

# Modeling Tractor-style Azimuthing Podded Drives

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### OVERVIEW

Tractor-style azimuthing podded drives (APDs) have recently become an attractive propulsor option. By careful consideration of the underlying elements of the APD pod style of propulsion, it is possible to model their performance in parametric performance prediction software, such as NavCad. By choosing proper correlation coefficients (i.e.,  $K_T$  and  $K_Q$  multipliers), propeller series and propulsive coefficients, you can reliably model an APD with standard propeller series data.

### PROPELLER PERFORMANCE

One might expect that the efficiency of propellers for APDs would be higher than for a standard series propeller (e.g., B-series, Gawn). In fact, this is not generally true. APD propellers have a large hub (>30%) and often have design features to help mitigate noise and vibration concerns, which degrade the efficiency a few percent. These features typically include variable pitch distribution to "off-load" the tip and root areas, and a forward leading rake to increase the distance from the propeller to the pod structure immediately aft.

We have found that a consistent numerical model can be constructed by using the Gawn propeller as the basic propeller series. To account for the reduction in efficiency versus the Gawn, we can choose  $K_T$  and  $K_Q$  multipliers that reflect this. Based on published data, typical values in the normal design range would be  $K_{Tmult}=1.02$  and  $K_{Qmult}=1.06$ .

### RESISTANCE

Model testing of hulls fitted with APDs have shown that the drag of a vessel with pods is often a bit less than the sum of the bare-hull vessel drag plus the independent APD pod drag. In other words, the "whole is better than the sum of its parts". It is surmised that the

pods act like small stern bulbs and introduce a beneficial change in the wave system - in the same fashion as we see with bulbous bows. This notion is compatible with visual observations of the wave system. It is our suggestion that the appendage drag of ADP pods be modeled and added to the bare hull as for any appendage. Any actual resulting improvement in the resistance of the podded hull can then be held as a design margin.

### PROPULSIVE COEFFICIENTS

The amount of published information for self-propulsion tests of APD models is very limited. From the literature, however, we can make a few recommendations for typical values - wake fraction ( $W$ ) is 0.05-0.08, thrust deduction ( $TD$ ) is 0.04-0.06, and relative-rotative ( $RR$ ) efficiency is 1.04-1.07.

It is important to correlate  $W$  and  $TD$ , so that values in the low range of  $W$  match values in the low range of  $TD$ , and vice versa. The intent of this is to keep the hull efficiency relatively consistent at 1.01-1.02.

### SYSTEM IMPROVEMENTS

The high  $RR$  is one of the principal reasons for the high efficiency of APD systems. Placing a propeller in front of the pod strut induces the recovery of rotational energy. In other words, the strut aft of the propeller acts like a stator in the flow stream.

Even though the propeller itself may be a bit less efficient due to the large hub and design features used to minimize noise and vibration, the amount of improvement of the APD system versus a conventional propeller can be significant - on the order of 2%-4%.

## SUMMARY

Based on this information, a strategy for modeling APD propulsors is:

- Model and add APD pod appendage drag.
- $W=0.05-0.08$
- $TD=0.04-0.06$  (or,  $=0.8*W$ )
- $RR=1.04-1.07$ .
- Gawn AEW propeller.
- $KT_{mult}=1.02$  and  $KQ_{mult}=1.06$ .

As with all design data, this information is subject to a designer's own information or preferences.

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