեք փորձանմուշներով կատարված համապատասխանաբար գործնական և լաբորատոր փորձարկման աշխատանքները: Հիմք ընդունելով դրանց չափագրման և ուղղաձիգ շարժերի հաշվարկման մեթոդներն, հեղինակների կողմից առաջարկվել է ՀԴՆՀ-ի նոր կատարելագործված համակարգի նախագիծ, որում նախկին համակարգերի նկատմամբ կատարվել են հետևյալ փոփոխությունները՝ աշխատանքային հեղուկի բաքում տեղադրվել է շարժական բաք, որը կիսով չափ ընկղմված է աշխատանքային հեղուկի մեջ: Շարժական բաքի տեղաշարժերը կարգավորվում է աշխատանքային բաքի վերևում տեղադրված միկրոշարժիչի միջոցով հաստատուն արագությամբ:

Ելակետային տվիչում տեղադրվել են երեք էլեկտրոդ ասեղներ, որոնցից ամենանեքևինը հանդիսանում է հեղուկի պիեզոմետրիական շարժման գծի սկզբնամասի կորության ավելի արագ ընթացող գծի շարժի համեմատական մարման համար, երկրորդը՝ որպես ելային տվիչի չափագրման հաշվեցույց վերցնելու, իսկ երրորդն առաջին ցիկլի չափումների ավարտից հետո աշխատանքային հեղուկի շարժը դադարեցնելու համար, որով աշխատանքային հեղուկի մակերևույթն հավասարեցվում է բոլոր տվիչներում, դրանից հետո շարժիչի միջոցով հավասարաչափ շարժով հեղուկի հանդարտ մակերևույթից կատարվում է չափագրման հակադարձ ընթացքը: Աշխատանքային հեղուկի միևնույն արագության շարժի, հեղուկի մակերևույթի հանդարտ վիճակից չափագրման գործընթացի և տվիչների միացումների ու պոլիէթիլպոլիէթիլենայինային

խողովակների միևնույն կտրվածքի հաշվին փոքրանում է հեղուկի շարժի դիմադրությունը, որի արդյունքում մեծանում է համակարգի չափման ճշտության աստիճանը:

Բանալի բառեր. Աշխատանքային հեղուկ, բաք, տվիչ, էլեկտրոդ ասեղ, չափման ճշտության աստիճան, հեղուկի շարժման դիմադրություն, վերազանցում:

ПРОЕКТ СОЗДАНИЯ НОВОЙ УСОВЕРШЕНСТВЕННОЙ ГИДРОДИНАМИЧЕСКОЙ СИСТЕМЫ НИВЛИРОВАНИЯ

О.С. Петросян[1], Ф.А. Паликян[2], М.Р. Варданян[1], М.В. Маркосян[2]
[1]Армянский национальный университет архитектуры и строительства
[2]Институт водных проблем и гидротехники им. академика И.В.Егиазарова

Изучены и проанализированы практические и лабораторные испытания, выполненные СГДН-10Д, созданными ЕрПИ, и тремя образцами СГДН, усовершенствованными Проблемной лабораторией геодезии НУАС, соответственно. На основе методов их измерения и расчета вертикальных движений автором предложен проект новой усовершенствованной системы СГДН, в котором в предыдущие системы были внесены следующие изменения: в баке рабочей жидкости установлен передвижной бак, который наполовину погружен в рабочую жидкость. Движение передвижного бака регулируется микромотором, установленным сверху рабочего бака с постоянной скоростью. В исходной датчике установлены три электродные иглы, нижняя из которых предназначена для сравнительного демпфирования более быстро движущейся линии кривизны начальной точки пьезометрического движения жидкости, вторая - для снятия отчета о исходного датчика, а третий - для остановки движения рабочей жидкости после завершения измерений первого цикла, при этом поверхность рабочей жидкости выравнивается во всех датчиках, после чего происходит обратный процесс измерения. выполняется со спокойной поверхности жидкости при равномерном движении через мотор. За счет движения рабочей жидкости с одинаковой скоростью, процесса измерения из состояния покоя поверхности жидкости, а также одинакового разреза соединений датчика и полиэтиленовых трубок сопротивление движению жидкости снижается, в результате при этом повышается степень точности измерения системы.

Ключевые слова: Рабочая жидкость, бак, датчик, электрод-игла, степень точности измерения, сопротивление движению жидкости, превышение.

Submitted on 06.11.2024
Sent for review on 14.11.2024
Guaranteed for printing on 20.12.2025