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Ship-Model Wake Correlation Based on Equivalent Flat Plate and Form Factor Conceptions

In the paper a method of calculation of the viscous wake component is suggested based on the frictional wake of an equivalent flat plate which depends on the Reynolds number and the propeller diameter-ship length ratio. The friction wake fraction of the flat plate combined with the form factor gives the viscous wake component which can be used to correlate the ship and model nominal mean wake fractions. The method proposed has been verified by comparison with test results for four series of geometrically similar models.

1. Introduction

One of the most important problems of the ship hydrodynamics is estimation of the velocity field at the propeller disc. The propeller is working in wake caused by: 1) potential flow along the hull of finite breadth, 2) development of boundary layer, 3) wave motion of the free surface of water. These three phenomena influence both the velocity distribution in the wake and the mean inflow velocity to the propeller (advance velocity) V_P and form three components of the wake: potential, viscous and wave. The advance velocity is expressed in practice in the form of nondimensional coefficient, so called wake fraction

$$W=\frac{V_S-V_P}{V_S},$$

where V_S is the ship speed.

Two kinds of the wake fraction can be distinguished, viz: the nominal wake W_N due to the distribution effect of the hull only and the effective wake W_T due to the propeller action. In view of lack of theoretical methods enabling us to predict the velocity field in the wake of the ship's hull it is necessary to use experimental methods and geometrically similar models. This way of modelling physical phenomena does not ensure the complete fulfilment of the scaling law. The difference in the Reynolds number of the object and its model causes differences in modelling viscous effects. This difference is called „the scale effect". Knowledge of the scale effect is necessary to establish a correct method for predicting any hydrodynamic phenomenon connected with the ship motion, basing on model experiments.

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From among three components of the wake fraction the viscous one is first of all subject to the scale effect. It is assumed that two other components, viz. the potential wake and the wave wake do not depend on the Reynolds number and are the same for the ship and the model. At moderate Froude numbers the wave component is negligibly small and will not be taken into account in the further considerations.

At present efforts to assess the wake scale effect are based on the following principles:

1. The total wake fraction W_V can be expressed as a sum of two components: viscous wake W_V dependent on the Reynolds number and potential wake W_P dependent on the Froude number:

$$W_N = W_V + W_P .$$

2. Potential wake does not depend on the model scale; it means that it does not change with the Reynolds number.

In order to find the scale effect of the wake fraction W_N it is necessary to know the viscous component W_V.

Two ways are used to achieve this aim:

– Experimental estimation or theoretical computation of the potential wake W_P and its subtraction from W_N, known from measurements on the ship model

$$W_{V\,\mathrm{mod}} = W_{N\,\mathrm{mod}} - W_P .$$

Then assuming $W_P = \mathrm{const}$, $W_{V\mathrm{mod}}$ can be reduced to the ship scale proportionally to the ratio of the ship and model friction coefficients;

– Direct estimation of the viscous wake fraction W_V.

Most of the methods currently used to correlate the model and ship wake fraction are based on the first of the above mentioned ways.

In the present work the direct estimation of the viscous wake fraction is suggested. It is based on the concept of wake of the equivalent flat plate and form factor as used in the case of correlation of the ship and model resistance. Both the viscous resistance of the ship C_V and viscous wake fraction W_V depend on the Reynolds number and the hull shape. It has been shown that C_V can be expressed in the following way

$$C_V = kC_{Fo} , \tag{1}$$

where k is a form factor (function of the hull form only), C_{Fo}, is the friction coefficient of a flat plate of the same length and wetted surface as for the ship (function of the Reynolds number only).

Similar relation can be assumed in the case of the viscous component of the wake fraction

$$W_V = kW_0 , \tag{2}$$

where W_0 is the flat plate wake.

The purpose of the paper is to prove that the analogy, as expressed by equation (1) and (2), between the viscous resistance and the viscous component of wake fraction can be accepted. The analysis carried out is based on the available approximate theory of flat plate boundary layer and viscous resistance of ship-like body.

The considerations are restricted to a turbulent flow and hydraulically smooth surfaces.

2. Scale effect of the nominal wake fraction

According to the statement made in the previous section we have the following relation for the ship

$$W_{NS} = W_{VS} + W_P \tag{3}$$

and for the model

$$W_{NM} = W_{VM} + W_P. \tag{4}$$

From (3) and (4) we find

$$W_{NS} = W_{NM} - W_{VM} + W_{VS} \tag{5}$$

Subscripts S and M refer to the ship and the model respectively.

Equation (5) is used for the estimation of the ship wake fraction W_{NS} on the basis of W_{NM} taken from model experiments, provided the viscous wake fractions W_V for ship and model are known. Below the method for calculating this wake component based on equation (2) is described.

2.1. Calculation of the viscous wake component

The origin of the viscous wake fraction is connected with the development of the boundary layer around the immersed part of the ship's hull. We accept there following assumptions:

1) the viscous wake component depends only on the Reynolds number,

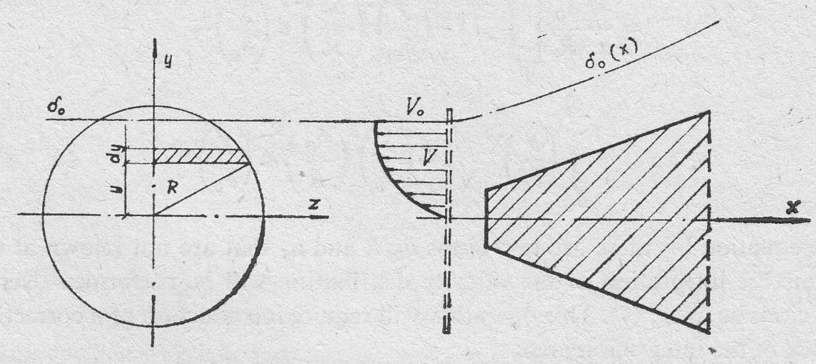

Fig. 1. Calculation of the wake fraction from the boundary layer characteristics

$$W = \frac{\int_0^{\delta_0} \left(1 - \frac{V}{V_0}\right) \sqrt{R^2 - y^2}\, dy}{\frac{\pi R^2}{4}}$$

2) the velocity profile in the boundary layer follows the exponential function with the exponent dependent on the Reynolds number [1, 2, 3].

$$\frac{V}{V_0} = \left(\frac{y}{\delta_0}\right)^{1/n_s} \tag{6}$$

where V – local velocity in the boundary layer at a distance y from the body surface, V_0 – velocity at the outer edge of the boundary layer, δ_0 – boundary layer thickness,

3) the boundary layer thickness does not depend on the draught of the ship.

With the above assumptions the viscous wake component can be obtained by integration of the velocity distribution in the propeller disc (Fig. 1)

$$W_V = \frac{\int\limits_0^{\delta_0} \left(1-\frac{V}{V_0}\right)\sqrt{R^2-y^2}\,dy}{\frac{\pi R^2}{4}}. \tag{7}$$

Assuming that $V_0 = V_S$, where V_S is the ship speed, and rearranging eq. (7) we obtain

$$\begin{aligned} W_V &= \frac{4}{\pi}\frac{\delta_0}{R}\int\limits_0^1 \left(1-\frac{V}{V_S}\right)\sqrt{1-\left(\frac{y}{R}\right)^2}\,d\left(\frac{y}{\delta_0}\right) = \\ &= \frac{4}{\pi}\frac{\delta_0}{R}\int\limits_0^1 \left(1-\frac{V}{V_S}\right)\sqrt{1-\left(\frac{y}{R}\right)^2\left(\frac{\delta_0}{R}\right)^2}\,d\left(\frac{y}{\delta_0}\right) = \\ &= \frac{4}{\pi}\frac{\delta_0}{R}\left[\int\limits_0^1 \sqrt{1-\left(\frac{y}{\delta_0}\right)^2\left(\frac{\delta_0}{R}\right)^2}\,d\left(\frac{y}{\delta_0}\right) - \right. \\ &\left. - \int\limits_0^1 \left(\frac{y}{\delta_0}\right)^{\frac{1}{nS}}\sqrt{1-\left(\frac{y}{\delta_0}\right)^2\left(\frac{\delta_0}{R}\right)^2}\,d\left(\frac{y}{\delta_0}\right)\right]. \end{aligned} \tag{8}$$

In the equation (8) there are two terms δ_0/R and n_S that are not known at this stage. Due to this the integration of the velocity distribution will be performed over a square instead a circle as in eq. (7). This operation will require introduction of a correction due to a difference in the integration area:

$$W_V = \frac{4}{\pi R^2}\int\limits_0^{\delta_0}\left(1-\frac{V}{V_0}\right)\sqrt{R^2-y^2}\,dy = b\,\frac{\int\limits_0^{\delta_0}\left(1-\frac{V}{V_0}\right)R\,dy}{\frac{\pi R^2}{4}}, \tag{9}$$

where b is the correction.

Putting

$$W_{V1} = \frac{4}{\pi R^2}\int\limits_0^{\delta_0}\left(1-\frac{V}{V_0}\right)R\,dy \tag{10}$$

we have

$$W_V = bW_{V1}. \tag{11}$$

Equation (10) can be expressed in the following way

$$W_{V1} = \frac{4}{\pi R^2} \int_0^{\delta_0} \left(1 - \frac{V}{V_0}\right) dy = \frac{4}{\pi R} \delta_1, \tag{12}$$

where δ_1 is the displacement thickness of the boundary layer. Equation (12) can be expressed as follows

$$W_{V1} = \frac{4}{\pi R} \frac{\delta_1}{\delta_2} \delta_2 = \frac{4}{\pi R} H\delta_2, \tag{13}$$

where δ_2 is the momentum thickness of the boundary layer

$$H = \frac{\delta_1}{\delta_2} = \frac{n_S + 2}{n_S}. \tag{14}$$

According to Squire [4] δ_2 can be expressed in terms of the ship viscous resistance C_V

$$\delta_2 = \frac{L}{2} C_V, \tag{15}$$

where L is the ship length.

Setting eqs. (14) and (15) into eq. (13) we obtain

$$W_{V1} = \frac{4}{\pi R} \frac{L}{2} \frac{n_S + 2}{n_S} C_V \tag{16}$$

and setting eq. (16) into eq. (11) we have

$$W_V = b \frac{4}{\pi R} \frac{L}{2} \frac{n_S + 2}{n_S} C_V. \tag{17}$$

In equation (17) the viscous coefficient can be expressed in terms of the friction coefficient of the equivalent flat plate. We will find relation between the wake fraction and the flat plate friction coefficient to calculate viscous wake fraction W_V of the ship.

By analogy to the equation (17) we can write for the flat plate

$$W_0 = a \frac{4}{\pi R} \frac{L}{2} \frac{n_0 + 2}{n_0} C_{Fo}, \tag{18}$$

where W_0 – wake fraction of the equivalent flat plate, a – correction, n_0 – exponent in the boundary layer velocity distribution function, C_{Fo} – friction coefficient of the flat plate.

Dividing equation (17) by equation (18) we have

$$\frac{W_V}{W_0} = \frac{b}{a} \frac{n_S + 2}{n_S} \frac{n_0}{n_0 + 2} \frac{C_V}{C_{Fo}}, \tag{19}$$

where n_S for the ship after Coles [4] and n_0 for the flat plate after Kacman [1] depend in the Reynolds number. The dependence can be expressed in terms of the frictional coefficient C_{Fo} instead of the Reynolds number as shown in Fig. 2.

Values of n_S and n_0 were calculated for various values of C_{Fo}. Coefficients a and b in eq. (19) were evaluated for various D/L (where $D=2R$ – propeller diameter) and than

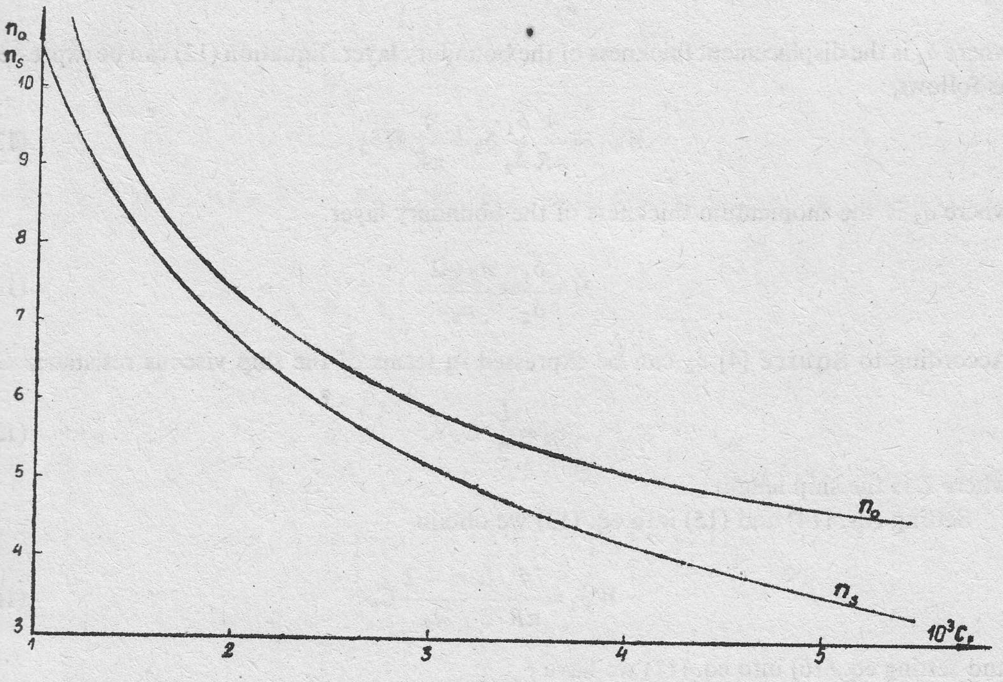

Fig. 2. Relationship between exponents n_S and n_0 of the boundary layer velocity profile and C_{Fo}

value of W_V was estimated. Detailed computations are given in [11]. From the computations it appeared that independently of the D/L ratio the following relationship is valid

$$\frac{W_V}{W_0}=\frac{C_V}{C_{Fo}}. \tag{20}$$

Equation (20) is a basis on which the suggested method for wake correlation of the ship and her model is founded. From equation (20) it can be concluded that the influence of ship form on the wake is the same as on the frictional resistance.

The viscous resistance coefficient C_V can be found from equation (1)

$$C_V=kC_{Fo}.$$

From this

$$k=C_V/C_{Fo}$$

and from eq. (20)

$$k=W_V/W_0$$

or

$$W_V = kW_0. \tag{21}$$

We use eq. (21) to calculate the viscous wake component W_V of the ship and the model. For this purpose it is necessary to compute W_0 for the flat plate.

3. Computation of the friction wake component for a flat plate

The friction wake component W_0 can be found by integration of the velocity field over the propeller disc. To this aim it is necessary to assume the velocity profile in the boundary layer. Research has shown that the velocity profile for the flat plate can be approximated either by an exponential or by a logarithmic function [6]. In the first case we have

$$\frac{V}{V_0} = \left(\frac{y}{\delta}\right)^{\frac{1}{n_0}}, \tag{22}$$

in the latter

$$\frac{V_0 - V}{V_1} = f\left(\log \frac{y}{\delta}\right), \tag{23}$$

where $V_0 = V_S$ is the velocity at the outer edge of the boundary layer, $V_1 = \sqrt{\tau/\rho}$ – the dynamic velocity, and τ – the shear stress, The logarithmic velocity profile has universal character in the sense that it does not depend on the Reynolds number.

3.1. Computation of W_0 for an exponential velocity profile in the boundary layer

In Appendix 1 of [11] an equation, (1.18), has been derived in the following form

$$W_0 = \frac{2}{2n_0 + 1} S_0, \tag{24}$$

where

$$S_0 = C_0(1 - C_0)^2 + \arcsin C_0 + 2\frac{n_0}{n_0 + 1} C_0 + \frac{1}{3}\frac{n_0}{3n_0 + 1} C_0^3 + \ldots$$

$$C_0 = \frac{\delta}{R}.$$

From this equation values of W_0 have been computed for various D/L ratios and given in Table 1 as a function of Reynolds number.

3.2. Computation of W_0 for a logarithmic velocity profile in the boundary layer

In Appendix 2 of [11] the following equation (2.14) has been derived

$$W_0 = \frac{1}{\pi}\sqrt{\frac{C_f}{2}}\,[3{,}894(b + h) - 1{,}396(e + g)]. \tag{25}$$

As in the previous case the values of W_0 were computed for various D/L ratios and presented in Table 1.

Table 1

Relationship between W_0 (D/L) and C_{F_0} for flat plate

1	lg R_n	6,3	6,5	7,0	7,5	8,0	8,5	9,0
2	$C_{F_0} \cdot 10^3$	3,863	3,547	2,909	2,429	2,059	1,767	1,533
3	W_0 (1) $D/L=$					0,135	0,1155	0,0974
4	W_0 (2) 0,025					0,136	0,115	0,0974
5	W_0 (1) $D/L=$				0,1382	0,1185	0,101	0,085
6	W_0 (2) 0,029				0,139	0,117	0,0991	0,0853
7	W_0 (1) $D/L=$			0,149	0,123	0,105	0,0896	0,075
8	W_0 (2) 0,033			0,149	0,124	0,104	0,0880	0,0755
9	W_0 (1) $D/L=$		0,165	0,138	0,1137	0,0968	0,0825	0,0692
10	W_0 (2) 0,036		0,172	0,138	0,1140	0,096	0,0811	0,0695
11	W_0 (1) $D/L=$	0,169	0,155	0,129	0,106	0,090	0,0765	0,0641
12	W_0 (2) 0,039	0,175	0,160	0,129	0,106	0,089	0,075	0,0640
13	W_0 (1) $D/L=$	0,159	0,144	0,125	0,0985	0,0842	0,0712	0,0593
14	W_0 (2) 0,042	0,165	0,150	0,120	0,099	0,083	0,070	0,060
15	W_0 (1) $D/L=$	0,148	0,135	0,112	0,0925	0,0785	0,0666	0,0560
16	W_0 (2) 0,045	0,155	0,141	0,113	0,093	0,0774	0,065	0,056

Note: W_0 (1) and W_0 (2) are calculated from equations (24) and (25), respectively, C_{F_0} after Schoenherr.

It was previously shown that between the frictional wake component W_0 and the friction resistance coefficient of the flat plate C_{F_0} there is a close relation (equation (20)). After computing W_0 this relation could be evaluated, had the function $C_{F_0}R_n$ been known. For this purpose the Schoenherr friction line has been used which is convenient from the

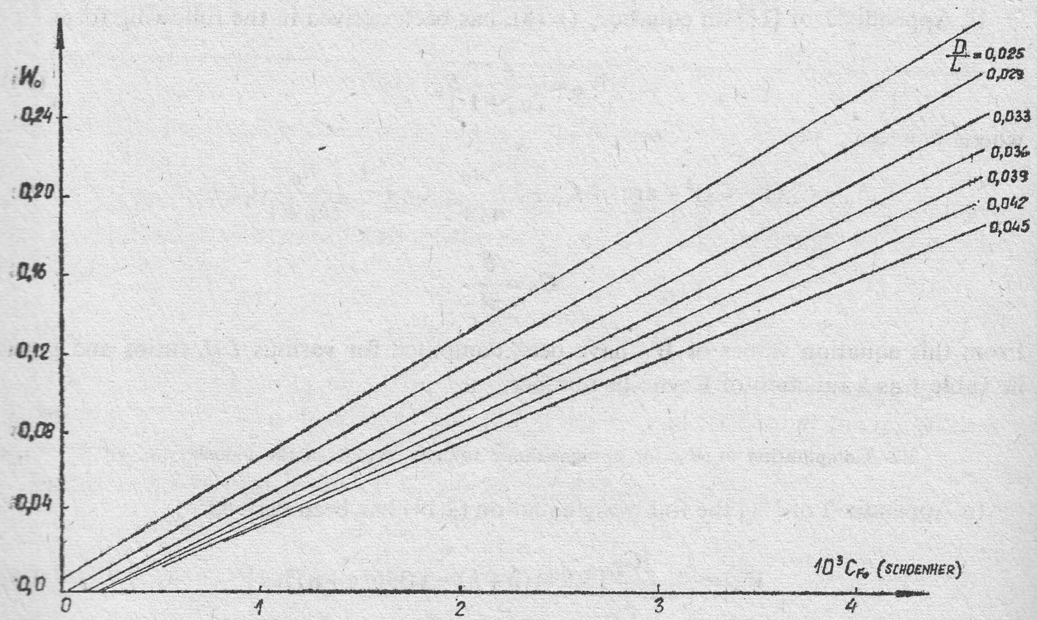

Fig. 3. Relationship between the frictional wake fraction and the frictional resistance coefficient for a flat plate

resistance correlation point of view [7]

$$\frac{1}{C_{Fo}}=4{,}13\log(R_n\cdot C_{Fo})\,. \tag{26}$$

The relationship between W_0 and C_{Fo} for various D/L ratios is shown in Fig. 3. Numerical values of the relationship are given in Table 1. From Fig. 3 it appears that there is a linear relationship between W_0 and C_{Fo}

$$W_0=aC_{Fo}+b\,, \tag{27}$$

where a and b are coefficients dependent on the D/L ratio

$$a=955{,}55\,\frac{D}{L}+85{,}09\,, \tag{28}$$

$$b=71{,}5\left(\frac{D}{L}-0{,}04\right)^2-0{,}01\,. \tag{29}$$

With equation (27) W_0 can be evaluated. This, introduced to equation (21), enables us to calculate W_V if the form factor k is known. The form factor can be found from one of the known empirical formulae or estimated from model resistance test results.

The way of application of the above described procedure for the correlation of the ship and the model nominal wake fraction is shown by the equation (5).

4. Comparison of the computed viscous wake with experimental data

The above described procedure for computation of the viscous wake component is a basis of the proposed ship-model wake correlation method. Now it could be interesting to compare the calculated viscous wake according to equation (21) with the experimental values. It was decided to use for the comparison test results for a series of geometrically similar models (geosims). Four series of „geosims" were available for which nominal wake fraction is known, viz. „Victory" series (8 models) [8], „Simon Bolivar" (6 models) [9], „Meteor" series (3 models) [10] and „Tanker" series (5 models) [10]. The „geosim" series are very useful for this kind of comparison because they make possible the influence of the Reynolds number to be examined. The largest model of each series was chosen as the object for which W_N was calculated by means of the proposed method based on the test results for remaining models. The comparison of the computed values with the test results is given in Tables 2 and 5.

From the results contained in Tables 2 and 5 the following conclusions can be drawn:

1. The wake fraction predicted from model test results by means of the proposed method is in agreement with experimental data. In particular, good agreement is obtained in the case of „Victory", „Simon Bolivar" and „Meteor" forms (Tab. 2 to 4). Also in the case

Table 2

Comparison of W_V calculated and obtained from experiment for ,,Victory'' model series

1	α	50	40	36	30	25	23	18	6
2	$\lg R_n$	6,42	6,55	6,63	6,75	6,85	6,92	7,07	7,82
3	$C_V \cdot 10^3$	4,21	4,03	3,92	3,765	3,64	3,565	3,395	
4	$C_{Fo} \cdot 10^3$	3,669	3,475	3,363	3,205	3,081	2,999	2,834	2,182
5	C_V/C_{Fo}	1,147	1,160	1,165	1,175	1,18	1,19	1,198	
6	W_0	0,162	0,153	0,148	0,141	0,135	0,131	0,123	0,0926
7	$W_V = W_0 \dfrac{C_V}{C_{Fo}}$	0,186	0,178	0,172	0,165	0,159	0,156	0,147	
8	W_N	0,434	0,404	0,402	0,376	0,380	0,362	0,371	0,317
9	$W_P = W_N - W_V$	0,248	0,226	0,230	0,211	0,221	0,206	0,224	
10	$W_{V6} = W_{06} \dfrac{C_V}{C_{Fo}}$	0,106	0,107	0,108	0,109	0,109	0,110	0,111	
11	$W_{N6} = (9)+(10)$	0,354	0,333	0,338	0,320	0,330	0,316	0,335	
12	W_{N6} (exp)	0,317	0,317	0,317	0,317	0,317	0,317	0,317	
13	$W_{V\,mean}$	0,190	0,180	0,174	0,166	0,159	0,154	0,145	0,109
14	$W_N = W_{V\,mean} + W_{P\,mean}$	0,414	0,404	0,398	0,390	0,383	0,378	0,369	0,333
15	W_N (exp)	0,434	0,404	0,402	0,376	0,380	0,362	0,371	0,317

Note: (11) predicted nominal wake fraction for the model in the scale $\alpha = 6$,
(12) nominal wake fraction for the model in the scale $\alpha = 6$ from experiment,
(14) nominal wake fraction predicted for the mean value of k for the entire series.

Table 3

Comparison of W_V calculated and obtained from experiment for ,,Simon Bolivar'' model series

1	α	50	36	25	21	18	15
2	$\lg R_n$	6,34	6,55	6,794	6,899	7,004	7,106
3	$C_V \cdot 10^3$	4,36	4,015	3,67	3,53	3,42	
4	$C_{Fo} \cdot 10^3$	3,796	3,475	3,149	3,023	2,905	2,796
5	C_V/C_{Fo}	1,149	1,155	1,165	1,168	1,177	
6	W_0	0,150	0,137	0,123	0,118	0,113	0,108
7	$W_V = W_0 \dfrac{C_V}{C_{FO}}$	0,172	0,158	0,143	0,138	0,133	
8	W_N	0,275	0,264	0,256	0,255	0,244	
9	$W_P = W_N - W_V$	0,103	0,106	0,113	0,117	0,111	
10	$W_{V18} = W_{018} \dfrac{C_V}{C_{Fo}}$	0,130	0,131	0,132	0,132	0,133	
11	$W_{N18} = (9)+(10)$	0,233	0,237	0,245	0,249	0,244	
12	W_{N18} (exp)	0,244	0,244	0,244	0,244	0,244	
13	$W_{V\,mean}$	0,175	0,159	0,143	0,137	0,131	0,126
14	$W_N = W_{V\,mean} + W_{P\,mean}$	0,285	0,269	0,253	0,248	0,242	0,236
15	W_N (exp)	0,275	0,264	0,256	0,255	0,244	

of ,,Tanker'' form the results obtained are acceptable from the practical point of view (Tab. 5).

2. The potential wake component W_P found as a difference between the measured wake fraction V_N and the computed viscous wake W_V (line 9 of Tab. 2 to 5) varies within a

Table 4

Comparison of W_V calculated and obtained from experiment for „Meteor'' model series

1	α	25	19	13,75
2	$\lg R_n$	6,498	6,677	6,881
3	$C_V \cdot 10^3$	4,233	3,930	3,640
4	$C_{Fo} \cdot 10^3$	3,550	3,30	3,045
5	C_V / C_{Fo}	1,192	1,191	1,195
6	W_O	0,157	0,145	0,133
7	$W_V = W_O \dfrac{C_V}{C_{Fo}}$	0,187	0,173	0,159
8	W_N	0,192	0,171	0,153
9	$W_P = W_N - W_V$	0,005	−0,002	−0,006
10	$W_{V13,75} = W_{O13,75} \dfrac{C_V}{C_{Fo}}$	0,159	0,159	0,159
11	$W_{N13,75} = (9) + (10)$	0,159	0,159	0,159
12	$W_{N13,75}$ (exp)	0,153	0,153	0,153
13	$W_{V\,mean}$	0,187	0,173	0,159
14	$W_N = W_{V\,mean} + W_{P\,mean}$	0,187	0,173	0,159
15	W_N (exp)	0,192	0,171	0,153

Table 5

Comparison of W_V calculated and obtained from experiment for „Tanker'' model series

1	α	55	45	35	25	7,5
2	$\lg R_n$	6,474	6,603	6,768	6,987	7,77
3	$C_V \cdot 10^3$	4,135	3,915	3,665	3,385	
4	$C_{Fo} \cdot 10^3$	3,586	3,40	3,182	2,924	2,218
5	C_C / C_{Fo}	1,153	1,151	1,152	1,157	
6	W_O	0,1 1	0,171	0,160	0,146	0,109
7	$W_V = W_O \dfrac{C_V}{C_{Fo}}$	0,209	0,197	0,184	0,169	
8	W_N	0,410	0,403	0,397	0,381	0,317
9	$W_P = W_N - W_V$	0,210	0,206	0,213	0,212	
10	$W_{V7,5} = W_{O7,5} \dfrac{C_V}{C_{Fo}}$	0,126	0,126	0,126	0,126	
11	$W_{N7,5} = (9) + (10)$	0,327	0,332	0,339	0,338	
12	$W_{N7,5}$ (exp)	0,317	0,317	0,317	0,317	
13	$W_{V\,mean}$	0,209	0,197	0,185	0,169	0,126
14	$W_N = W_{V\,mean} + W_{P\,mean}$	0,417	0,405	0,393	0,377	0,334
15	W_N (exp)	0,410	0,403	0,397	0,381	0,317

very narrow range with the model scale and it can be assumed that W_P is constant over at least the model range of the Reynolds number. Thus the basic assumption connected with the adopted method of the ship-model wake correlation is satisfied with the proposed procedure for the viscous wake calculation.

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Metoda korelacji współczynnika nadążającego modelu i statku oparta na koncepcji ekwiwalentnej płaskiej płyty i współczynnika kształtu

Streszczenie

W artykule zaproponowano metodę obliczania składnika lepkościowego współczynnika strumienia nadążającego, opartą na znajomości tarciowego strumienia nadążającego ekwiwalentnej płaskiej płyty, który zależy od liczby Reynoldsa oraz od stosunku średnicy pędnika i długości statku. Tarciowy współczynnik strumienia nadążającego pomnożony przez współczynnik kształtu pozwala na wyznaczenie składnika lepkościowego strumienia nadążającego, który można wykorzystać do korelacji nominalnego strumienia nadążającego modelu i statku. Zaproponowana metoda została zweryfikowana za pomocą wnikliwych badań czterech serii geometrycznie podobnych modeli.

Метод корреляции попутного потока модели и судна

Резюме

В статье предложен метод расчета вязкостной составляющей коэффициента попутного потока, в котором коэффициент корреляции модель-судно определяется на основании результатов расчета попутного потока плоской плиты и коэффициента формы. В данном методе используются вязкостные составляющие попутного потока плоской плиты, зависящие от числа Рейнольдса и от отношения диаметра движителя к длине судна. Произведение этих составляющих на коэффициент формы позволяет определить вязкостные составляющие попутного потока судна, которые и используют для корреляции номинального попутного потока модели и судна.

Проверку предложенного метода выполнено на основе результатов исследований 4 серий геометрически подобных моделей.