Prof. Dr.-Ing. M. Schmiechen
Bartningallee 16
D-10557 Berlin (Tiergarten)
Germany

Phone: +49-(0)30-392 71 64
E-mail: m.schm@t-online.de
www.t-online.de/home/m.schm

Berlin, 30.07.1998

To whom it may be of interest

On the logics of the evaluation of ship speed trials

Introduction

The traditional way of conducting and evaluating ship speed trials is very costly and involved and at the same time not very trustworthy. The reason for this situation is that the logics behind the whole procedure is very obscure to say the least. An attempt is being made here to promote the necessary clarification. The ideas developed are certainly not readily acceptable, but maybe they can form the nucleus of a discussion.

In a proposal for a clear-cut procedure, prepared as a contribution to the current ISO/WD 15016 and to be found at the Website of the author, it as been shown how the power function of ship propellers in the behind condition can be identified with systems identification techniques from a minimum of test runs, which need not even be stationary, and with a minimum of conventions and without reference to model test results, as it should be.

Power function

This power function

$$P = \text{Power}(V, N)$$

relates the shaft power of the ship with the speed V of the ship through the water and the rate of shaft revolutions N. This function may be visualized as a surface in three dimensional space. The format of the function and the details of the identification of its parameters are not subjects of this paper.

The power functions hold not only at the test conditions but for conditions deviating considerably from these conditions, provided the working conditions of the propellers are not changed significantly.

Contract conditions

The Power function is sufficient to establish the fullfillment of contract conditions requiring power P_{contr} at speed V_{contr} and at the rate of revolutions N_{contr} . These conditions may have been derived from or may at least have been confirmed by model test results taking into account the weather condititons at contract conditions.

Depending on the formulation of the contract the criterion for acceptance may take different forms, e. g.

$$\Delta N = | N_{nec} – N_{contr} | < \Delta N_{contr} ,$$

where N_{req} denotes the rate of revolution required at contract conditions to be determined from the equation

$$P_{contr} = Power(V_{contr}, N_{req})$$

and ΔN_{contr} its maximum contracted deviation from the contracted rate of revolution at contracted speed and power. Evidently corresponding formulations in terms of speed and power can be obtained easily.

Resistance function

Provided thrust measurements could be taken as cost-effectively and reliably as and together with the power measurements the corresponding resistance function of the ship under investigation could be established as has been shown in the METEOR project. For ready reference the report may be found at the Website of the author as well.

This resistance function

$$R = Resist(V, N)$$

relates the resistance of the ship with the speed V of the ship through the water and the shaft rate of revolutions N. Again this function may be visualized as a surface in three dimensional space. And again the format of this function and the details of the identification of its parameters are not subjects of this paper.

Any pair of values of the speed V relative to the water and of the rate of revolutions N corresponds to a pair of values of the power P and the resistance R . In contracts the power at given weather condition and speed plays the dominant role, while the resistance is not being mentioned at all.

Traditional procedure

Quite to the contrary the resistance plays a dominant role in the traditional evaluation of ship speed trials, which does not take the direct route indicated, but a diversion via the resistance surface. The model behind this reasoning is that changes in power are due to changes in resistance to be overcome.

Starting from a given trial condition V_{trial} , N_{trial} , P_{trial} and R_{trial} in the traditional procedure a increase in resistance

$$\Delta R = R_{trial} - R_{contr}$$

between contract and trial conditions is being determined and subsequently the extrapolated resistance

$$R_{extr} = R_{trial} - \Delta R ,$$

at contract conditions.

This contract resistance and the contract velocity permit to determine the required rate of shaft revolutions from the equation

$$R_{extr} = Resist(V_{contr} , N_{req}) .$$

and subsequently the required power

$$P_{req} = Power(V_{contr}, N_{req}) .$$

If every step in this procedure is free of error, systematic or random, the required rate of revolutions equals the one determined in the direct procedure and the required power equals the contracted power:

$$P_{req} = P_{contr} .$$

Unsolved problems

Unfortunately the condition that every step is free of error will never be met. Quite to the contrary there are a number of problems along this route, which cannot be solved easily and satisfactorily.

Firstly the resistance function can in practice not be determined directly for the ship due to the difficulties in thrust measurements. The usual solution is to rely on the results of model tests. While the thrust function may be determined rather reliably the traditional conventions on the thrust deduction fraction are very crude, maybe too crude.

The traditional conventions that the value of the thrust deduction fraction is the same for ship and model and that it is independent of the propeller loading are certainly not correct.

Secondly the determination of the contract resistance is quite complex and has to rely on a large number of traditional rules or more or less involved computations, as e. g. in the estimation of resistance due to wind and waves.

Consequently the values of the extrapolated resistance to the weather conditions contracted and of the corresponding required rate of revolutions are certainly unreliable.

As a consequence the usual procedure is to cross-check the indirect determination of the power via an approach similar to the direct way. But instead of using the behind condition to be identified for the ship itself, the concepts of the propeller open water condition and of the wake are being introduced.

In view of the fact that the analysis is not carried as far as possible, and as shown in the METEOR report, reference needs again to be made to model test results. And in view of the scale effects in the power function and in the wake fraction these are even less certain than in the case of thrust.

The traditional procedure is further obscured by the iterative identification of the power function and the current velocity. In the proposed method optimum estimates are obtained for both in one step, identifying them together by solving only one system of linear equations.

Usually in the discussion normalised quantities are being used instead of physical quantities. This does of course not change the argument but introduces further confusion although instead of two arguments, speed and rate of revolution, only one, the advance ratio is necessary.

Open question

In view of these problems the question arises why one should climb all the way through the resistance surface, not directly identified, and arrive at best approximately at a point, which can be reached exactly without any problem on the direct route along the directly identified power surface?