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Marine Performance Technology Exchange

The Marine Performance Technology Exchange is an electronic newsletter whose mission is to share contemporary propulsion and powering topics.

Design power and RPM for propeller sizing

I have been told that I should size propellers for 50 to 100 RPM above rated RPM. Is this proper?

This practice has been one that engine builders often suggest for sizing propellers. The intent of this practice is to insure that the propeller is a bit "under-pitched" so that it does not overload the engine, particularly at delivery trials. In my opinion, under-pitching a propeller is almost always a good idea. Consider an example of a 14.5 m (48 ft) work boat with 150 kW (201 hp) engines rated at 2800 RPM.

Sizing the propellers at 100% rated power and RPM results in a propeller suitable for 19.4 knots top speed, with its P/D = 1.100 and the EAR = 0.71 (sized for a 10% cavitation limit). Now, let us assume for this example that it encounters a 10% increase in drag. (This could be due to increase in weight or hull roughness over time, or a temporary increase in load due to wind and waves, shallow water, or any number of other circumstances.) The top speed will go down to 18.2 knots, the engine will be overloaded by 75 RPM, and cavitation will increase just a bit to 11%.

If we had sized the propeller initially for full power but at 50 RPM above rated (e.g., 2850 RPM), we find a propeller with P/D = 1.075, EAR = 0.70 (for a 10% cavitation limit), and a top speed of 19.0 knots. A 10% increase in drag with this propeller results in 18.4 knots top speed while maintaining full rated RPM. Cavitation levels also increase very slightly to 11%.

So, if the boat owner is willing to give up 0.4 knots of top speed (from 19.4 to 19.0), then he will be assured of maintaining full RPM even with a 10% increase in vessel load. The boat will even be able to run 0.2 knots faster in this increased load condition (from 18.0 to 18.2 knots). Having the ability to maintain speed in this condition may be when the owner needs it most – if the load is coming from wind and waves in a storm, for example.

Having said all this, sizing for full power and 50 to 100 RPM above rated would not be my recommended approach. At HydroComp, when we want to under-pitch a propeller to consider a potential increase in vessel loading, we never increase RPM – we reduce power. In the example above, we would size the propeller for 95% rated power and full rated RPM. There are two reasons for this.

1. Running 50 to 100 RPM above rated RPM at full power is an artificial condition that is simply not a point within the engine's "power envelope". This fictional design point results in more EAR than is necessary. Using the power reduction approach, the propeller has an identical pitch and top speed, but the EAR is sized at 0.68 (vs 0.70). The extra blade area is not needed until there is an increased vessel loading, so using the smaller – and slightly more efficient – EAR would be our approach.

2. The shape of a boat's drag curve is different for displacement and planing hulls. Added drag more closely correlates to power than to RPM, so a practice of accounting for increased load with a standard design power figure (e.g., 95%) should prove more consistent than with a standard increase in RPM (e.g., 50 RPM).

Trade shows and events

You can discuss product capabilities with HydroComp staff at these upcoming trade shows:

Propellers '06, VA Beach [Sep 12-13]
SNAME, Ft. Lauderdale [Oct 10-13]
IBEX, Miami [Nov 1-3]
NMPA, Las Vegas [Nov 10-12]
METS, Amsterdam [Nov 14-16]

Check your version

The following is a list of current program versions and dates. If you have a current MSU subscription, you can click on the appropriate link below to go to the update download page. (Note: users of SwiftTrial and SwiftCraft are on a perpetual subscription.)

NavCad 2006 [5.22.0110, Apr 2006]
PropCad 2006 [4.50.0150, Mar 2006]
PropExpert 2006 [5.21.0075, Mar 2006]
SwiftCraft 2006 [1.40.0049, Apr 2006]
SwiftTrial 2006 [1.20.0022, Apr 2006]

It is never too late to update your MSU subscription! Contact HydroComp to receive a version feature summary.

New product features

Below are lists of recent feature additions to HydroComp software:

NavCad
Improved report formatting
Effect of shaft angle on thrust and torque
New cavitation algorithms

PropExpert
Effect of shaft angle on thrust and torque
New cavitation algorithms
Improved analysis of heavy cavitation

PropCad
New sections – Cleaver, Thruster
Export to CFD tools
Improved control of section geometry

Stern wedges

I've been reading that adding a stern wedge will improve performance. Is this true for all boats, such as a fishing trawler?

To our knowledge, the benefits of a stern wedge (or the similar stern flap) on a displacement hull workboat have never been evaluated, so the answer to your question is "we're not sure". However, extensive testing has been conducted for faster vessels, such as frigates and patrol craft. This body of work does suggest that stern wedges might be able to help improve performance on slower and fuller vessels, such as trawlers and workboats.

Model and full scale testing by the U.S. Navy and others indicate that stern wedges are beneficial in a Froude number speed range from approximately 0.3 to 0.9, with wedges being detrimental at slower and faster speeds. The magnitude of best power reduction in this range varied from 2% to 14%.

Let's relate this to a 25 m (80 ft) stern trawler with a free run speed of 12 knots. This speed is at a Froude number of approximately 0.4, which is just within the range that the testing showed potential benefit. The results at this Froude number point to potential power reductions of 4% to 9%. Of course, hull geometries differ between workboats and patrol craft, but we believe that the basic hydrodynamic principles of stern wedges should still apply.

A stern wedge is simply a wedge-shaped appendage that is installed directly beneath the transom. The water flowing under the stern is slowed as it approaches the wedge, then when reaching the wedge increases in velocity and exits the transom. A vessel with a wedge has a sharper separation of the flow at the transom and a less turbulent wake pattern.

It also has an increase in local pressure under the stern corresponding to the reduced water velocity, which can actually provide some applied lift and thrust on the upward sloping stern. (You can think of this as a reduction in the thrust deduction.) Even though the wedge itself has drag, this lift and thrust plus the drag reduction due to the cleaner separation results in a ship with less required power. (There may also be beneficial changes in running trim for some vessels.)

Secondary benefits include a better operating environment for the propeller. The higher local pressure means it can carry more thrust before the inception of cavitation, and may allow for a somewhat smaller blade area to be used. It also may contribute to a more uniform velocity distribution into the propeller.

Reduced drag, applied thrust, and improved propeller performance all translate into decreased fuel consumption. The U.S. Navy is so keen on the idea that they recently patented a variant of the stern wedge. We know of no model or full-scale testing of stern wedges on workboats, but we do believe that they have potential merit for this class of vessels. (We have begun a more extensive R&D program into the application of stern wedges to a variety of hull types, and would be particularly pleased to hear from anyone interested in implementing stern wedges on workboats.)

A useful reference:

Karafiath, G., and Cusanelli, D., "Stern Flaps", *Professional BoatBuilder*, No. 70, April/May 2001

NavCad training in London!

HydroComp's Donald MacPherson (Technical Director) and Vincent Puleo (Project Engineer) have recently returned from hosting a NavCad training seminar in London. Users came from Europe and the Far East to extend their skills in using HydroComp's NavCad resistance and propulsion software. One user commented,

> *"For being a new user, the course had a structure that catered to me, as well as the experienced users. I felt it beneficial to listen to other people's inquiries. I am now applying what I learned to all my projects."*

If you are interested in training for any of HydroComp's products or would like to learn more about HydroComp's specialized consulting and training services, please email us at info@hydrocompinc.com or call (603)868-3344.

HydroComp and Design Systems & Technologies Celebrate 15 Years of Partnership

HydroComp is celebrating 15 years of collaboration with our European representative – *Design Systems & Technologies* (DS&T) of Antibes, France. Since 1991, HydroComp and DS&T have become a dynamic and seamless team attending trade shows, providing end-user support, presenting technical papers, and hosting training events. Together, this team has been able to support HydroComp's growing customer base of more than 500 clients in nearly 50 countries worldwide for both software sales and consultancy.

We especially want to thank Nick Danese for his expert skills, professional support, and long-lasting friendship.