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An experimental study of interceptors for drag reduction on high-performance sailing yachts

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ABSTRACT

Interceptors have been widely used in recent years in fast ferries and small high-speed leisure and commercial craft for ride and trim control, and steering. In the context of high-performance sailing yachts, they first appeared in 2008 on the yacht Ecover 3 which was dismasted while leading the Vendee Globe Challenge race. However, in spite of their popularity in power craft, few studies have been published investigating the impact of interceptors on vessel performance, and apparently none in the case of sailing yachts. In the current study, interceptors are compared with an aerodynamic device known as a Gurney flap. It is shown that interceptors are generally substantially smaller than Gurney flaps. A comprehensive experiment programme is presented exploring the impact of interceptors on the performance of an Open 60 yacht hull. Results show a marked reduction in calm-water resistance over a wide speed range, with benefits of 10–18% in the speed range between 8 and 20 knots, accompanied by reduced sinkage and trim. The gains observed are much larger than those observed in powercraft, and also substantially greater than those achievable through trim changes by moving ballast longitudinally. The benefits appear to be largely sustained in small waves.

1. Introduction

An *interceptor* essentially consists of a thin plate fitted on or near the transom of a boat approximately normal to the centreplane, and extending either vertically or transversely beyond the section at the stern. The interceptor modifies the local flow near the stern to generate substantial additional pressure normal to the hull surface. The concept is related to an aerodynamic device usually referred to as a *Gurney flap*, developed in the 1970s for car racer Dan Gurney to improve down-force on the rear wing of his *Olsonite Eagle* Indycar (Fig. 1(a)). In its simplest form the Gurney flap consists of a small vertical fence fitted in the span-wise direction along the high-pressure side of the trailing edge of an aerofoil. These devices have been widely studied in a variety of aerodynamic applications in recent years.

Interceptors became well-known as active ride control for high-speed catamaran ferries in the early 2000s. Their relatively low mass allows rapid movement, and they can thus be used to compensate for first-order wave-induced motions, allowing pitch and roll motions in particular to be reduced. When fitted to the side of the transom on water-jet powered vessels, they allow the possibility of steering without the requirement of vectoring the thrust (Fig. 1(b)). In recent years they have also become increasingly popular as trim and heel control devices for moderate to high-speed power craft, particularly for semi-planing and planing hull forms, offering the kind of performance benefits possible with trim tabs or transom wedges, but with the potential for simpler, cheaper and more compact installation, easier adjustment, lower power requirements, and reduced risk of damage from floating debris (Fig. 1(c)).

Similar benefits can potentially be achieved on high-performance sailing yachts, where rules permit. Possibly the best known example of a sailing yacht fitted with an interceptor is the Owen Clarke-designed IMOCA (International 60 ft Monohull Open Class Association) Open 60 class yacht *Ecover* 3 (Fig. 1(d)), which was leading the 2008 Vendée Globe Challenge round-the-world yacht race when dismasted in December 2008. The designers claimed a typical reduction of resistance of 10–16% through the use of the interceptor (http://www.owenclarkedesign.com/da/11189).

However, in spite of the popularity of interceptors, and in contrast with the extensive aerodynamic studies of Gurney flaps, there have been relatively few published studies investigating the impact of interceptors on hull resistance, and apparently none specifically aimed at sailing yacht resistance.

The current study aims to develop improved understanding of the impact of interceptors on hull resistance, particularly for sailing yachts. The objectives of the study are:

- to review published literature on interceptors and Gurney flaps;
- to examine the relationships between Gurney flaps and interceptors;

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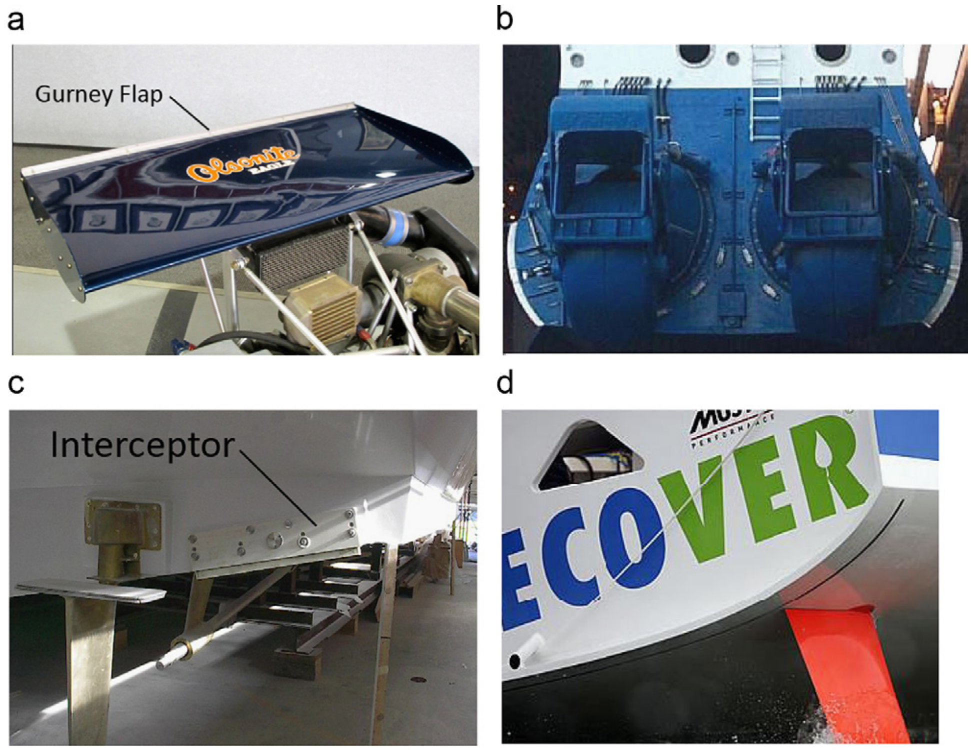

Fig. 1. Gurney flaps and interceptors. (a) Gurney flap on *Olsonite Eagle* Indycar rear wing; (b) interceptor steering system on Stena HSS; (c) small interceptor unit on hard-chine hull; and (d) interceptor slot on *Ecover* 3

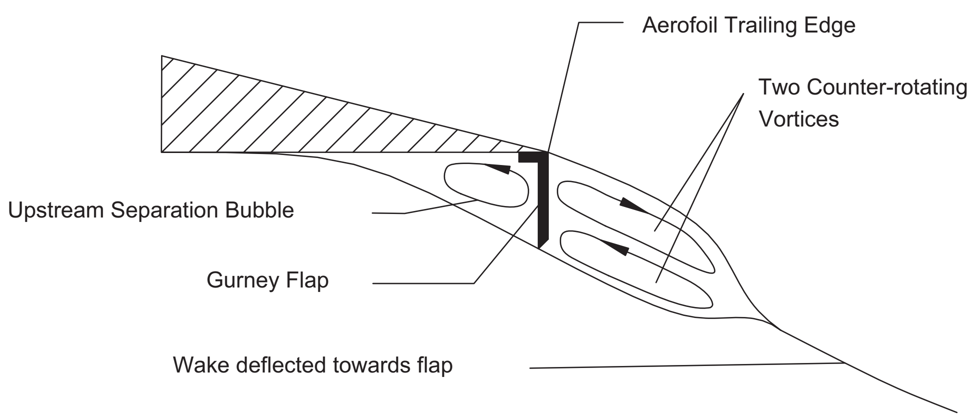

Fig. 2. Flow system generated by Gurney flap (after Liebeck, 1978).

- to examine the impact of interceptors on high-performance sailing yacht resistance through an experimental study;
- to develop further insight into the mechanisms by which interceptors generate reductions in resistance; hence, explore relationships between interceptor size, boat speed and performance.

2. Gurney flaps

The Gurney flap was originally developed as a high-lift device for car racer Dan Gurney in the early 1970s (though some authors have pointed out that similar devices had previously been proposed as long ago as 1935). However, serious interest from the aircraft industry only started in the late 1970s when the device was wind-tunnel tests at the Douglas Aircraft Corporation (Liebeck, 1978) on a Newman aerofoil. It was found that a flap with a height h of 1.25% of the chord, c, increased lift coefficient in the high-lift regime whilst also reducing drag in this region. Liebeck concluded that a flap height between 1% and 2% c maximized the aerodynamic benefits.

Subsequent studies produced broadly similar conclusions; the Gurney flap provided increased lift throughout the range of angles of attack compared to the "bare" foil, and improves lift to drag ratio at high lift coefficient (e.g. $c_l > 1$). However the flap gives a penalty of increased drag and reduced lift-to-drag ratio at small or moderate angles of attack, and reduced stall angle. Foils fitted with larger Gurney flaps ($>2\%$ c) have been observed to stall abruptly. Hence in aircraft applications an ideal situation would be to close the Gurney flap during cruise.

The time-averaged flow system generated by the Gurney flap is illustrated in Fig. 2. It is suggested (e.g. Nikolic, 2006b) that the upstream separation bubble results in a pressure rise on the high-pressure side of the foil in this region, whilst the vortex shedding