Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Antonio Sanchez-Gaja
Affiliation	VTT

Name of Technical Committee or group to be discussed	Propulsion Committee

Written Discussion (within 1,000 words of length)

It was mentioned that the scale effects predicted by CFD usually are larger than those predicted by ITTC method. The main reason should be the assumption in CFD computation that the flow is fully turbulent.

Computations made with partially laminar flow (Sanchez-Gaja et al. 2014) suggest that the scale effect is reduced due to lower friction connected to laminar flow. In the computation with laminar flow, flow detachment is present, but its effect on efficiency is lower than that due to friction reduction.

Reply from the 27th Committee :
The proposed reason why the scale effects predicted by CFD usually are larger than those predicted by ITTC method, is certainly the right one. More participants in the PTTC benchmark would be useful to confirm the trends. Another way to confirm the trend would be to compute the model scale case with different assumption on the boundary layer hypothesis (turbulent, laminar or partially turbulent and laminar).

Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Clemens Strasser
Affiliation	Vienna Model Basin Ltd.

Name of Technical Committee or group to be discussed	Propulsion Committee

Written Discussion (within 1,000 words of length)

With regard to the accuracy of the model propeller and open water tests, what are the criteria to satisfy the requirements? Is there any proof that a certain inaccuracy in the geometry of the model propeller has an impact on the results of the measurements ?

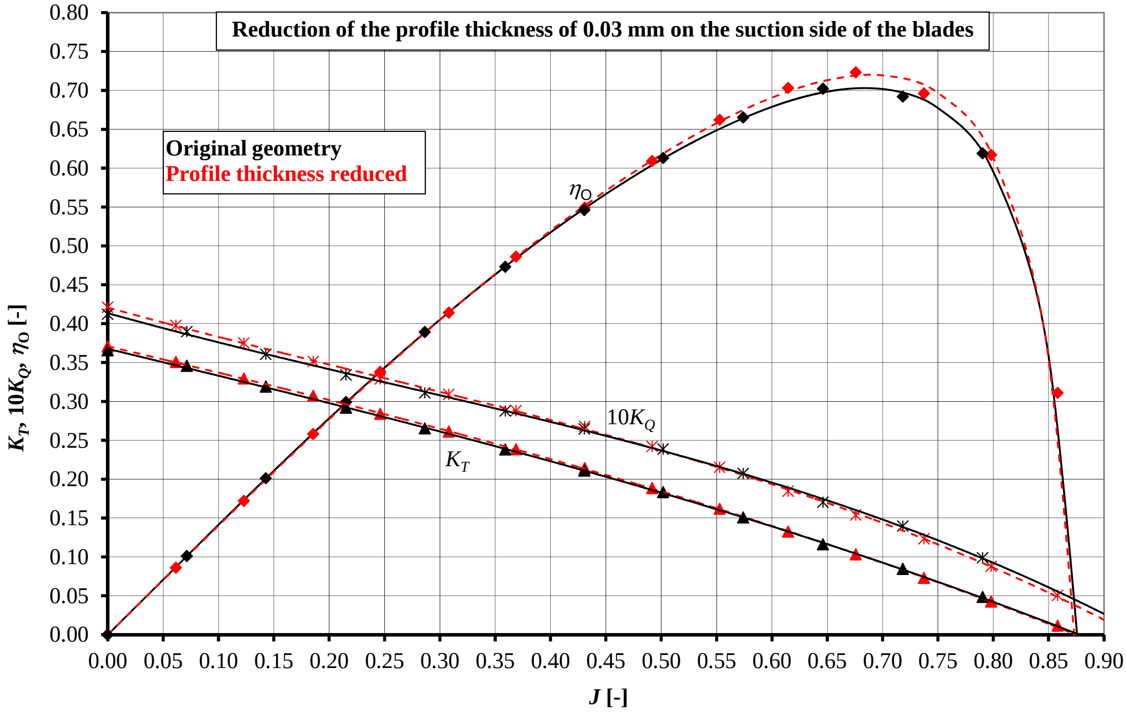
An example:
We made experiments with a model propeller accounting for different surface roughness and could not measure any difference between a smooth and a rough propeller surface. This observation was independent from the Re. No. effects.

Reply from the ITTC Committee:

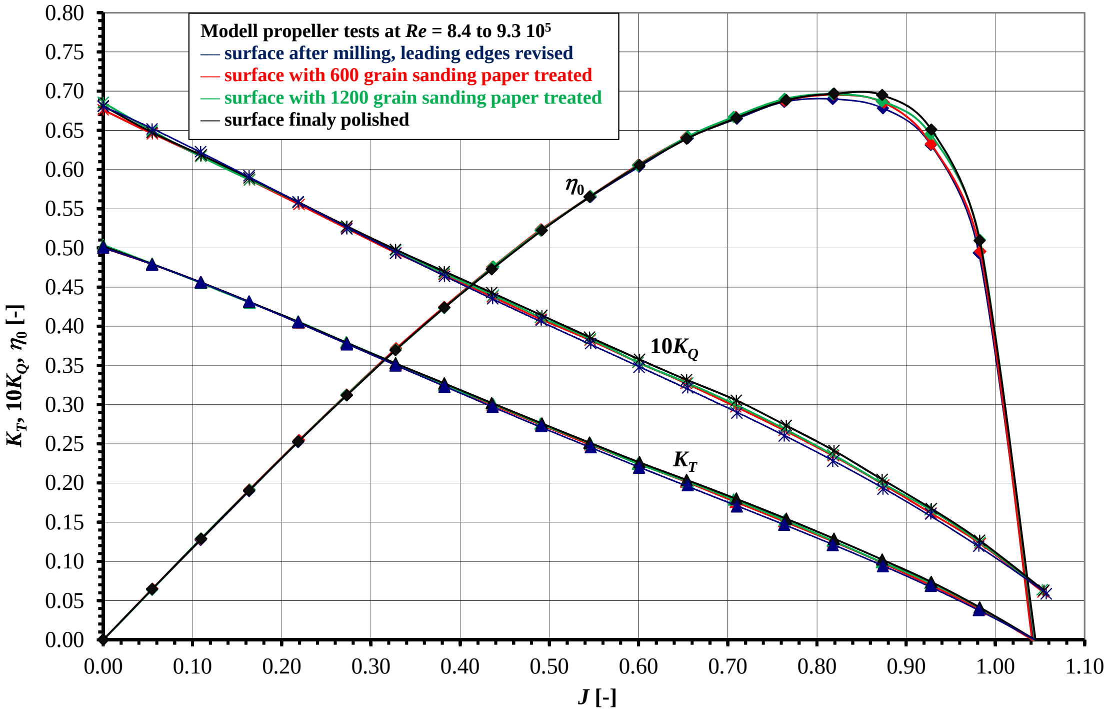
The recommendations for propeller model accuracy are pointed out in the ITTC procedure 7.5-01-01-01 ”Ship Models” and ITTC procedure 7.5-01-02-02 “Propeller Model Accuracy”. The sources for the recommended manufacturing tolerances include the ISO standards 484/1 and 484/2, quality standards for model propellers at different model basins and the results of systematic calculations to study the influence of propeller parameters on the propeller characteristics (report of the propulsion committee, proceedings of the 24th ITTC).

Investigations of final propellers in open water, propulsion and cavitation tests show the need of a high accuracy of the model propeller regarding the ITTC procedures. The following two diagrams show as an example the influence of a reduction of the profile thickness of the propeller blades and the influence of the final manual labour on the open water characteristic of model propellers.

In the interest of a correct comparison of different propeller designs in model tests, the accuracy of the propeller models should be in the ranges given in the ITTC procedures.



Influence of the reduction of the profile thickness of 0.03 mm on the suction side of the propeller blades on the open water characteristic of the model propeller



Influence of different final manual labour steps on the open water characteristic of a model propeller

As recommended by the 7.5-02 -03-02.1 Open Water Test procedure, propeller open water tests should be conducted at least at two Reynolds Numbers; one should be at the Reynolds Number used for the evaluation of the propulsion test, which should be not lower than 2.10^5 and the other should be as high as possible.

$$Re = \frac{c_{0.7R}\left(V_A^2 + (0.7\pi n D)^2\right)^{1/2}}{\nu}$$

For modern blade section, values higher than 5.10^5 is certainly to be recommended.

Those recommendations are consistent with the fact that, when the Reynolds number is high enough, the surface roughness has no or less effect on the open water results.

Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Da-Qing Li
Affiliation	SSPA Sweden AB, Sweden

Name of Technical Committee or group to be discussed	Propulsion Committee

Written Discussion (within 1,000 words of length)

In connection with Dr. Wang's question on the uncertainty issue of the PPTC propeller benchmark data, I'd like to raise another issue on the possible discrepancy introduced to K_T (and K_Q) in the experiment due to the subtraction of dummy hub force (and torque). The ITTC recommended procedure for a POW test is to derive the thrust force (same for torque) on propeller blades from the total thrust force measured on the propeller hub configuration in a POW test by subtracting the hub force measured in a separate force measurement towing test for a dummy hub alone, i.e. "dummy hub" test. The K_T and K_Q presented in a POW curve represent only the blade force and torque. The procedure assumes that the difference of the hub force in these two tests is negligible. However, PPTC has three features that are quite different from a conventional propeller.

(1): The hub has a conical profile with a large hub diameter; (2) blade section near root is thick; (3) it has five blades.

As a result, flow passing over the hub surface in each blade passage experiences a strong blockage effect, and the pressure field near the blade root has a meaningful influence on the pressure distribution on the hub in this case. Therefore, the assumption on the negligible difference in hub force in the two tests may not be valid. This means that an incorrect or inaccurate hub force is subtracted from the total axial force of a propeller-hub configuration, thereby introducing a small difference in the blade force.

Unlike the experiment, the way to obtain the blade force in a RANS method is simply an integration of pressure and viscous force on blades only, not involving any subtraction of hub force. In my opinion, the difference between the RANS predicted blade force and the blade force derived from the POW test by subtracting hub force may give an explanation of the somewhat large discrepancy between the RANS predicted K_T and the K_T from a POW test. A fair comparison would have been to compare the total force (blade + hub) between the RANS predicted and the measured data.

Reply from the 27th committee:

The difficulties with the correction of the propeller open water characteristic with the force and torque at the dummy hub are well known. That's why the Potsdam report [1] with the results of the open water tests of the PPTC contains the complete set of measurement results:

- forces and moments, measured with the dummy hub
- open water characteristics of the propeller corrected with the idle torque
- open water characteristics of the propeller corrected with the idle torque and the hub resistance

So the comparison of the measured characteristic of the propeller with hub and nose cap with RANS calculations is possible.

[1] Barkmann, U. H.
Potsdam Propeller Test Case (PPTC), Open Water Tests with the Model Propeller VP1304,
SVA report 3752, April 2011
http://sva-potsdam.de/pptc_data.html#openwater

Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Jinbao Wang
Affiliation	Marine Design and Research Institute of China (MARIC)

Name of Technical Committee or group to be discussed	Propulsion Committee

Written Discussion (within 1,000 words of length)

It's an excellent report. There are two questions for the committee.

1. When scaling the wake of pre-swirl stator (PSS), the report follows ITTC 1999, that is, the difference between with and without PSS at model scale is correlated to the full scale without any correction. My question is, is this formula suitable for other energy saving device, such as pre-swirl duct?

2. About comparison between CFD and EFD for PPTC case, I suggest plenty of information should be provided so that all participants will have the same geometry including large radius even the tip of the blade. Also, the geometry of blade for milling machine should be carefully treated, so as to provide a reliable base for CFD. Set up for CFD and EFD should try to keep the same.

Reply from the 27th Committee :

Part 1 :
Regarding the scaling problem, it becomes an issue not only due to the need of performances prediction accuracy but also due to the EEDI matter. Even for the pre-swirl stator case ITTC 1999 method might be somewhat exaggerated the wake scaling because the stator makes the axial flow retardation as well as contra rotating tangential flow on the propeller plane. It is very difficult to extract the potential term which might be some percentage of totals. According to the some ship yards experience, the correlation between the full-scale sea trial results and evaluated results by ITTC 1999 method is rather good. That might be due to the absence of stator drag scaling whose local Reynolds number is very low in comparison with the model ship. The overestimated wake gain might compensate the scale of stator drag.

For the case of pre-swirl duct, the tangential component portion might be less than that of pre-swirl stator which means that if the ITTC 1999 method is applied to the pre-swirl duct, the result might be optimistic. In our opinion, the ITTC 1978 method is more realistic for pre-swirl duct rather than

ITTC 1999 method in efficiency point of view which is expected to be validated by full-scale data.

Part 2 :
The geometry of the propeller for the PPTC is given on the web site of the SVA Potsdam. All information about geometry and test arrangement is available on the website. We agree that the set up for CFD and EFD should the same as far as possible.

http://sva-potsdam.de/pptc_data.html#openwater

Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Kourosh Koushan
Affiliation	Marintek

Name of Technical Committee or group to be discussed	Propulsion Committee

Written Discussion (within 1,000 words of length)

Model testing of composite propellers.

There is no perfect solution, because both hydrodynamic and structural (deflection) are to be scaled correctly. It is important to use correct E-module and build up of layers and direction of fibers. In the EU-project COMARPROP, MARINTEK performed model testing of a carbon fiber composite propeller.

To achieve the right E-module and deflection, the thickness of the blade was reduced, but suction and pressure side as well as fiber layers and directions were conserved.

In this way deflection is modelled correctly in different loading and inflow conditions. Drawback is reduced thickness.

Reply from the 27th Committee :
The model testing of a composite propeller is a tough challenge. You pointed out the main issue which is having a model scale propeller which will be in right mechanical similarity to full scale i.e. to have a similar E-modulus. But this condition is only required if the flow speed or towing speed is equal to the full scale ship speed. If the test is not carried out at the full scale speed, the E-modulus need not to be equal to the full scale one to ensure the same deflection.
From what we understand, your experience show that it is possible the same modulus but the blade thickness has to be reduced, which raises several questions. How to ensure that the pressure distribution on the blade sections will be representative to full scale with the right loading, especially at the leading edge of the section which is critical for ? How to certify that the blade deformation would be the right one ? What kind of measurement technique is able to measure the blade deflection while rotating ? It seems that those issues are not easy to overcome. That is the reason why the committee seems to be more reasonable to use CFD calculation with EFD validation based on a specific test on large scale composite propeller or large scale composite foil, even if there are not in similarity with a given full scale propeller or foil.

Form of Written Discussion at the 27th ITTC Conference

Discusser	
Name	Michael Schmiechen
Affiliation	VWS, the Berlin Model Basin

Name of Technical Committee or group to be discussed	Propulsion Committee

Written Discussion (within 1,000 words of length)

In view of all the wake adopted, more or less unconventional propulsors discussed, I wonder what may be the purpose of open water tests, provided they can be performed at all, and the meaning of their results.

(Continued after the strictly conventional answer of Dr. Minchev).

Even if meaningful hull towing and propulsor open water tests can be performed on model scale, they definitely cannot be performed on full scale under service conditions. But the related problems will be subjects of the discussions ad the following session.

Addendum: At the session of the SC on PSS, the problems have not (!) been discussed.

Reply from the 27th Committee :

As pointed out during the discussion, the open water test is part of the procedure for performance prediction method developed by the ITTC community and applied for many years now by all the marine institutes. As largely described in the 7.5–02 03–01.4 Procedure (1978 ITTC Performance Prediction Method), the open water test enables the calculation of the effective wake fraction and the relative rotative efficiency and the extrapolation of the wake fraction to full scale. The basic reason of the propulsion performances prediction procedure is to take care of the Reynolds effects between model scale and full scale, because the Reynolds similarity is not respected.
The committee does agree that for some nonconventional and hull highly integrated propulsors, we might raise a limit of those methods. So far, for a large majority of ship propulsion systems, this procedure is still valid and worth using it.
In the future, the best way to overcome those Reynolds effects limitations of model scale would be to directly have a CFD calculation on the propulsor(s) operating behind the hull at the full scale Reynolds number. As pointed out by the specialist committee on CFD in Marine Hydrodynamics, RANS code and RANS-LES hybrid approaches are increasing the accuracy to predict the propulsion performances, although verification and validation are still required.