Selecting a new prop - Trade A Boat Magazine (April 07)

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If not properly sized or correctly designed, a vessel's propeller can cause a performance drop in excess of 30 percent. Compared with one performing to its maximum potential, that means a huge amount of extra diesel to cover the same distance, at a slower speed. **John Menzies** explains.

Gearbox ratios, shaft angles, propeller clearance and other factors can affect propeller efficiency. Assuming all these have been done correctly, the propeller itself can have a major bearing on how the vessel is pushed through the water.

Propellers, like people, come in all shapes and sizes, as well as different materials. No two are exactly alike. Each propeller manufacturer has his own designs for different types of vessels, whether displacement, semi-displacement or planning hulls. Propellers come in two, three, four, or up to five blades with multitude of different profiles and blade edges.

A couple of years ago, a client of mine spent a small fortune repowering his luxury vessel. A new set of propellers was selected but on initial sea trials the speed was seven knots slower than what has been predicted. Taking into account the shaft rpm at maximum speed, the propeller slip was calculated at being in excess of 35 percent, where the original propellers' slip was just under 20 percent.

The propeller manufacturer tried to improve on them but was unsuccessful, so the vessel owner arranged for another manufacturer to make two new propellers. The new and more expensive propellers once again got the vessel's speed to nearly 30 knots (an improvement of 7 knots) along with a slip factor of under 20 percent.

So where does the boat owner begin when contemplating new props?

If you have an existing planning hull vessel you should be able to calculate a reasonably realistic "expected maximum speed" using this tried formula:

Speed (V) equals K factor multiplied by the square root of the total shaft horsepower divided by the weight (in long tonnes), $V=K \times \sqrt{SHP/W}$

The K factor can be determined by the following table:

Loaded Waterline (feet)	Soft Chine Round Bilge Flat at transom	V Bottom Hard Chine	Stepped V Bottom Hard Chine
	K	K	K
20	2.25	2.75	3.60
25	2.40	2.90	3.80
30	2.60	3.15	3.96

35	2.80	3.40	4.15
40	3.05	3.65	4.30
45	3.24	3.85	4.48
50	3.34	4.00	4.60
55	3.45	4.10	4.70
60	3.53	4.20	4.78

Say your vessel is a planing hull of 45ft with a waterline length of 40ft, a weight of 12 tonnes and powered by twin, 250 shaft horsepower engines. Putting these figures through the above formula we get a theoretical maximum speed of 23.5 knots.

If your vessel's maximum speed with a clean bottom is within five percent of its theoretical maximum, it is probably performing within expectation and your propellers are working efficiently. If your speed is lower that this parameter, you probably have a propeller problem. How do we solve it?

First, check to see if the engine is delivering its maximum power at its rated rpm.

Is the engine achieving its rated rpm at wide open throttle? If in doubt get the vessel's rev counters calibrated or independently checked with an accurate, hand-held rev counter. We often find rev counters out by more than 300 rpm.

If rated rpm is not being achieved, the engine is over-propped and will not deliver its rated horsepower. If the rated rpm is easily achieved (or over), the propeller is probably too small or under pitched for the engine and again, its full potential horsepower is not getting into the water.

A simple test to see if the vessel is under-propped is to put the vessel into a gradually tightening turn and see if the engine rpm falls off. A properly propped vessel will start to drop revs almost immediately you start the turn as the engine loads up to a point where the governor can't deliver any more fuel, so the revs drop back.

In an under-propped vessel, as the load increases with the turn, the governor continues to feed in the extra fuel it has available holding up the revs until finally the load of the increasing turn reaches a point where maximum fuel is being delivered to the injectors and finally the engine revs starts to drop off.

The test does not give you an exact measure of how much your propeller is under sized - only that it is. An accurate measurement demands a sea trial where we fit fuel consumption measuring equipment to the engine. By measuring the actual fuel burn rate at the maximum rpm and comparing the result with the engine manufacturer's specifications, we can calculate the actual horsepower of the engine being used relative to what it is capable of. A propeller manufacturer can then use these figure to accurately repitch the propeller or build a new propeller.

What does a propeller do?

- Its ability to move a vessel through the water depends on several factors:
- The rotational speed of the propeller, which corresponds to the propeller shaft rpm
- The angle or pitch of the propeller blades
- The diameter and blade area

To understand the operation of a propeller, let us define the its parts:

- The blade does the work; it pushes water. The wider the blade face the more water it can push. the more water that can be pushed, the stronger the thrust on the vessel and therefore, a greater amount of work can be done resulting in increase in speed.
- Propeller diameter is the diameter of the circle described by the tips of the rotating propeller blades.
- Pitch is the angle the blade makes in relation to the centre line of the hub. It is normally expressed as the distance (in inches) that the blade would advance in one revolution, if it were a screw working in a solid substance (ie like a bolt being screwed into a nut).

By viewing the propeller as an axial pump that delivers a stream of water aft of the vessel, itis this stream of water, equivalent in size to the diameter of the propeller, that is the power that provides thrust to move the vessel through the water.

To provide thrust, however, the propeller must accelerate the mass of water it pushes against. In so doing, a portion of the pitch advance is lost to the work of accelerating the water mass. This is known as "propeller slip".

Generally propeller slip will be in the vicinity of 18-25 percent for a planing hull and 25-30+ percent for a displacement hull. Slip greater than this usually indicates a propeller or installation program.

The important thing to remember is that all propellers are a compromise. The general practice is to use the largest diameter propeller turning at the slowest possible speed for the vessel's application within practical limits. These limitations are:

- the size of the propeller aperture
- the type of work the vessel will be doing - tug or pleasure craft
- excessive shaft installation angle that may be required when using large diameter propellers
- the size of shafting required for large diameter propellers
- comparative weights of propellers, shafts and gearboxes with respect to the size of the vessel
- the vessel's inherent ability to absorb the high torque that results from the use of large, slow-turning propellers
- comparing the capital cost of using large diameter propellers against any increases in efficiency and performance.

How many blades?

In theory, the propeller with the smallest number of blades (ie two) is the most efficient. However, in most cases, diameter and technical limitations necessitates the use of more blades. Three bladed propellers are more efficient over a wider range of applications than any other propeller.

Four and five bladed propellers are used to increase area in high horse powered vessels and to reduce vibration. All other conditions being equal, the efficiency of a four-bladed propeller is approximately 96 percent of that of a four blade propeller having the same pitch ratio and blades of the same proportion and shape.

An old waterfront rule of thumb for all propeller selection is:
"Towboats - big wheel, small pitch"
"Speedboats - small wheel, big pitch"

All other applications can be shaded between these two statements of extremes. Propellers are an art, not an exact science!