The Seakeeping Committee

Committee Chairman: Mr. David C. Murdey
Session Chairman: Dr. Hiroshi Kagemoto

1. DISCUSSIONS

1.1 Discussion to the 24th ITTC Seakeeping Committee by Young-Woo Lee, Hyundai Maritime Research Institute, Korea

The contribution of initial conditions in ship motions for the onset of parametric roll needs to be investigated both in the numerical simulations and experiments. In a model testing procedure aimed at parametric roll identification, roll instability basin identifying the initial ship motion conditions which lead to parametric roll needs to be constructed in the phase plane of roll displacement and roll velocity. According to HMRI's experience in the seakeeping experiments in regular head waves, no parametric roll occurred even in highest wave conditions unless initial forced disturbance in roll motion was imposed on the modern containership model.

Model test procedure in predicting the onset and magnitude of parametric roll in irregular head sea in a longitudinal towing tank needs to be established to ensure sufficient number of encountering of critical waves whose period is vulnerable to the onset of parametric roll. Special attention is required during the investigations to see if parametric roll can be predicted in irregular head seas in a longitudinal towing tank, when the ship model is restricted in sway and yaw. Recommendations for a proper model test procedure in predicting parametric roll for this restricted test condition need to be suggested by ITTC.

1.2 Contribution to the 24th ITTC Seakeeping Committee by Theodoros Loukakis, Gregory Grigoropoulos, Georgios Katsaounis, National Technical University of Athens, Greece and Philippe Corrignan, SIREHNA, France, on Large Scale Model Testing at Sea

Introduction. Testing of large ship models at sea is not something new in the art of tankery, although it has never been a widespread procedure.

Recently the procedure has been revived through some important research programs. A brief description of the pertinent advantages and disadvantages, as well as the instrumentation used for the testing is presented in the following contribution.

As a general rule, large models at sea are obliged to have at least one licensed person onboard, even when all measuring systems operate automatically.

Resistance and Propulsion. Since large Towing Tanks can use models of similar size (about 10m) to the size of the seagoing models, there is no advantage in going to sea, if the required test conditions can be met.

Thus, measuring resistance and propulsion characteristics at sea in calm water, which is rather easy to find in sheltered waters at the appropriate time of the day is recommended when:

- No large Towing Tank is available,
- The Towing Tank cannot accommodate the width of the model, as e.g. when testing large models of multi-hulls,
- The Towing Tank carriage cannot achieve the required speed, such as 20m/s for a large model of a fast modern vessel.

Resistance Measurements: The resistance of a large model is measured using an outboard engine, with a long pod so that the interaction coefficients (w and t) have values very close to zero. The outboard motor is attached to the model via a special six-component flange-type dynamometer, inserted between the transom and the outboard. The dynamometer has been developed for use in industrial robots and can measure all the components of force and moment transmitted to the model.

Self-Propulsion Measurements: The situation is similar to Towing Tank testing, but testing at sea has the additional requirement or disadvantage that the propulsor should be driven either using an internal combustion engine, with its inherent torsional unsteadiness or using an electric motor, which uses electricity generated onboard.

Wash Measurements: The waves generated by modern large and fast ships, such as Ferries with displacement of 1000mt, moving at 40 knots or the platform of European project VRSHIPS/ROPAX, see the Section on "Examples of Testing Large Models at Sea", which will have a displacement of 17500mt and a speed of 38 knots, are a restrictive factor in their operation as they can cause serious problems when they reach shallow water, sometimes miles away (to the side) of the ship.

Obviously, the wash waves can be measured readily at sea, whereas it is almost impossible to measure them in the Towing Tank far away from the model.

Seakeeping Tests. Real life, short crested, wind generated waves cannot be produced artificially. Therefore, realistic seakeeping tests can only be performed at sea.

This does not mean, of course, that the standard Towing Tank practices of testing in regular and pseudo-random unidirectional waves are not useful. But if one needs to know what the dynamic behaviour of a ship will actually be at sea, one should test a large model at sea.

Fortunately, wind waves are self-similar, which means that their spectral form is the same, when plotted in a non-dimensional fashion. Thus, when a "model" sea state is found, testing a same scale model for its dynamic characteristics is very close to reality since, except for rolling, the discrepancy in Reynolds number does not affect the ship responses.

Obviously, only at sea can one test for all ship headings.

Measuring the Sea-State: The testing site should be chosen essentially on the basis of the wind waves usually present at Lavrion, where LSMH/NTUA is usually testing (see Figs. 1.1 and 1.2).

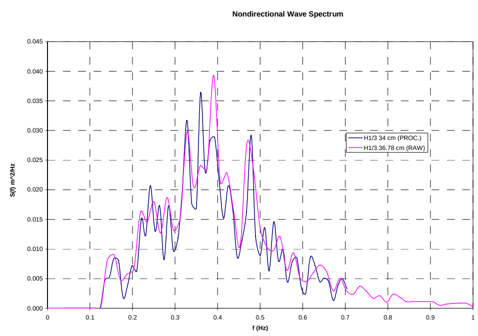

Figure 1.1- Point spectrum of sea waves.

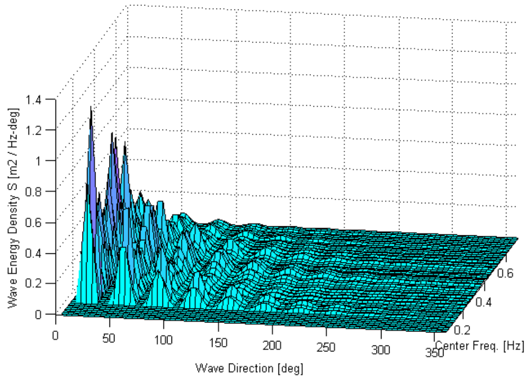

Figure 1.2- Directional spectrum of sea waves.

Measuring the Ship Motions: The dynamic behaviour of the model at sea can be continuously measured, using either commercially available instruments (such as SEATEX MRU-6 using three accelerometers for the transitional responses and three axes fluxgate magnetic compass for the angular responses) or a custom designed system as the one used by LSMH/NTUA. The latter is a very handy and reliable system of seven strap-down accelerometers (Fig. 1.3) to measure the six D-O-F dynamic responses of ships and models. The full non-linear system of equations of motions is used to derive the six D-O-F motions. The system was used onboard of large ships and small models with very satisfactory results. An example of the system evaluation for a model attached on a five-component dynamometer in the towing tank is presented in Fig. 1.4. The pitch motion time history calculated from the data collected by the six D-O-F system compares very well with the one directly measured via the potentiometer sensor on the dynamometer.

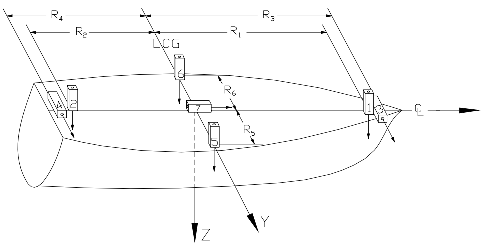

Figure 1.3- Layout of the seven accelerometers to derive the six D-O-F motions of a floating body.

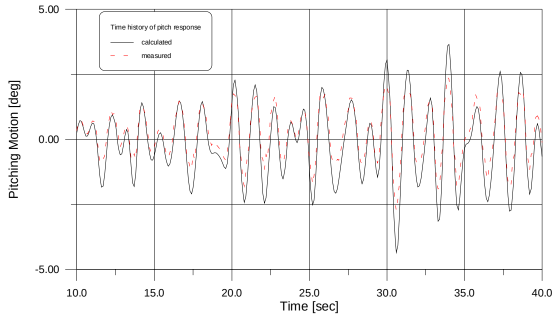

Figure 1.4- Comparison of the pitch response of a model as calculated via the six DOF system data and directly measured via the potentiometer of the dynamometer.

Events Measuring (recording) Seakeeping: One of the known shortcomings of seakeeping tests in a Towing Tank is their inability to model seakeeping events correctly such as slamming, deck wetness and propeller emergence.

Figure 1.5- Testing at high model sea states.

The true realism of testing at sea (Fig. 1.5), in conjunction with proper instruments and video recording (using special cameras) of the events, is one of the advantages of testing at sea.

In the same context, only at sea can one measure the dynamic behaviour under extreme wave conditions, such as survivability and safe passage.

Added Resistance and Power in Waves: The measurement of the added resistance and power in waves, corresponding to the propulsion system of the model, outboard motor / model at the ship propulsor, is a free fringe benefit of testing at sea.

Observing the Results in Real Time: The realism of seakeeping tests at sea is enhanced by the possibility to observe the video recording of the tests in real (ship) time, which is now readily done by exploiting digital recording.

Manoeuvring Tests. Free running models are being used for manoeuvring tests as a standard procedure. The results of this way of testing are now better, when the model track is monitored by a Real Time Kinematics (RTK) System. This generation of satellite based systems, which use the phase of the carrier signal, can record up to 20 times per second the instant position of the model, compared to single measurement per second capability of the standard GPS, while they also significantly improve the accuracy to 1-2 cm in the horizontal plane.

An additional advantage of testing at sea is that the manoeuvring characteristics of the model in waves can now also be determined.

Examples of Testing Large Models at Sea.

1. LSMH/NTUA testing of a 9m model of a naval ship. This extensive series of testing at sea was just completed with rewarding results (Fig. 1.5).
2. Within the scope of the EEC sponsored research project EFFISES the LSMH of NTUA tested at sea a 9m by 3m model of a surface effect catamaran (Fig. 1.6).
3. With the scope of EEC sponsored research project VRSHIPS/ROPAX, a model designed and constructed by SIREHNA of an innovative 240m fast ROPAX designed by Chantiers de l'Atlantique, is being tested by SIREHNA and LSMH/NTUA in August and September 2005. This platform is composed of two segments connected to an elastic beam in order to model at scale the first longitudinal bending node of the full-scale ship. The beam is equipped with strain gauges to measure the vertical bending moment on waves. The platform is also equipped with an automated system which allows you to program a mission (speed/course, way-points) and of a set of sensors for motion and trajectory measurements. The main particulars of the platform (Fig. 1.7) are: L_{OA} = 11.75m, Beam = 1.60m and Displacement = 2.3mt.

Figure 1.6- Testing the model of EFFISES at sea.

Figure 1.7- VRSHIPS/ROPAX testing platform.

1.3 Contribution to the 24th ITTC Seakeeping Committee by Anton Minchev, FORCE Technology, Denmark, on the ITTC Recommended Procedure 7.5-02-07-02, "Predicting of Power Increase in Irregular Waves from Model Experiments in Regular Waves"

The above Procedure derives the power increase in irregular waves from experiments in regular waves. The Committee claims that this approach is superior compared to the direct self-propulsion tests in irregular waves, because of the possibility to calculate power increase in any arbitrary irregular wave condition, by multiplying the added power response function (derived from regular wave self-propulsion tests) with the corresponding irregular sea state wave spectrum. This is in general true, but practically equally or (in some cases) more time and labour consuming than performing direct irregular seakeeping tests. Indeed, the recent commercial seakeeping testing practice at FORCE Technology shows that the significant majority of the seakeeping tests for self-propelled vessels are performed at irregular sea states (typically one or two sea states and three to four ship speeds at each sea state). This is a requirement, normally originating from the vessel building specification, where the vessel performance, attainable speed/power requirement, is usually specified within certain given sea conditions, either BF wind speed and associated waves, or directly with a given wave spectrum, significant wave height and period. Furthermore, the results from the self-propulsion seakeeping tests in the specified irregular waves are used to derive general vessel responses, such as motions, accelerations, rarely occurring events and slamming. Hence the experimental time to conduct these tests is optimised to cover all necessary experimental information for subsequent seakeeping performance evaluation.

The present written contribution presents in brief, the technical procedure used at FORCE Technology to predict directly the required power and propeller revolutions in the specific irregular sea state conditions tested. The approach refers only to head or following sea conditions, at which the tests are possible to be carried out.

- Prior to the actual seakeeping runs, some still water self-propulsion control runs are normally performed to account for corrections of the wave probes mounted on the model. The ship model is free-sailing during the seakeeping runs with zero towing force, at the model self-propulsion point. Repetitive runs are normally conducted to accumulate necessary full-scale run duration (20 to 30 min). Average model speed, propeller thrust, torque and revolutions are logged.
- Required towing force F_D including associated wind force F_W is calculated for the respective sea states and vessel speeds.
- For each ship speed the average measured propeller torque and RPM are plotted, together with still-water self-propulsion test reference data, as function of towing force F_D, as shown in Figs. 1.8 and 1.9. As seen, the still water $Q = f(F_D)$ and $RPM = f(F_D)$ could be very well approximated with straight lines, providing a basis for different loading (F_D value) correction. Assuming equal slope, the required (sea-keeping tests) $Q = f(F_D)$ and $RPM = f(F_D)$ are constructed through measured torque and RPM (at zero F_D) values.
- With calculated F_D value as input, accounting for model-ship correlation, as well as wind effect, the corresponding model propeller torque and revolution values are determined, and subsequently propeller full-scale shaft power and revolutions are finally calculated, as illustrated in Fig. 1.10.

The advantages of the method are: relatively short seakeeping experiment combined with the measurements of the other vessel responses; calculated full-scale shaft power accounts for the effect of actual towing and wind forces; alternative propeller loading conditions could be easily checked by simply varying the required towing force; separate effect of waves and wind on shaft power could be calculated when necessary, as shown in Fig. 1.10.

The disadvantages of this approach are that the results are applicable only for the specific sea states tested. This could be partly compensated for by constructing family curves of required shaft power versus wave height at constant speed values, on basis of experimental results from the actual sea conditions tested, for example Hs = 0m, still water, Hs = 2m and Hs = 4m. Quick approximate checks of added power in different sea states could be easily performed by simple interpolation.

When revising and updating Procedure 7.5-02-07-02, the Seakeeping Committee is recommended to review and consider not only regular wave test basis, but also added power/speed loss procedures based on self-propulsion tests in irregular sea states. The current tank practice indicates that this is the more frequently used approach.

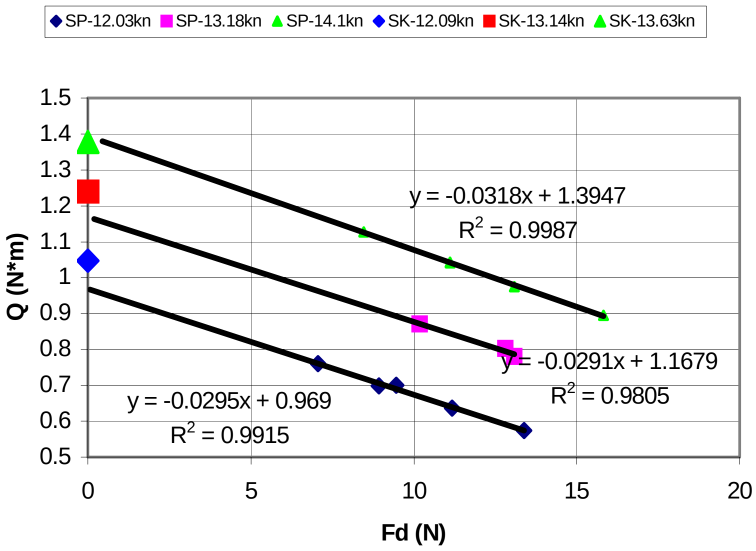

Figure 1.8- Plot of Model Torque for Towing Force Correction.
(‘SP’ stands for self-propulsion in still water; ‘SK’ stands for self-propulsion in waves)

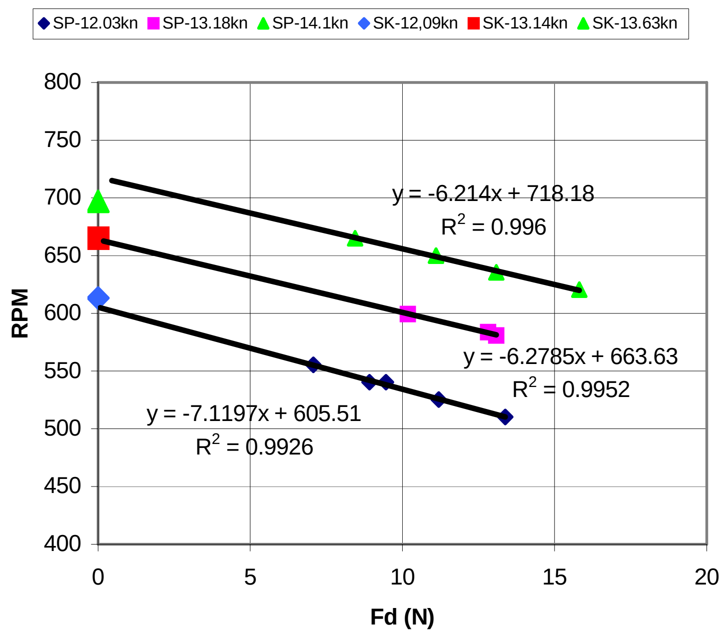

Figure 1.9- Plot of Model RPM for Towing Force Correction.
(‘SP’ stands for self-propulsion in still water; ‘SK’ stands for self-propulsion in waves)

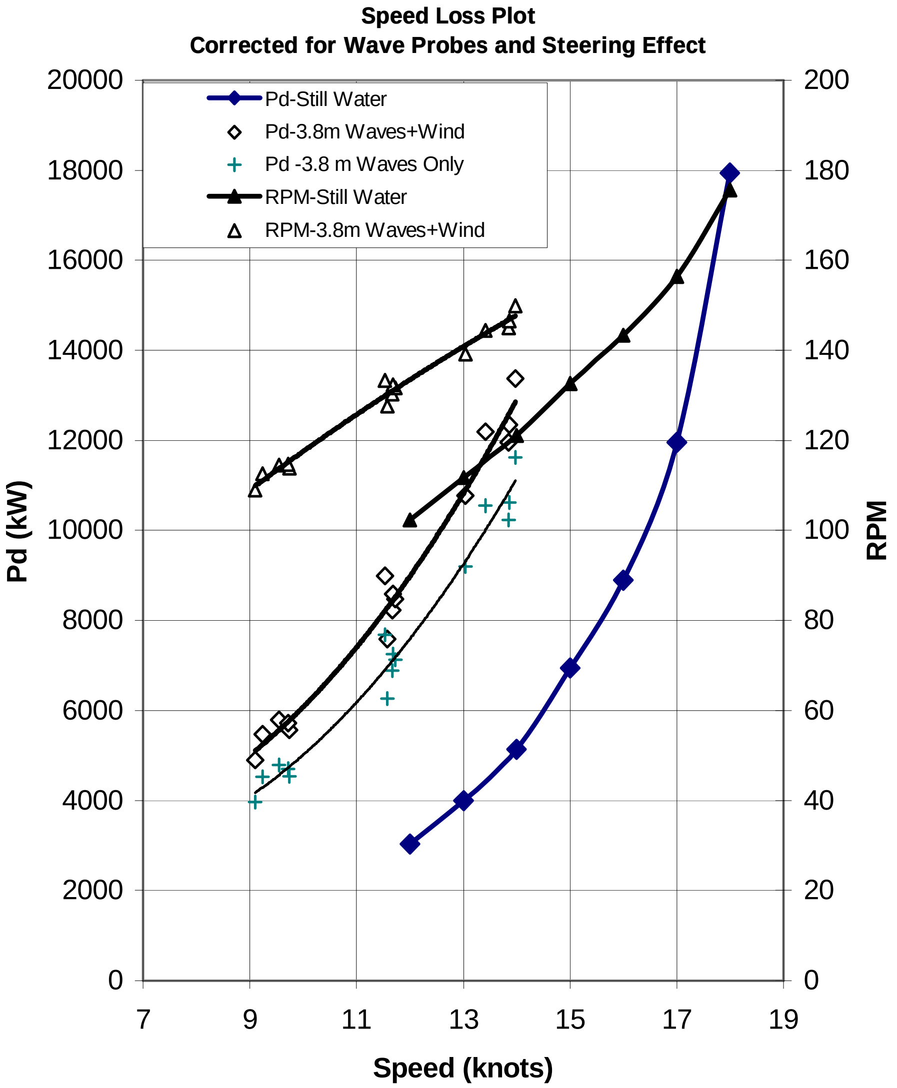

Figure 1.10- Speed Loss Plot.

2. COMMITTEE REPLIES

2.1 Reply of the 24th ITTC Seakeeping Committee to Young-Woo Lee

We agree that the onset of and the magnitude of parametric rolling are quite susceptible to the initial conditions and the irregularities of waves. This fact is closely associated with the non-ergodic nature of parametric rolling, which we indicated in our presentation in the 24th ITTC.

From the point of view of ship design and operation, the extraction and quantification of the general features contributing to the parametric rolling of a particular ship that could be used for her design and operation is problematic. It also makes it difficult to obtain statistically meaningful results in tank experiments, as we indicated in our presentation in the 24th ITTC and you indicated as well.

Regardless, we agree that these problems associated with parametric rolling should be continuously dealt with in the next ITTC Committees.

2.2 Reply from the 24th ITTC Seakeeping Committee to Theodoros Loukakis, Gregory Grigoropoulos, Georgios Katsaounis, and Philippe Corrignan

We agree that a large-scale model test in real seas has plenty of advantages compared to a model test in an experimental tank, as you indicated. It may be a good idea to include the procedures for testing in real seas, such as those you proposed, in the current procedures on experiments, but we leave the judgment to the next Seakeeping Committee.

2.3 Reply from the 24th ITTC Seakeeping Committee to Anton Minchev

We understand that the objective of making the Procedure on "Predicting the power increase in irregular waves from model experiments in regular waves" is not to identify one particular method, but to recommend methods which the ITTC considers scientifically and technically reasonable and feasible. In this respect, we think the method you proposed is certainly worth being considered for inclusion in the procedure, but, again, we leave the judgment to the next ITTC Seakeeping Committee.