Propulsor Committee

Committee Chair: Mr. J.T. Ligtelijn
Session Chair: Dr. M.W.C. Oosterveld

I DISCUSSIONS

Written discussion to the Propulsor Committee

by Prof. Gilbert Dyne, SSPA, Göteborg

The Committee has, without any reservations, referred to the so called "new momentum theory" developed by Perez Gomez. According to this theory, propeller end plates can be used to change the relation between the induced velocities at the propeller disk, ΔV_1, and in the ultimate wake ΔV_2. This relation is for a conventional propeller near $\Delta V_1/\Delta V_2 = 0.5$, but it can be increased by a flow accelerating duct and reduced by a flow decelerating duct surrounding the propeller. According to the new momentum theorem the end plates can reduce $\Delta V_1/\Delta V_2$ considerably, not by using the same effect as a duct, but by taking away the propeller tip vortices, or as stated by dr. Gomez: "The alternative tip plate model is characterized because the bound vorticity continues along the tip plates until its extinction instead of finalizing at the discontinuity surface constituted by the tip plates as is the case of TVF and CLT propellers. This modelization presents the inconvenience that from the surface of the tip plates some important free vortices are separated, leading to higher induced velocities than the ones corresponding to an equivalent CLT propeller". In my opinion this statement is clearly violating the vortex laws. The wording the Propulsor Committee has used in the report can give the impression that the Committee is accepting this theory and my question to you is therefore:

Is it really your opinion that

- the new momentum theory is correct and
- the energy gains of 15 - 18 % for CLT and TVF propellers reported in almost every issue of The Naval Architect are reliable?

If not, why don't you say so?

To the Propulsor Committee
Some issue related to CFD prediction of propeller performance

by P.G. Esposito
INSEAN - Istituto Nazionale per Studi ed Esperienze di Architettura Navale

A comparative workshop on CFD methods for the prediction of propeller performance is certainly useful for the assessment of such techniques, but, in our opinion, a propeller "Mistery Case" is not sufficient to ensure a correct comparison among existing codes. In fact many factors contribute to a difference in prediction:

Geometry. The propeller geometry is usually given in terms of discrete contributions of rake, pitch, skew and chord length. The interpolation of such data can be achieved by bicubic splines, NURBS, ... Different techniques can lead to slightly different propeller geometries.

Surface gridding. Many panel distribution on the blade surface can be found: some authors use a cosine distribution both in chordwise and radial direction...

Wake. Many codes use a devised wake, but the shape of the wake is based on different assumptions and/or experimental investigations.

For such reasons our suggestion is to carry out a comparative workshop with these conditions:

- Propeller "Mistery Case"
- Computations on two grids, one of which assigned by the workshop organizing committee.
- Computations using two wake shapes, one of which assigned by the workshop organizing committee.

Contribution to the discussion on propulsors

by J. Holtrop
MARIN, Wageningen

I convey my sincere congratulations to the Propulsor Committee for preparing a comprehensive and very fine report. When reviewing the recommendations given to the committee three years ago it appears that a treatment of the Reynolds number scale effects on the performance of the propulsor is still one of the major concerns within the ITTC. See recommendations 1, 2, 6 and 7.

Especially when dealing with sectional profiles which are apt to produce a vast extent of laminar flow and complex propulsors with stators, nozzles and slowly rotating components, where Reynolds numbers in model experiments become quite low, there is an urgent need to preserve the quality of the predictions through model experiments.

In this respect I wonder why the committee has not taken the opportunity to include in the procedure proposal for the open-water test the recommendations given as regards minimum Reynolds numbers to be adhered to (ITTC-1978). Neither is reflected the procedure that the open water experiment provides an excellent means to identify whether or not a particular propulsor is sensitive to Reynolds number effects on model scale.

Addressing the Reynolds scale effect problem I like to draw attention again to my contribution to the Session on Powering Performance at the ITTC in 1993 where I suggested to determine the most sensitive part of the scale effect correction from the difference in open water test results carried out both for the normal and for the highest Reynolds number attainable.

Since it is recognised that the Reynolds number effects depend on the type of sectional profiles it seems that a "standard" rule for scale effect corrections as those given in the report on page 174 will not provide an adequate solution. Probably, boundary layer calculations are likely to give a better chance of success to quantify the scale effect corrections needed. Such calculations could also validate and support the use of flow tripping devices on propulsors.

It seems that only by such an integrated approach in which the experimental procedures (high Reynolds number testing, flow tripping) are linked to CFD calculations the quality of the predictions can be improved and the acceptance of the use of flow tripping in propulsion experiments can be raised.

Discussion to the report of the Propulsor Committee

by M. Ikehata
Yokohama National University
Yokohama, Japan

I would like to express two requests to the Committee.

1. In this report there are no reviews about the propeller with stators (post-swirl vanes). I hope that the Committee will collect the information of actual installed ships and their data of effects of the stator on the propulsive performance.

2. Concerning to Kutta condition, the flow and the pressure near the trailing edge of the wings should be investigated experimentally and theoretically more and more. For this aim I hope that the Committee will propose a plan of the systematic studies of Kutta condition by flow visualization and measurements and by computational simulation using numerical Navier-Stokes equation solvers. Reynolds number should cover the range from 10^3 to 10^7 every 10^1.

Discussion to the Propulsor Committee

On a High Speed Propulsor and Interaction Effects for High Speed Marine Vehicles

Ukon, Y.
Ship Performance Division, Ship Research Institute
Streckwall, H.
Hamburg Ship Model Basin, HSVA.

We would like to add some words to the conclusion of chapter seven. The recent development of not only supercavitating (SC) propeller design methods and analytical performance methods but also the high performance SC propellers reviewed in this report, will encourage the practical application of SC propellers to high speed marine vehicles. However, we have to say that there still remains room for improvement in SC propeller design and analysis, not clearly mentioned in the report.

One area is the modelling of interactions between the cavity and viscous flow for non-leading edge supercavitation, which appears on the blade of lightly loaded SC propellers. Another one is the consideration of the effect of an inclined flow or turning motion flow. SC propellers are usually used with an inclined propeller shaft. Lower speed propellers than SC propellers also face this problem.

Table 1 Particulars of Propeller Model

MP No.	391
Diameter[m]	0.235
Boss Ratio	0.1383
Pitch Ratio	1.4255
Exp. Area Ratio	0.800
No. of Blade	3

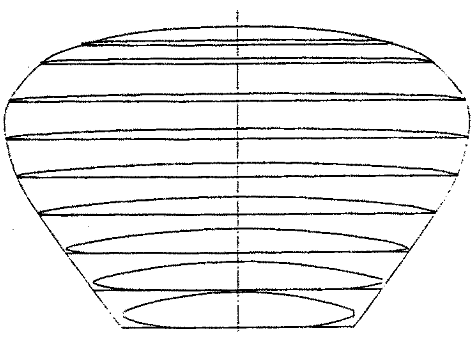


Fig. 1 Propeller Geometry

In order to determine the diameter of the propeller shaft for a small high speed boat, a reliable prediction of propeller shaft forces is necessary. This type of propeller operates in an inclined flow with a narrow wake behind a shaft bracket. In The Ship Research Institute, the measurement of propeller shaft force was performed using a special dynamometer to measure six-component forces with 12 degree inclination of a propeller shaft. Consistent measured results were obtained and not affected by tested revolution rates of a propeller model shown in Table 1 and Fig. 1. The coordinate system and the definition of propeller forces are shown in Fig. 2.

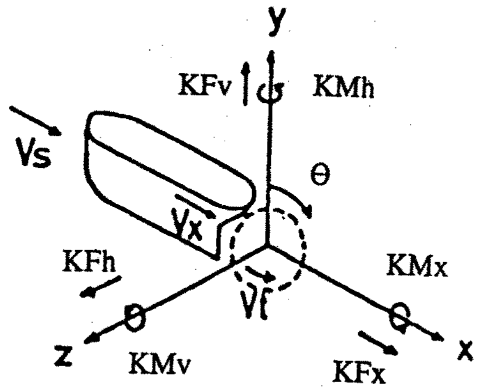


Fig. 2 Coordinate System and Definition of Propeller Forces

The measured results at the advance ratio of J=1.0 are compared with existing propeller lifting surface theories, as shown in Fig. 3. KEM [1], HPUF3A [2] and HSVA-QCM [3] have been developed by the SRI, MIT and HSVA, respectively. QUaS is a quasi-steady computational method for predicting propeller shaft forces based on propeller open test results. The non-dimensionalized side force KFy and bending moment KMy are given by

$$KFy = KFv \cos\Theta - KFh \sin\Theta, \quad KMy = Kmh \cos\Theta - KMv \sin\Theta$$

The computed results by the respective methods agree well as shown in Table 2, while the measured values are larger. One of the reasons for disagreement could be that in any computations the vortex wake shed from a propeller is assumed to lie parallel to the shaft line, while observation in a cavitation tunnel indicates that the vortex wake is shed in line with the main flow. Similar trends are found in Fig. 3.3 of chapter three in this committee report. Calculated shaft forces by MHI-QCM are always smaller than both full scale data and model measurements even in a straight run.

Therefore, there still exists a need to improve existing propeller lifting surface theory to predict reliable propeller forces not only for SC propellers but also conventional high speed propellers. The committee should encourage the development of more practical measurement techniques and theoretical solutions rather than concentrating on CFD codes.

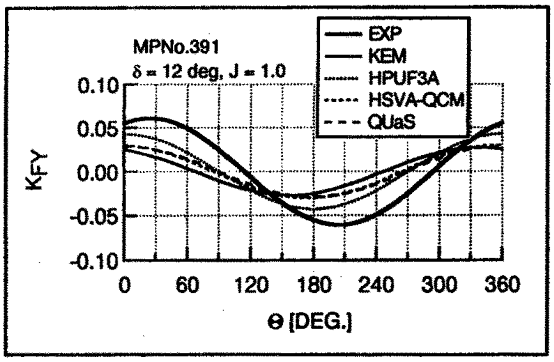
References

1. Koyama, K., 1975, "A Numerical Method for Propeller Lifting Surface in Non-

Uniform Flow and Its Application", SNAJ,Vol. 137.
2. Kerwin, J.E., Lee, C-S, 1978, "Prediction of Steady and Unsteady Marine Propeller by Performance by Numerical Lifting-Surface Theory", Trans. SNAME, Vol. 86.
3. Streckwall, H., 1992, "Calculations for the 20th ITTC Propulsor Committee", Workshop on Surface Panel Method for Marine Propeller, Seoul.

Table 2. Comparison of Propeller Shaft Forces between Measurements and Computations

	KFx	KFv	KFh	KMx	KMh	KMv
KEM	-0.2532	0.0251	0.0104	0.0525	0.0104	0.0039
HPUF3A	-0.2235	0.0430	-0.0005	0.0529	0.0134	-0.0034
HSVA-QCM	-0.2094	0.0301	0.0024	0.0460	0.0129	-0.0029
QUaS	-0.2425	0.0292	0.0000	0.0577	0.0162	0.0000



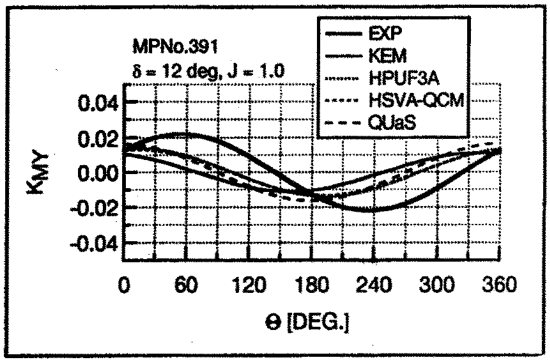


Fig. 3 Comparison of Propeller Shaft Forces between Measurements and Computations

II REPLIES

Reply to Prof. Dyne

The Committee thanks Prof. Dyne for his challenging discussion.

It was a specific task of this Committee to evaluate experimental and theoretical techniques for, among others, tip plate propellers. In the report of the Committee various theories for the design of propellers are mentioned and discussed. Not only propellers with end plates, but also for instance contra-rotating propellers, propellers with vane wheels, boss cap fins, ducted propellers, super-cavitating and surface piercing propellers. Undoubtedly every theoretical method has its shortcomings, or may even contain errors. In many cases such shortcomings or errors can be compensated by empirical corrections, and may turn out to be methods by means of which practical propellers can be designed.

Specifically now addressing the matter of propellers with end plates, three different theories for the design of such propellers are discussed in the report. These three methods are addressed because they are described in literature, and used for practical propeller designs. The fact that the Committee discussed all three of them is not the same as accepting or weighing them. So far, limited model test results have been reported in the open literature about the Danish and the Dutch design, whereas no model test results are known to the Committee with the CLT propeller. On full scale no applications are known to the Committee in case of the Danish or the Dutch design, whereas more than 150 applications of the CLT propeller have been reported, including large sea-going ships. The CLT propeller is therefore of practical relevance and should as such be discussed by the Committee.

The Committee mentions in the report that the theory of Perez Gomez differs from the classical linear momentum theory, and discussed certain shortcomings of that theory, for which the CLT designers might have found a practical solution. The Committee has indeed certain reservations regarding the new momentum theory, but has also noted that many practical propeller designs have been made with it. Questions similar to those of Prof. Dyne have for instance been put forward by the Committee chairman during the SNAME Propeller & Shafting Symposium in 1994, which were answered by Mr. Perez Gomez in a very detailed way, thus contributing to ongoing discussion about this theory. The questions of Prof. Dyne to this Committee show that the discussion about the new momentum theory will continue for some time, possibly until more becomes known (either experimentally or computationally) about the detailed flow around the propeller tip.

As for energy savings in the order of 15 to 18%, claimed in several magazines by the designers, the Committee is of the opinion that such high numbers are difficult to understand. The model tests with the Danish and Dutch end plate propellers show a few per cent improvement on model scale, and the Committee expects that similar savings can be achieved with CLT propellers. The claimed savings of CLT propellers also have not been supported in the open literature by well-documented and verifiable results of sea trials and/or model tests. It is therefore impossible to judge whether these claims are true or not.

The Committee is of the opinion (as stated in the report) that application of panel methods and RANS codes might eventually shed more light on the theoretical questions surrounding all kinds of end plate propellers, and that fully documented and verifiable model tests and in particular full scale measurements are needed to judge properly the energy savings that can be achieved in practice.

Reply to Mr. Esposito

The Committee thanks Mr. Esposito for his contribution to the discussion and agrees that he mentioned some valid points. The Committee mentions in addition to those some other interesting themes on pages 159 and 160 of its report, such as non-linear Kutta condition, hydroelastic effects, effective wake, leading edge vortex, etc. On page 569 of Volume 1 of the proceedings the recommended tasks for the 22nd Propulsion Committee are listed, and one of them is to organize comparative calculations.

The Committee likes to underline that the final choice of themes to be considered in a comparative exercise is left to the next Committee, and that such an exercise is not limited to the use of CFD, but could also include lifting line/lifting surface and panel methods. It would be useful for the next Committee to have many suggestions about the themes and the details of the comparative exercise.

Reply to Mr. Holtrop

The Committee thanks Mr. Holtrop for his discussion and agrees that Reynolds numbers in experiments is an important issue. It is the Committee`s understanding of the ISO requirements that they are general and not prescriptive, but require the recording and reporting of Reynolds numbers. The choice of the Reynolds number is the responsibility of the laboratory. Regarding this choice, the work and recommendations of previous Propulsor and Powering Performance Committees can be used as guidelines.

The issue of Reynolds number is a complex one and deriving simple equations of scale effect corrections will never fully describe these effects. The 15th ITTC Powering Performance Committee recommended the use of ΔK_T and ΔK_Q for scale effect corrections, which are found not fully adequate for propellers with high skew and/or unconventional section types. The Mishkevich formulae (1981 and 1995) for turbulent flow are a later attempt to improve scale effect corrections, but seem to over predict the scale effect on lift. The Committee agrees that these formulae may not prove an adequate solution in certain applications and that an integrated approach of experimental and CFD procedures will provide a promising way forward.

Reply to Prof. Ikehata

The Committee thanks Prof. Ikehata for his contribution. The Committee would like to reply to his two questions as follows:

Propulsion test guidelines for post-swirl devices have been included in the recommended tasks for the 22nd ITTC specialist Committee for Unconventional Propulsors, so they will receive the attention that Prof. Ikehata encouraged.

Two-dimensional foil work related to investigation of the Kutta condition was performed by Lurie (1993) at MIT, described briefly in section 6 of the Propulsor Committee report. Detailed unsteady flow measurements were made near the trailing edge at relatively high reduced frequency. The Committee would support any numerical investigation of the Kutta condition to improve potential based prediction methods. Full viscous calculations, detailing the trailing edge region can help to understand reasonable implementation of the Kutta condition.

Reply to Dr. Ukon

The Committee thanks Dr. Ukon for his contribution, and fully agrees that there is room for improvement. The matters of predicting dynamic shaft forces and modeling of the vortex wake are also recognized by the Committee as areas in which more work is needed to be done. The Committee encourages Dr. Ukon to write a full paper on the results of his recent investigations, so that it can be discussed by the next Committee in more detail.

Finally, Dr. Ukon is requesting the Committee to encourage the development of more practical measurement techniques and theoretical solutions, rather than concentrating on CFD codes. Regarding measurement techniques it is understood that this refers specifically to six component shaft forces measurements, which is a difficult type of measurement, for which any way of making that more practical would be a positive development. It is understood that by "theoretical solution" analysis methods like lifting surface methods are meant, and as such the Committee supports the idea of further improving them. However, at the same time the Committee would encourage further development of CFD codes, since they will become increasingly important in the future.