

Ships turning basins in ports for big container vessels

Manewry obrotu dużych kontenerowców w basenach portowych

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Abstract

Container traffic grew very fast and many ports have prepared infrastructure and superstructure for the container vessels. During the last decade, many of Eastern Baltic ports container terminals started working with container vessels and in the same time looked for the bigger container vessels with limited possible investments [1]. In many ports are very limit space inside the ports and it make additional difficulties increase entry to the ports ships size. Container terminals usually are located in the middle or in the end parts of the ports and find enough space for the ships turning basins raise difficulties. Big container vessels navigational safety must be linked with ports infrastructure, but very often ports are orientated on the old standards and design recommendations, so are trying to keep big safety coefficients regarding water ways depths, widths, and hydrometeorological conditions limitations. Old standards did not include new accuracy navigational equipment such as RTK systems, which are implemented in many ports and increase navigational possibilities and navigational safety. This paper addresses the theoretical approach of the influence of new big container vessels sailing within ports areas, namely ships turning basins, possibilities and navigational safety of the ships, which have big wind surface and good manoeuvrability.

Słowa kluczowe: kontenerowiec, infrastruktura portowa, manewry

Abstrakt

Intensywny wzrost ruchu kontenerowców narzucił konieczność odpowiedniego przygotowania infrastruktury portowej. W ciągu ostatniej dekady wiele spośród terminali portowych na Bałtyku Wschodnim rozpoczęło współpracę ze statkami kontenerowymi, poszukując równocześnie innych dużych jednostek tego typu z ograniczonymi możliwościami inwestowania [1]. W wielu portach powierzchnie ich basenów nie odpowiadają potrzebom kontenerowców, co powoduje trudności przy wejściu. Terminale dla statków kontenerowych zwykle położone są w środku lub na końcu portu i znalezienie tam odpowiedniej powierzchni, by wykonać manewr obrotu stwarza wiele trudności. Bezpieczeństwo nawigacji w przypadku dużych jednostek musi być powiązane z infrastrukturą portową, jednak bardzo często porty pracują w oparciu o stare normy i zalecenia, w związku z czym starają się zachować wysoki współczynnik bezpieczeństwa pod względem głębokości i szerokości dróg wodnych oraz warunków hydrometeorologicznych. Stare standardy nie uwzględniają też nowoczesnych urządzeń, takich jak systemy RTK, służących dokładności nawigacyjnej, które są wprowadzone w wielu portach i zwiększają możliwości i bezpieczeństwo. Artykuł stanowi teoretyczne ujęcie żeglugi nowych kontenerowców w obszarze basenów portowych, omawia bezpieczeństwo i możliwości nawigacyjne statków o dużych gabarytach i dobrej sterowności.

Introduction

Ships sailing, turning and mooring to quay walls in ports areas, especially for the ships with big wind surface areas, must be taken into account possible ship's drift, rolling and squat effects acting.

Theoretical basis for ship's sailing, turning and mooring in complicated conditions is needed for the preparation of correct practical solutions and recommendations to insure safety for the ships in complicate conditions and minimize any risks [2, 3, 4].

Many ports are located close to the sea shore and ships turning basins influence by wind, waves and current. Channels bends, ships turning basins in ports, narrow places and places, which have changes of the outer factors in short distances, make additional difficulties for the ships sailing, especially for the big ships like container ships [5, 6].

Complicated navigational places in the ports identification are very important to take precautions to increase navigational and shipping safety within port areas. Correct information and knowledge about possible influence on the big ships in concrete place of the port, should assist to find correct technical, like dredging, and organizational measures, like using port tugs for the ship's steering in complicated places.

Big container ships have huge wind surface, are long and have big draft. In many ports for such type of ships turning basins in case of strong currents are main complicated places in ports.

Port entrances and ships turning basins always are more dangerous places in ports, but in the same time are orientated to the big ships, because ships turning basins planning close to terminals orientated for big ships, such as oil, bulk etc [1, 5]. Inside the ports on the way to container terminals should be prepared safe conditions for big container vessels as well.

Theoretical basis for the safe ships sailing and turning inside the ports

Theoretical investigations of the container ships sailing and turning to the port mainly are orientated on [7]:

- possible minimal channels width,
- possible minimal channels and port waters depths,
- ships turning basins in case of limitation conditions.

Theoretically ships turning basins and other channels width could be calculated as follows [4, 7, 8, 9]:

$$B_k = L + \Delta l + L \sin \beta + B \cos \beta + L \sin \Delta K + P' \sigma_y + b_n \quad (1)$$

where: L – ship's length; Δl – additional length request for the tugs or ship's movement during turning in ships turning basins and could be taken as tug line length; B – ship's width; β – ship's drift angle on entrance to ships turning basins or in channel; ΔK – ship's fluctuation around course angle on entrance to ships turning basins or in

channel; b_n – navigation width navigational add as accuracy of the ships turning basins or channels slop; P' – probability coefficient, in case of probability not less than 95% $P'=2.5$; σ_y – ship's position observation accuracy.

Ship's drift angle could be calculated as follows:

$$\beta = \arctg \beta = \frac{v_d}{v} \quad (2)$$

where: v – ship's speed on entrance to ships turning basins or in channel; v_d – ship's drift speed.

Ships turning basins, channels and other port waters depths calculation should take in account:

- possible maximum ship's draft,
- sounded depth,
- survey tolerance,
- saltation,
- ship's squat allowance,
- ship's rolling (heel) influence,
- waves response in places where waves are acting,
- navigation add depths depends possible changes of the depths and other non typical situations.

In this case calculation formula could be described as shown per bellow [6, 10]:

$$H_{\min} = T + \Delta T_V + \Delta T_\theta + \Delta T_\psi + \Delta H_m + \Delta H_{V.L} + \Delta H_{\Delta V.L} + \Delta H_n \quad (3)$$

where: T – ship's maximum draft; ΔT_V – ship's squat allowance; ΔT_θ – ship's rolling (heel) influence; ΔT_ψ – waves response; ΔH_m – survey tolerance; $\Delta H_{V.L}$ – water level in given place (astronomical tide); $\Delta H_{\Delta V.L}$ – water level measuring accuracy; ΔH_n – navigational depth add.

Ship's draft directly depends of the cargo quantity and loading conditions. Ship's squat allowance in case of low speed (up to 6 knots, which is allowed in port areas) is not very big and could be calculated as follows:

$$\Delta T_V = \sqrt{\frac{1 + K_{11}}{1 + K_{11}^1}} \quad (4)$$

where: K_{11} and K_{11}^1 – added mass in case big depths and shallow waters accordingly and can be find or calculated by ship's theory method.

Ship's rolling (heel) influence can be calculated as follows:

$$\Delta T_{\theta} = \left(\frac{B}{2} - 0.7 \cdot r_h \right) \operatorname{tg} \theta \quad (5)$$

where: θ – ship's rolling (hell) angle; r_h – ship's hull between board and bottom radius.

Ship's wave response is important at the approach channels and in other port places where can penetrate waves and it can be taken from special tables depending on ship's length and waves parameters. Survey tolerance depends on measurement equipment and organizational system, that means how often is measured and it influence very much on navigational depth add.

Water level in different port places in some ports can be big and water level fixed and prediction system are very important. In the same time tidal residential depends on used measurement equipment and organization of this works is very important.

Ship's turning basins must guaranty safe ship's turning with tugs or using thrusters. Ships like container, Ro-Ro vessels, and some tankers have thrusters and can turn without tugs. In case of using tugs, minimal turning basin width (diameter) can be calculated by formula (1), which can be used for the channels as well, or as follows:

$$B_a = L + L_v + \Delta l \quad (6)$$

where: L – ship's length overall; L_1 – tug length; Δl – additional distance needed for the change of at least one tug location depending to the ship, which should take in account tug rope length and ship's drift influence.

For the ships, which has thrusters, minimal turning basin width should be not less than [5]:

$$B_a \geq 1.25 \cdot L \quad (7)$$

Theoretical calculations were compared with simulation results and real ships experimental results.

Practical evaluations of the ports turning basins

As the example is taken given port for evaluation of big container vessels entry, turning and sailing within the port are and possibilities during different hydro meteorological conditions. Such example can be Klaipeda port, which is located close to the sea shore, has approach channel, bends in the approach channel just after breakwaters, port channel is located close to the oil terminal berths, has few ships turning basins, also are other complicated places inside of the port.

During SW, W and NW wind up to 14 m/s, waves acting in case of ship's speed is up to 6.0–6.5 knots. In the same time must be the main engine reserved power to improve situation, as well as a good helmsman must be on the ship's bridge, who properly can react on ship's turning tendency and can keep ship on the channels lead line or in the proper ships turning basin's place.

Theoretical calculations, simulation testing, together with experimental results of the real big ships data, received in ports, for the widths and depths of the port turning basins for the Panamax and Postpanamax type of container vessels shown good results correlation.

For the ships turning basins parameters evaluation is taken for the Panamax (ship's length 296 m; width – 32 m), for the Postpanamax (ship's length 347 m; width – 43 m) types Container vessels: drift angle up to 5°–7°; ship's fluctuation around course angle in channel (ΔK) for such type of ships is up to 2°–3°; navigation width add depends on channel slops stability and accuracy in ports can be taken as 0.6 B (ship's width); ship's position regarding ships turning basin place observation accuracy in case of lead line about 3 m.

Ships turning basins depth for the Panamax (draft 10.5 m) and Postpanamax (draft 13.0 m) type of the container vessels can be taken next data: ship's squat allowance up to 0.2 m; ship's rolling (heel); influence up to 0.15 m (mainly on channels bend and ships turning places); survey tolerance up to 0.10 m; water level measuring accuracy up to 0.1 m; navigational depth add up to 0.2 m.

For the presented example for the Panamax type vessel minimal depth of the ships turning basins must be not less than 11.6 m, for the Postpanamax type of ship inside ships turning basins depths must be not less 13.9 m.

For the presented container vessels turning basin's width for the Panamax type of ship (length 296 m) must be not less than 390 m and for the Postpanamax type of the ship (length 347 m) – not less than 450 m. Length of the turning basins must take in account possible current and ship's drift influence on ship during ship's turning, usually up to 180°. In many cases big ships turning rate could be up to 15–20 deg/min. In example case turning basin form must be oval, which length in case of current 1 kn and wind velocity 14 m/s, should be for the Panamax type of container vessel about 715 m and for the Postpanamax type of vessel about 740 m.

Simulation results received by SIMFLEX Navigator simulator presented on figure 1 to figure 7.

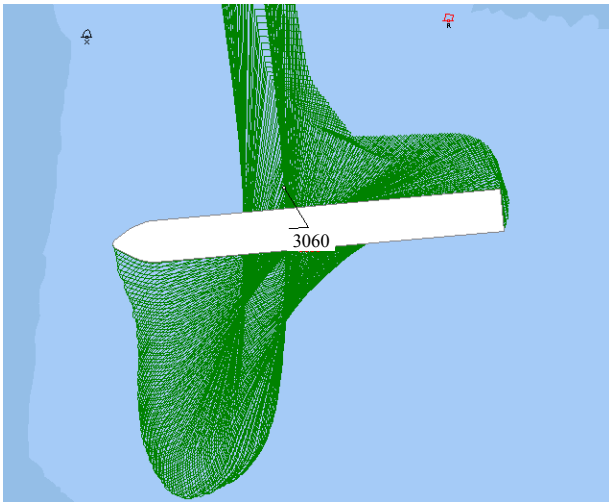


Fig. 1. Panamax type container vessel ($L = 294$ m) turning in ships turning basin near quay walls 101–104 in Klaipeda port
Rys. 1. Kontenerowiec typu Panama (dł. 294 m) w czasie obrotu w basenie portowym w pobliżu ścian nabrzeża 101–104 w porcie Kłajpeda

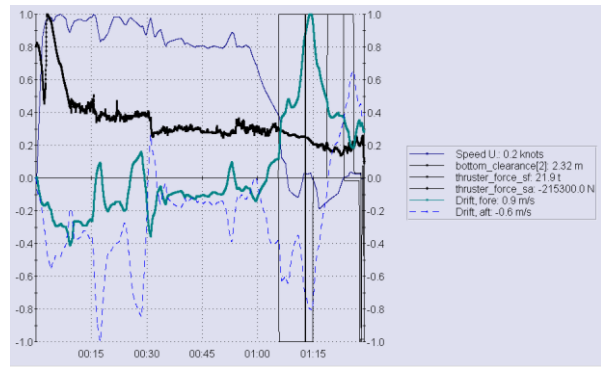


Fig. 2. Panamax type container vessel ($L = 294$ m) turning parameters (vertical line in time 01:12 shows ship position on figure 1)
Rys. 2. Parametry obrotu kontenerowca typu Panamax (dł. 294 m) (linia pionowa w czasie 01:12 pokazuje pozycję statku na rysunku 1)

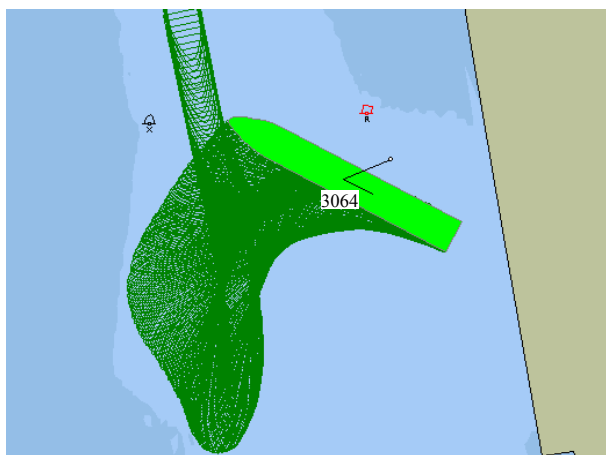


Fig. 3. Postpanamax type container vessel ($L = 318$ m), turning in ships turning basin near quay walls 101–104 in Klaipeda port by oven thrusters assistance
Rys. 3. Kontenerowiec typu Panamax (dł. 318 m) w czasie obrotu w basenie portowym w porcie Kłajpeda przy wspomaganiu sterów strumieniowych

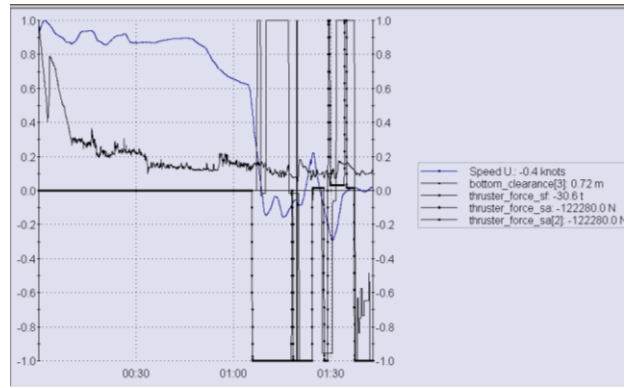


Fig. 4. Panamax type Container vessel ($L = 318$ m) turning parameters (vertical line in time 01:20 shows ship position on figure 3)
Rys. 4. Parametry obrotu kontenerowca typu Panamax (dł. 318 m) (linia pionowa w czasie 01:20 pokazuje pozycję statku na rysunku 3)

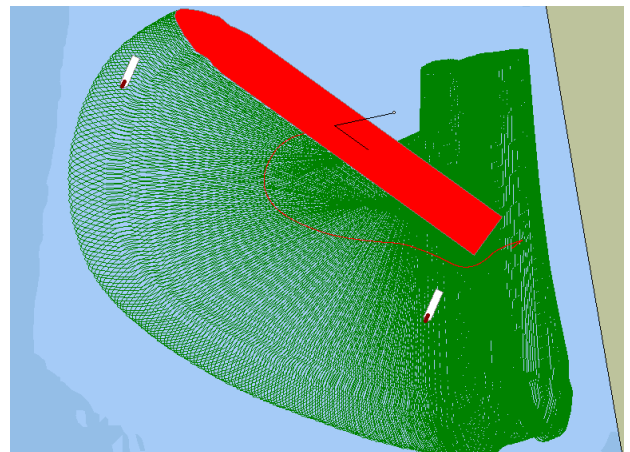


Fig. 5. Postpanamax type container vessel's ($L = 347$ m) turning in turning basin with tugs assistance
Rys. 5. Kontenerowiec typu Postpanamax (dł. 347 m) podczas obrotu w basenie portowym przy pomocy holowników

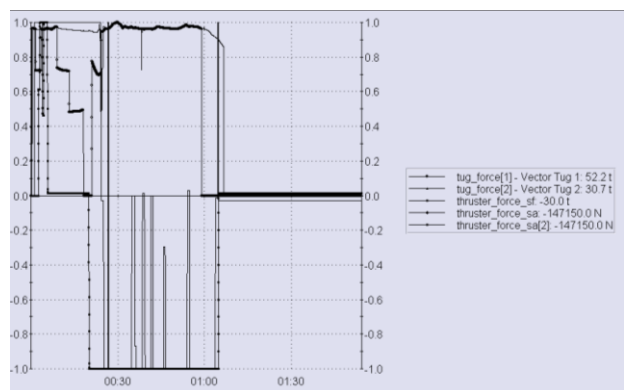


Fig. 6. Postpanamax type container vessel ($L = 347$ m) turning parameters in turning basin with tugs assistance (parameters on the right side show last vessel position)
Rys. 6. Parametry obrotu kontenerowca typu Panamax (dł. 347 m) w basenie portowym przy pomocy holowników (parametry po stronie prawej pokazują ostatnią pozycję statku)

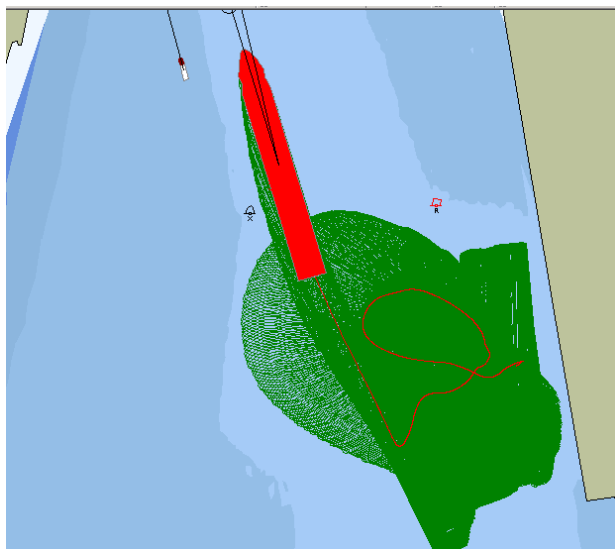


Fig. 7. Postpanamax type container vessel ($L = 347$ m) departure from quay wall and turning in turning basin with tugs assistance (request minimum ships turning basin parameters)

Rys. 7. Kontenerowiec typu Postpanamax (dł. 347 m) w czasie odbijania od ścian nabrzeża w basenie portowym przy pomocy holowników (minimalne wymagane parametry dla basenu portowego)

Practical experience were made on big bulk carriers in ballast, which have equal wind surface and berth to the same quay walls, that means use the same port inside channels and turning basins. Received results have shown, that theoretical calculations, simulations on full mission simulator and real practical experience results are equal and on the first study stage it is possible to use theoretical calculation method presented in this article.

Conclusions

1. Ports improvement for big container vessels' entry in ports in all with minimum possible investment could be realized in case of precise calculations, simulation testing and real experimental results.

2. Methodology presented in this paper can assist receiving correct results for the big container vessels turning possibilities in ports and sailing to terminal quay wall.
3. Additional investigations for example by simulations are recommended for checking big container vessels turning in ships turning basins, complicated places in ports inside such as bends, ships moored close to navigational channels and other possible difficulties.
4. Correct calculations and additional testing for big container ships possibilities turning in ships turning basins can assist to find right ships turning basins parameters, which should positive influence on shipping safety in limited conditions and ports economical results.

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