UDK 528.023.2

# METHOD FOR DETERMINING THE PLANNED POSITION OF THE TACKING POINTSAT PERFORMING THE MEASURING WORK ON THE INNER WATER AREA

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**Key words:** tack, control point, intersection

**Formulation of the problem**

One of the important questions of marine geodesy is the question of improvement of the performance of the measuring work on inner water areas. For solution of this problem, there were various measurement methods, which are divided into: visual, radio engineering, autonomous and satellite.

The first group includes methods, when measurements are implemented within the line of sight with the help of visual-electronic devices. These methods belong to methods of high accuracy of determining on the plane coordinates of the measurement points. In most cases they are used at the measuring works on inland waters and on the coastal part of the seas. In this group of methods for the determine the coordinates of measurement points are used the method of intersections. In most cases, determination is made by polar or straight angular intersections. In compare to other intersections, each of the intersections has advantages and disadvantages. The accuracy of the determination of coordinates is in the range of 1–10 m by means of intersections [2].

To the second group of methods includes methods for determining of coordinates of a mobile or stationary object using radio engineering devices whose operation principle is based on the use of electromagnetic waves of the radio range for measuring distances. When carrying out such measurements it is used the complex of ground and ship radio engineering stations. The ground stations are installed on strong points with known coordinates, and ship stations are on objects the coordinates of which need to be determined. In this group of methods for determining the coordinates of objects on the water areas radio-geodetic systems of the ultra-short wave of radio range are used. The accuracy of determining the coordinates of these objects is 3–10 m [2].

Autonomous group is practically not applied for the described works. In recent years, methods based on the use of satellite geodesy methods have been widely used to determine the coordinates of a measurement vessel. In this case we are talking about the use of satellite navigation system. Its main purpose is the determining of location (coordinates) of ground, water and air objects. The principle of operation of these systems is based on measuring the distance between the mobile object, the coordinates of which must be obtained, and the satellites, whose coordinates are known with the proper accuracy. Measurements of distances to several satellites of this system allow using the usual geometric constructions to calculate the position of the mobile object in space. In marine conditions, the accuracy of such determinations is within 5–20 m [2].

**Analysis of recent research and publications**

The current normative document for conducting the measuring works on inner water reservoir is [1]. According to the provisions of this document, the main method for surveying the bottom of the water area is soundings. According to [1], soundings is a complex of works to measure the depths which is performed directly on a water object and is associated with the collection of data, necessary to detect the state of the vertical dimensions of objects, on which navigation takes place: rivers, canals, port water areas, etc. The aim of the measuring works is to determine the depths – heights of the bottom points of the water areas, which are necessary for revealing the character of the bottom of the given water area [2].

The essence of the soundings on the inner water areas consists in measuring the depths at the corresponding points of the projected survey tacks and determining their plane coordinates. For the successful carrying out of measuring works it is necessary to create a plane and high-altitude geodetic base, which in this case is represented as a network of strong points with known coordinates. Previously the coordinates of these points were determined by thickening of existing geodetic networks by using

triangulation, trilateration and polygonometry methods. Currently these works are performed by using GNSS technologies.

For this type of works, the mean square error of position of points of surveying justification a relative to the initial (reference) points not exceed 2 m when the survey at a scale of 1: 10.000 and over, and 0,2 mm in the scale of plan [1]. The density of the measuring points is determined taking into account the permissible value of the mean square error in the coordinates of the points at which the depth measurements were carried out. This error should not exceed 1,5 mm in the scale of survey relatively to the points of the surveying justification. The distances between the measurement points when to surveying the shelf zone of the seas and inner water reservoir should correspond to 3–4 cm in the scale of the tablet and do not more than 2 cm when the surveying of rivers are taken [1]. In order to avoid the effect of systematic errors, it is recommended that the measurement of the coordinates of points should be additionally performed by other independent methods.

**Formulation of the problem**

As already mentioned, visual methods are used mainly to determine the coordinates of the points on the inner waters. A prerequisite for such definitions is the creation of a geodetically planned and a high-altitude base. It is necessary element of all existing methods for performing of the measuring work. In this case, the base is created by a pawning of the theodolite posts – points with the known coordinates on the coastal part of the water area, the use of which makes it possible to determine the coordinates of the tacking points.

To solve this problem, we propose a method, which is based on the modification of kinematic method of the GPS technologies “Stop & Go”. The main difference between these two methods is to replace a GPS receiver with a GPS receiver Magellan type.

**Exposition the main material of the research**

As is known, the therapeutic muds are sediments on the bottom of lakes, bogs, bays, estuaries, etc. For the determination of reserves of mud on the entire territory of mentioned water areas, survey works are carried out on separate layers of mudding sediments. When performing such survey works, the entire territory of the water area is evenly covered with rows of points on which drilling is carried out using special geological boer’s. As a result of drilling, we get the thickness of mudding layer. The geodesic part of this kind of measurements consists in determining the coordinates x, y of the points of drilling. These coordinates are determined in the conditional local coordinate system with an accuracy of 2 meters. Such works in essence do not differ from the measuring works of marine geodesy, performed on pre-planned tacks.

The experimental part of the work consisted in carrying out the measuring works and processing the materials of these works by classical and proposed methods on one of the saline lakes in the southern part of Ukraine. This lake has size of 450×1200 meters with a depth`s that did not exceed five meters. From the preliminary measurements of the depths on the lake, a calm relief of the bottom was discovered – the depths slowly to increase when approaching the middle of the lake (Fig. 1). In this connection, according to [1], on water areas of this type, the measuring tacks are laid at distances of 50 meters between them with the density of the points of depth measurements (in our case – drilling points) 10 meters on each of tack.

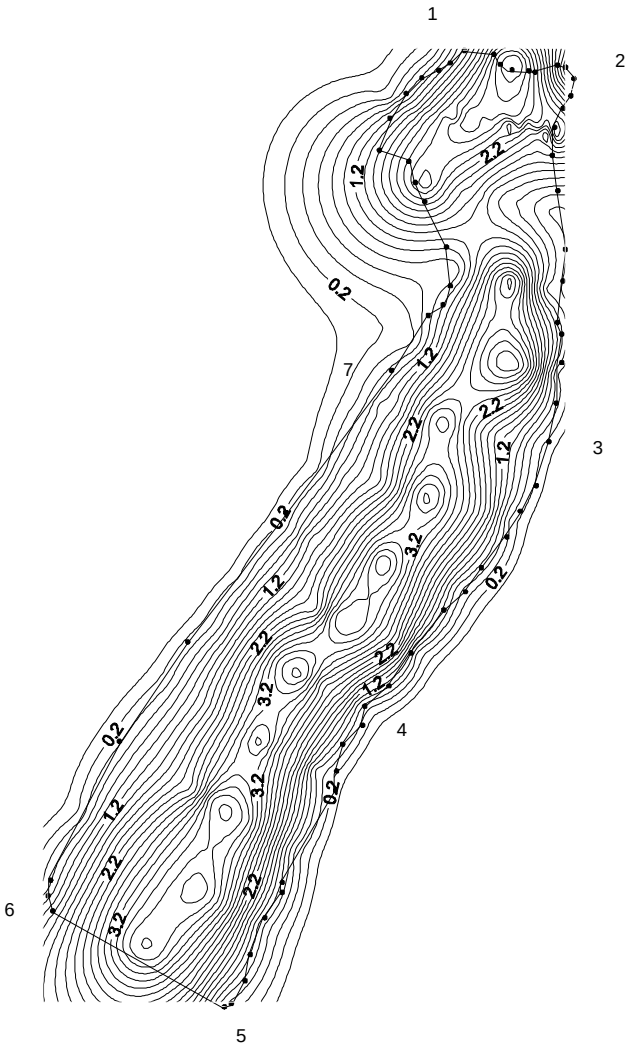


*Fig. 1. Relief of the bottom and the coastal part of the lake*

Before the start of the measuring works on the lake the planned geodetic base was projected. Considering the open area of the object of work, the geodetic base was constructed in the following form: a two ground rappers were laid (on the lake scheme they are denoted by numbers 1 and 2), on there their coordinates were determined by Leica GPS receivers, and a six reference points – a theodolite posts (with numbers on the scheme from 2 to 8), were located along the coastline (Fig. 2). In the future, the survey work carried out on the lake, all these points were used for the determination of coordinates x, y of the drilling points. The coordinates of points 1 and 2 were determined to obtain of directional angle of the line between these points, since the coordinates of all points and points in the performance of the measuring works on the lake were determined in a conditional coordinate system.

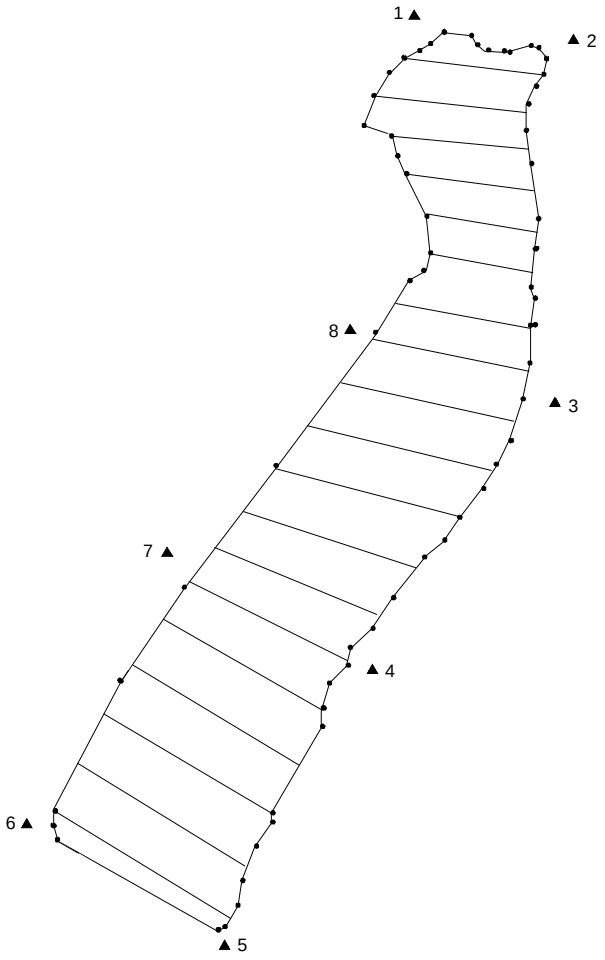


*Fig. 2. Scheme of Lake with projected tack*

For the design of start and final points of the tacks, it was necessary to obtain a plan of the lake with a fixed position of the points of the coastline. The coordinates of the characteristic points of the coastline were determined by the polar intersection method using an electronic total station Sokkisha. For the account of the possible changes in depth, near the point 6 (in the area the dam), a water-measuring post in the form of a geodesic milestone was installed. According to its dividing the level readings the water was recorded a three times of day.

To determine the coordinates of the drilling points lines of tacks were designed, along which the measuring boat were moved. The lines of tacks were laid with a distance between them about 50 m (Fig. 2). The drilling points were selected on each tack after 10 m taking into account the relief of the bottom of lake. The end points of the line of each tack were fixed by milestones on the shore.

The determination of the coordinates of the drilling points on the lines of tacks was carried out by the method of a polar intersection. The electronic total station was setting at point 2. The horizontal circle of the total station was oriented at the directional angle of the line 2–1. The measuring boat is begin moving along of the first tack. When the boat stopped for the drilling, the assistant observer established a reflector on the boer, after which the coordinates of the drilling point were displayed on the total station. The coordinates of the remaining drilling points were determined a similarly on all the lines of tacks with sequential displacement of the total station to the points 3-8.

In parallel to carrying out the measurements on the lake, experimental determinations were made. They consisted in the application of the navigation GPS receiver Magellan to determine the coordinates of the measurement points on the lines of tacks. This device allows absolute determinations of the coordinates of points achieving accuracy of 2–5 meters, and the relative position of adjacent points (the distance between them) – with an accuracy of 40–60 cm.

Before the beginning of the work the coordinates at point 2 were determined with this device, after that to determine the coordinates of the drilling points. The further determination of the coordinates at the measuring points by the line of tacks was determined the assistant. At the time of drilling, this device was placed above the drill. Such measurements were carried out in parallel with the performance of the main survey work. Comparison of the coordinates obtained by this technique with the coordinates obtained by the polar intersection method showed that the differences in coordinates are gradually changing with time at respect to the initial measurements on point 2. In three hours after the initial measurements, the difference in coordinates reached 60 cm.

To resolve this problem, it was a proposed to complete the determination of the coordinates of the

points by repeated determinations at point 2. The difference in the coordinates of point 2 at the beginning and at the end of the survey was assumed as systematic error with a functional dependence on time. After the introduction of this correction in certain coordinates of the tacking points by the GPS receiver, the difference in coordinates did not exceed 15 cm in the case when the interval of repeated measurements at point 2 did not exceed 1.5 hours. The coordinates of the drilling points obtained in this way were compared with the corresponding coordinates of the classical method for their determination. In Table the differences in the coordinates obtained by the polar intersection method and the method using the navigation GPS receiver Magellan for two randomly selected tacks, the measurements on which was to made on different days are shown.

**Difference of coordinates of measurement points**

| Галс 9 | | Галс 24 | |
|---|---|---|---|
| *x* | *y* | *x* | *y* |
| 0.64 | –0.56 | –0.71 | –0.45 |
| 0.39 | –0.39 | –0.75 | –0.54 |
| 0.77 | –0.58 | –0.84 | –0.54 |
| 0.52 | –0.39 | –0.76 | –0.54 |
| 0.38 | –0.39 | –0.54 | –0.54 |
| 0.53 | –0.37 | –0.54 | –0.57 |
| 0.57 | –0.65 | –0.51 | –0.61 |
| 0.53 | –0.61 | –0.54 | –0.56 |
| 0.51 | –0.52 | –0.53 | –0.69 |
| 0.77 | –0.62 | –0.57 | –0.67 |
| | | –0.55 | –0.86 |
| | | –0.36 | –0.84 |

**Conclusions**

Comparison of the coordinates of the drilling points, obtained by the two methods indicates that the differences in the coordinates of the measurement points did not exceed 90 cm with a specified accuracy of 2 m. This allows us to conclude that the Magellan type GPS navigation receivers can be used when performing survey operations in the water areas. From the above description of the new method, we can to conclude that it is similar to the «Stop & Go» method of the kinematic method of GPS measurements.

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**Спосіб визначення планового положення галсових точок під час виконання промірних робіт на внутрішніх акваторіях**

О. Денисов, А. Задемленюк, О. Лісник, В. Жидков

Запропоновано спосіб проведення промірних робіт на внутрішніх водоймах з використанням навігаційного GPS-приймача типу Magellan.

**Способ определения планового положения галсовых точек при выполнении промерных работ на внутренних акваториях**

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Предложен способ проведения промерных работ на внутренних водоемах с использованием навигационного GPS-приемника типа Magellan.

**Method for determining the planned position of the tacking pointsat performing the measuring work on the inner water area**

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A method for conducting the measuring works on inner water reservoir using a Magellan navigation GPS receiver is proposed.