On ship speed trials

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Problem

The traditional way of conducting and evaluating ship speed trials is very costly and involved and at the same time **not very trustworthy**. **Consequently there is a need for standardisation.**

Japanese colleagues have taken the lead and submitted an ISO/WD 15016, now on the way from an ISO/CD to an ISO/DIS.

ISO/CD 15016

The **ISO 15016** concerns the shipbuilders not only in Japan.

While the colleagues in England claimed, that the procedure cannot be standardised at all, in Germany the DIN/NSMT has formed a WG Speed Trials, which has actively contributed to the formulation of the standard.

Schedule

On 1999.07.29 the secretariat of ISO/TC8/SC9 at JSMA has circulated a **revised version of ISO/CD 15016 (Committee Draft) including a new example '<u>for voting until 1999.10.10</u> concerning distribution of the draft as an ISO/DIS (Draft ISO Standard)'**

ITTC SC Trials

At the 22nd ITTC the Specialist Committee on Trials and Monitoring asked the Conference to be continued, even though it will not actively contribute to work of the ISO/TC8/SC9/ WG2!

And that may be too late anyway, if the ISO schedule is being followed and not disrupted in view of serious concerns expressed by many experts.

View of present author

From the beginning of the discussion the present author has expressed the view that there is not only a need for standard-isation, but **at the same time a need for rationalisation based on adequate theories and methods.**

Model

Based on the METEOR experience a **top-down approach embedded in the theory of the rational resolution of conflicts** has been suggested.

A detailed proposal for a clear-cut proce-dure along this line has been submitted together with two examples as contri-bution to the ISO/WD 15016.

Rational method

Advantages of the rational procedure are

- a minimum number of simple conventions
- and the consistent application of systems identification methods
- requiring no reference to model test results
- and any other prior information,

<u>as it should be.</u>

References

All contributions 'On the evaluation of ship speed trials', including cover letters and **a large number of examples**, to be found under the 'Recent papers' on the website of the author: **t-online.de/home/m.schm**.

A summary paper **trl_sum.htm contains hyperlinks** to all the material except for the latest evaluation of the ISO example.

Further development

Of course **the rational method proposed**, being still in its infancy, **needs the joint effort and agreement of all experts** before it can be established as a reference and a standard.

The results produced so far are very pro-missing, but those concerned are not yet concerned!

Power supplied / current

Firstly the parameters of the power supplied or delivered, more precisely of the **propeller performance** in the behind condition, in the full scale wake (!), and of the **current velocity** can be **identified simultaneously by solving one set of linear equations.**

Power supplied

The ‘local’ model

$\mathbf{P = p_0\, n^3 - p_1\, n^2\, V}$

relating shaft power P, rate of revolutions n and speed through the water V, can be visualized as a surface in a three dimensional space.

Only rate of revolutions and torque, and consequently power, are to be measured.

Speed through water

The speed through the water

$\mathbf{V = V_{Grd} - V_{Curr}}$,

cannot to be measured directly, but speed over ground. The current is unknown!

Simplest cases harmonic tidal currents or

$\mathbf{V_{Curr} = \Sigma\, v_j\, t^j}$.

Attention! Components in ship direction! Vectorial subtraction of velocities!

Identification

The **two plus four parameters** of the two models may be identified from four or better five double runs **without any reference to model test results**.

In the proposed method optimum estimates, are obtained for both in one step, **identi-fying them simultaneous by solving only one system of linear equations.**

Ill-conditioned problems

In view of the **ill-conditioned problems arising** there is **<u>no chance to solve the equations with do-it-yourself algorithms</u>**, singular value decomposition is an absolute requirement.

The traditional procedure is obscured by the iterative identification of the ‘laws’ for power and current velocity.

Normalisation

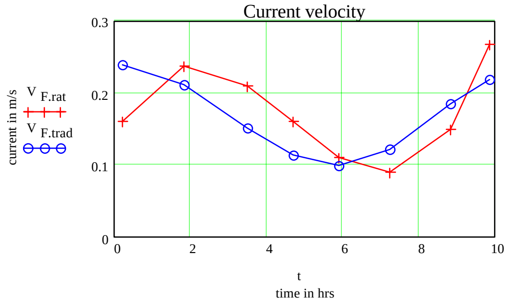
For the purposes of visualisation norma-lised quantities are being used instead of physical quantities. This has the advantage that instead of two arguments, speed and rate of revolutions, only one, the advance ratio, is necessary.

Further, systematic effects become evident.

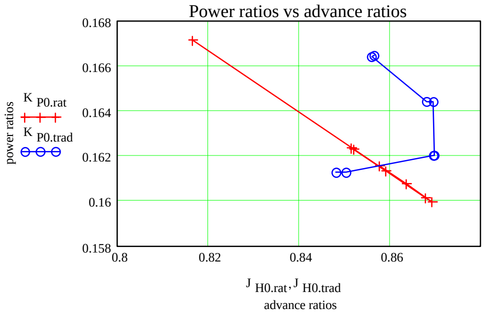
Examples

In a great number of examples, based on actual data from industry, it has been shown that the **rational procedure is superior to the traditional procedures of solving eight or ten simultaneous equations iteratively.** **<u>The author has no idea how this can be done reliably!</u>**

TID 21010: Current velocity



TID 21010: Power supplied



Contract conditions

Contracted power P_{contr} at the speed V_{contr} and at the rate of revolutions n_{contr}, **derived from or at least confirmed by model test results**.

For given power P_{contr} and speed V_{contr} rate of revolutions actually required is the solution of the equation

$$P_{contr} = p_0\, \mathbf{n_{req}}^{\mathbf{3}} \,\mathbf{-}\, p_1\, \mathbf{n_{req}}^{\mathbf{2}}\, V_{contr} .$$

Compliance

Consequently compliance with contracted conditions can be established **without the usual reference to resistance data.**

Ideally the required rate of revolutions equals the contracted rate:

$$n_{req} = n_{contr} .$$

Ill-defined averages

Many problems in the evaluation of trials are **due to**

- **waiting for steady conditions,**
- **ignoring all interesting information,**
- **and using ill-defined average values.**

Time histories

The author has fully endorsed Recommendation of the SC on Trials to the ITTC concerning the recording of 'time histories'.

Even if runs are considered stationary **sound performance and confidence analyses have to be based on quasi-instantaneous values** of the data.

Quasi-steady testing

In the METEOR and CORSAIR trials **quasi-steady test manoeuvres** have been shown to be much superior to steady testing, the former **providing not only much more information, but <u>at the same time the necessary references for the suppression of the omnipresent noise</u>, even at service conditions in heavy weather.**

Further evaluation

Usually a **speed power relation at a given weather condition** is being contracted.

If one wants to do that, one opens a **Pandora's box of problems**. The assumptions underlying the traditional procedure are simply too shaky.

The only way to escape is to **try and adhere to the principles stated. And this is possible!**

Changes in power

More direct is the approach via changes of power due to changes of loading and weather conditions. Traditionally the relevant parameters are taken to be known apriori from former tests etc.

Rational is the identification of the parameters of simple models of the power required from the trials data as well.

Power required

Simple models for powers required due to water resistance

$$\mathbf{P_{Water} = a_1\, V + a_2\, V^2 + a_3\, V^3}$$

and due to wind resistance

$$\mathbf{P_{Wind} = b\, |\, V_{Wind,\, rel}\, |\, V_{Wind,\, rel}\, V.}$$

Similarly the added power due to waves can be accounted for.

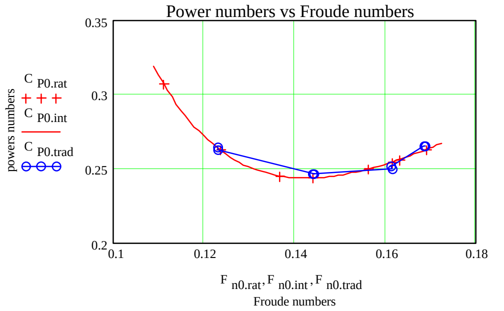
Identification

All the parameters may be identified simultaneously from a second set of linear equations based on the same trials data. Again the problem arising is ill-conditioned.

The power required at the no wind condition is simply

$$\mathbf{P_{Air} = b\, V^3}\,.$$

TID 21010: Power required

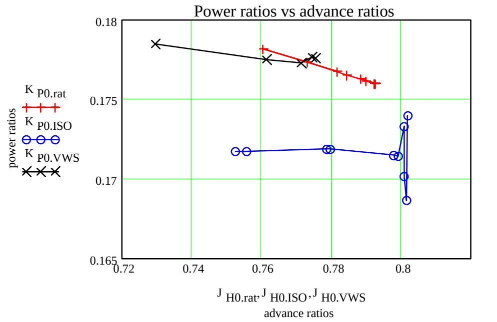


Generalisation

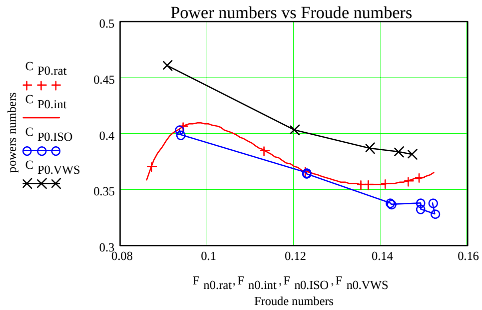
The simple example may be generalized **provided the data are sufficient** for the identification of the parameters of the changes of power due to changes of loading and weather conditions.

This has been done successfully in case of the new example provided with the ISO/CD 15016.

TID 23010: Power supplied



TID 23010: Power required



Agreements / Discrepancies

There are **encouraging agreements and <u>disturbing discrepancies</u> to be noticed** between the results of the re-evaluation and of the underlying ISO example. The **final results according to the proposed ISO method show a 'behaviour', <u>to be attributed to inconsistencies of the ISO method</u>, so that nobody can seriously consider it as acceptable.**

Quasisteady testing

Sufficient data for the identification of the parameters can be obtained if trials are not limited to a few steady double runs.

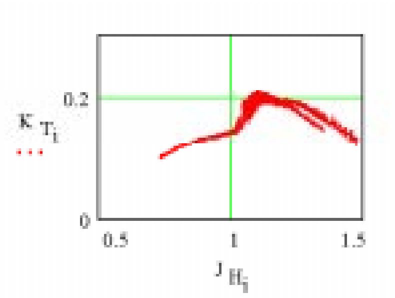
In the present technique conditions at 'steady' states are observed and averages are provided, which are ill-defined to say the least.

Detailed analysis

In the METEOR project it has been shown that a **complete analysis of the powering performance can be based on data from quasi-steady tests**.

And in the CORSAIR project it has been shown that **even the inertia of the ship and the resistance in shallow water can be identified**.

CORSAIR: thrust function, behind



Performance parameters, behind

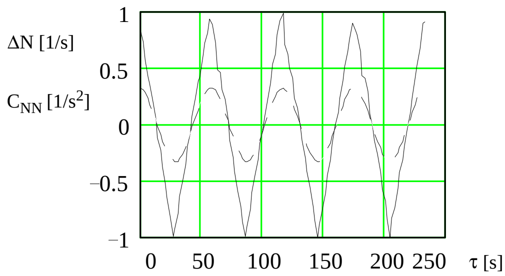
KT = KT0 + KTH JH

KQ = KQ0 + KQH JH

	JHmin	JHmax
JH	0.4	0.5
	KX0	KXH
KT	0.0186	0.2854
KQ	0.0128	0.0278

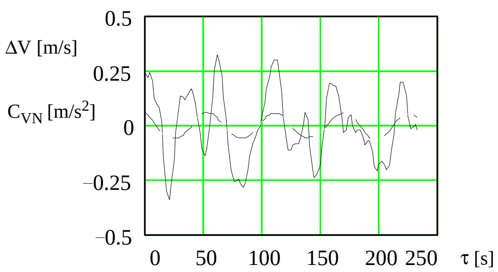
Rate of revolutions

Oscillations and auto covariance



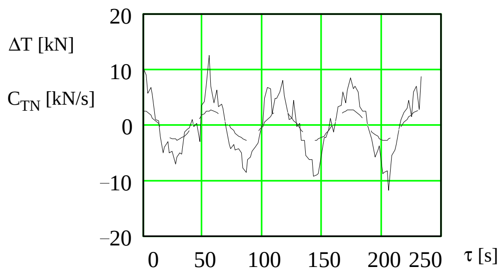
Velocity over ground

Oscillations and covariance with revs



Thrust

Oscillations and covariance with revs



Momentum balance

Momentum balance

$M\,A + R(V) + S(V,N) = T(V,N) + F$

Mean values

$M\,A_m + R_m + t_m\,T_m = T_m$

Oscillations

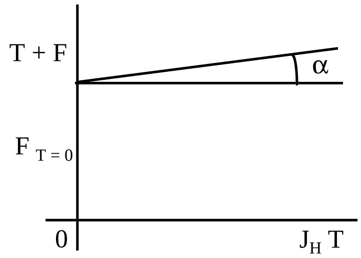
$M\,\Delta A + R_V\,\Delta V + t_m\,\Delta T = \Delta T$

Linearized equation

$(M\,i\,\omega + R_o)\,V_t = (1 - t_m)\,T_t - T_m\,t_t$

Thrust deduction axiom

according to Schmiechen



$R + S = T + F$

$R = F_{T=0}$

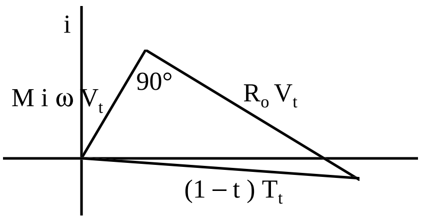
$S = t\,T$

$t = t_H\,J_H$

$t_H = \mathrm{tg}\,\alpha$

Complex force diagram

In case of constant thrust deduction fraction

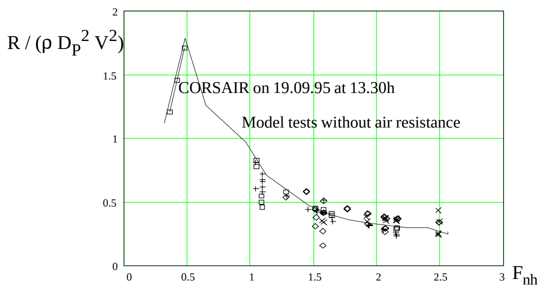


Data identified

N_m	10.84	Hz
V_m	5.878	m/s
A_m	-0.001	m/s^2
T_m	73.70	kN
M	158.9	t
R_V	39.54	kN s/m
t_m	0.020	1
R_m	72.47	kN

Resistance

Normalised as function of Froude number



Conclusions

It has been shown that a rational evaluation of ship speed trials without reference to model data is possible. If necessary **the conventions (axioms) and procedures proposed can be improved according to the principles stated**.

There is no way and no need to go back to the traditional conventions and procedures.