

## Less is More

# A Vignette on Efficient Design and Constructability

By Inga Scholz & Chris Townsend

Although shipping is still the eco-friendliest mode of transportation, green issues and concerns about the impact on the environment by maritime operations are becoming increasingly important for operators and vessel designers.

Despite the gloomy economic climate, the sometimes quite costly commitment

to cleaner shipping and protection of the marine environment is of high importance to many — at least in theory. Approaches to minimize environmental degradation are primarily regulatory-driven but we can see a growing emphasis on voluntary corporate policies to improve environmental credentials.

In the offshore sector for instance,

these approaches, both regulatory- or corporate-image driven, focus on tank segregation to decrease the risk of oil or other hazardous substances spills, reduction of engine emissions and sewage pollution, as well as obtaining Clean Class notations. MARPOL and EPA Tier regulations are the most significant provisions currently affecting

offshore designs to improve the effects of vessel operations on the environment.

Another recent, much talked about, endeavor in the right, environmentally conscious direction is the first hybrid tug, owned by Foss Maritime and delivered in early 2009, which is partially battery-powered to improve power distribution and emissions. The additional cost associated with the hybrid propulsion system is estimated at around \$2-3 million, which is a significant disincentive to adopt this technology voluntarily.

Not every step taken to execute environmentally conscious and fuel-efficient operations needs to come at a high cost as is often assumed. The basis for environmentally sound operations begins with an efficient hull form, which can improve fuel consumption.

For the purposes of this discussion, an efficient hull form that can improve fuel consumption must have good resistance characteristics — that is, the power required to move the ship at a given speed should be minimized. The hull form must also possess good directional stability, eliminating fuel-consuming rudder movements required to correct course deviation.

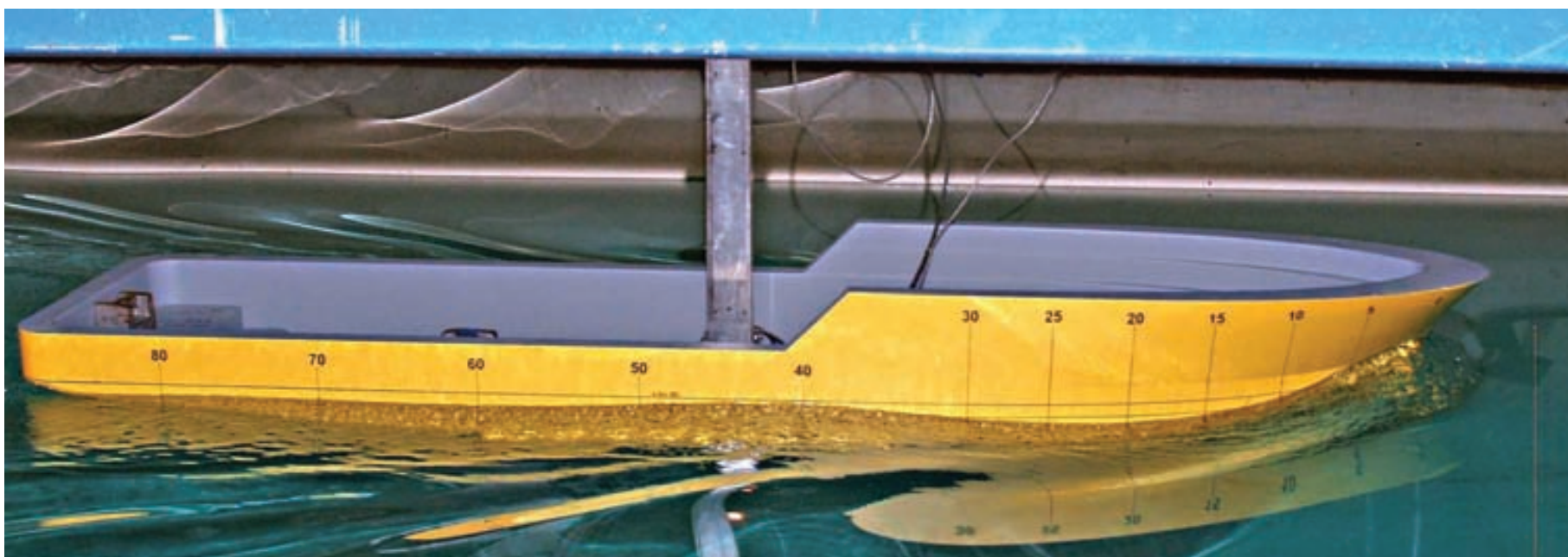
Classical engineering texts suggest "a streamlined body ... presents the simplest case of resistance," thus vessel design trends have focused on sleek, fully faired round-bilge hull forms. Further studies of hydrodynamics also lead to the introduction of faired appendages and the bulbous bow, features that are capable of lowering total resistance under ideal conditions. However, the realization of these reductions in resistance often results in added complexity and cost.

In reality, the conditions in which ships operate are hardly ideal. Thus, design considerations for production that have a minimal impact on resistance characteristics but greatly simplify the construction of the vessel have been widely accepted as an effective compromise.

The retirement of offshore vessels above 25 years of age has led to a steep increase in replacement tonnage in recent years. Many operators were and still are confronted with the need for more advanced vessels capable of fulfilling stricter environmental, safety and comfort requirements, among other things resulting from vessel deployment

One of GPA's single-curvature hull forms (GPA 254L AHTS) under construction at Dayang Shipyard in China.





**Model Test of a Chined Hull (GPA 654 PSV).**

in deeper waters and harsher environments as activities for oil exploration and production venture further from shore.

The priorities of most vessel operators investing in new-build programs will, due to new mandatory requirements, corporate policies and financial reasons, probably revolve around excellent fuel economy and environmentally friendly operations while paying a favorable price.

When commissioning the design for a new, efficient hull form, purpose built for operations, vessel owners can theoretically go into two different directions: A complicated, costly round-bilge hull form with excellent resistance characteristics, or a simple but now well-proven hull form featuring chines with resistance characteristics nearly or as ideal as a round-bilge hull but cheaper to build. In a variety of applications, but typically for medium to large displacement vessels, well-designed hard-chined hull forms have been proven to approximately have the same resistance characteristics of an equivalent round bilge hull form.

Model tests, which are conducted by Guido Perla and Associates, Inc. (GPA) for every major design, especially if performance in terms of speed is a priority, have shown that hard chined designs perform as efficient as round hulls, sometimes even better. Such was the case with a 116-meter gas carrier a few years ago for which the original choice, a round hull, was model-tested versus a hard chined hull developed by GPA. The resistance of the hard-chined hull was significantly lower and upon those results, the gas carrier's hull form was replaced by GPA's hull design (See Graph 1, above right).

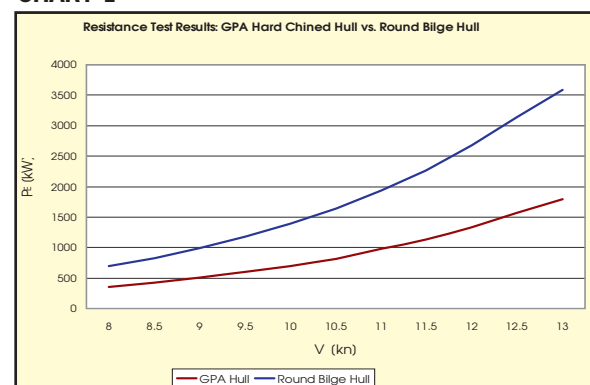
Measuring speed and directional stability, the results of sea trials repeatedly meet the operators', shipyards' and designer's expectations, solidifying the trend towards hard-chined vessel designs and confirming GPA's constructability strategies.

"You can design a good or bad round hull just like you can design a good or bad hard-chined hull." Guido Perla, Chairman of GPA, uses this statement quite often, as GPA's long-lasting experience with hard-chined, single-curvature hulls has turned into the standard for the naval architecture firm with a track record of currently over 130 offshore vessels of GPA-design either in service or under construction. While a

chined hull form may be a departure from nautical tradition, there can be no doubt of the efficient compromise offered by a well-designed chined hull form, which has desirable resistance characteristics and is easy to build.

While well-designed hard-chined, single-curvature hulls can result in efficient operations and fuel savings, the benefit of lower building cost is the result of simplified construction methods. In modern shipbuilding, two main processes are used in plate and stiffener

**CHART 1**



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forming: Cold forming involving rolls and presses or thermal forming using line heating with torches and lasers. Single-curvature plates, shaped only in one direction or with only a slight amount of backset, can be formed using rolls while the more complex double-curvature plates need to be fabricated using large hydraulic presses. Such processes are very labor intensive and require high skills, demanding a significant portion of the total structural man-hours. Furthermore, being a manual process requiring high skill, it is not repeatable and may suffer from inaccuracy.

Not only the hull form itself, but transverse framing, as well as flanged plate framing, contribute to constructability and therefore to decreased construction time and cost. Transverse framing, with main frame members running from keel to deck and from side to side as deck frames, and featuring longitudinal frames spaced widely, simplifies the exact fitting process of frames within individual modules and later on in joining these modules. Longitudinal framing, in which a comparatively small number of large transverse frames is employed and the chief framing mem-

bers are longitudinal, running the full length of the ship from bow to stern, complicates the joining of each frame across the entire length of the vessel.

The typical length of a wave is about 300 feet and ships of this length or greater are subject to considerable bending stress. For such vessels, it is reasonable to longitudinally use framing or a combination of longitudinal or transverse framing but for vessels below the length of 300 feet, typical for most modern offshore vessels, longitudinal framing has no advantage over transverse framing but definitely shows a disadvantage in construction cost.

The other factor decreasing construction time and cost, flanged plate framing, does not require the individual frames to be rolled in a complex, costly process, with many frames shaped differently, to achieve the faired hull form but the frames are cut into shape to achieve the faired characteristics of the hull at a much lower cost, which can be done efficiently at a lower skill level.

Constructability offers improvements in all the metrics of shipbuilding: man-hours, cost, and total build time. These improvements can clearly be recognized in the Bourbon Offshore Liberty vessel

newbuild program, which is sustaining the delivery of a GPA designed vessel every two weeks.

To determine the ideal cost/performance ratio customized to a vessel's operational profile, operators need to also consider an adequate propulsion system. Besides the simplified hull form, other applications can contribute to environmentally friendlier operations through efficiency and fuel savings, such as diesel-electric propulsion systems, which are becoming more prominent worldwide. While Engine Emissions regulations, as well as Clean Class notations, address and continuously improve the minimization of measured emissions output, these standards do not enforce limitations on the actual fuel consumption and therefore fuel efficiency of the vessel. Until recently, there was not sufficient motivation to consider overall fuel consumption and efficiency for PSV/OSV operations. The possibilities in improving fuel economy have grown through the use of diesel-electric propulsion configurations, facilitating improvements in fuel consumption and emissions by 30%. The requirements for Dynamic Positioning (DP) are detrimental to fuel economy due to operating at a

reduced engine demand. Diesel-electric systems can considerably improve actual fuel consumption to mitigate this by providing greater flexibility in the use of power, especially during DP operations. Besides reduced fuel consumption, diesel-electric can further contribute to a vessel's profitability as it creates flexibility in lower deck cargo space arrangements, and if taken advantage of properly, can increase cargo capacities by up to 30% while offering the ability to carry a greater variety of products.

Until certain amendments to further protect the environment and minimize the ecological impact of maritime operations become mandatory, a range of options is available to operators not requiring extensive financial investments but instead can even lead to construction and operational cost savings while taking the environment into consideration. Depending on a vessel's operational profile, the optimum hull might have to be a trade-off between production cost and operation cost while the ideal solution for fuel consumption has still not been widely accepted due to higher capital cost investments, but the industry seems to be embracing the idea of environmentally friendlier solutions.




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