Chapter 2
Development of Mono and Multihull Resistance Sustainable Marine Technology Development and Green Innovation

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ABSTRACT

During the last decade, multihull ships have rapidly evolved into a dominant mode of sea transportation. Their particular area of proliferation is in short sea shipping where they show considerable superiority over competitive designs in attributes such as power requirements, economy, space availability, and sea keeping quality. The rapid growth of the market has led to the need for an expanded range of multihull designs in terms of size, speed, and payload diversity (passengers, vehicles, containers). However, even now there is a scarcity of publicly available preliminary design tools for multihull vessels. This fact hinders the ship owner and naval architect from being able to quickly assess the relative merit of alternative potential designs without having to resort to expensive expert consultancy solutions.

INTRODUCTION

Resistance characteristics and power requirements are principal aspects of the multihull design spiral as they are strongly coupled with speed and fuel economy, and, consequently, the operating and cost efficiencies of the vessel. Saving fuel cost is a big economic motivation and naval architects have been creative about producing hull shapes for minimum resistance. In a complementary way, propulsion systems have been made more and more efficient through better knowledge of hydrodynamics. Both of these approaches reduce the amount of fuel burned and in turn reduce the

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amount of greenhouse gas released into the atmosphere. Other ways to reduce greenhouse gases are to use sails to supplement the propulsion power when the wind is favourable and replace fossil fuel with renewable bio-fuel from grains. Alternative technologies take away the need for the internal combustion engine. These include providing other power sources such as solar panels, wind turbines, and fuel cells for either propulsion systems or life support systems. The purpose of this chapter is to give insight, through studies and a wide range of illustrations, into how multihull resistance performs, how hull resistance improves, including its propulsive efficiency, and, most importantly, how this multihull deals with the important issue of Sustainable Marine Technology Development and Green Innovation.

DEVELOPMENT OF MONO AND MULTIHULL CONFIGURATION

Fast displacement ships are of interest due to low cost to build and less weight critical characteristics compared to Advance Marine Vehicles (AMVs). Fast displacement ships are defined as vessels operating above Fr= 0.4 based on the waterline length. Between Fr= 0.4 and 0.5 (pre-primary resistance hump regime) displacement ships experience significant wave resistance. This is because the hull length is less than one wavelength. The bow is supported by the peak of the wave while the stern is only supported by the hollow. The result is an unfavourable bow-up trim. Broad transoms and flat buttocks are required to minimise the bow-up trim. In order to minimise the power requirement, $L/V^{1/3}$ values > 8. Typical ships operated in these conditions are frigates and destroyers. In so called post-primary resistance hump regime (0.5< Fr <0.7), the displacement ship experiences wave length of more than twice the waterline length. The wave resistance is mainly made up of the bow wave. Hence it is essential to reduce the bow wave in order to minimise the power requirement, i.e. to reduce the bow-up trim. This can be achieved by very fine bowlines, known as slender ships. $L/V^{1/3}$ must be in excess of 10. These ships have improved sea-keeping properties over their higher displacement counterparts.

The Froude number range between 0.7 and 1.0 is the regime of the so called semi-displacement or semi-planning hulls (Figure 1) (Insel, 2000). If the hull has suitably designed flat buttocks, a significant amount of dynamic lift (20% - 30% of the displacement) is generated. This causes appreciable reduction in the wetted surface. $L/V^{1/3}$ values are in the range of 6 to 7 at the higher speeds. Here the ship beam becomes more important for the generation of dynamic lift. Speeds in excess of Fr= 0.7, the dynamic lift generated by the hull reaches more than 50% of the hull displacement. This is called planning craft regime. The hull features a hard chine and/or well defined spray rails. Length displacement ratio ($L/V^{1/3}$) is typically between 4-5 for calm speed, 6-7 for rough sea operation. V sections are used with convex or concave lines (see Figure 1). In the planning hull, the speed is superior to a comparable size displacement vessel, the behaviour in a seaway is not so.

Figure 1. High speed semi-displacement hard chine form (Insel, 2000)