Horrigan Labs Briefing

Propeller Efficiency and the SolidWater™ Propeller

Propeller efficiencies defined;

Fuel efficiency = smallest fuel quantity to reach hull speed or acceleration requirements (thrust).

Flow Efficiency = laminar discharge lowers turbulence, cavitation, boundary layer drag and thrust dispersion, all of which equate to improved efficiency

Quiet efficiency = noise from cavitation and turbulence equals energy and productivity losses.

Corrosion efficiency = cavitation (and precavitation) pock and erode propeller surfaces and cause blades to have to be replaced frequently.

Energy efficiency = smallest engine (hp) to reach hull speed or acceleration requirements (thrust).

Cost efficiency = smallest construction and operational costs to perform work desired (engine, rudder and gear costs)

Maintenance efficiency = lowest cost per year to run the propeller

Versatility efficiency = prop that will pull efficiently as well as go at high speed efficiently

Directionality efficiency = A prop that can steer, maneuver and stop the vessel has important virtues and its ability to do this is an efficiency.

Retrofit efficiency = easy to adapt or fit to existing vessels is more efficiency

Other efficiencies = repair at sea, cost of renewal, simplicity of design, toughness in weather, anti-fouling, environmental, swimmer safe, etc.

Ship drag (including hull and appendages) and ship weight plus machinery efficiencies (engine, marine gear and shaft) define the required load. They also define the speed and acceleration requirements. A longer, narrower ship will go faster for a given amount of power. A more efficient propeller will deliver that speed for less power. A high thrust propeller will deliver better acceleration up to the hull speed.

Traditional propeller energy efficiency for rotational propellers is defined by the following formula—Efficiency = (propeller axial thrust force times mean inflow velocity) divided by (2**π** times rotational speed in rev-per-sec times propeller shaft torque)

This formula does not apply to the SolidWater™ Propeller because it does not have propeller axial thrust (doesn't rotate and spin the water outward or doesn't have deflective, torsional or rotational inertia energy losses). Likewise the mean inflow velocity doesn't apply to our propeller as it changes angle of attack through out its cycle so it is optimized for every inflow velocity, not fixed as a regular propeller. The 2**π** and rotational speed along with shaft torque assume a rotational movement through water, again not pertinent to the SolidWater™ design.

Factors that improve efficiency that are useful to evaluate the SolidWater design are;
Blade Length (longer = more efficiency)
Blade speed (slower = more efficiency)
Blade aspect ratio (narrower = more efficiency)
Obstructions and disturbed inflow = (less = more efficiency)

Factors Continued…

Idealized angle of attack relative to flow = more efficiency
Elimination of “prop walk” = more efficiency
Propeller axial thrust wastes energy = less efficiency
Percentage of blade that is optimized for thrust at given speed = more efficiency

The Rolls Royce Azimuthing Propeller is 30% more energy efficient than traditional propellers because it gets clear water input flow from its pulling design. It also utilizes a scimitar design that minimizes inertial flow deflection losses. It is also its own rudder which eliminates drag.

The Cummins Dual Prop and the Volvo Penta Duoprop get a 20% improvement in energy efficiency using counter-rotating props which reduce (not eliminate) deflective energy losses.

The SolidWater™ propeller can be made as long as possible and length is not limited by vessel draft as the prop can be installed horizontally and be many times the width of the ship in length. Installed vertically in normal ship installations it can be 2-3 times as long as a rotating prop without significant draft interference as the blades are not distributed around a central shaft and massive hub.
The blade is designed to be slow but can move faster than foil-chorded propellers without penalty due to the elimination of the precavitational state. This is a state of flow where there is a perpetual and stationary low pressure environment located adjacent to the face of the blade. This low pressure area is not conducive to directing flow and creates a large boundary bubble layer many times the size of the what needs to be moved for ideal discharge flow. This is the most dramatic feature of the SolidWater™ prop - the elimination of this precavitational state and the energy losses involved in maintaining it.
The SolidWater Prop aspect ratio is not only slender, it is also consistent with more of the prop blade being utilized. This is because there is no reinforcement at the root of the blade or hub, as it doesn’t have a hub.
Since the SolidWater™ propeller is it's own rudder, and it hangs down into clear water without a hub or struts and as such it has very little drag to deal with.
Since the propeller can be tilted on its vertical axis it can be tuned to eliminate low pressure hull drag as well.
And since the SolidWater™ propeller blades don't rotate, the SolidWater™ design also eliminates prop walk and propeller axial thrust energy losses.

As to the “Other efficiencies” category above, the SolidWater™ propeller excels in all of those areas. Contact our engineering department for more information and a detailed demonstration talk (1.5-2 hr).