POSITION KEEPING EXPERIMENT USING LOPRS AND DGPS IN ROUGH SEA

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Introduction. The DP system is a computerized dynamic positioning system that provides automatic control of the position and course of the vessel [1]. The set points of the position and course are set by the operator [2], after which the dynamic positioning system produces control signals for all propulsion engines, including propellers of the main engines. Deviations of the heading and position from the set points are displayed automatically, and the dynamic positioning system produces control signals for the thrusters to compensate for these deviations. The system can receive vessel position data from various reference systems such as Laser Optical Position Reference System (LOPRS) and DGPS. DP vessels are equipped with reference systems that are based on different principles of work in order to ensure the best reliability in the process of performing various tasks.

The relevance of research. Many studies have been devoted to improving accuracy and reliability of the control systems, in particular, in works [3-12] the capabilities of automatic systems are considered.

Due to the peculiarities of the work performed in the offshore zone, most offshore vessels are built in small sizes, in comparison with standard cargo vessels. The big drawback of such vessels is that they are highly susceptible to pitching and rolling in bad weather, which worsens the performance of the DP system. The task was to find out the difference between how exactly the vessel will keep a given position with the LOPRS and GNSS working under the influence of pitching and rolling. The data obtained in this work will help the DP operator to determine the risks of the upcoming operation using LOPRS, as well as to choose the optimal reference when working in rough sea.

Problem formulation. It is required to identify the accuracy and reliability of the LOPRS and DGPS in conditions of rough sea.

Research results. The experiments were carried out on the platform supply vessel "ADNOC 225" (DP-2). The first vessel positioning experiment used the latest model of DGPS Kongsberg DRS 500. GNSS receiver channel configuration: 240 channels; GPS - L1, L2, L2C, L5; GLONASS L1, L2; BeiDou2 B1, B2; Galileo E1, E5a, E5b, AltBOC; SBAS; QZSS; L-Band. The second vessel positioning experiment used the laser-optical positioning reference system (LOPRS) consisting of the first-class IEC60825 semiconductor laser diode, 30 KHz, 12º vertical beam, 0.13º horizontal beam, 0.5% accuracy and reflectance, scanning frequency of 1 Hz (60 rpm), or 2 Hz (120 rpm).

Fig. 1 shows graphs of the vessels pitching and rolling parameters during the GPS positioning period.

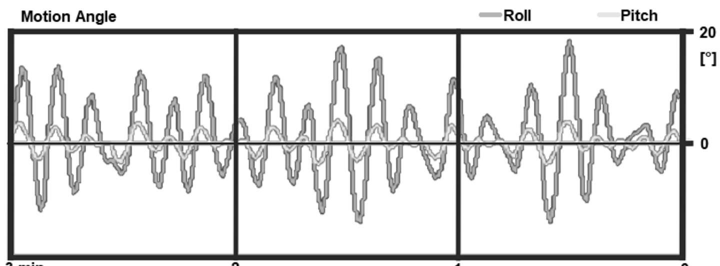

Figure 1 –Graphs of the vessels pitching and rolling parameters during the GPS positioning period

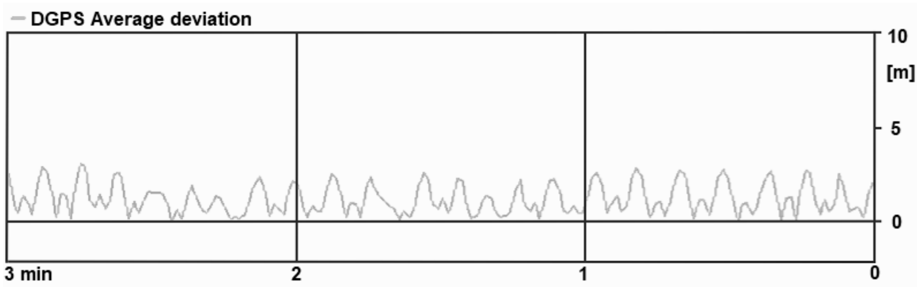

Figure 2 – Graph of the DGPS average deviation

Fig. 2 shows a graph of DGPS average deviation at the values of pitching and strong rolling. The average deviation of DGPS was 1-1.5 m. and the maximum is 2.5 m.

In Fig. 3, we could observe the plotter of the Kongsberg K-POS 21 dynamic positioning system, which displayed the position of the vessel relative to the set point when the DGPS was operating at the values of pitching and strong rolling. In this experiment, it was observed that the deviation of the vessel from the required position did not exceed 1.5 m, thus never exceeding the established limit of 2 m.

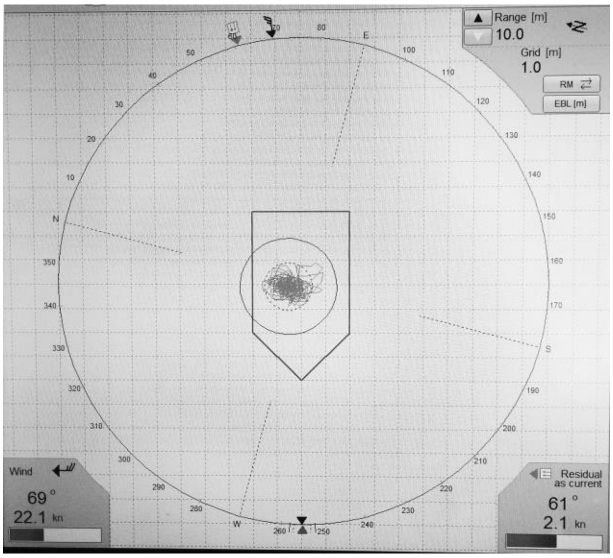

Figure 3 – DGPS positioning accuracy in bad weather conditions

Fig. 4 shows graphs of the vessels pitching and rolling parameters during the LOPRS positioning period.

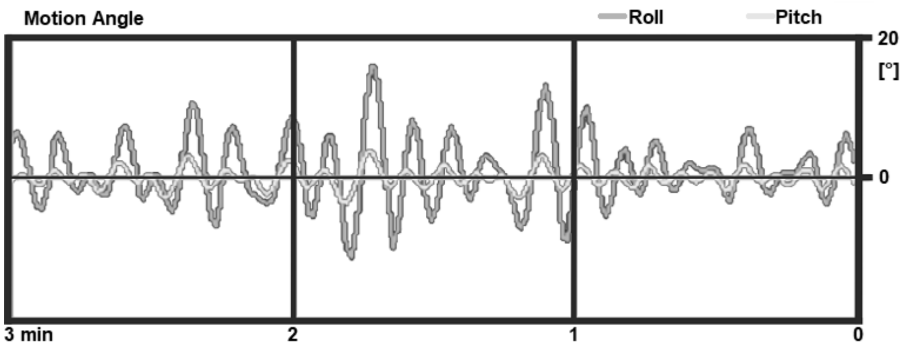

Figure 4 – Graphs of the vessels pitching and rolling parameters during the LOPRS positioning period

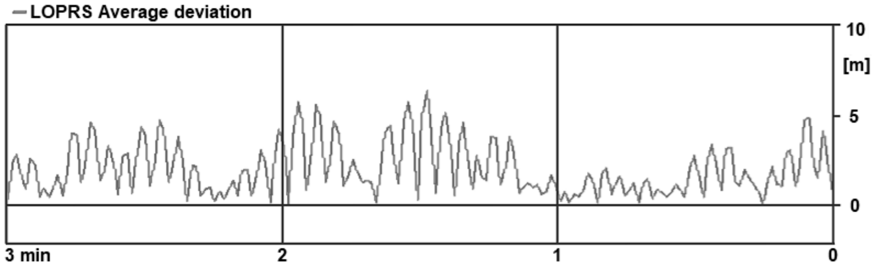

Figure 5 – Graph of the LOPRS average deviation

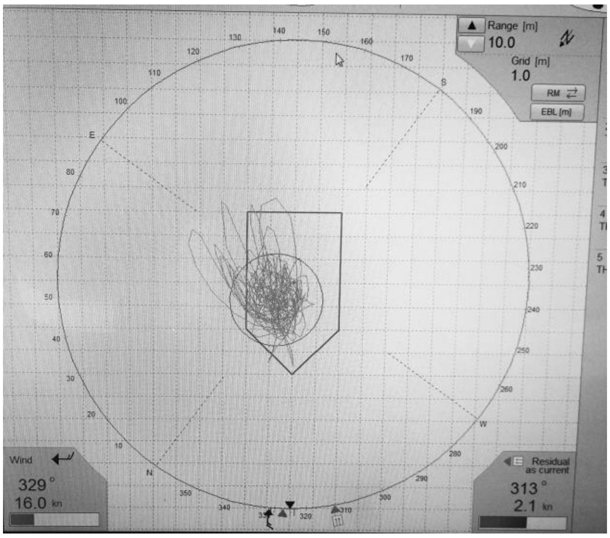

Figure 6 – LOPRS positioning accuracy in bad weather conditions

In Fig. 6, we could observe that the deviation of the vessel from the required position exceeded established limit of 2 m. and it reached up to 5 m.

Conclusions. The paper indicates the difference in keeping the position of the vessel using LOPR and GPS. As we can see, in a rough sea, the vessel was more accurately positioned by DGPS than by LOPR. This is due to the fact that the DGPS does not have mechanical rotating elements that are installed in the LOPR, so the refresh rate is higher. LOPRS needs to constantly scan the position of the reflector, which is very difficult in rough seas and gives a lot of position errors.

REFERENCES

1. Dynamic positioning vessel design philosophy guidelines. Det Norske Veritas Germanischer Lloyd (2015)

2. Moiseienko V.S. (2020) Determination of Dangerous Actions of Offshore Vessel Operators During Use of Laser-Optical Positioning Reference System. *Transport Development*, No 2(7), pp111-123. DOI: 10.33082/td.2020.2-7.10

3. Zinchenko, S.M., Nosov P.S., Mateychuk, V.M., Mamenko, P.P. & Grosheva, O.O. (2019). Automatic Collision Avoidance with multiple targets, including maneuvering ones. Radio Electronics, Computer Science, Control, № 4, pp. 211-221. DOI 10.15588/1607-3274-2019-4-20

4. Mamenko P.P., Zinchenko S.N., Kobets V.M, Nosov P.S, Popovych I.S. (2021) Solution of the Problem of Optimizing Route with Using the Risk Criterion [Text] // In: Babichev S., Lytvynenko V. (eds) Lecture Notes in Computational Intelligence and Decision Making. ISDMCI 2021. Lecture Notes on Data Engineering and Communications Technologies, vol 77. P. 252-265, Springer, Cham. https://doi.org/10.1007/978-3-030-82014-5_17.

5. Zinchenko S., Mateichuk V., Nosov P., Popovych I., Solovey O., Mamenko P., Grosheva O. Use of simulator Equipment for the development and testing of vessel control

system // Electrical, Control and Communication Engineering. Sciendo. Riga technical university. 2021. Vol. 16, Nom. 2, P. 58-64. DOI:10.2478/ecce-2020-0009

6. Zinchenko S.M., Ben A.P., Nosov P.S., Mamenko P.P., Mateichuk V.M. Improving the accuracy and reability of automatic vessel moution control system // Materials of the XII International Scientific and Practical Conference "Advanced Information and Innovative Technologies for Transport (MINTT - 2020), May 27-29, 2020, Kherson p. 54-58.
7. Zinchenko S., Moiseienko V., Tovstokoryi O., Nosov P., Popovych I. (2021) Automatic Beam Aiming of the Laser Optical Reference System at the Center of Reflector to Improve the Accuracy and Reliability of Dynamic Positioning. In: Hu Z., Petoukhov S., Dychka I., He M. (eds) Advances in Computer Science for Engineering and Education IV. ICCSEEA 2021. Lecture Notes on Data Engineering and Communications Technologies, vol 83. Springer, Cham. https://doi.org/10.1007/978-3-030-80472-5_1.
8. Zinchenko S.M., Tovstokoryi O.M., Nosov, Popovych I.S., Kobets V., Abramov G. Mathematical support of the vessel information and risk control systems P. 335-354. // CEUR Workshop Proceedings, 2805. http://ceur-ws.org/Vol-2805/paper25.pdf
9. Zinchenko, S.M., Nosov, P.S., Mateichuk, V.M., Mamenko, P.P., Popovych, I.S. & Grosheva, O.O. (2019). Automatic collision avoidance system with multiple targets, including maneuvering ones. Bulletin of University of Karaganda. Technical Physics, № 4(96), pp. 69-79. DOI: 10.31489/2019Ph4/69-79
10. Zinchenko, S.M., Mateichuk, V.M., Nosov, P.S., Popovych I.S. & Appazov, E.S. (2020). Improving the accuracy of automatic control with mathematical meter model in on-board controller. Radio Electronics, Computer Science, Control, pp. 197-207. DOI: https://doi.org/10.15588/1607-3274-2020-4-19
11. Zinchenko, S., Tovstokoryi, O., Nosov, P., Popovych, I., Kobets, V. & Abramov, G. (2020). Mathematical support of the vessel information and risk control systems. CEUR Workshop Proceedings, Vol. 2805, pp. 335-354. http://ceur-ws.org/Vol-2805/paper25.pdf
12. Zinchenko, S., Ben, A., Nosov, P., Popovich, I., Mamenko, P. & Mateychuk, V. (2020). Improving the Accuracy and Reliability of Automatic Vessel Motion Control Systems. Radio Electronics, Computer Science, Control, № 2, pp. 183-195. DOI: https://doi.org/10.15588/1607-3274-2020-2-19