Analysis of ships turn manoeuvres in port water area

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ABSTRACT: The turning basin is a special part of port water area described by dimensions in horizontal and vertical directions. Such area should be insuring the proper level of safety due to ship manoeuvres. The paper presents the analysis of ships turn manoeuvres on aspect of turning basin designing. The examples of such basins in polish port are showed.

1 INTRODUCTION

1.1 *What this is the turning basin*

The turning basin is understood as the maneuvering reservoir or also the hydro technical building artificial or natural about suitable horizontal and vertical dimensions, where the considerable alterations of the course of the ship are done. Because the ray of the circulation of the ship in the movement, even near small speeds, he is considerable, so the ship practices the turning over „in the place". This should be understand as the change of the course of the ship whose linear speeds are zero in relation to water during the maneuver or are close to zero. Turning over the ship is done on the turning basin as a result of the planned tactics of maneuvering and can be done on itself or in co-operation with tugs or use of anchors or spring. Turning basins are both reservoirs appointed and the reservoirs not appointed on which the turn of the ship is done with the considerable value of the course and they make up the part of channels or port basins. Turning basin as the hydro technical building, from the safety of considerations, it always has to be larger than the turning basin understood as the maneuver reservoir to avoid the collision with bottom or bank.

1.2 *The definition of turning basin in polish law*

The polish law defines the turning basin of ships as the limited navigational reservoir, situated on the point of contact of basins and port channels or on the water track, designed to safe executing the maneuvers of ships in the aim of the entry to port basins or the altering course or mooring of the ships in the harbor, with the use of own engine or with the help of tugs (Dz.U.98.101.645).

In the thought of the law, the dimensions and location of turning basins are determined in the support of the navigational analysis. During projecting the turning basins or reconstruction already existing, the smallest diameter of the turning basin can not be smaller than values passed in table 1.

Table 1. The dimensions of the diameter of turning basins (Dz.U.98.101.645)

The way of the ships turning	The building of new turning basins	The reconstruction of existing turning basins
The turn on spring fixed to bollard on the sea building	1.5 * L_c	1.3 * L_c
Turn for the help of the tugs of tankers, gas carriers or chemical tankers	(2.0-2.5) * L_c	2.0 * L_c
The turn for the help of the tugs of ships different than the tankers, gas carriers and chemical tankers	2.0 * L_c	1.6 * L_c

where L_c = the total length of the hull.

On reservoirs, where the current of water with measured speeds and the directions of the occurrence, has influence on reliable floatable

objects, location and dimensions of the turning basins are projected in the approximate shape to the ellipse, which the large axis definite dimensions in the table 1. The depth of water on the turning basins is defined in dependence from loading status of turned over ships (Dz.U.98.101.645).

2 SHIPS MANOEUVERS ON TURNING BASIN

Many ways of the realization of the turn of ship exist in dependence on accessible reservoir, reigning hydro meteorologically conditions and the accessible kinds of steering the ship. Special influence on this maneuver has the kind of the used propulsion, use of tugs, the use of the anchor or spring.

The presentations, in the following points, of the realizations of maneuvers were used application of simulation of maneuvering the ship – SMART (Artyszuk 2005).

2.1 *The turning of the ship using the own drive*

The turning of the ship using the only own propulsion complies on small ships the most often. This consists in executing "kick ahead" maneuvers ahead on transformations with the work astern to keep the rotation of ship till the setting of the ship on the desirable course (Fig. 1).

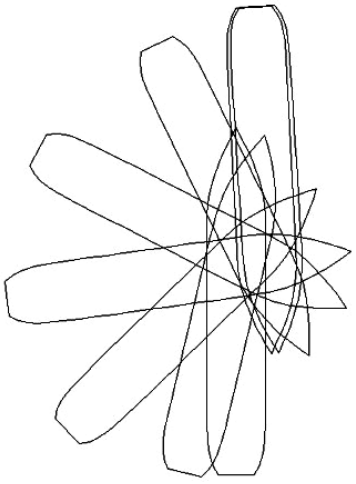

Fig. 1. Turning the ship of to use of the main engine (ship's positions every 60 seconds)

Mostly the turn of the ship complies consistent with the tendency to the alteration of the course through ship during the work of propulsion astern (consistent with turning effect of propeller). It happens that in case of wind conditions the realization of turning maneuver in the opposite direction of turning effect of propeller is easier then turning consistent with it.

The use of thrusters is additional element helping the process of the turning of the ship. The applying thrusters on the forward as additional force applied opposing with force produced by the propeller-rudder arrangement seem to be sufficient for simpler maneuvers of the turning. And the use of additional thrusters on the aft allows to considerable facilitation in the realization of the maneuver of the turning (Fig. 2).

Such solutions with many thrusters not only on the forward, but also on the aft, comply particularly on large ships.

It should be remembered that thrusters have their limited power. They in particularly unfavorable conditions may be completely insufficient.

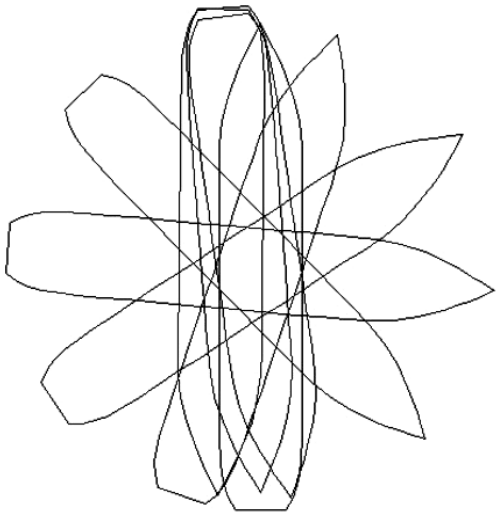

Fig. 2. Turning of the ship using the main engine and thruster (ship's positions every 60 seconds)

In case of using thrusters, while turning of the ships, in the smaller degree can be take the turning effect of propeller then in case of turning of the ships without their use.

Using only the main engine while the turning of the ship, she will also move along to the forward or to the aft enlarging the maneuvering reservoir on the turning basin. The use of thrusters will result in smaller use of the main engine and simultaneously decrease moves the ship along.

2.2 *The turning of the ship using tugs*

In the case of lack on the ship of thrusters, their insufficient power, the large sizes of the ship or unfavorable hydro meteorological conditions to turning over the ship uses tugs. Different quantity and the way of tugs work can depend from the scale of the difficulty and the kind of the tugs which are at one's disposal. The solution complies with one tug fixed on the long tow on the forward or with two fixed on long tows on the forward and on the stern the most often. Such solution does not require applying tug about more complicated and expensive propulsion arrangements. It should be remembered the maneuvering reservoir increase of the

maneuvering reservoir of tugs in this case. Tugs are place perpendicularly to the axis of the symmetry of the ship during the turning and they are pulling only forward or both forward and stern according to the direction of turn.

Second the solution, which does not cause the increase the reservoir of maneuvering, is the uses of tugs on the short tow. This requires, for the full control, the tugs with expensive propulsions solutions. Such method is applied in the USA and Canada universally. Tugs while the turning thrust the forward, the stern or they thrust and pull being on same side or turn together with the ship (Nowicki 1992).

The shape of the maneuver reservoir can be still more approximate to circular in the case of the turning of the ship with the use of tugs. There is the larger guarantee of the successful and failure-free maneuver additionally. Port authority, in dependence on the accessible fleet of tugs, the size of ship and the degree of the difficulty, define the minimum quantity of the tugs which has to participate from the safety of considerations in port maneuvers.

2.3 *The turning of the ship using the anchor*

The turnings of ships with the use of anchors apply more seldom. Such maneuver is executed through the ship herself without the tows assist. The aim is to limit the influence of the current on the size of the maneuver reservoir and to improve the maneuverability of the ship through the considerable limitation of the possibility of acceleration using "kick ahead" maneuvers. Maneuver this is prohibited by port authority because of the danger of the port reservoir bottom decay very often, and applied in ports of small urbanization as the natural outlets of rivers or open sea coasts. The shape of the maneuver reservoir is bring nearer to the semicircle and the pivot point of the ship turns is near a forward (Fig. 3).

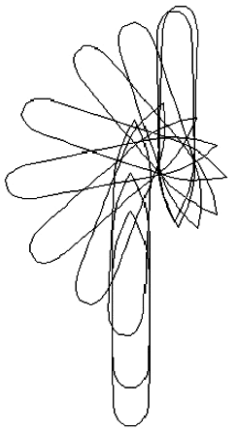

Fig. 3. The turning of the ship on the anchor (ship's positions every 60 seconds)

The executing of this maneuver can considerably limit the frequency of setting propulsion astern. The ship should be stopped or move with the very small speed in relation to the bottom to lower the anchor. Next the ship can be turned over using the small settings of the propulsion ahead in the monotonous way with rudder on same side as the anchor was lowered.

2.4 *The turning of the ship using spring*

The maneuver of the turning of the ship on spring is common on the berth, the most often during departure or approach. It can be applied while coming in to the locks or during the turning of the ship around dolphin. He consists in the approach to the hydro technical building and send a forward spring or unmoor and keep the forward spring fast. Then use small power of propulsion ahead with rudder on the side according to the direction of the turn. As soon as the ship aligns perpendicularly to the quay the propulsion should be set astern to avoid hull or bulb damages and to tighten forward spring to continue ships turning (Fig. 4).

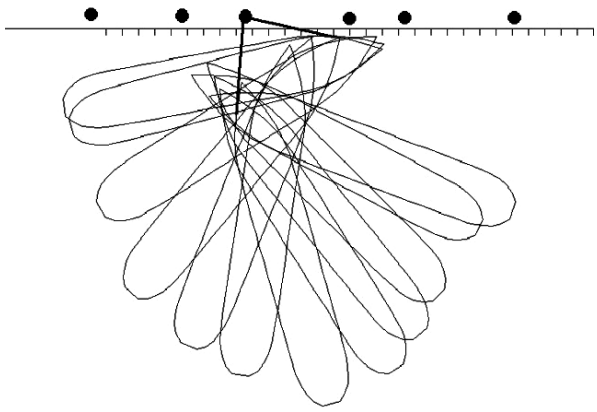

Fig. 4. The turning of the ship on spring (ship's positions every 60 seconds)

In the case of unmooring suffice to let go forward spring on the end of the maneuver of turning and to go away from berth. When mooring is the aim next ropes should be passed from the mooring side and the spring on which the turning took place should be let go.

3 THE METHOD OF DESIGNING THE TURNING BASINS

Two methods of designing the turning basins: analytic method and simulating method are comply (Gucma 2001).

3.1 *The analytic method of designing the turning basins*

The sizes of the maneuvering reservoir while making the turning of the ship depend on so many factors. So in practice these are applying the very simplified analytic method. It consists in dividing turning basins on two kinds: turning basins on reservoirs without currents and turning basins on current reservoirs. This takes the root that the turning basin has the shape of the wheel on reservoirs without current and the elliptic shape has on current reservoirs, for simplification, the contained surface in shape between two circles, like without current, shifted about the distance, which the ship will pass under the influence of the current. The dimension of the turning basin on the reservoir without current defines the example Equation1 (Gucma & Jagniszczak 1997; Gucma 2001; Gucma & Jagniszczak 2006):

$$d_o = 1.5L \tag{1}$$

where d_o = the diameter of the turning basin; L = the length of the ship.

This is introduced on figure 5:

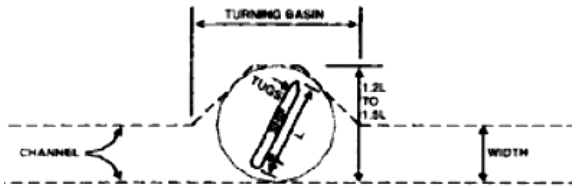

Fig. 5. Parameters of turning basin on reservoirs without currents (McCartney 2005)

The dimensions of the turning basin on the current reservoir define the examples Equations 2, 3:

$$l_o = 1.5L + v_c t_o \tag{2}$$

$$b_o = 1.5L \tag{3}$$

where l_o = the length of the turning basin; b_o = the width of the turning basin; L = the length of the ship; v_c = the speed of the current; t_o= the time of the turning.

This is introduced on figure 6:

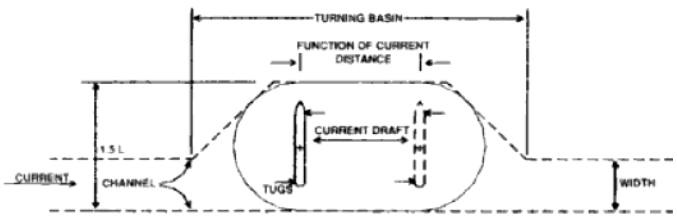

Fig. 6. Parameters of turning basins on current reservoir (McCartney 2005)

3.2 *The simulating method of designing the turning basins*

The simulating method of designing the parameters of turning basins depend execution of series of tests in comparable conditions on prepared model of reservoir and the model of the ship planned to use the turning basin. The results of tests are subjected the statistical processing. This is the characteristic feature of the simulating method, that simulating models of the ship maneuvering are especially designed to the solved problem. Effect of that kind of research is delimitation of the reservoirs of maneuvering on the turning basin according to the various foundations of hydro meteorological conditions, various parameters of ships and various levels of the trust.

Below, shown reservoirs of harbors: Świnoujście (Fig. 7, 8), Kołobrzeg (Fig. 9) and Police (Fig. 10), were introduced designed turning basins in:

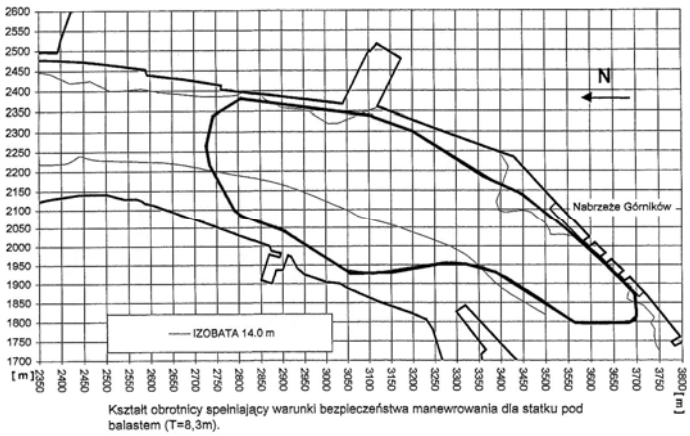

Fig. 7. Parameters of the turning basin near the embankment Górników in Świnoujście (the collective work 2000)

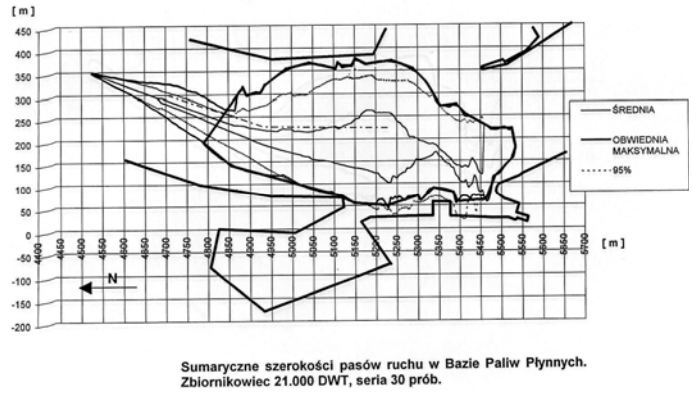

Fig. 8. Parameters the turning basin near the base smooth fuels in Świnoujście (the collective work 1995a)

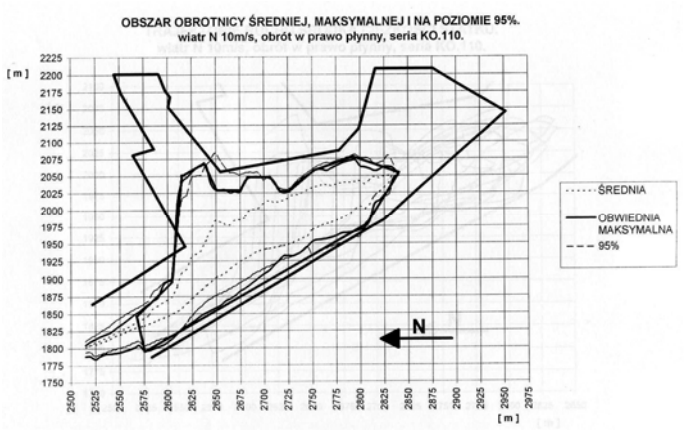

Fig. 9. Parameters of the turning basin in the harbor Kołobrzeg (the collective work 1995b)

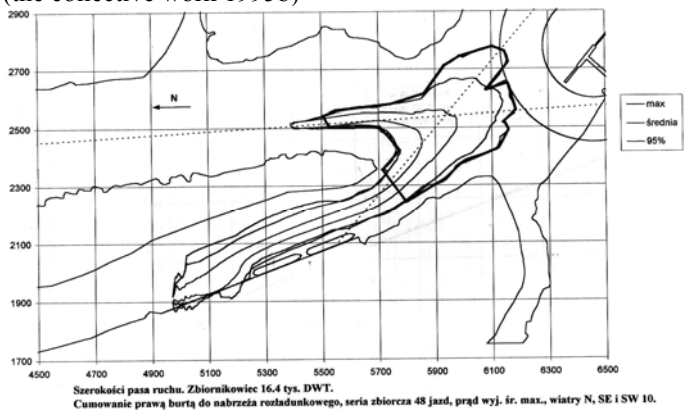

Fig. 10. Parameters of turning basin in harbor Police (the collective work 1998)

You can see that the shape of turning basin dependence from accessible reservoir and hydro meteorological conditions is different and very irregular.

3.3 *The real investigations method of designing the turning basins*

These investigations are leaning about real observations consisting in the measurements of the position of the ship and concurrent tugs during the maneuver of the turning. This method can not be used to marking parameters of designed or modernized turning basins from obvious regards. However, this method finds the use to the verification of analytic and simulating methods on the basis which they already became built turning basins.

This method requires the study of investigative firing ground and measuring methods. They can be base about measurements on the maneuvering ship or for the help of external measurements. First way requires the installation on the maneuvering ship (if she does not possess them) the system of positioning about the suitable level of the exactitude of defining the position. It should be remembered that the ship is not the punctual object here and the measurements of the position of the ship should be bring back to the water plane of the ship. The qualification of the position of tugs (even to four) is difficult here.

Near the way of external measurements to find distance of the ship can be applied laser rangefinders at list of two points (on forward and stern) and the distance to tugs. The different method is the fotogrametric method. The use of the digital autograph is the best way.

The methods of real investigations are time--consuming and expensive. The results of investigations, similarly as near the simulating method, should be subjected the statistical processing.

4 THE OPTIMIZATION OF TURNING BASINS

The minimization of the costs of building or the modernization of the reservoir of the turning basins is the aim of the optimization. The safety of navigation of the executed the turning maneuver is the condition restrictive determined the navigational risk.

Criterion function for the method of the optimization can be introduced of the parameters of the turning basin as follows:

$$K = a * V - b \tag{4}$$

where a = the isolated cost of getting out the $1m^3$ of the output; V = the quantity of the output which was not obtained in the consequence of the minimum dimensions of the turning basin; b = losses of the bank collision.

Following figure 11 represents the pattern of the optimization of the dimensions of the turning basin.

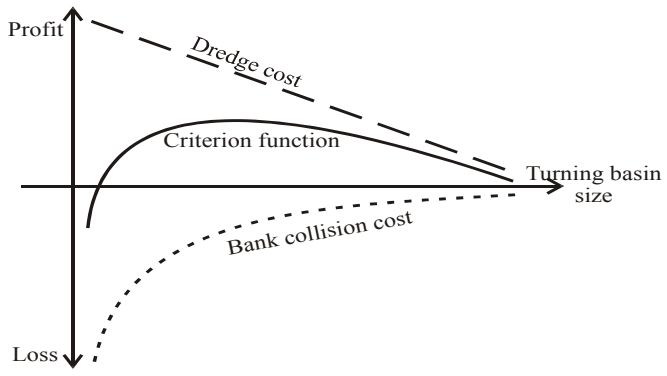

Fig. 11. Pattern of the optimization of the turning basin

5 CONCLUSIONS

The existing analytic methods of marking and the optimization of turning basin are exact little.

The turning basin on the reservoir with the stepping out current of water is the special type of

the turning basin. The analytic method takes into account the time of the turn of the ship and the speed of the current, while it is definite for the help of the circular shape in many cases.

Simulating methods, although they are more labor-consuming, they give large exactitude. However this did not become so far in the sufficient way definite.

According to existing experiences in projecting and making of turning basins on reservoirs ports of Świnoujście, Police, Szczecin and Kołobrzeg, their shape runs away from the wheel considerably. This results of investigations leanings about simulating methods concerns.

The study of the methods of the optimization of the size of turning basins will let lower the costs of their building or modernization near the behavior of the suitable level of the safety.

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REFERENCES

Artyszuk, J. 2005. Methodical guide of the ships maneuvering simulation with application. Naval University of Szczecin.

Dz.U.98.101.645 Minister Transportation and Sea Economy decree „w sprawie warunków technicznych, jakim powinny odpowiadać morskie budowle hydrotechniczne i ich usytuowanie".

Gucma, S. 2001. Inżynieria ruchu morskiego. Gdańsk: Okrętownictwo i Żegluga.

Gucma, S. & Jagniszczak, I. 2006. Nawigacja dla kapitanów. Gdańsk: Fundacja Promocji Przemysłu Okrętowego i Gospodarki Morskiej.

McCartney B. 2005. Ship Channel Design and Operation. American Society of Civil Engineers No. 107.

The unpublished report 1995a. Badania symulacyjne ruchu statków w bazie paliw płynnych w Świnoujściu. Naval University of Szczecin.

The unpublished report 1995b. Określenie optymalnego wariantu przebudowy wejścia do portu Kołobrzeg w oparciu o badania symulacyjnego ruchu statków. Naval University of Szczecin.

The unpublished report 1998. Badanie możliwości optymalnej lokalizacji przeładowni kwasu fosforowego w Porcie Police. Naval University of Szczecin.

The unpublished report 2000. Analiza nawigacyjna dla przebudowanego Nabrzeża Górników w porcie handlowym Świnoujście. Naval University of Szczecin.