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Analysis of the Influence of Current on the Manoeuvres of the Turning of the Ship on the Ports Turning-Basins

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ABSTRACT: The paper presents the problem of the influence of current on ship during the manoeuvre of the turning and influence on this manoeuvre. The test of the different qualification of the influence of current on the manoeuvre of the turning of the ship was undertaken. The analysis of the influence of the current was conducted on this manoeuvre.

1 INTRODUCTION

1.1 *The turning basins*

Can be understood as a two different meanings. First as the manoeuvring area appointed by the ships. Second as the hydro-technical building artificial or natural with suitable horizontal and vertical dimensions, where the considerable alterations of the course of the ship are executed.

The manoeuvre of ships turning is one of the often port manoeuvres. The ships turning is executed every time during the ships port call. Simultaneously, it is comparatively little examined. We know that the influence on the size of turning basin during the manoeuvre have the large quantity of factors.

The turnings of the ships are practices „in the place". This should be understand as the change of the course of the ship whose linear speeds, during the manoeuvre, are close to zero. Turning the ship over is done on the turning basin as a result of the planned tactics of manoeuvring and can be done on itself or in co-operation with tugs or use of anchors or spring.

Turning basins are areas appointed and the reservoirs not appointed on which the turn of the ship is executed with the considerable value of the course and they are a part of channels or port basins. Certainly due to safety, the turning basin as the hydro technical building always has to be larger in all dimensions than the manoeuvre area to avoid the collision with bottom or bank (Kornacki & Galor 2007).

1.2 *Designing of turning basins*

Two methods of defining their dimensions can be use. Those are analytic method and simulating method (Kornacki, 2007).

Analytic method is the very simplified. Turning basins are divided on two groups. First group establish non-currents turning basins. Second group establish turning basins on currents waters. It is premised that the turn of the ship is described by the circular area and in the case of currents waters, the area is described by the shape similar to figures definite by two semicircle and two straight lines joining them - the stretched wheel similar to ellipse. The depth of water on the turning basins is defined in dependence from loading status of turned over ships (Kornacki, 2007; Dz.U.98.101.645).

The dimension of the turning basin on the non-current waters defines the equation 1 (Gucma & Jagniszczak, 2006; McCartney, 2005):

$$d_o = 1.5L_{OA} \quad (1)$$

The dimensions of turning basins on the current waters define the equations 2, 3 (Gucma & Jagniszczak, 2006; McCartney, 2005):

$$l_o = 1.5L_{OA} + v_c t_o \quad (2)$$

$$b_o = 1.5L_{OA} \quad (3)$$

The simulating method of designing the parameters of turning basins are based on 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. Effect of that kind of research is delimitation of the area of manoeuvring on the turning basin according to the various foundations of hydro meteorological conditions, various parameters of ships and various levels of the trust. Characteristic feature of the simulating method is that simulating models of the ship manoeuvring are especially designed to the solved problem (Guziewicz & Ślączka, 1997; The unpublished report 1995; The unpublished report 2000).

2 CURRENTS INFLUENCE

A feature of any river manoeuvres is the current. It is common for a river berth to lie in the same direction as the prevailing current so that the current can assist with turning and berthing. In this case, a turning can be done with a current or opposite a current.

Opposite current give the advantage of relatively high speed through the water with a reduced speed over the ground. Consequently, steerage at low ground speed is improved by the good water flow over the rudder. The ship will be easier to stop.

Certainly, manoeuvring with a current give completely different situation. High speed over the ground may mean low speed through the water. It is necessary to take care of ground speed all the time.

Below figure show the tendency of the stopped ship movement.

We should note that currents are usually complex, with varying rates and directions that can change hourly. Local knowledge is essential for safe navigation. A ship making headway into a current, but stopped over the ground, will have a forward pivot point.

The influence on manoeuvring is serious for even weak currents like ½ knots. It depends of the ship type and the objectives of manoeuvring in a smaller extent than in case of strong wind. On restricted water area everything is fine as long as manoeuvring ship remains under a speed of a few knots and the current is not so strong. The situation can be worst in case of dynamic positioning or low speed manoeuvring like ship's turning.

The ship outline is demonstrated in Figure 2.

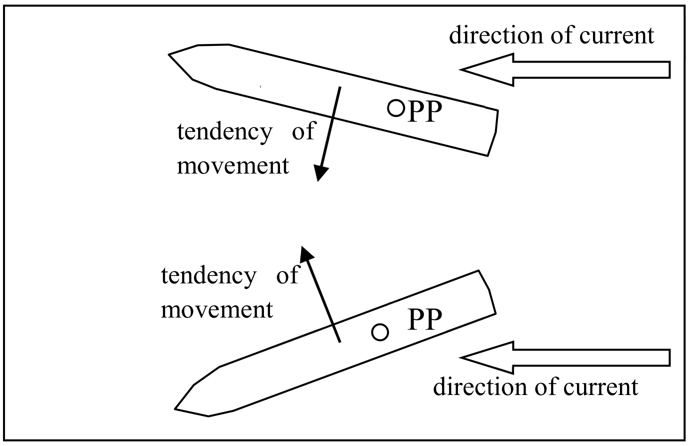

Figure 1. The tendency of the stopped ship movement with opposite current.

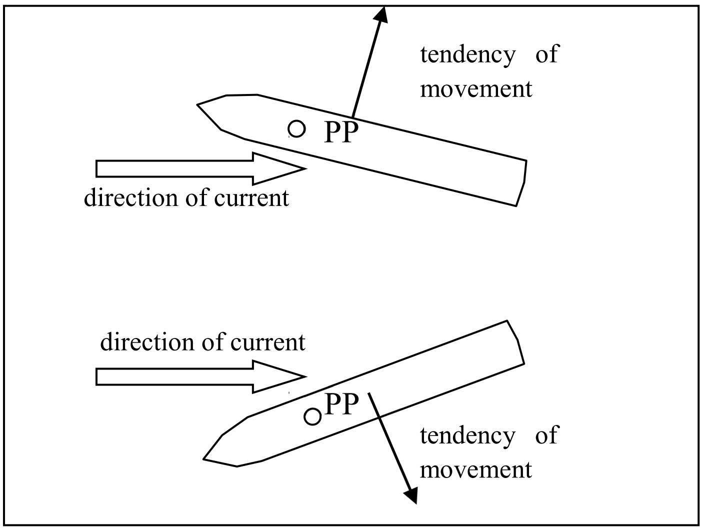

Figure 2. The tendency of the stopped ship movement with current.

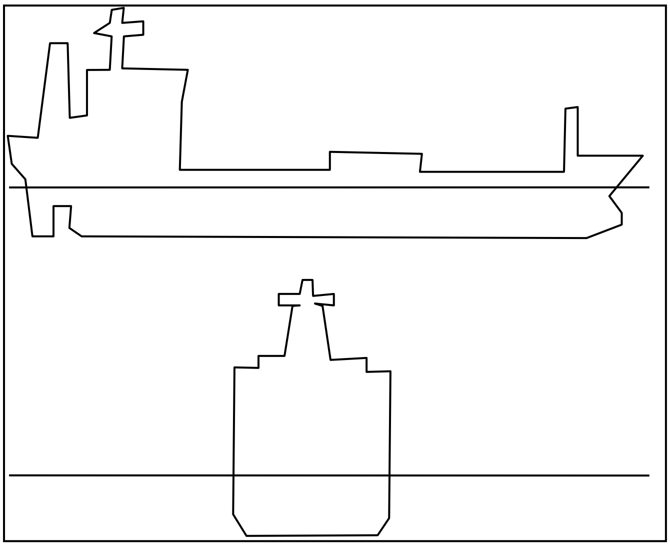

Figure 3. The lateral and longitudinal ships area with wet surface.

The ship manoeuvring motion equations are as follows (Artyszuk 2002):

$$\begin{cases} (m+m_{11})\dfrac{dv_x}{dt} - (m+m_{22})v_y\omega_z = F_x \\ (m+m_{22})\dfrac{dv_y}{dt} + (m+m_{11})v_x\omega_z = F_y \\ (J_{zz}+m_{66})\dfrac{d\omega_z}{dt} + (m_{22}-m_{11})v_x v_y = M_{Az} \end{cases} \qquad (4)$$

The influence of current is a part of hull forces, which are a part of:

$$\begin{cases} F_x = F_{xH} + F_{xP} + F_{xR} + F_{xA} \\ F_y = F_{yH} + F_{yP} + F_{yR} + F_{yA} \\ M_{Az} = M_{AzH} + M_{AzP} + M_{AzR} + M_{AzA} \end{cases} \quad (5)$$

Hull forces can be shown:

$$F_H = 0.5 \rho L T v_{xy}^2 c_{fh} \left(\beta, \overline{\omega_z}, \frac{h}{T}, \frac{b}{B} \right) \quad (6)$$

3 ANALYSIS OF CURRENT EFFECT DURING SHIPS TURNING TRIALS

Tests of ships turning are based on chemical tanker model. The ship data is summarised in Tab. 1 (Artyszuk 2005).

Table 1. Ships model data.

TYPE: chemical tanker	
L_{OA}	103.6 [m]
L_{BP}	97.4 [m]
B_M	16.6 [m]
T_M	7.1 [m]
H	9.4 [m]
H_A	35.2 [m]

The analysis of the current effect during ships turning on the turning basin is based on the series of turning-tests. The tests were executed in the wide port channel in various current conditions. Tests were executed apply the model of the ship mentioned above chemical-tanker, without the use of tugboats, with own propulsion, standard 35 degrees rudder and thrusters (Artyszuk 2005). Port channel had the width of the quadruple of the length of the ship and had not the influence on the area of manoeuvring. The tests were begun from the same places and interrupt after turn over ship to final course 270°.

3.1 *Turning manoeuvres without current*

First, for the comparison, the series of tests was conducted without current. All tests were in same environmental condition. It means: shallow water, slow speed, no wind, starboard and port turning and usage of ruder, main propulsion (ahead/astern) and bow thruster if necessary. Results are introduced below.

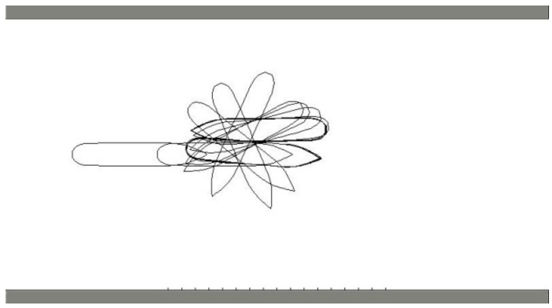

Figure 4. The turning manoeuvre without current – ship shapes in time of commands.

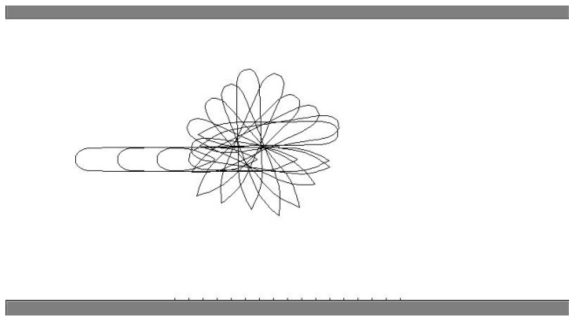

Figure 5. The turning manoeuvre without current – ship shapes in every 30s.

Figure 4 and 5 present typical turning manoeuvre with starboard turn without current. Below are present manoeuvring areas on turning basin (Fig. 6) and comparison with analytic method (Fig. 7).

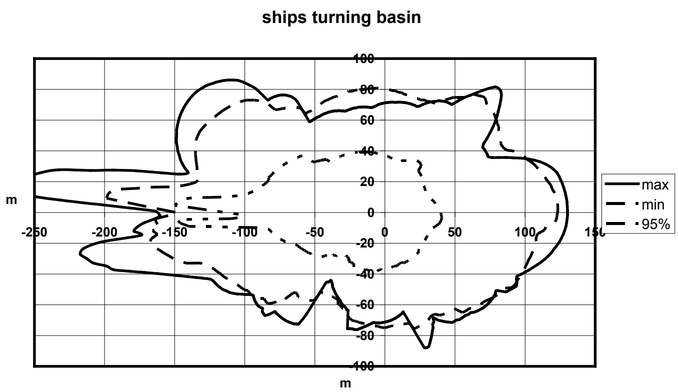

Figure 6. The manoeuvring areas on turning basin without current.

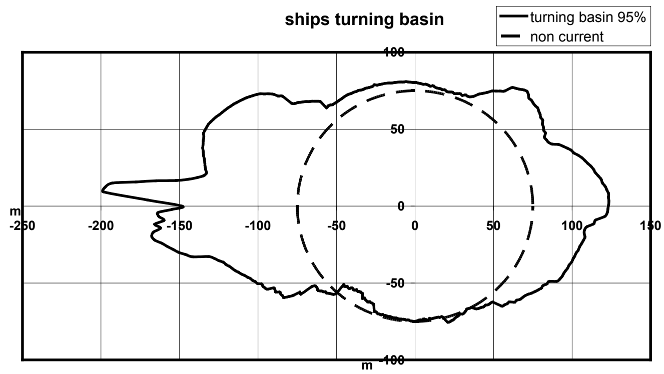

Figure 7. The manoeuvring areas on turning basin without current compared with analytic method.

Results base on series of 30 tests.

3.2 *Turning manoeuvres with opposite current*

All tests were in same environmental condition as without current (shallow water, slow speed, no wind, starboard and port turning and usage of ruder, main propulsion and bow thruster). Similar as before 30 tests were conducted. Current had 2 knots and direction 270º. Results are introduced below.

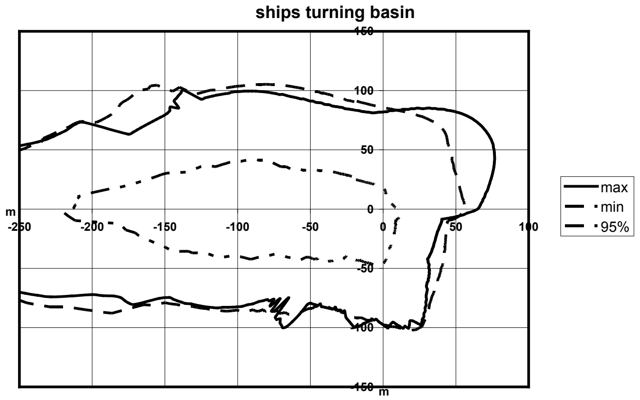

Figure 8. The manoeuvring areas on turning basin with opposite current.

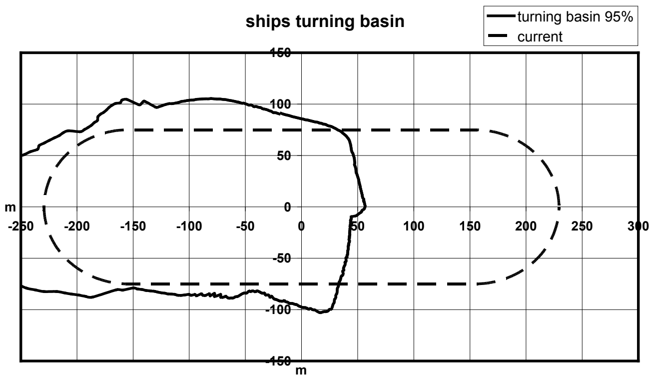

Figure 9. The manoeuvring areas on turning basin with opposite current compared with analytic method.

Figure 8 presents manoeuvring areas on turning basin with opposite current. In all cases tests were conducted as much as possible around beginning of co-ordinates. Figure 9 presents comparison results of analytic method and simulating method.

3.3 *Turning manoeuvres with current*

During tests of turning manoeuvres with current, similar like before, all environmental conditions stay the same. Current had 2 knots and direction 090º.

First, the shapes of typical tests are presented.

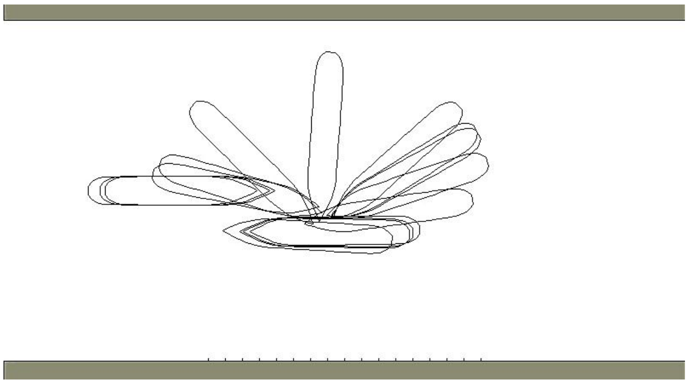

Figure 10. The turning manoeuvre, starboard turn, with current 090º and 2 knots – ship shapes in time of commands.

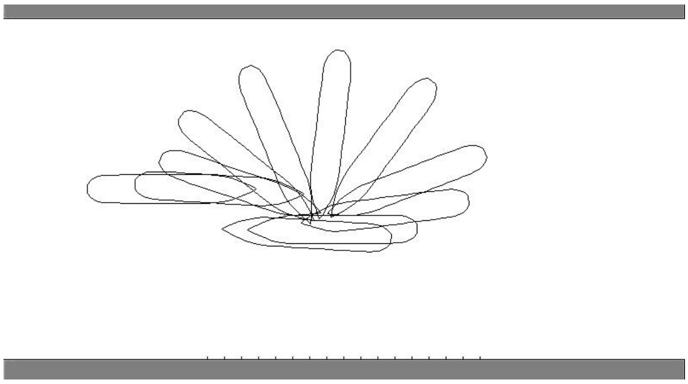

Figure 11. The turning manoeuvre, starboard turn, with current 090º and 2 knots – ship shapes in every 30s.

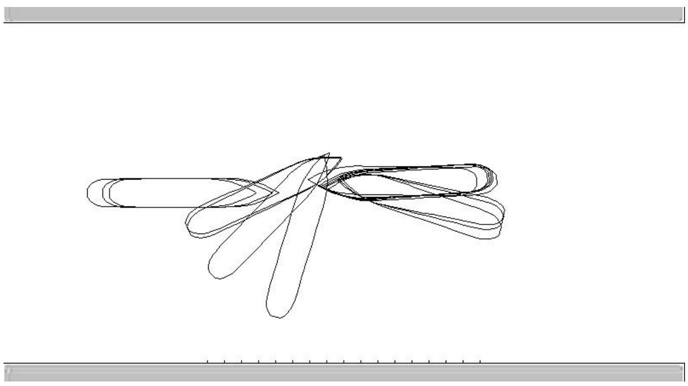

Figure 12. The turning manoeuvre, portside turn, with current 090º and 2 knots – ship shapes in time of commands.

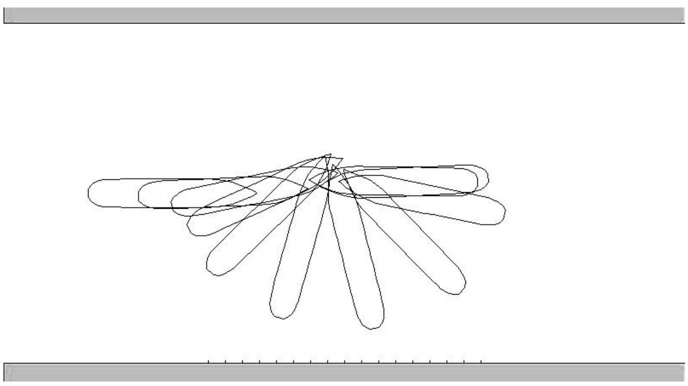

Figure 13. The turning manoeuvre, portside turn, with current 090º and 2 knots – ship shapes in every 30s.

Next, manoeuvring areas on turning basin with current are presents (Fig.14).

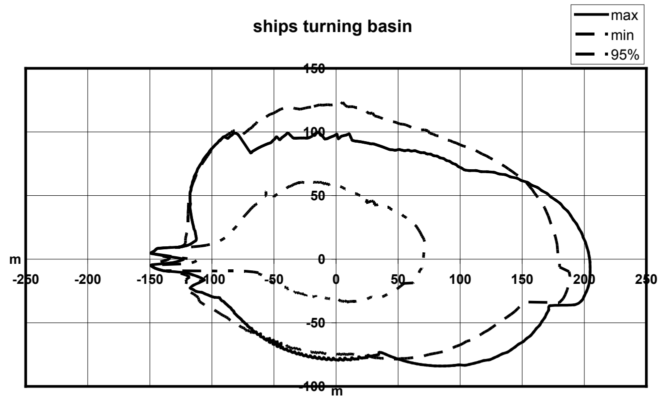

Figure 14. The manoeuvring areas on turning basin with current.

Comparison of results of analytic method and simulating method is presented below.

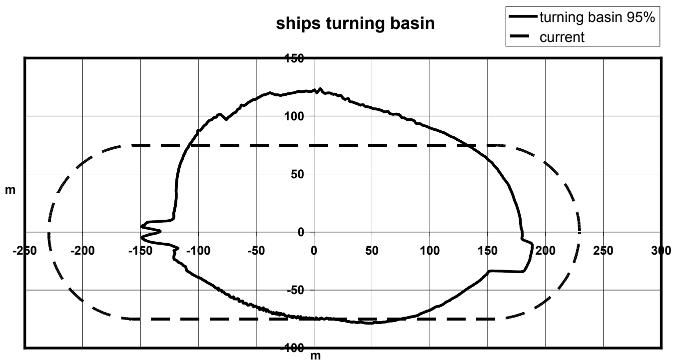

Figure 15. The manoeuvring areas on turning basin with current compared with analytic method.

3.4 *Comparison of turning manoeuvres in different current conditions*

It was interesting what differences are between the various tests groups of the manoeuvres of the turning of the ship. One can observe differences in manoeuvring areas appointed for various current conditions. But, if the influence of the current on different elements for this hides.

The comparison of the profile of yow velocity was introduced in dependence from the course of the ship for three typical current situations below.

It is easily to notice that there are no considerable differences in the course between individual situations. One can qualify the phase of the growth of the yow velocity, then the period of changing course in dependence from the tactics of the manoeuvre with the possible to the qualification maximum, and finally the phase of slowing down the yow velocity in the aim of the position of the ship on the new course.

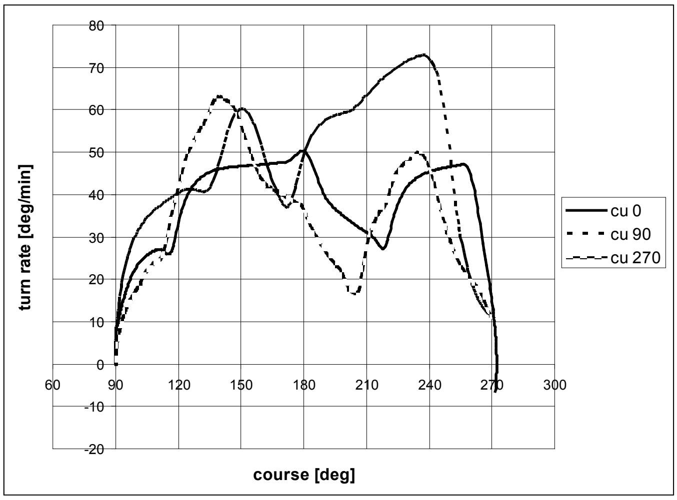

Figure 16. Turning rate [deg/min] on different tests groups.

You can not also see the considerable difference of period of executing manoeuvres.

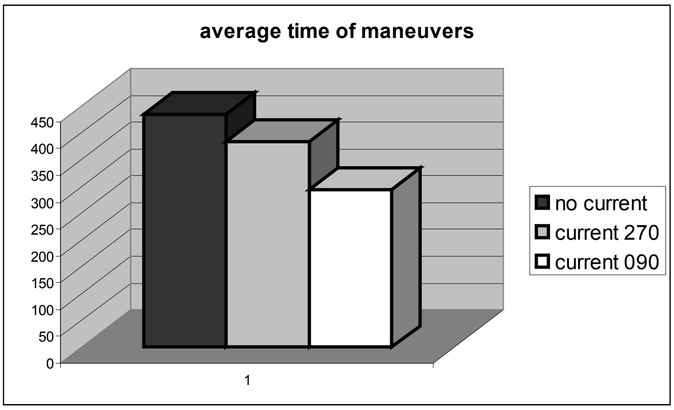

Figure 17. Average time of manoeuvres on different tests groups.

The differences what can be observe they are the result of hurry during the executing of the manoeuvre rather, in the aim his of the safe realization.

3.5 *Work of current*

Looking on the manoeuvring areas of individual groups, you can see that current has the influence not only on the growth of the dimension in the axis of the working of the current but he also influences growth of width of such area. We observe the differences in width of manoeuvring areas of grade ten percent of the width of the manoeuvring area without current. Accepting the steady working of the current, it can be:

$$\begin{cases} F_H = 0.5\rho L_{BP} T_M v_{xy}^2 c_{fh}\left(\beta, \overline{\omega_z}, \frac{h}{T}, \frac{b}{B}\right) \\ W_C = F_H s_C \end{cases} \qquad (7)$$

Working of the current can be understood as the kinetic energy causing position offset.

4 CONCLUSIONS

According to the above examinations some general points could be formulated.

The manoeuvring area is not complaint with this appointed by the analytic method.

It was observed, larger from foreseen, the extension of the size of the turning basin upon the width.

It was observed, smaller from foreseen, the extension of the size of the turning basin upon the length.

The current does not have the significant influence on stepping out yow velocity and the time of the manoeuvre. However certain influence has on accelerations, what joins with the occurrence of additional strengths on the hull and different moving the ship causes.

The ship on the current behaves like the wing and not as the inert object moving oneself together with the surrounding her environment. It joins with the use of ships drive propulsions obviously, and occurrence on the hull of the suction side and the pressure side.

One can apply the work of the current on the hulk to the qualification of the sizes of the turning basin while manoeuvring on the current.

5 SYMBOLS AND UNITS

b_o - width of the turning basin [m],

B_M - moulded breadth [m],

β - drift angel [º],

c_{fxC}, c_{fyC}, c_{mzC} - hall coefficients [-], [-], [-],

d_o - diameter of the turning basin [m],

F_x, F_y, M_{Az} - external total surge, sway forces and yaw moment [N], [N], [Nm],

h - depth [m],

H_A - air draught from the keel [m],

L_{BP} - length between perpendiculars [m],

L_{OA} - length over all [m],

l_o - length of the turning basin [m],

m, J_{zz} - mass and inertia moment [kg], [kg m^2],

m_{11}, m_{22}, m_{66} - virtual masses [kg], [kg], [kg m^2],

s_C - length ship track to final position offset [m],

T_M - draught [m],

t_o - time of the turning [s],

v_c - speed of the current [m/s],

v_d - drifting speed [m/s],

v_x, v_y, ω_z - surge, sway and yaw velocity [m/s], [m/s], [1/s],

ρ - water density [kg/m^3],

W_C - work of wind [J],

H, P, R, A - subscripts indicating respectively: hull, propeller, rudder or wind

ACKNOWLEDGEMENTS

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Some part of tests was executed using the Shiphandling Simulator.

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