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Performance evaluation of the Triade concept

Summary of the Computational Fluid Dynamics, Velocity Prediction Program, and Resistance CalculationsPP – R&P

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Ordered by:

Mr. G. J. Bilkert and Mr. M. G. Reissenweber.

Author(s):

M. Bovio M. Eng; N. Moerke M.Sc. B.Eng.
Van Oossanen Naval Architects b.v.
Costerweg 1B
6702 AA, Wageningen
The Netherlands
www.oossanen.nl

Approved by:

Dr. Peter van Oossanen)

CONTENTS

1. INTRODUCTION

The Triade concept, developed from an idea by Mr. G. J. Bilkert, is a trimaran in which the centreline of the side hulls, in transverse view, is set at a specific angle to the vertical. This arrangement of the side hulls allows for a nearly symmetrical hull form when the hull is sailing at heel angles approximating those of a sailing yacht beating to windward. This arrangement also allows for a significant reduction of the phenomenon referred to as “box slamming”, which occurs in the case of conventional catamaran-, trimaran- and SWATH hulls in waves, when the deck between the hulls is hit from below by a wave. The decreased spacing between the hulls with increasing height above the water surface of the Triade hull allows for significantly more damping in heave and pitch than in the case of more conventional hull forms. In addition, the Triade concept possesses positive stability up to heel angles in excess of 90 degrees, the angle of vanishing stability being considerably higher than in the case of other multi-hull configurations. Finally, in the case the hull is adopted for a sailing yacht, the draft of the hull to the bottom of the keels on each side hull is small, and no lead ballast is needed such as is the case with a conventional sailing yacht.

The original Triade hull form was the subject of an extensive model test program at the Maritime Research Institute Netherlands (MARIN)some years ago. The research programme included tests on 2 variants of the base design prepared by Triade b.v., the company set up by Mr. Bilkert and partners for the purpose of developing the concept.

Early in 2010, messrs. Bilkert and Reissenweber approached Van Oossanen Naval Architects (VONA) for the purpose of further developing the hull form and the design based thereon. The initial evaluation revealed that the concept suffered from a high rise in resistance at and above hull speed because of an unfavourable wave interaction between the hulls. VONA carried out a large series of Computational Fluid Dynamics (CFD) calculations to determine how to reduce this wave interaction. These calculations are reported on in VONA Report No. 10-008-690-016, in June 2012. It was found that if the spacing between the hulls is to remain largely unchanged, the only way this can be achieved is by the fitting of foils between the hulls forward and aft, to control longitudinal trim and to provide some degree of foil-assist. Further optimization of the hull forms finally led to a configuration in which the rise of the resistance curve at and beyond the hull speed was reduced by some 50%.

This report presents a brief summary of the optimization and performance-evaluation work performed for the Triade concept, for a base design with an overall length of 15 m, for both sailing and motor yacht variants. Figures 1.1 and 1.2 provide an impression of the geometry, of the hull form up to deck level.

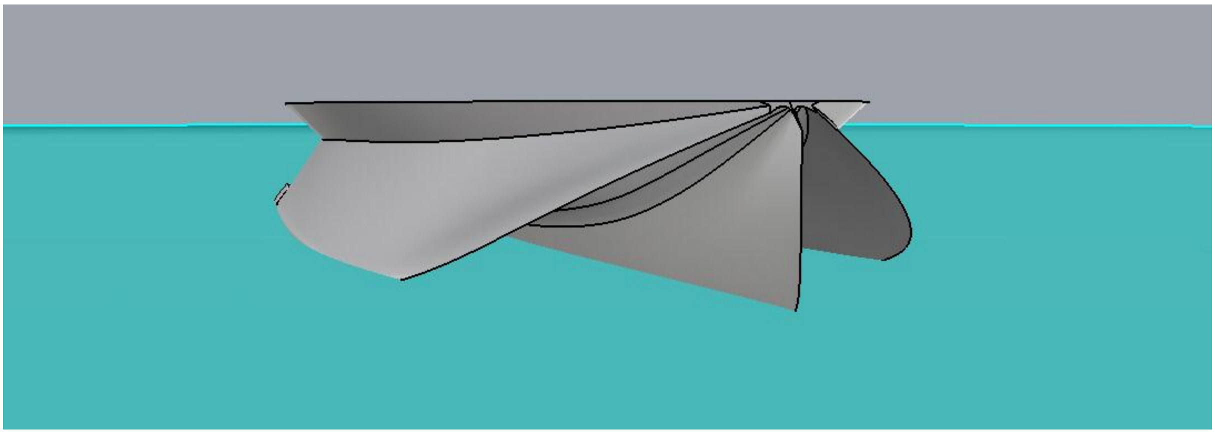

Figure 1.1 Impression of the Triade concept for a motor yacht

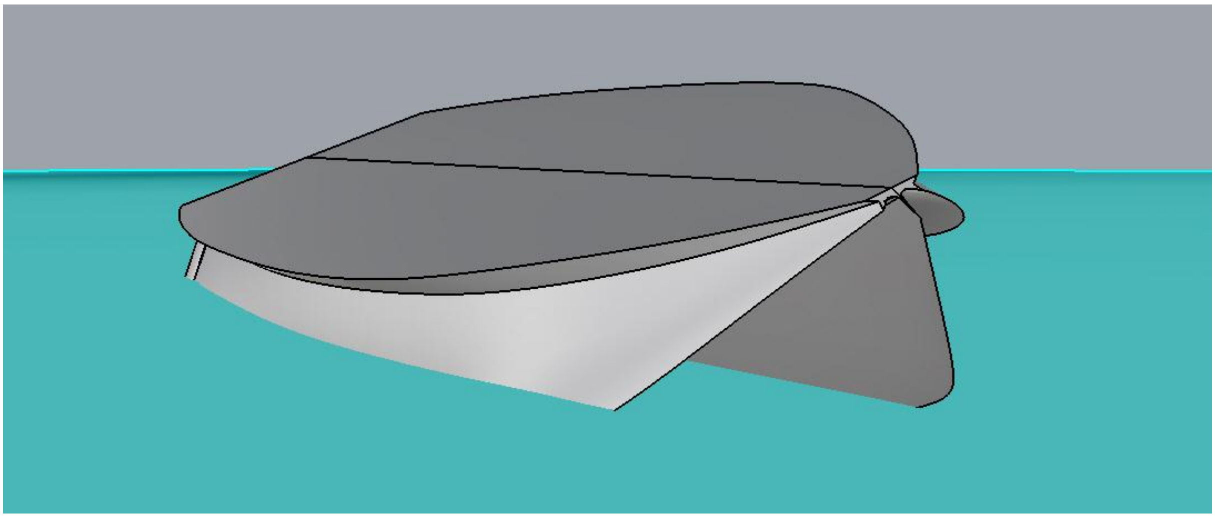

Figure 1.2 Impression of the Triade concept for a sailing yacht

In this report the results are reviewed of the optimisation work using CFD software, the results of Velocity Prediction Program (VPP) calculations for the Triade hull when adopted for a 15 m sailing yacht in comparison with a well-known 50 ft sailing yacht of conventional design, and a comparison of the performance of the Triade hull when used as a motor yacht in comparison with two other, more conventional motor yachts.

An overview of the CFD runs carried out for the finally-derived hull form is given in chapter 2. Chapter 3 provides details of the VPP calculations for the Triade concept when used for a sailing yacht and shows the comparison of the obtained polar performance with the polar performance of a conventional 50 ft sailing cruising yacht. Chapter 4 gives the resistance comparisons between the Triade concept and two motor yachts. Discussions of the results and conclusions are given in chapter 5.

2. COMPUTATIONAL FLUID DYNAMICS (CFD) CALCULATIONS

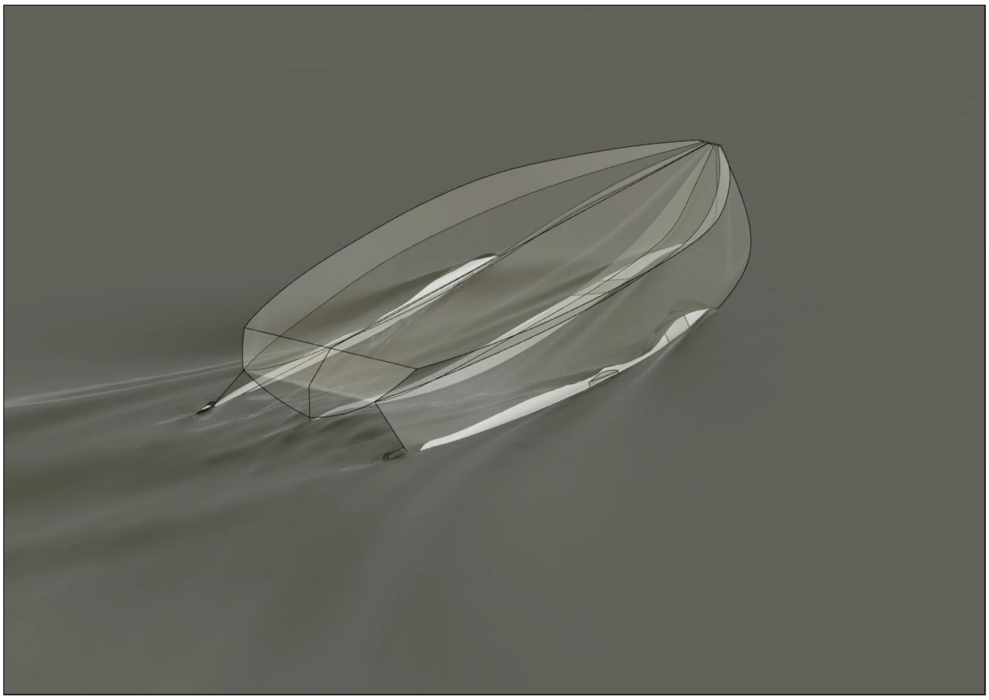

Figure 2.1 Shaded wave pattern around the hull, as seen from aft.

Figure 2.2 Shaded wave pattern around the hull, as seen from the front.

Results for the optimized hull shape sailing upwind:

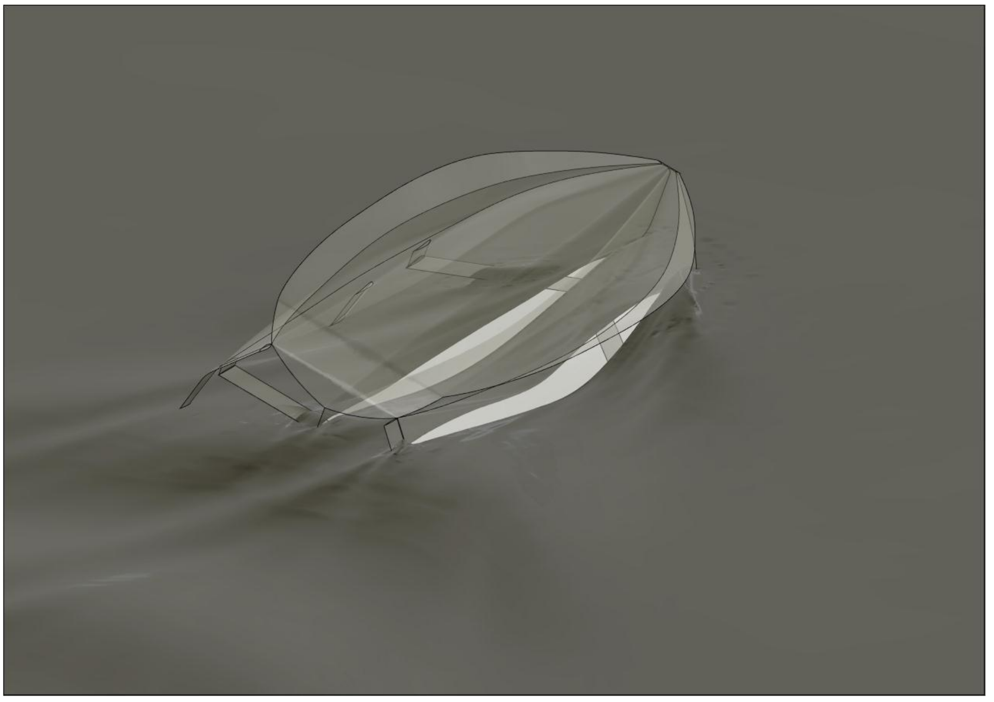

Figure 2.3 Shaded wave pattern around the hull, as seen from aft.

Figure 2.4 Shaded wave pattern around the hull, as seen from the front.

3. VELOCITY PREDICTION PROGRAM (VPP) CALCULATIONS

3.1 INTRODUCTION

To evaluate the performance of the Triade hull when adopted for a sailing yacht a Velocity Prediction Program (VPP) analyses was carried out and compared with the results of the same VPP calculations for a conventional 50 ft mono-hull sailing yacht.

The main particulars of the yachts are:

Table 3.1 Main particulars of the conventional 50 ft sailing yacht and the Triade

Data	Units	Conventional sailing yacht	Triade
Loa	m	15.00	15.43
Lwl	m	12.90	15.28
Boa	m	4.58	6.50
Bwl	m	4.06	6.48
Tmax	m	2.00	1.60
Deck area	m^2	49.10	76.18
Displacement	tonnes	18.00	13.00
Sail area	m^2	124.4	124.3 (incl. gennaker)
GZ @ 10°	m	0.28	0.63

The main input parameters for a VPP are:

1. Overall dimensions of the hull such as length of the waterline, beam of the waterline, displacement, etc.;
2. Sail plan dimensions;
3. Stability characteristics;
4. Resistance curve.

The weight and centre of gravity location, and the sail plan geometry, were based on preliminary design drawings prepared earlier by Triade b.v. Due to the specific hull shape of the Triade concept the GZ curve is rather unusual as shown in Figure 3.1.

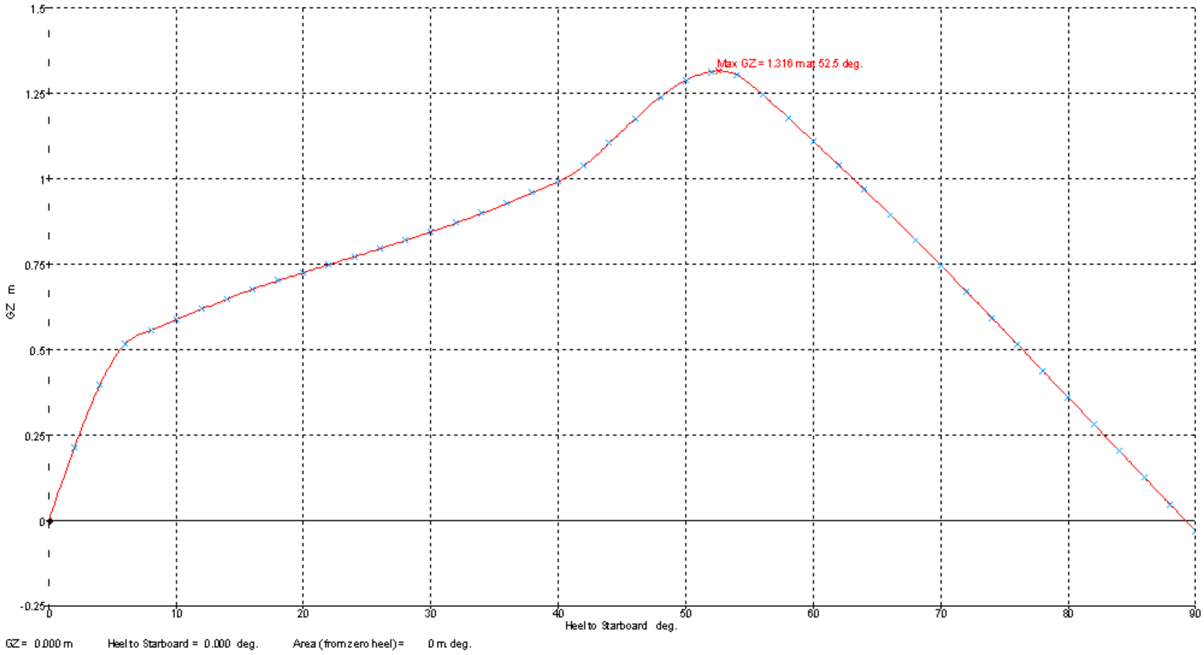

Figure 3.1 GZ curve of the Triade concept

The first part of the stability curve of the Triade is steep, resulting in a stable yacht. At around 6 degrees of heel the gradient of the stability curve is less but increases to a relatively high value at heel angles in excess of 50 degrees. The stability remains positive up to heel angles of approximately 90 degrees for the configuration studied. This represents a vast improvement over the GZ curves of conventional catamarans and trimarans. No superstructure was taken into account in the subject hydrostatic model. A watertight superstructure will improve the stability even further.

3.2 Results of VPP calculations

The results of VPP calculations are typically presented in a so-called polar diagram. For the Triade concept as optimized using CFD, the results are shown in Figure 3.2. These VPP calculations were performed with the well-known program WINDESIGN developed by the Wolfson Unit of the University of Southampton.

A similar set of calculations was carried out for a well-known cruising sailing yacht of 50 ft in length. The results are shown in Figure 3.3. On comparing the figures 3.2 and 3.3 it follows that, except for low wind speeds, the Triade concept offers considerable greater speed potential.

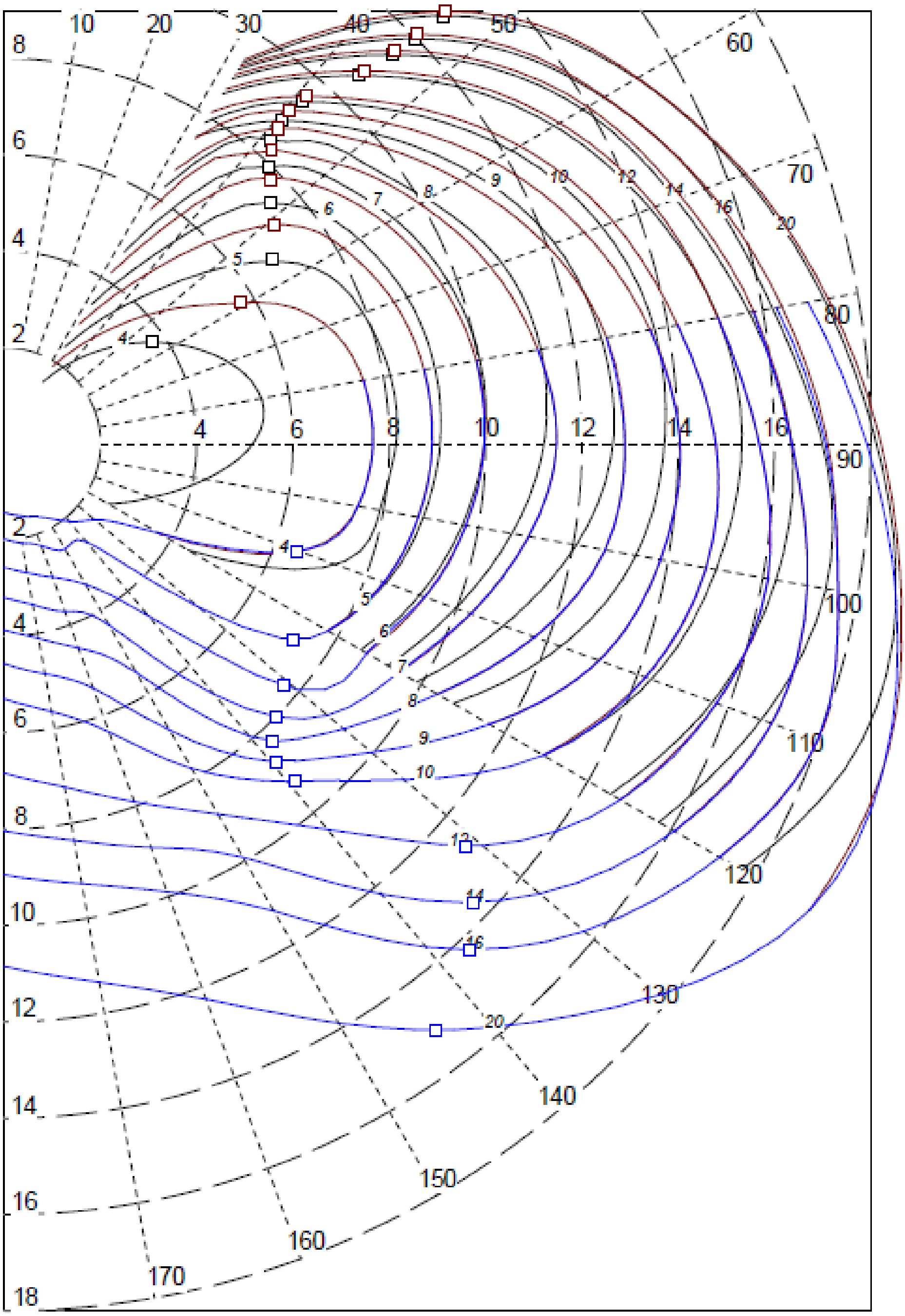

Figure 3.2 *Polar diagram based on VPP calculations showing the sailing performance of the Triade concept. The semi- circular dashed lines are the lines of constant boat speed. The actual performance is plotted as blue lines, one for each considered wind speed (from 4 to 20 knots).*

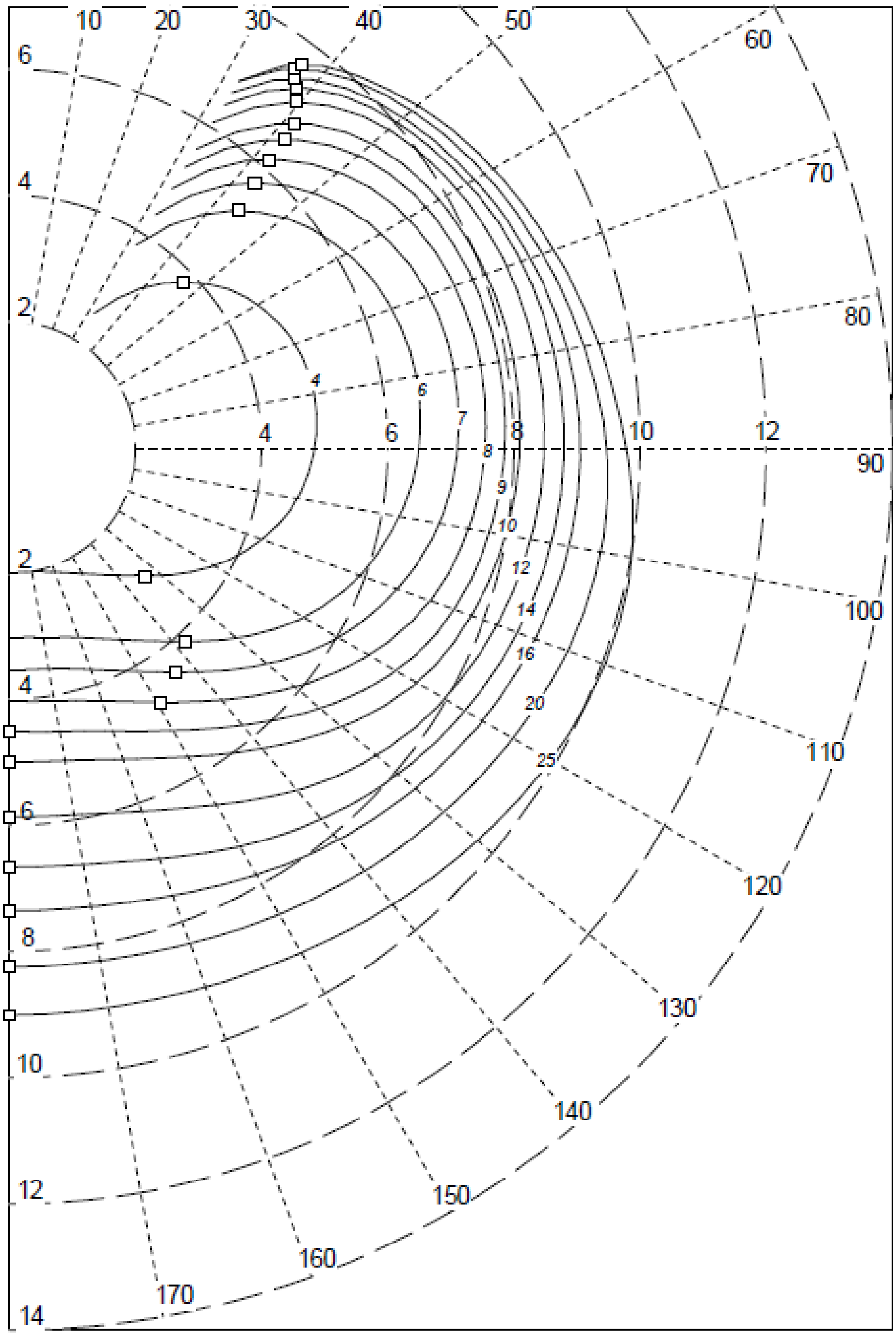

Figure 3.3 *Polar diagram based on VPP calculations showing the sailing performance of the conventional sailing yacht. The semi- circular dashed lines are the lines of constant boat speed. The actual performance is plotted as blue lines, one for each considered wind speed (from 2 to 20 knots).*

4. PERFORMANCE OF THE TRIADE CONCEPT AS A MOTOR YACHT

4.1 INTRODUCTION

The performance of the Triade hull when used for a motor yacht can be ascertained by simply comparing the resistance curves for zero heel and zero leeway angle. This has been carried out using the results of the CFD calculations. The results are compared with the resistance curves for 2 other motor yachts. One of these is a relatively heavy steel motor yacht of the same length (referred to in the graph below as a “Standard motor yacht”). The other is the resistance curve of a high-performance motor yacht designed by VONA. All 3 configurations have an overall length of 15 m. The results of these comparisons are given in this chapter.

4.2 RESISTANCE CURVES

The resistance curves of the three motor yachts are given in Figure 4.1, while the corresponding comparison of the required engine power is given in Figure 4.2.

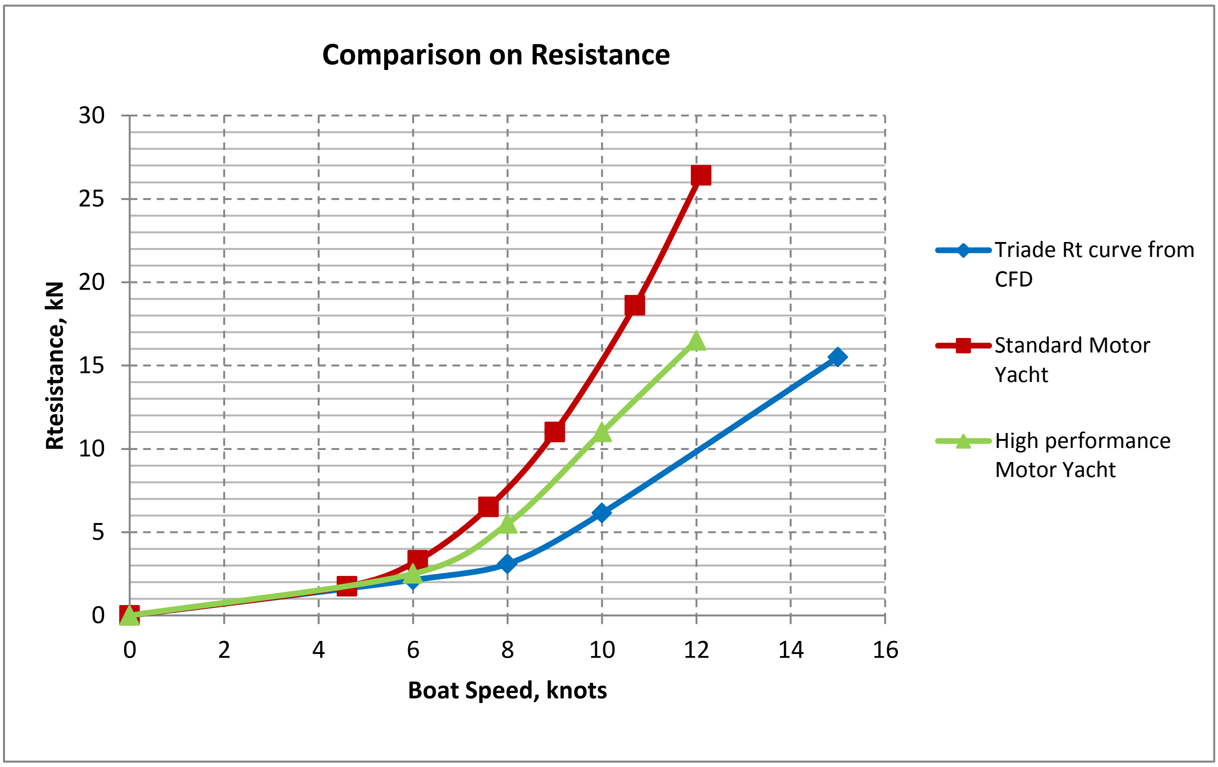

Figure 4.1 Comparison between the resistance curves of comparable motor yachts

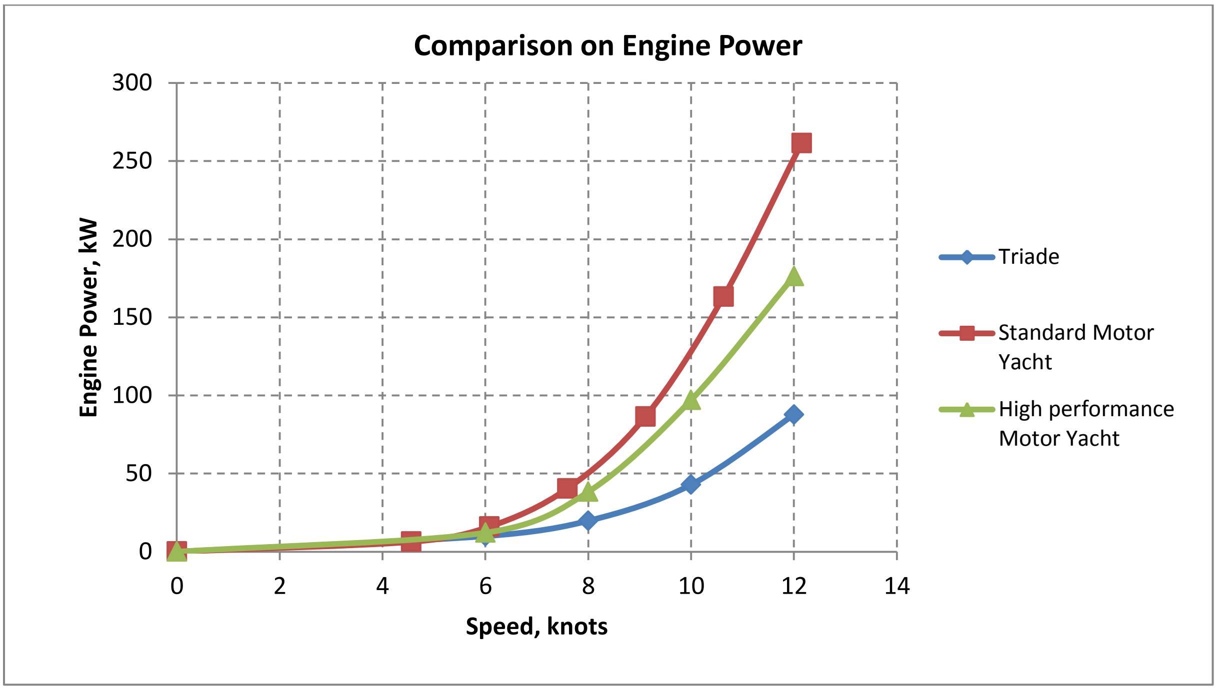

Figure 4.2 Comparison of the absorbed engine power of comparable motor yachts

5. CONCLUSIONS

Based on the results as presented in this report the following conclusions can be drawn:

1. The wave pattern around the Triade hull at 10 knots shows good characteristics. This is displayed by the value of the total resistance, which is low for the considered displacement and length;

2. The Triade concept, as either a sailing yacht or a motor yacht, is capable of reaching speeds in excess of 20 knots;

3. The Triade concept, when used for a sailing yacht, shows greater speed potential at higher wind speeds than in the case of sailing yachts of conventional design;

4. The transverse stability of the Triade concept, for the lengths and displacements studied is positive up to heel angles in excess of 90 degrees;

5. The upwind performance in the case of a sailing yacht, requires the generation of appreciable side force. This needs the incorporation of modest keels on each of the side hulls. These keels are not required in the case of a motor yacht;

6. The comparison of the resistance and power curves of the Triade concept when adopted for a motor yacht show favourable resistance characteristics, particularly at higher speeds.

visit & mail us:

Costerweg 1B

6702 AA, Wageningen

The Netherlands

contact us:

T +31 (0) 317 451573

info@oossanen.nl

follow us:

www.oossanen.nl

@oossanen