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The reasons to introduce a new definition of the effective mean velocity in model propulsion tests

PART II *)

SUMMARY

The essence of the effective mean velocity definition is analysed by the author. This definition is indivisibly connected with the effective velocity field being in interaction with the ship screw propeller.

The effective mean velocity is set against the mean value of the isolated effective velocity field. The differences in the relations between criterional quantities in the averaging process in both cases are specified.

These differences make the necessity of introducing a new effective mean velocity definition to the model propulsion tests and to the numerical simulation procedures well justified.

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THE COMPARISON BETWEEN THE EFFECTIVE MEAN VELOCITIES FROM THE OLD DEFINITION AND THE PROPOSED ONE

Twelve ship model propulsion tests were selected to be analysed from the effective mean velocity point of view. The specification of these tests can be found in [1].

The effective mean velocities $(v_T)_l$ and $(v_Q)_l$ were determined. The numerical simulation method worked out by the author was used.

The experimental values of the effective mean velocities were only incompletely helpful in the comparison procedures because only the definition 1 is in common use in experimental practice.

The calculated effective mean velocities v_{Tl}, v_{Ql} and v_{TQ} are presented in Tab. 1 and the relations between them are shown in Fig. 3.

Tab. 1 The results of effective mean velocity determination from numerical simulation of 12 selected model propulsion tests

$\left(\frac{v_T}{v_S}\right)_l$	$\left(\frac{v_Q}{v_S}\right)_l$	$\frac{v_{TQ}}{v_S}$	$\frac{1}{2}\left[\left(\frac{v_T}{v_S}\right)_l+\left(\frac{v_Q}{v_S}\right)_l\right]$	BN
0,6266	0,6700	0,6076	0,6483	1
0,6538	0,6241	0,6408	0,6390	2
0,6430	0,6732	0,6287	0,6581	3
0,7030	0,7160	0,6866	0,7095	4
0,6960	0,7097	0,6867	0,7029	5
0,4585	0,4638	0,4419	0,46115	7M
0,4828	0,4884	0,4640	0,4856	7F
0,5922	0,6110	0,5662	0,6016	8M
0,6001	0,6202	0,5685	0,6102	8F
0,5368	0,5663	0,4844	0,5516	9
0,6029	0,6389	0,5561	0,6209	10
0,5828	0,6227	0,5388	0,6028	11

Note: BN 1, 2, 3 etc. in the last colum n stand for the symbols of the reports referred to in [1] (see Bibliography).

The arithmetic mean of v_{Tl} and v_{Ql} is given in Tab. 1 and in Fig. 3 for comparison purposes. This quantity is sometimes accepted in ship hydrodynamics parallel to v_{Tl}.

In the Fig. 3 one line is distinguished by the number "0":

$$y=\left(\frac{v_T}{v_S}\right)_l \qquad (39)$$

where $(v_T/v_S)_l$ is the abcissa. All points corresponding to the effective mean velocities, being presented in Fig. 3 as functions of $(v_T/v_S)_l$ which comply with the 0-line, are equal to $(v_T/v_S)_l$. In this sense the 0-line is a reference line. The deviations of $(v_Q/v_S)_l$ and (v_{TQ}/v_S) from $(v_T/v_S)_l$ can be fixed without difficulty and are directly illustrated in Fig. 3.

The points in Fig. 3 corresponding to v_{TQ}/v_S were interpolated with the 1-line which is parallel to the 0-line. It is only the first approximative step taking into account only a twelve data set:

$$\frac{v_{TQ}}{v_S}=\left(\frac{v_T}{v_S}\right)_l-0{,}015 \qquad (40)$$

The points $(v_Q/v_S)_1$ were interpolated similarly to the 3-line:

$$\left(\frac{v_Q}{v_S}\right)_1 = \left(\frac{v_T}{v_S}\right)_1 + 0,024 \qquad (41)$$

The arithmetic mean value of the values $(v_T/v_S)_1$ and $(v_Q/v_S)_1$ is represented in Fig. 3 in the form of the 2-line interpolation:

$$\frac{1}{2}\left[\left(\frac{v_T}{v_S}\right)_1 + \left(\frac{v_Q}{v_S}\right)_2\right] = \left(\frac{v_T}{v_S}\right)_1 + 0,012 \qquad (42)$$

When the definition 1 is used in $(v_T/v_S)_1$ and $(v_Q/v_S)_1$ determination different mean values are obtained. One can observe a real dispersion between

$$(v_Q/v_S)_1, \quad \frac{1}{2}\left[\left(\frac{v_T}{v_S}\right)_1 + \left(\frac{v_Q}{v_S}\right)_1\right] \text{ and } (v_T/v_S)_1. \qquad (43)$$

The question arises what could be the reasons that only the $(v_T/v_S)_1$ value from definition 2, v_{TQ}/v_S, should be excluded apriori. It seems that other factors must be taken into account in justifying which of these values is the right one. The argument of univocal nature of the effective mean velocity according to the definition 2 and of univocal nature of all quantities derived seems to be decisive.

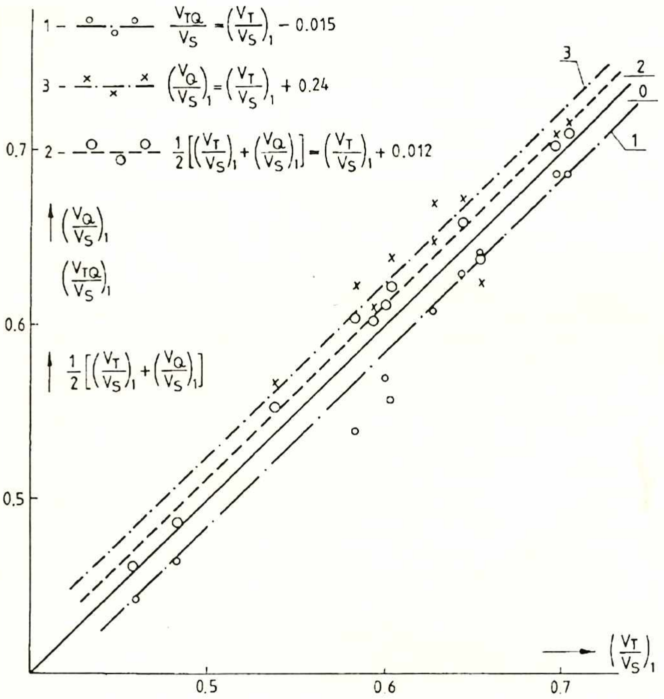

Fig. 3. Comparison between the different effective mean velocities

CONCLUSIONS

● In the case of an isolated velocity field the mean velocity is determined according to one of the possible criteria. The averaging criterion is built upon the identity of the criterional quantity in nonuniform *FB* and uniform *FO* velocity field.

- Different critieria give different velocity mean values, being in the relation:

$$v_V < v_M < v_E$$

- It is not possible to receive the equality:

$$v_V = v_M = v_E$$

when the velocity field is nonuniform.

● In the case of an effective velocity field being in interaction with screw propeller the effective mean velocity can be determined. The criterional quantities in the averaging process are thrust, torque or power.

- The criterional quantity of the same *SB* screw propeller in both velocity fields *FB* and *FO* can be equalized.

The averaging procedure can be written as:

$$SB \times FB \rightarrow SB \times FO.$$

The effective mean velocity is obtained being dependent on the uniformity factor, on the criterion used and on the geometry of the screw. The relations:

$$v_T < v_Q \text{ or } v_T > v_Q$$

can occur. The first relation will take place in the case when the screw *SB* is better adjusted to the field *FB* than to *FO*.

- When the screw *SB* is the optimum one in the field *FB* the averaging procedure can be noted:

$$SB_{opt} \times FB \rightarrow SB_{opt} \times FO$$

and the mean values according to thrust and torque equality are in the relation: $v_T < v_Q$

- One can introduce two different screw propellers: one being optimum in the *FB* field, the other one in the *FO* field:

$$SB_{opt} \times FB \rightarrow SO_{opt} \times FO$$

In such a case one has always: $v_T = v_Q$

This case is supposed to be the basis of the new proposed definition of the effective mean velocity.

● New procedures of the model propulsion test should be elaborated to realize the new definition of the effective mean velocity.

● The new definition can be realized numerically with the help of the simulation method.

● A comparison process should be realized to compare the results of effective mean velocity determination according to both definitions.

NOMENCLATURE

v - velocity

v_V, v_M, v_E - mean velocities of an isolated velocity field, respectively: from output, momentum and energy identity

v_T, v_Q, v_P - effective mean velocities, respectively: from thrust, torque and power identity,

K_{TB}, K_{TO} - thrust coefficients of the behind screw and the open one, respectively

K_{QB}, K_{QO} - torque coefficients of the behind screw and the open one, respectively

η_D - propulsion efficiency

η_B, η_O - efficiency of the behind and the open screw respectively

η_H - hull "efficiency"

η_R - relative rotating "efficiency"

t - thrust deduction factor

SB - the behind screw propeller

SO - the open screw propeller

FB - the behind velocity field

FO - the uniform velocity field

T, Q as lower indices - reference to thrust and torque, respectively.

BIBLIOGRAPHY - see page 22