HydroComp, Inc.

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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.

Contribution of a nozzle in ducted propeller performance

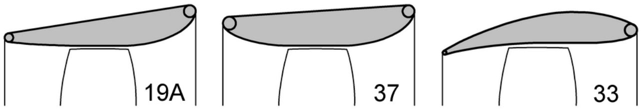
Can you give me an overview of the nozzle's contribution to the performance of a ducted propeller?

Chapters for textbooks have been written about this topic, so my reply must be considered just as a practical overview of the subject. With this in mind, let me start by saying that the nozzle has two principal effects – a) changing the environment for the propeller within the nozzle, and b) contributing a lift force that has a vector component in the ahead axial direction.

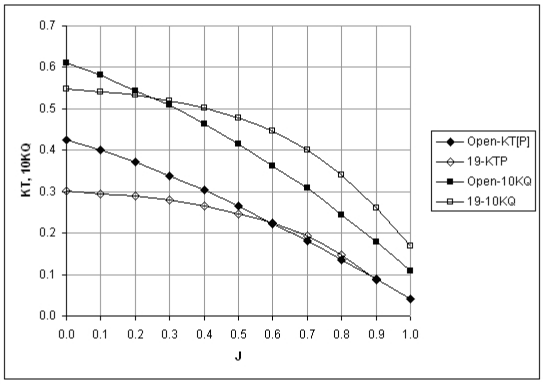
Changing the environment for the propeller

The idea that the nozzle changes the water flow into the propeller should be intuitive. The specific changes – relative to an open propeller – include a) changing the overall incoming water velocity, b) creating more uniformity in the velocity, and c) altering the radial velocity distribution.

Nozzles can be "accelerating" or "decelerating", meaning the average water velocity at the propeller can be either faster or slower than the equivalent open propeller free-stream speed of advance. Most nozzles in commercial use are of the "accelerating" type, as these provide the greatest gains in thrust-to-power efficiency. You typically find "decelerating" nozzles only in circumstances where you might want to reduce cavitation and noise, as in some of the integrated propulsors for naval submarines. Of the ducted propeller series used in HydroComp software, nozzles 19A and 37 are "accelerating" and nozzle 33 is "decelerating".



With and "accelerating" nozzle, the increase in water velocity into the propeller disc lightens loading of the propeller. Consider the following plot of KT and KQ for a B-Series 4.55 propeller and the same propeller in a #19 nozzle (similar to the 19A). Note that the KT is for the propeller only (i.e., KTP) [Oosterveld, 1970].



Visit our updated blog!

To enhance the original mission of our blog – which is to to provide valuable, insightful technical information in a more candid format – HydroComp has updated our blog in a new format.

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In particular, we encourage readers to sign up for the email notification of new blog articles. Recent topics include:

- Election "Un-Coverage"
- Commercial software for academic use
- Revolutionary new fuel saving strategy
- From the floor at IBEX 2008

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 SwiftCraft are on a perpetual subscription.)

NavCad 2008 [5.42.0122, Oct 2008]
PropCad 2008 [4.71.0162, Nov 2008]
PropExpert 2008 [5.41.0086, Sep 2008]

Look for a new update of SwiftCraft in 2009 Q1.

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

Article: *Applied hydrodynamics*

Read about HydroComp's various applied hydrodynamics research and development projects in the July-August 2008 issue RINA's *The Naval Architect*. Learn how hull form and propulsor studies make their way from novel R&D to implementation in HydroComp's software tools. To read the article online, click to:

http://publishing.yudu.com/Aqmh9/NAJulAug08/resources/74.htm

You can see a distinct flattening of the thrust (KT) and torque (10KQ) curves at low J, due to the increased water velocity that comes with an "accelerating" nozzles with high thrust loading (the "towing" condition). This characteristic is important for propeller sizing in that it suggests a larger tolerance in the selection of a design speed. In other words, for low speed / high thrust applications, it is not necessary to precisely determine a design speed.

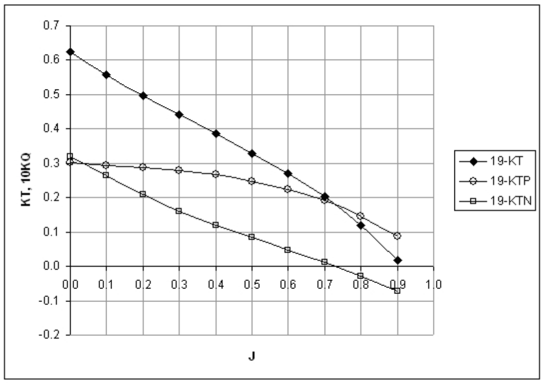
The nozzle also acts like a flow "dampener" to some extent, softening the variations in water velocity caused by hull geometry ahead of the propeller. It also "straightens" the flow, reducing the oblique flow over the propeller. These can have a variety of beneficial effects, including increased propeller efficiency, as well as reduced variations in forces and pressures.

Finally, a nozzle imparts a distinct radial distribution on the local water velocity, typically with greater velocities toward the outer radii. This would suggest that an increasing pitch distribution from root to tip will offer the best "wake-adapted" efficiency. However, research also indicates that across a range of thrust loading (from "towing" to "free-run"), there is only a nominal 1% loss of efficiency when using a constant-pitch propeller versus a wake-adapted variable-pitch propeller [Van Manen, 1962].

Axial lift component

The flow that is created by the propeller pulls water from ahead and outside of the nozzle into the propeller disc and discharges it aft. The direction of flow lines are not axial, but move into the nozzle at some angle. Depending on the amount of flow convergence (due to the thrust loading) and the shape of the nozzle's profile and camber, the nozzle will have an "angle of attack" into the flow and create a lift vector with a component of forward thrust.

This nozzle thrust component (KTN) and propeller thrust component (KTP) are independently measured as a part of the model testing of the ducted propeller. These are added to determine the total thrust (KT) for the unit. The relative contribution of nozzle and propeller on the total thrust can be seen in the example plot below.



At the low J ("towing") condition, a well-designed nozzle contributes as much to the overall thrust as the propeller! However, at high J ("free-run"), the nozzle KTN becomes negative, indicating that the nozzle drag at higher vessel speeds is now greater than its lift vector thrust. ¤

Van Manen, J. D., "Effect of Radial Load Distribution on the Performance of Shrouded Propellers", *International Shipbuilding Progress*, Vol. 9, No. 93, May 1962.

Oosterveld, M.W.C., "Wake Adapted Ducted Propellers", *MARIN Publication 345*. 1970.

For more technical articles like these,
visit the ***HydroComp Knowledge Library:***

www.hydrocompinc.com/knowledge/library.htm

Propeller model tests needed

…for a database project by the SNAME's H8 "Propulsion Hydrodynamics" panel. Contact Don MacPherson at HydroComp if you can provide test data for the project.

New product features

Below are lists of recent feature additions to HydroComp software:

NavCad
User-selection of standard analysis setup
User managed Task List utility
New "Quick-Calcs" (hydroacoustics)

PropExpert
Integrated report viewer with PDF,CSV
Improved calculations

PropCad
Integrated report viewer with PDF,CSV
Improved control for custom profiles
Updated class rule thickness calcs
Builder – "Modified Kaplan" section

Technical presentation notices

"Biologically-Inspired Innovations in Naval Architecture" is the working title of a presentation to be delivered to the New England Section of SNAME in January 2009 by HydroComp's Donald MacPherson, Adam Kaplan, and Caleigh MacPherson. The presentation will describe historical and contemporary innovations in naval architecture that are based on biological characteristics of fish, marine mammals, and invertebrates.

"Chronic Propeller Problems" was the title of a presentation delivered by Donald MacPherson at IBEX 2008 in Miami. The topic was an overview of problems that are typically blamed on the propeller, but which may in fact be due to other sources, such as: overload, underload, vibration, shaft angle effects, root cavitation, and singing.

HydroComp, Inc. is the leading supplier of software and services for marine performance prediction, propulsion analysis, and propeller design. For more information, please visit our web site, at:

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