SESSION ON HIGH–SPEED MARINE VEHICLE

Chairman: Prof. J. Aláez

High–Speed Marine Vehicle Committee Memberships: D. Savitsky (Chairman) – P. Knowles (Secretary) – J. A. Aláez (for two years) – A. Koops – B. Müller-Graf – O. Rutgersson – K. Rozhdestvensky – H. Tanaka – R. A. Wilson

Discussion of the Report and the Draft Recommendations of the High–Speed Marine Vehicle Committee. (Cf. Proceedings, Volume 1, p. 275–344.)

I . DISCUSSIONS

HS–1

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ON THE PERFORMANCE PREDICTION FOR SHIPS WITH WATERJETS

Section 5 of the Report of the High–Speed Marine Vehicle Committee can be supplemented with the problems related to ship performance prediction and analysis of full scale trial results of ships with waterjets. It is suggested that the approach of the Powering Performance Committee be used, which is expressed in development of a method, analogous to the 1978 ITTC Performance Prediction Method.

The prediction of the performance characteristics of ships with waterjets is realized on the basis of the results from towing and self–propulsion tests and pump performance tests. In the theoretical model the following parameters are determined:

– the wake fraction

$$Q=\rho v(1-w)F_I \qquad (1)$$

– the thrust of the waterjet

$$T=\rho Q[v_J-v(1-w)] \qquad (2)$$

– the pump head

$$H=\frac{v^2}{2g}[(\frac{v_J}{v})^2(1+k_O)-(1-w)^2(1-k_I-k_J)] \qquad (3)$$

where, F_I – inlet area
k_O, k_I, k_J – nozzle, inlet and jet loss coefficients.

The procedure of ship performance prediction, described in [1], is presented schematically in Tables 1, 2 and 3. Table 1 gives the analysis of the model test results, Table 2 – the performance prediction and Table 3 – the analysis of the full scale trial results.

Table 1*

(1)	v_S	ship speed, given
(2)	F_D	$F_D = \frac{1}{2}\rho_M v^2_M (C_{TM} - C_{TS})$
(3)	M_{MB}, n_{MB}	from self-propulsion tests at ship self-propulsion point
(4)	K_{MMB}	impeller torque coefficient
(5)	K_{QM}, K_{HM}, η_{PM}	from pump characteristics using torque identity
(6)	$K_{HMB} = K_{HM}$ $K_{QMB} = K_{QM}$ $\eta_{PMB} = \eta_{PM}$	assumed
(7)	Q_{MB}	$Q_{MB} = K_{QMB} \cdot n_{MB} \cdot D_M^3$
(8)	H_{MB}	$H_{MB} = K_{HMB} \cdot n_{MB}^2 \cdot D_M^2$
(9)	w_M	eq(1)
(10)	v_{JM}	$v_{JM} = \frac{Q_{MB}}{A_J}$
(11)	T_M	eq(2)
(12)	$t_M = 1 - \frac{R_{TM}}{T_M}$	R_{TM} from towing tests
(13)	$\eta_{JM} = \frac{\eta_{DM}}{\eta_{PMM}}$	$_{DM}$ from self-propulsion tests at ship self-propulsion point
(14)	K_{IM}	eq(3), assuming $K_{OM} = 0.02$

Table 2*

(1)	η_{PS}	scale effect correction using Stephenson's formula
(2)	$K_{MS}(K_{QS},\sigma)$	$K_{MS}(K_{QS},\sigma) = K_{MM}(K_{QM},\sigma) \cdot \frac{PM}{PS}$
(3)	$w_S = 1 - (1 - w_M) e_W$	e_W from model-ship correlation data
(4)	$K_{IS} = K_{IM} \cdot e_K$	e_K from model-ship correlation data
(5)	t_S, K_{OS}	$t_M = t_S$, $K_{OS} = K_{OM} = 0.02$, assumed
(6)	Q_{SB}	eq(1)
(7)	$v_{JS} = v_S(1 - w_S) + \frac{R_{TS}}{\rho_S Q_S (1 - t_S)}$,	R_{TS} - predicted from towing tests results
(8)	H_{SB}	eq.(3)
(9)	$\left(\frac{K_H}{K_Q^2}\right)_{SB}$	
(10)	K_{QS}, K_{MS}, K_{HS}	from full scale pump characteristics, assuming $\left(\frac{K_H}{K_Q^2}\right)_{SB} = \left(\frac{K_H}{K_Q^2}\right)_S$
(11)	n_{SB}	$n_{SB} = \frac{Q_{SB}}{K_{QS} \cdot D_S^3}$
(12)	P_D	

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* The indices M,S,B and TR refer to model, ship, behind condition and full scale trials respectively.

Table 3**

(1)	V_S	ship speed given
(2)	M_{SB}^{TR}, K_{MSB}^{TR}	from full scale trial results
(3)	K_{QS}, K_{HS}, η_{PS}	from full scale pump characteristics using torque identity
(4)	$K_{QSB}^{TR} = K_{QS}$ $K_{HSB}^{TR} = K_{HS}$ $\eta_{PSS}^{TR} = \eta_{PS}$	assumed
(5)	Q_{SB}^{TR}, V_{JS}^{TR}, H_{SB}^{TR} w_S^{TR}, T_S^{TR}	
(6)	R_{TS}^{TR}	$R_{TS}^{TR} = T_S^{TR}(1-t_S)$
(7)	η_{DS}^{TR}, η_{JS}^{TR}	
(8)	K_{IS}^{TR}	eq.(3), assuming $K_{OS} = 0.02$
(9)	e_W, Δw	$e_W = \frac{1-w_S^{TR}}{1-w_M}$, $\Delta w = w_S^{TR} - w_S$
(10)	e_R, ΔC_{FC}	$e_R = \frac{R_{TS}^{TR}}{R_{TS}}$, $\Delta C_{FC} = \Delta C_P^{TR} - \Delta C_F$
(11)	e_K	$e_K = \frac{K_{IS}^{TR}}{K_{IM}}$

The method proposed is directed to the cases where determination and differentiated investigation is needed, of the parameters forming the performance characteristics of ships with waterjets aiming design of optimum propellers. In cases of final waterjets, the prediction of the ship performance characteristics and the analysis of the full scale trials can be effected only by results from self–propulsion tests. For this purpose, in [1] an approach is proposed, basd on the Holtrop's ideas, laid down in the New NSMB Method.

Reference

[1] Lazarov S., "Performance Prediction of Ships with Waterjets", BSHC Report No. SP–87–205, July 1987.

HS−2

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PROPELLER CHARACTERISTICS IN OBLIQUE FLOW : THE EFFECT OF CAVITATION

The HSMVC report gives an excellent summary of some major features and approaches for solving of variety of specific tasks inherent to high speed marine craft investigations. Among these problems the propeller operation in oblique flow which is rather important for high speed vessels is discussed (see items 3.2 and 3.4 of Committee report) One of most significant effects is caused by the normal force, affecting both running trim and available horizontal thrust. Obviously, the magnitude of the normal force should be taken properly into account in all propulsive and performance calculations as well as in model testing. Regarding the calculation of normal force the Committee report (page 295) gives reference to Gutsche's paper [1], presenting a quasi−steady approach for calculation of oblique flow propeller characterstics (thrust, torque, normal force), introduced earlier by Miniovich [2]. However, references cited above are dealing with non − cavitating propellers; at the same time high − speed craft, operating regularly above 33 − 35 knots are equipped with cavitating propellers, and the influence of cavitation on propeller forces in oblique flow deserves special attention. An extensive research programme on cavitating propeller operation in oblique flow was completed several years ago in the BSHC. Large amount of experimental work has been carried out, including tests with new systematic propeller series [3], [4]. Special emphasis was given to normal force measuremens. All experimental results were compared with calculations, based on quasi − steady approach accounting for cavitation pattern changes in oblique flow [5]; the main assumptions of this approach are validated experimentally [6].

In this way, the main propeller characteristics in oblique flow are presented using respective quantities for uniform axial flow, which are available from series cavitating propellers systematic tests.

The general conclusions from these investigations are :

(a) Experiments show rather different tendencies in propeller thrust and torque change (with respect to axial flow parameters) during oblique flow operation : higher values in non − cavitating conditions and lower values in developed cavitating conditions (the latter is pronounced at design advance coefficient range) ;

(b) The normal force is reduced significantly with development of cavitation as shwn on Fig. 1, representing experimental data for different cavitation numbers σ ;

(c) The proposed quasi − steady approach predicts pretty well propeller thrust and torque in oblique flow ;

(d) The discrepancies between calculated and measured normal force might be in some cases significant due to assumption for equivalent blade section ; a general tendency was observed (as illustrated in [6] and [7] for normal force overpredicting at non−cavitating conditions and underpredicting at developed cavitation.

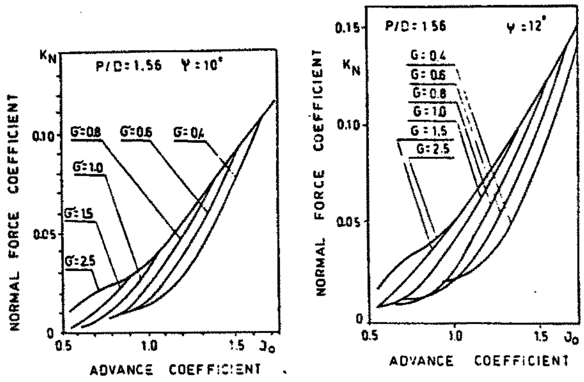

Fig. 1

The comments above support the Committee's view regarding the importance of accounting all features of oblique flow propeller operation. It is felt, however, that even at initial stages the effect of cavitation on main propeller characterstics should be taken into account. On the basis of extensive model tests and summarizing other available information a data base is created in BSHC [8], providing for computer – aided design and analysis of cavitating propellers for high – speed craft.

References

[1] Gutsche, F.: "Untersuchungen von Schiffsschrauben in Schräger Antrömung," Schiffbauforschung, 1964, No. 3/4.

[2] Miniovich, I.Y.: "Operation of a Ship Propeller in Oblique Flow.," Trans. Krylov Shipbuilding Research Inst., No. 14, 1946.

[3] Sadovnikov, Y., Frolo, V. Kalchev, R., Kozhukharov P.: "Tests of Series of Cavitating Screw Propellers in Oblique FLow," Proc. BSHC Jubilee Sci. Session, vol. 1, Varna, 1981.

[4] Kozhukharov, P.: "Experimental Investigations of Cavitating and Supercavitating Screw Propellers," EUROMECH Colloquium 146, Villard de Lans, 1981.

[5] Sadovnikov, Y., Kozhukharov, P.: "On the Evaluation of Hydrodynamic Characteristics of Cavitating Screw Propellers in Oblique FLow, Proc. BSHC Jubilee Sci. Session, vol. 1. Varna, 1981.

[6] Kozhukharov, P., Sadovnikov, Y., Frolov V.: "Investigation on Cavitating Screw Propellers Operating in Oblique FLow," Second IME Conference on Cavitation, Ednburgh, 1983.

[7] Kozhukharov, P., Hadjimikhalev,V.: "An Approach to Computer – Aided High – Speed propeller Design," Int. Symp. on Propellers and Cavitation, Wuxi, 1986.

[8] Kozhukharov, P.: "Creation and Utilization of Date Base for Design and Analysis of Cavitating Screw Propellers," EUROMECH Colloquium 222, Wageningen, 1987.

HS–3

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INVESTIGATIONS OF SPORTS SKIMMER WITH CATAMARAN TYPE HULL

A number of tests with full–scale sports skimmer were carried out at BSHC. The scope of the investigation comprises laboratory tests in tank conditions, design and manufacturing of a propeller and trial tests at real operational conditions.

The full–scale sports skimming boat has main dimensions as follows :

– length overall L = 3.77 m ;
– breadth overall B = 1.72 m ;
– weight displacement (design) 1700 N

The skimmer is a catamaran type (Fig. 1) and according to the subsequent requirement it belongs to the SB and SC international sports classes. It is considered that the skimmer is equipped with standard series outboard motor "Neptun – 23", providing 23 h.p. at 2880 r.p.m. of the propeller shaft [1].

The laboratory tests were carried out with the high speed towing carriage, mounted in the BSHC deep water towing tank. The main features of this carriage are described in details in [2]. It is console type carriage, driven with a special rope system and the maximum speed is about 20 m/sec.

Different towing tests are considered to be held, including separate tests with the naked hull (without motor) and tests with the motor itself, as well as experiments with the skimmer equipped with the motor. All tests are performed in the speed range typical for the normal boat operation (maximum speed about 16 m/sec) when equipped with the motor under consideration.

When testing the hull a certain amount of ballast is provided, considering for the weight of the pilot, weight of the fuel and motor weight (at naked hull conditions). The longitudinal position (X_g) of the center of gravity is varied in the possible limits. The main purpose of these tests is to perform comparative resistance investigations at different arrangements.

The main laboratory experiments together with details of measurements are described in [3]. Here some results are presented, illustrating measured total resistance and running trim angle for four experimental modes as described in Table 1.

Table 1 Main Characteristics of the Experiments with the Skimmer

Mode No.	Arrangement	Total Weight N	x_g/L
1	" Naked	1770	0.31
2	Hull "	1850	0.28
3	Hull and outboard	1890	0.25
4	motor	1890	0.23

Also towing tests with the isolated outboard motor were carried out and the main parameter here is depth of shaft centreline immersion, which is varied during the tests as it is shown in Table 2.

Table 2 Main Characterstics of the Tests with Isolated Motor

Mode No.	Depth of Shaft Immersion mm
5	28
6	58
7	118
8	168

Some main results from the towing tests performed are presented in graphical form in Figs. 2, 3 and 4. Here the measured towing resistance R and the running trim angle θ_0 (with respect to the theoretical hull base line) are plotted versus carriage speed V. There is only a slight difference between the test coditions at modes No. 1 and No. 2, which is the reason for obtaining of results very close to each other (Figs. 2 and 3). When the equipped hull is tested (modes 3 and 4) the towing resistance is markly increased because of the adding of the motor resistance. At the same time the centre of gravity is nearer to the transom, which explains the increase of the running trim angle especially at higher speeds where the aerodynamic lifting force has an additional influence. There is general tendency to obtain a "hump" in the towing resistance curve which occurs at speeds about 11 — 12 m/sec. The further increase of speed remarkably increases the motor resistance (Fig. 4) and therefore the total skimmer resistance (modes 3 nd 4) increases rapidly after the "hump". The

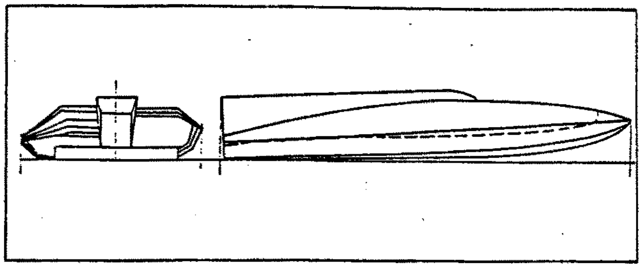

Fig. 1

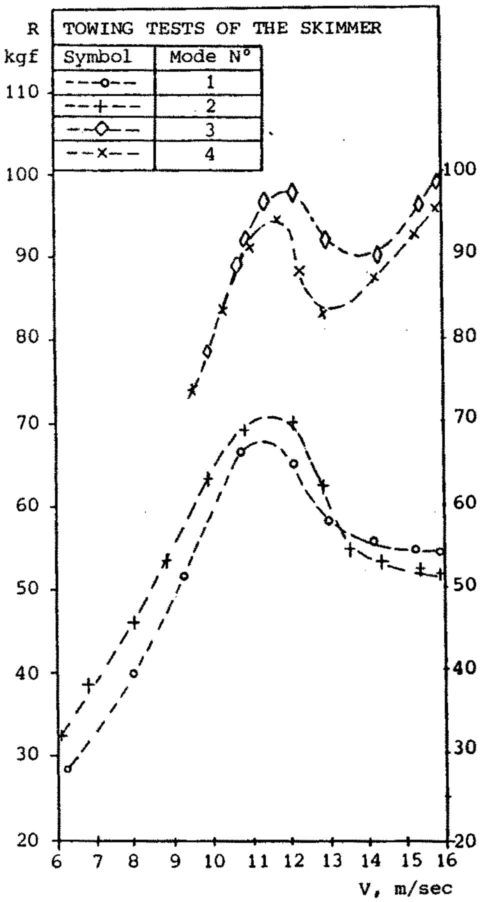

Fig. 2

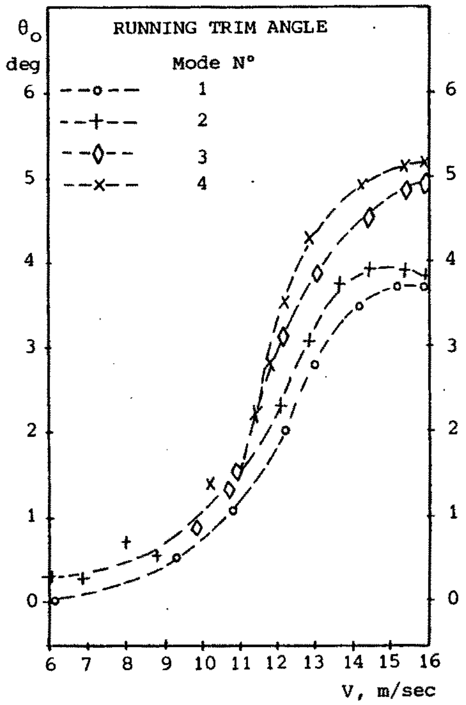

Fig. 3

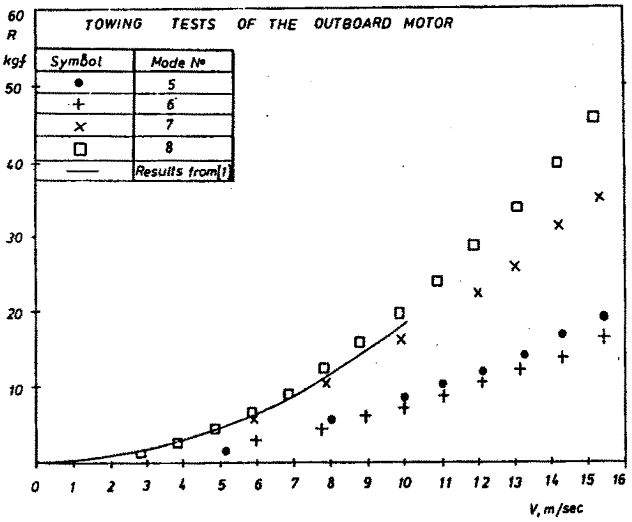

Fig. 4

latter is mainly due to the increased part of the motor spray resistance. It has to be mentioned that the deeper submersion of the motor doesn't lead obligatory to an increase of motor resistance (see for instance modes 5 and 6, Fig. 4). The underwater part of the motor has a complicated form and the waterplane area varies in some cases significantly, following a rather complicated relation with the shaft immersion.

All latoratory test data were carefully analyzed and on this basis subsequent propeller design calculations were performed, using data for systematic model series and computer code, described in [4]. Only fully submerged propellers are treated and some comparative designs are presented in Table 3. Performance calculations showed that propeller design No. 7 with highest efficiency can not overcome the "hump" resistance, therefore propeller design No. 4 was selected for the further investigations. An alluminium propeller was manufactured and the skimmer was tested in real operational conditions in a lake, providing for measurements of speed, r.p.m. and propeller effective thrust. These trials confirm almost exactly the predicted attainable speed. It should be notd that when operating in windy weather the aerodynamic lifting force "unloads" the hull and changes the speed of the

Table 3. Main Data for Comparative Propeller Designs

Design No.	Symetric Series	A_E/A_0	P/D	D	η_o
1	SK	0.65	1.556	0.2145	0.719
2	SK	0.70	1.544	0.2156	0.722
3	SK	0.75	1.526	0.2171	0.724
4	SK	0.80	1.539	0.2161	0.725
5	SK	0.85	1.561	0.2145	0.724
6	SK	0.90	1.579	0.2130	0.721
7	BSHC	0.95	1.727	0.2044	0.758

"hump" resistance. Obviously this effect should be considered when analyzing laboratory tests of catamaran type hulls.

In authors opinion the HSMVC Report recommendations for considering catamaran technology should be strongly supported. Besides the fast ferries, the designers of high speed racing boats and pleasure craft are introducing more widely catamaran hulls and the demand for hydrodynamic investigations rapidly grows.

References

[1] Messrs M.B., Chumakov E.L., Hydrodynamics of the Outboard Motor "Neptun — 23", Boats and Yachts, 53, No. 1, 1975, 64—66 (in Russian)

[2] Tzvetanov, Tz., Chepishev, G., Georgiev St., Facilities and Capabilities for Carrying out Speed Tests at BSHC, Proc. 13 SMSSH, BSHC, Varna, 1984.

[3] Kozhukharov P., Draganov N., Tzvetanov Tz., Bekyarov L., Investigations of a Skimmer with the BSHC Towing Carriage, Proc. 14 SMSSH, vol. 3, BSHC, Varna, 1985.

[4] Kozhukharov P., Hadjimikhalev V., An Approach to Computer — Aided High Speed Propeller Design, Int. Symp. on Propellers and Cavitation, Wuxi, China, 1986.

HS—4

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1. Survey of worldwide utilization of HSMVs

In addition to the developments in SES design and construction, mentioned in section 1.4, it is probably worthwhile to mention the individual development of two distinct SESs in The Netherlands.

The committee shows further a remarkable increase of high—speed catamarans in service as ferries. It is interesting to raise the question why this type of HSMV has become so popular with shipowners in the last 6 years. Of course, many considerations are of importance when deciding which HSMV is to be chosen for a certain purpose, many of them being outside the scope of the ITTC. When considering the most important hydrodynamic aspects related to vehicle type (powering and seakeeping aspects), however, it is not directly clear why the high—speed catamaran has become so popular, see e.g. [1], [2], and [3].

It is difficult to draw unambiguous conclusions from a comparison of all relevant hydromechanic properties. The relation between these properties and the operational requirements, set by the operator, is usually complex. Nevertheless, the hydromechanic properties exert an important influence on the choice of vehicle type. Does the committee see it as its task to advise relations between important hydromechanic properties and operational requirements for specific roles?

3. Induced effect of appendages

P 296, see 3.2.2.1

It is not clear how the induced appendage effect can be separated from the total appendage contribution to the running trim. The three types of model tests given, only give some data on the induced rudder effects. However, this induced effect may be for instance affected by the propeller shafts placed in front of the rudder.

Furthermore, the statement "The induced effect of the appendages is determined by the difference in trim angle between the bare and the appended hull under the same test conditions", is questionable because this trim difference will be predominantly determined by the appendage drag and only for a small amount by the induced effects.

"The variation of trim with speed is due to laminar separation (Fig. 33)".

This is not necessarily so. The complex interaction between a constant appendage trimming moment and an irregular hull trimming moment as a function of speed can lead to the irregular equilibrium trim difference as shown in Fig. 33.

9. Numerical methods

In addition to the given numerical methods for HSMVs some recently developed computer programs are given:

9.3 Propulsors
Waterjet propulsion characteristics for all types of HSMVs.

9.4 Hydrofoils
Smooth water resistance and powering prediction.

9.8 Catamarans
Smooth water resistance prediction.

References

[1] Lang, T.G. and Slogget, J.E.: "SWATH developments and performance comparison with other craft", International conference on SWATH ships and advanced multi-hulled vessels, RINA, London, April 1985.

[2] Rutgersson, O.: "Catamaran versus single hull concepts. A study of stability, powering and seakeeping qualities for small workships".

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HS-5

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BSHC SIX-COMPONENT DYNAMOMETER FOR CAPTIVE TESTS

As pointed out in item 8.2.1.1 of the Report of the High-Speed Marine Vehicle Committee, the model is rigidly fastened to the towing carriage by means of measuring frame, allowing measurements to be taken of all forces acting on the model.

A six-component dynamometer is elaboratd at BSHC for the purpose and is in use at the Centre.

As seen from Fig. 1, the dynamometer consists of an arbitrarily immobile frame 1, six one-component pick-ups F1...F6, an arbitrarily mobille plate 2 and kinematic levers 3. The body to be tested is positioned on to the plate 2 by means of the strut 4.

The pick-ups F1 ÷ F6 have a double elastic parallelogram configuration (Fig. 2a) and the levers 3 have special cross-sections (Fig. 2b). This allows the obtaining of the best reception and decomposition of measured foil loads.

The usage of the six-component dynamometer for hydrofoil tests is made by means of including it into an automated measuring system for data acquisition and processing by computer.

The Wheatstone bridge circuits of the force measuring pick-ups are connected to a specialized multichannel amplifier. Via the amplifier the signals from the bridges are amplified to the necessary level, the voltage obtained at the amplifier output being proportional to the forces acting on the foil being tested.

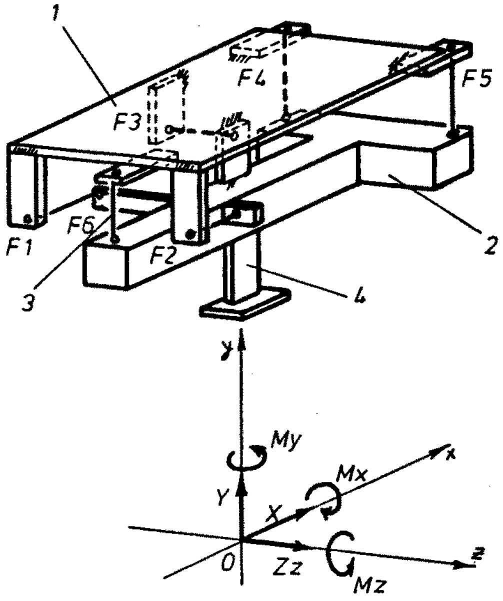
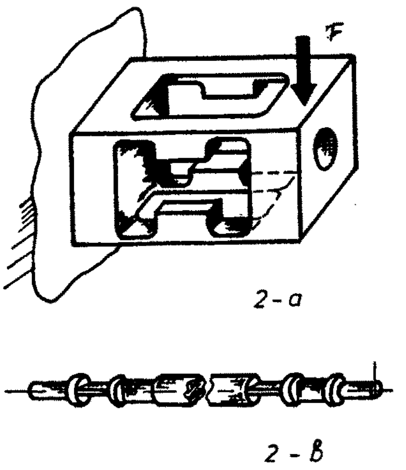


Fig. 1 Principle Scheme of the Dynamometer


2-a

2-б

Fig. 2 Principle Scheme of the Pick-up and the Kinematic Lever

The voltages obtained are fed to the computer. Signals for the rest of the model experiment parameters are also fed to the computer. This allows processing of the information in the course of the experiment.

The dynamometer's major technical data are:
- measured forces and moments:

X = 400, 1000 N; M_x = 175, 300 Nm;
Y = 500, 2000 N; M_y = 125, 300 Nm;
Z = 1000, 2000 N; M_z = 250, 300 Nm;

- measurement accuracy up to 1%;
- sensitivity of the pick-ups ~ 2 mV/V;
- angle of incidence ± 20° (relative to Z axis);
- angle of incidence ± 40° (relative to Y axis).

Reference

[1] Tz. Tzvetanov, "Six-Component Dynamometer for Hydrofoil Towing Tank Tests", BSHC Internal Report, 1985.

HS-6

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I have a comment concerning Recommendation 4 on page 339. I do not see how a catamaran can be considered as a high-speed marine vehicle. Therefore, Recommendation 4 should not be a recommendation for future work of this Committee. If the Conference considers this to be an important topic, then the other appropriate Committees (Powering Performance, Manoeuvrability and Seakeeping) should be instructed to consider this hull form. The same statement can be made for SWATH hull forms.

HS-7

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I would like refer to the method of testing of hydrodynamic characteristics of HSMV at the Ship Research Institute. Models of HSMV are tested in open water and for this purpose open−water facility has been developed on shore of Ilawa lake. Mostly large manned models are being utilized, scale of which varies between 7 and 3, the total length of the models being between 5 and 11 metres and with total mass of 0.5 to 1.5 ton. Propeller thrust, torque, trim angle, rolling and pitching amplitudes, vertical accelerations, loads and bottom pressures, manoeuvring characteristics and other quantities as required being measured.

This method was succesfully employed over the years for testing hydrofoil craft, hovercraft, high speed catamarans and planning boats. Models usually are tested in clam as well as in rough water. Smaller models are often used for preliminary tests as well for resistance tests where they are towed by the high−speed catamaran designed for this purpose.
We consider this method as being particularly effective giving wide range of possibilities of testing HSMV in varying external conditions (e.g. wind and waves from different directions) and allowing to gain an overall information on the behaviour of craft including stability and manoeuvrability.

HS−8

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CATAMARAN HULLS

The catamaran hulls seem to have broad possibility when it is combined with hydrofoil systems. Calkins first showed the concept of a hydrofoil catamaran [1]. The improved design at the Towing Tank Laboratory of the Univbersity of Tokyo has proved that this system (called HC) is superior to other systems in many aspects [2]. The resistance is very low at the Froude number of a 200−ton boat operating at 40 knots (see Fig. 1), and the seakeeping properties are remarkably improved.

The optimization of hybrid systems of this kind seems to be useful.

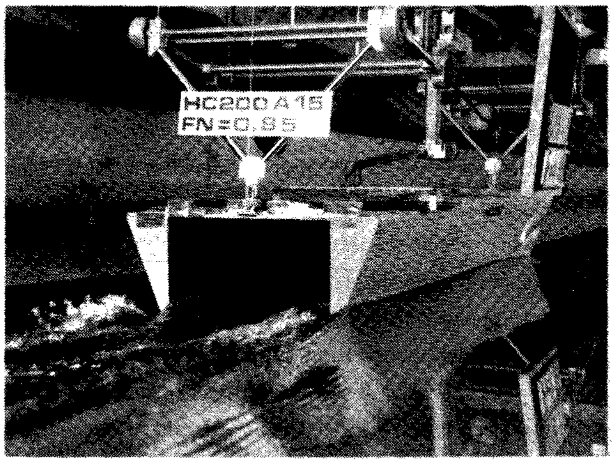

Fig. 1 HC200

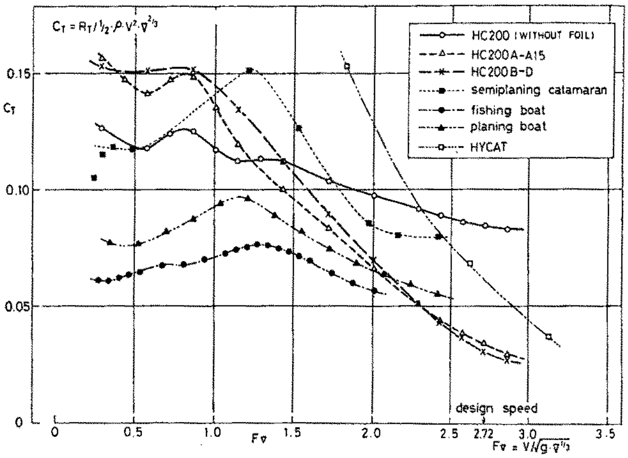

Fig. 2 Comparison of Total Resistance Coefficient

[1] Calkins, D. E.: HYCAT; Hybrid hydrofoil catamaran concept, AIAA paper 81−2079, 6th Advanced Marine Systems Conference, Seattle, (1981).

[2] Miyata, H. et al: Development of a New−Type Hydrofoil Catamaran, J. Soc. Naval Arch. Jpn. 162(to appear in 1987).

HS−9

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I would like to compliment the Committee on a most interesting report. My comments are related to Section II.2 and II.7.

Regarding the correlation factor η_n for high−speed propeller characterstics, given in Figs. 14 and 15, I would suggest that it is more practical to introduce the concept of an 'effective' cavitation number and derive cavitation number correlation (or reduction) factors. Such an engineering approach allows (mainly) for cavitation scale effects, but of couse also for changes of the (model) axial flow characteristics to those for the (full scale) 'behind' or inclined shaft conditions. The latter influence is often relatvely small for extensively cavitating propellers.

The actual correlation factors, as applicable to many test results (such as the Newton−Rader series data [15]) are usually between 0.75 and 0.85 [D1]. The results given in Fig. 15 would, if converted, be very close to these numbers. Such information can easily be used for many design purposes; the propeller characterstics are not too sensitive to some variations or scatter. This approach also allows a straightforward evaluation of η_P $(=\eta_H\eta_R\eta_S)$.

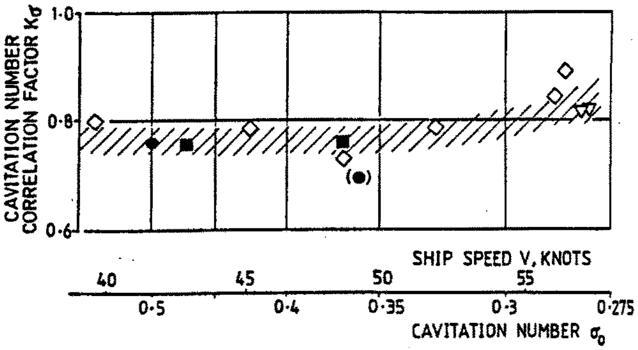

Fig. D.1 − Cavitation Number Correlation Factors for Newton−Radler Type Propellers

I read with interest the comments on dynamic instability at high speeds and agree entirely with the statement made about possible roll−yaw stability problems if models run at low trim and that stability checks should be made in such cases.

Finally, I would just like to add that the evidence for sudden instability (violent roll and severe broaching), referred to in 7.1.1, is perhaps not quite so 'recent' and has been mentioned and commented on, on several occasions, some time ago.

Reference

[D.1] Suhrbier, K.R. and Lecoffre, Y.: "Investigation of the Influence of Test Techniques, Water Speed and Nuclei Seeding on the Characterstics of a High−Speed Model Propeller and Correlation with Full Scale Measurements," Int. Shipb. Progress, Vol. 34, 1987.

HS−10

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On behalf of Powering Performance Committee, I should apologize High Speed Marine Vehicle Committee for having not offered extensive assistance to the wide range tasks the Committee tackled.

Frankly all that PP Committee did in this term was to investigate the problems relating to powering performamce prediction of high speed craft, to identify them and to send the draft report to HSMV Committee. This was due to the lack of expert and materials available to PP Committee.

However, now that the ITTC 1978 method for power and rpm prediction has been extended for twin screw vessels, the next PP Committee will be able to do more for HSMV Committee, including performamce of SWATH just mentioned by Dr. Morgan.

II. REPLY BY THE HIGH-SPEED MARINE VEHICLE COMMITTEE

Reply to the discussion by Dr. Varsamov (HS-1)

Dr. Varsamov proposes a different approach for the procedure of testing and analysis of waterjets than that presented in the committee report.
In Dr. Varsamov's method the principles used for conventional propellers is transformed to the testing of waterjets.

This means that by measuring the torque and number of revs on the pump it is proposed to derive flow rate, wake fraction and pump head from torque identity via pump performance tests in open water.

For the scaling it is then proposed to derive correlation factors for the wake fraction, hull resistance and inlet losses from full scale trial tests analysed in the same way as the model tests and to use these correlation factors for future predictions for similar arrangements.

The committee like to thank Dr. Varsamov for proposing this interesting idea. Our comments to the method deal most with the practicality of this approach.

First of all when running self propulsion tests with high speed crafts we usually have models smaller than 4-5 meters. Using Dr. Varsamov's aproach we then would need exact models of the waterjets in this small scale-implying possible difficulties with scale effects, not having available pump characteristics and with the costs involved in manufacturing exact models of the pumps.
Secondly we believe it is a drawback to rely so heavily on full scale correlation factors as proposed by Dr. Varsamov because this means we would have some difficulties for the first 2-3 predictions for new waterjet arrangements where the correlation factors are not known.

Using the method proposed in the committee report only the inlet and duct systems have to be modelled exactly for the self-propulsion tests. Any pump could be used as long as the necessary flow rate is maintained. With this method it is also possible to scale the flow rate and thrust without relying too much on correlation facotrs as the scaling of the wake fraction is based on calculations of the boundary before the inlet.
Anyway we think Dr. Varsamov's suggestion is interesting and we also very much welcome the more detailed description of the method referred to in the discussion.

Reply of the discussion by Dr. K. Yossifov (HS-2)

The committee welcomes the contributions of Dr. Yossifov concerning the effects of cavitation on the hydrodynamic characteristics of the propeller in oblique flow. We agree, that even at initial design or prediction stages this phenomenon should be taken into account carefully. The references, mentioned by Dr. Yossifov, are a usefull help to estimate the change in propeller normal force and in propeller efficiency under cavitating conditions.

Reply to the discussion by P. Kozhukharov, K. Yossifov, V. Dimitrov and N. Draganov (HS−3)

The committee thanks Dr. Yossifov and his associates at the Bulgarian Ship Hydrodynamics Centre for their continued interest in high speed marine vehicles and for sharing the results of their investigation of the sport skimmer catamaran. The results also make the technical community aware of the large velocity squared increment of appendage resistance exhibited by the design where the resistance of the hull and appendages are equal at high speeds.
These results continue to show the importance of high speed marine vehicle model tests and the need to fully understand the design and all components of resistance.

Reply to the discussion by Profs. Miyata and Kajitani (HS−8)

Catamaran hulls
The committee thanks Professors Miyata and Kajitani for their contributions. The committee agree that catamarans with hydrofoils represent an excellent resistance characteristic. The main feature of this type of hybrid catamaran is its constant resistance in a specific speed region at planing speeds. Due to the foil lift the hull emerges which reduces the wetted area and by this the frictional resistance, the main resistance component. This advantage has been confirmed since the end of the seventies by high speed tuna fishing boats and small pleasure craft of South Africa. At present improved prototypes of this hybrid catamaran called Hysucat are under trials in Malysia.

The committee has some doubts on the scale effects which must arise by using a large model scale ratio of $\lambda=32$ resulting in a foil abord length of 2.8 cm. We like to refer to the report of the high speed marine vehicle panel of the 16th ITTC.

Reply to the discussion by Mr. Terwisga and Mr. V. Walree (HS−4)

In reply to the questions raised by Mr. V. Terwisga and Mr. V. Walree concerning the worldwide increase of high−speed catamarans, the following answers can be given.

With respect to the reasons why the catamarans are becoming so pupular in the recent years, the committee can only guess. Reasons such as the large available deck space, the high transverse stability also at high speeds, reduced complexity compared to ship types such as, SES and hydrofoils resulting in lower operational and building cost play probably an important role.
With respect to the second question, whether the HSMV Committee regards it as a task to advise or define relations between hydromechanic properties and operational requirement to enable a comparison of the different crafts, the answer is no.

We as a committee see it as our primary task to define proper methods to predict the hydromechanics of the different ship types in the best possible way, either through the definition of model test procedures or through validation of numerical methods.

When these are applied at least a comparison between the hydromechanics qualities of the different ship types can be made. The latter is however only possible when criteria for operational requirements are properly defined. In that respect it was good to learn that the report of the seakeeping committee discusses the definition of criteria in their report, especially because the seakeeping properties will probably be the most important but also the most difficult ones to compare.

We are therefore very intersted to await the reaction of the conference whether the recommendation to the conference of the seakeeping committee, to get the towing tank community more involved in the definition of criteria will be followed up.

Concerning the question and the statements of Mr. Terwisga and Mr. Van Walree how the induced effects of appendages can be separated from the total appendage contribution to the running trim, the committee gives the following answer:

[1] The drag and the trimming moment caused by each appendage element can be calculated and by this its trim angle component.

[2] The appendage drag generates a trim moment which tends to reduce the hull trim angle. Due to the small lever of the moment the effect of this moment on running trim can be considered to be very small.

[3] The lever of the resulting pressure force acting at the bottom of the hull due to the induced effects of the appendages is comparatively very large. This moment causes a running trim by stern as shown by Fig. 33.

[4] It is clear that the trim angle in Fig. 33 includes also the effect of the appendage drag. Therefore the running trim dut to the indiced effects is greater by that amount which is given by the appendage drag effect.

Reply to the discussion by Mr. K. R. Suhrbier (HS−9)

The Committee thanks Mr. Suhrbier for his comments to the report. We believe his suggestion to introduce the concept of the "effective cavitation number" is a good idea and we will certainly look closed on that.

We are aware that a number of investigations looking on the problem of stability for high speed semidisplacement and planing vessels are going on and we think the next committee probably could report on some improved knowledge in this area.

Also the appendage drag scaling will probably be looked upon in some detail when the problem of powering performance predictions will be dealt with by a future committee. The present status of appendage scaling was given to the 17th ITTC in the HSMV committee report.

Reply to the discussion by Dr. Tzvetanov and Dr. Yossifov (HS−5)

Dr. Tzvetanov and Dr. Yossifov have shown the need for special instrumentation to make specific measurements need for high speed marine vehicles as the committee has shown in its reports to the 16th, 17th and 18th ITTC. The committee thanks them for sharing the schematic of the design of their new six−component dynamometer and we hope that they will share the results they obtain for hydrofoils with future high speed marine vehicle committees.

Reply to the discussion by Dr. Morgan (HS−6)

In response to Dr. Morgan's suggestion that the catamaran hull is a low speed hull form, it is noted a that there are in existence, of this time, nearly 150 catamaran ferries with speeds in excess of 25 knots. This clearly identifies them as high speed craft so that they should be included in the studies of the HSMVC.

The HSMVC continues to seek the assistance of other ITTC technical committees in solving all technical problems relating to high speed craft.

Reply to Prof. Kobylinski (HS−7) and Dr. Tanibayashi (HS−10)

The committe appreciates their useful discussions to the committee report.

Ⅲ. COMMITTEE REPORT ERRATA

The following corrections should be observed in reading the original Report of the 18th ITTC High Speed Marine Vehicle Committee (Vol. 1);

page	column	line	instead of	read
278	left	18th from top	50 LOA	50m LOA
279	left	last	300 hydrofoil craft	1200 hydrofoil craft
283	left	3rd from bottom	$\Delta C_f=0$	$\Delta C_A=0$
285	right	4th from bottom	computer	computed
286	right	21st from bottom	appendage	appended
293	left	Fig. 30	Δ=1.84,5 tonnes	Δ=184.5 tonnes
293	left	8th from bottom	model tank temperature of 15 centigrade	reference temperature of 15 centigrade used other Froude Method of frictional resistance correction
294	right	7th−10th from top	The appendage drag acts at a relatively small level of about 2.0 to 2.5 times the draft, therefore, this moment has a small effect	The moment due to appendage drag below the keel has a small effect
295	right	9th from top	cratf	draft
300	left	3rd from bottom	$F_n\cdot\sin\Psi$	$F_N\cdot\sin\Psi$
303	right	9th from bottom	performing	platforming
306	right	eqn (13)	$k=(k-2g\Delta h/V^{*2})$	$K=(k-2g\Delta h/V^{*2})$
308	right	eqn (20)	$={}^{T}\text{GROSS model}\cdot\lambda\frac{\rho_S}{\rho_M}$	$={}^{T}\text{GROSS model}\cdot\lambda^3\frac{\rho_S}{\rho_M}$
309	right	eqn (21)	$---\frac{1}{2}p(V^2\ V^2)---$	$---\frac{1}{2}p(V^2-V^2)---$

317	left	6th from top	Length to beam ratios	Length to depth ratios
321	left	8th from top	experiece	experience
330	left	1st	expended	expected
336	right	11th−12th from top	If spray railds	If incorporate spray rails