NAVAL ARCHITECTURE

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Summary

Ships are designed to meet the requirements of owners or some other missions; meanwhile, safety, seaworthiness, and adequately stability in functions are very vital so that it can serve as a secure platform for crew and cargo. Their features are dictated numerously by these requirements. Three kinds of physical support driving the watercraft are aerostatic, hydrodymanic, and hydrodtatic powers. Merchant ships, naval vessels, working craft and pleasure craft represent the other classification involving design purposes. In particular, cargo freighters, passenger ships, and fishing boats are three most common commerically-built vehicles.

A marine propeller is a propulsion device, which transforms the rotational energy from a main engine into an axial force to propel a marine vessel. A successful propulsion system is the one that the machinery must always develop the torque at various revolutions so that the ship reaches the required speed.

Seven most significant propellers described respectviely are Fixed Pitch Propellers (FPP), Controllable Pitch Propellers (CPP), Ducted Propellers, Contra-Rotating Propellers (CRP), Surface Piercing Propellers (SPP), Vertical-Axis Propellers, and Hydrid Propulsor

1. Ship Hull

Ships are designed to meet the requirements of owners or some other missions. Their features are dictated by these requirements and the forms they can take are numerous. For instance, a vessel might appear to be a moving hotel taking passengers along to some foreign destination; a floating fort bristling with missile launchers; or an elongated box conveying tanks of crude oil and topped with complex pipe connection. However, a ship must be safe, seaworthy, and adequately stable in its function, so that it can serve as a secure platform for crew and cargo. In order to discuss naval architecture, it is useful to put ships into certain categories. For this purpose, ships are usually classified according to their means of physical supporting forces and their designed purposes.

1.1. Ships Classified According to Means of Physical Support

With reference to the mode of physical support, ships are designed to operate above, on, or below the water surface. Because the nature of the physical environment is quite different for the three regions mentioned above, the physical characteristics of ships designed to operate in those regions could be different.

A. Aerostatic Support

There are two kinds of vessels that are supported above the sea surface on a self-induced cushion of air. Generally, these crafts are lightweight constructions and are designed for running at high speeds, because air resistance is much less than water resistance, and the avoidance of contact with small waves associated with flexible seals reduces the influence of water impact at high speed condition. These crafts use so-called lift fans to produce a cushion of low-pressure in a chamber seated at the bottom of ship bodies. This cushion of air must be supplied continuously in order to lift the weight of the crafts above the water surface.

The first type of craft is called an air cushion vehicle (ACV), which has flexible skirts that completely surround the air cushion and keep the ship body to rise wholly above the sea surface. This type of craft is also referred to hovercraft. They are normally driven by aircraft-style propeller and can be used over land and ice as well as over water, with speeds reaching 50 knots or more.

The other type of craft, called captured-air-bubble vehicle (CAB), has, on the contrary, rigid sidewalls or thin hulls that extend below the surface of the water to reduce the amount of airflow required holding the cushion pressure. This type of craft is also called surface effect ships (SES) or air cushion catamaran.

B. Hydrodynamic Support

Two kinds of crafts make use of dynamic lifting force generated by relatively quick forward motion of specially constructed hydrodynamic hull shapes either on or beneath the water surface. A principle of fluid mechanics states that any moving plate with an inclined angle to a fluid flow can generate a lift force perpendicular to the direction of flow. Just as an airfoil produces lift when moving through the air, a hydrofoil, located

beneath the free surface and attached by means of a surface-piercing strut, can dynamically support a ship's hull above the water.

Planing crafts are hull forms characterized by relatively flat bottoms and slight V-sections (generally forward of amidships) that produce partial to nearly full dynamic support for light displacement ships and small crafts at higher speeds. Planing crafts are generally restricted in size and displacement because of the required power-to-weight ratio and the structural loading associated with operating at high speed in waves. Most planing crafts are also limited to operations in reasonably calm water conditions, although some so-called "deep V" hull forms are capable of operation in rough water.

C. Hydrostatic Support

Hydrostatic support is the well-known and most reliable type of support. All ships, boats and primitive watercraft up to twentieth century have depended upon the easily attained buoyant force of water for their operation.

This hydrostatic support originated from water buoyant force can be explained by a fundamental physical law that Archimedes described in the second century B.C. Archimedes' principle states that a body immersed in a fluid is acted upon by a force equal to the weight of the fluid displaced. This principle applies to all vessels that float or submerge in water--salt or fresh. From this statement the name of the ships in the classification are used. They are generally called displacement hulls.

Although people are more or less familiar with this ship type, there are also some mixed types worth more discussion. For example, some crafts with reasonably high speed must be combined with the ability to carry light cargo or to have better seaworthiness in rough water than planing hulls. High-speed planing-hull properties can be changed to produce a semi-displacement hull or semi-planing hull. The hybrid crafts, not as fast as full-planing hulls, but faster than conventional displacement hulls, must have more power and less weight than the latter. Such types are surely the result of compromise.

However, displacement hulls are the most popular and easily recognizable type of ship and are widely adopted for passenger service, cargo trading, fishing by trawling, or for many of other tasks that do not require exceptional capacity, speed, submergence, or other special performance.

A typical vessel of this type is a tanker or supertanker. In order to express the size of a supertanker more briefly, three size categories LCC (Large Crude Carrier), VLCC (Very Large Crude Carrier) and ULCC (Ultra Large Crude Carrier) are introduced. Any tanker greater than 100,000 tons but less than 200,000 tons is a LCC, those between 200,000 and 400,000 tons are VLCCs, and those over 400,000 tons are ULCCs. Their service speed is very low (less than 15 knots).

These ships belong to a category of displacement vessel that has a great amount of buoyant support. In full-load condition, they have a very large and disproportionate hull volume below the water surface. In fact, the cargo weight far exceeds the weight of the ship hull itself. The draft required for a fully loaded VLCC runs to 15 or 18 meters and a

ULCC may be about 24 meters.

There is another type of displacement hull with extreme draft. This type of vessel is called the SWATH (Small Waterplane Area Twin Hull). This type of ship is designed for relatively high speed and stable platform in moderately rough sea. According to the theory, the wave-making resistance generated by moving a ship hull through the free surface can be reduced if the amount of displacement is placed well below the free surface and the above water platform or deck is supported through the narrow waterline fins or struts. The lower twin hulls are connected by an upper platform and provide the necessary operating stability.

The most significant type of displacement hull for particular application is the submarine, a vessel for completely submerged operation. It implies that the theory of Archimedes' Principle can be applied to this type of ships.

D. Multi-hull Vessels

There is one other type of hull called multi-hull vessel, for example, the catamaran and the trimaran. These vessels are most frequently displacement hulls in their larger sizes, such as the SWATH mentioned above, or more conventionally, ocean research vessels requiring stable platforms and protected areas for placing equipment. Actually, the multi-hull ship is a conversion of any of the basic hull categories to a special application that requires excellent transverse stability and/or deck working area.

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Biographical Sketch

Jen-Shing Kouh received PhD degree from University of Hanover and is now a professor in the Department of Naval Architecture and Ocean Engineering, National Taiwan University, Taiwan