Kroes en Poortinga

Results and recommendations for high speed craft

An literature investigation into the speed and seaworthiness

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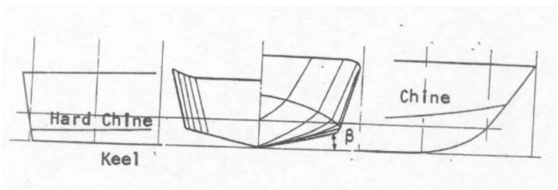
PREFACE

The research is split into two subjects, namely resistance calculations and the hydrodynamic features of the planing vessel. There is a lot of information available on the subject of high speed crafts, but not all methods apply to the scope applicable to the design. In example, there are no references made in the sources that calculate or descibe the effect of a tube on the ship. Of course the tube has a large portion in determining the sea worthiness, and several choices in respect to the sea worthiness and the tube are stated later on in the recommendations.

GENERAL BEHAVIOR OF SHIPS IN VARIOUS SPEED CONDITIONS

there are roughly three speeding conditions in respect to behavior in ships, namely displacement, semi displacement and full planing. Typical for the full planing speeding area, a hull is described to be a hard chine hull. When a ship is planing, it means that significant positive dynamic pressure act on the bottom of the ship. These positive pressures lift the hull and thereby reducing the buoyant component of the hull. Although this effect reduces the wetted area, and thereby the drag, the additional drag that comes from the dynamic lift results in a greater resistance weight ratio than that of displacement vessels.



To describe a typical lines plan the following features are evident:

- ✓ There are no convex surfaces as this form induces suction pressures in the bottom.
- ✓ Sharp edge chine's at the intersection of the bottom and sides to insure complete separation of the transverse flow component from the bottom, hence reducing wetted surface. This also gives the hull more dynamic lift.
- ✓ A deeply submerged wide transom with a sharp edge in the back to insure a complete ventilated transom, when in planning mode. This is to ensure there are no turbulent flows in the aft section.
- ✓ Straight horizontal buttock lines at the aft end.
- ✓ Vee bottom transverse sections with the deadrise increasing towards the bow. The deadrise is required to reduce the wave impact loads in a seaway and to provide lateral wetted surface required for course keeping stability and maneuvering. Naturally, the more deadrise, the better the course keeping stability, but the more power required to power the ship at an desirable speed.

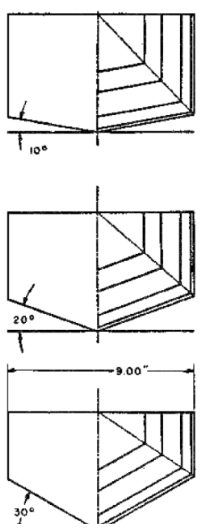
Resistance calculations

In order to determent the resistance of a ship, a number of calculation methods are presented on the internet to calculate the resistance in the planing regime. For this investigation, Savitsky is chosen to be used for this design. The major advantage of this method is that it's relatively easy to make an calculation, and programmable in an excel sheet. Also, using the Blount and Fox engineering factor, this method is accurate for many prismatic hull forms, even when not in planing condition, and with various deadrise angles.

The Savitsky calculation method uses deadrise angle, ship weight, maximum chine beam and LCG. Unfortunately, for wave resistance calculation the design fails to comply to the given range of applicability, hence making it inaccurate for the design.

In order to investigate the optimal condition for the design, a selection of parameters are altered to determine what the effect is of the changing parameter. The ship weight has been determent as a fixed parameter. That leaves three parameters for changing.

Deadrise; this is the value that describes the rake of keel in the transverse view of the ship. In Savitksy, the deadrise plays an vital role in the determination of the flat bottom lift coefficient. This poses a problem in the determination of the best deadrise angle. It is obvious that zero deadrise is the best deadrise for a planning craft, as the deadrise is used as an factor for the flat planning surface, increasing its value as it increases. The deadrise will be determent as a factor in the sea worthiness. Results in variations in respect to resistance are given in Appendix B.



FIGUUR 1 DEADRISE VARIATION

LCG; The LCG can easily be adjusted in the design, because the lower deck of the ship has little requirements. The LCG is a value that contributes to the resistance because it is a value that has effect on the running trim angle. Savitksy states in his rapport that a favorable running trim angle is in the region of 3 or 4 degree. If the design has that trim angle, the resistance is at his minimum. Of course the LCG has to be of a practical value, so for the alteration, the value's are chosen within a range of 46% to 40% of LWL. Around 19 kn is the line were the ship tends to plane. In Appendix A the results are presented for the variations in trim, and proof is presented for the statement made by Savitsky. The intended LCG is 5,7 meter, if possible in respect of general arrangement. The reason to choose this value is the behavior of the ship before 32 kn.

For practical reasons the chine beam is limited to the installed engine power. The client asked for a specific engine type for towing arrangement and requested a lowered aft cockpit. Therefore in order to maintain a practical aft ship arrangement, the beam is set at 3.6 meter.

SEA KEEPING STABILITY

Assessing the sea keeping stability is a difficult subject when dealing with planning vessels. There are several options to use for predicting the ships motions in high seas. There are hydrodynamic analysis, statistic, or statisical studies. There is an analytic study made by Fridsma and later by Zarnick. Zarnick constructed a low aspect ratio strip theory, bases upon this theory POWERSEA predicts the motions and added resistance of waves for planing hulls. Hydrodynamic analysis consist of a CFD calculation, or tank tests.

The first two options are not feasible, as they require expensive software and experience in the field of advanced mathematics. Although these studies are very interesting, for this project these studies are too time consuming. The statistical study made by Savitsky and brown was based upon the work of Fridsma. Unfortunately this is not for the design applicable. The reason is that it is statistical, and although it is a easy method to use, the range is limited as the design has to have similar features in respect to the test ships.

Besides prediction methods, there are several studies found on the internet that describe design choices of the hull. These support the gut feeling in respect of sea keeping behavior of ships.

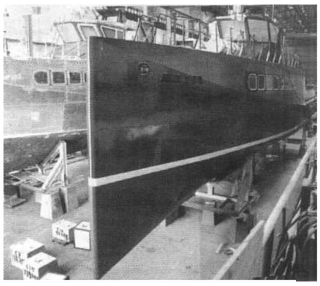
One of the important questions in sea keeping analysis is what the functions are the boat has to have. Therefore a large beam is favorable, because in this case, the design has to be able to withstand storm conditions, and be able to provide the crew with a stable platform for rescue tasks. In respect of the resistance calculations, this function is in conflict with designing a ship with a low power speed ratio.

Another conflict in resistance versus sea keeping is the deadrise angle. in respect of speed, the fewer the deadrise, the better. In respect of sea keeping capability's, the more deadrise, the better. This conflict gives a comforting thought, namely you can't really go wrong. For practical reasons, the design will have a deadrise angle between 15 and 20 degree at the mid ship, and the bow region will be more, 45 degree.

Another problem that is of great importance, is slamming. This phenomenon happens when the bow of a ship is lifted out of the water, or a ship shoots thought the water from crest to crest. Several changes can be made to make slamming less demanding for crew and passengers. As the ship will be fitted with a large rubber tube, it is important to contemplate what this does with wave tolerances.

FIGUUR 3

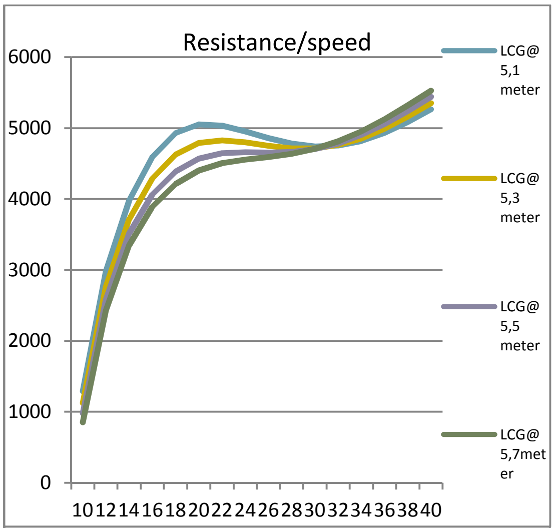
when the tube gets submerge in water this additional buoyancy component will give a considerable acceleration at the bow, resulting in violet motions in the wheel house. "figuur 2" gives a good example of this effect. In the new design, the tube and pushing equipment will be raised. Another design change is reducing the bow flare. A lot of bow flare will give the ship a lot of additional buoyancy in waves. A small amount of bow flare will give the ship less buoyancy, hence letting him be more susceptible for nose diving. The problem of nose diving can be overruled by deepening the fore foot, hence creating more buoyancy in the front. Therefore the nose of the ship will have rather steep buttock line at the stem. An example of this method is shown in "Figuur 3".



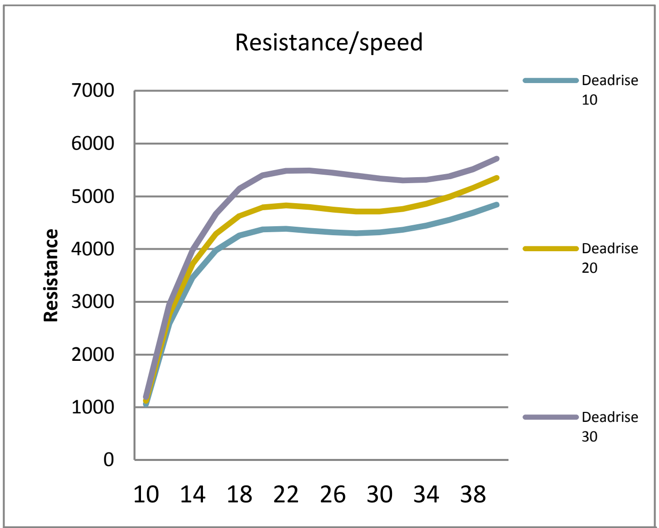
FIGUUR 2

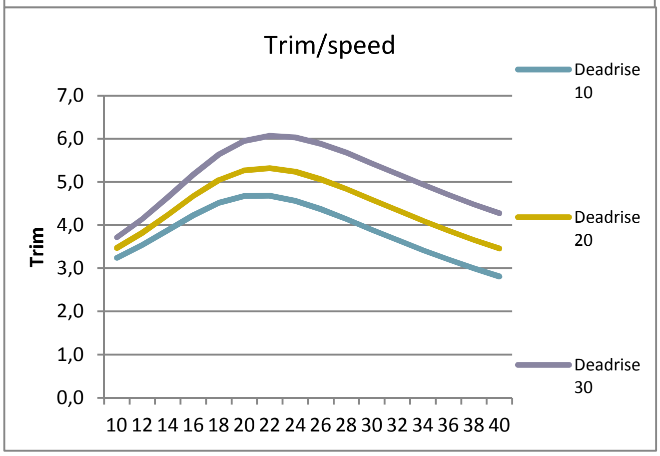
This is not applicable for this design, but the process of thought and principles are more or less the same.

Appendix A: LCG variation in Savitsky calculation



Appendix B: Deadrise variation in Savitsky calculation





Testrun Kroes en Poortinga tender, @0.45 wave impact
http://www.youtube.com/watch?v=QJkACoru-30&NR=1&feature=fvwp

Broaching
http://www.youtube.com/watch?v=EIG9HNML5zw&feature=related

1. Savitsky and Brown, Procedures for hydrodynamic evaluation of planing hulls in smooth and rough water, october 1976
2. The prediction of porpoising inception for modern planning craft, Tulio Celano, 1998
3. James p Day, Richard J Haag Planing boat porpoising, webb institute of naval architecture New York 1952
4. Donald L.Blount and David L. Fox small craft power prediction jan 1976 marine technology
5. Optimal deadrise hull Analysis and design space study of naval special warfare high speed planning boats, todd E Whalen, 1995
6. The effect of bowshape on the seakeeping performance of a fast monhull, Keuning Toxopeus, Pinkster, FAST2001
7. Dynamic Analysis of Planing Hulls in the vertical plane, Richard H. Akers, 1999
8. http://www.proteusengineering.com/softwareupdates.htm
9. “planning Craft”,chapter IV Naval Engineers Journal febr. 1995
10. Principles of Yacht design Lars Larsson, Rolf E Elaisson 2007