Advanced Propulsion System GEM 423E Week 9: Podded Propulsion&Propellers

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Contents

- WHAT IS PODDED PROPELLER ?
- HISTORICAL DEVELOPMENT OF PODDED PROPELLER
- THE ADVANTAGES OF PODDED PROPULSION
- THE DISADVANTAGES OF PODDED PROPULSION
- SCIENTIFIC INFORMATIONS

PODS in Service

WHAT IS PODDED PROPELLER ?

WHAT IS PODDED PROPELLER ?

- One of the latest developments in ship propulsion is the increasing use of podded propulsion.
- This is provided by an azimuthing main propulsion unit.
- The unit incorporates an electric motor, which is located inside the pod.
- The use of mechanically driven azimuthing main propulsors is a proven technology, especially in tugs and supply vessels.

Fig 1 Large but fast ship, can she be effectively driven by pods?

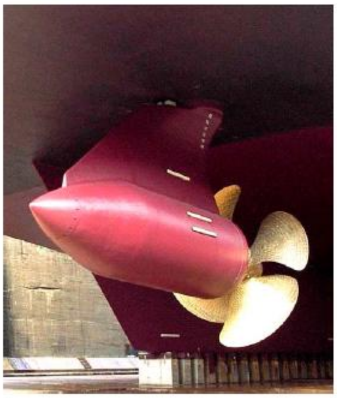
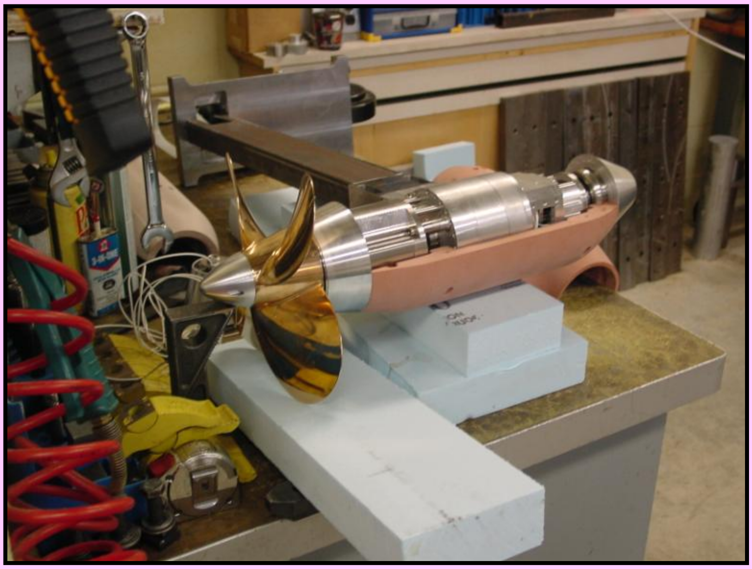


Fig 2 Azimuthing podded drive, can it be attractive for a large and fast ship?

HISTORICAL DEVELOPMENT OF PODDED PROPELLER

- The use of pod propulsion, on the other hand, is a relatively new invention.
- The first known installation was made by what is now ABB Azipod in 1990 in a buoy handling vessel belonging to the Finnish Maritime Administration.
- The following installations were made in ice-going vessels but the main breakthrough was their installation into the cruise liners ms Elation of Carnival Cruise Lines in 1998, by Kvaerner Masa-Yards.
- Since then, development has been rapid. Today, there are at least four commercial manufacturers.

Shipyards	Pod manufacters
Chantiers de l'Atlantique	Azipod
Masa-Yards	Mermaid
Fincantieri	SSP
Meyer Werft	Lips

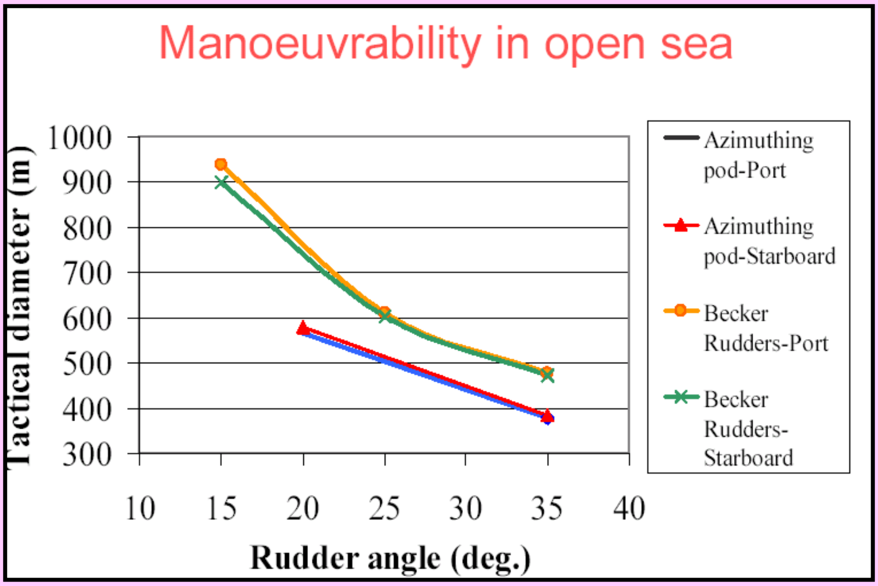


THE ADVANTAGES OF PODDED PROPELLERS

- High maneuverability
- Fuel oil savings
- Performance low noise and vibration
- Safety
- Resistance
- High efficiency

Maneuverability

The main benefit of podded propulsion is of course, dramatically increased maneuverability.



- **Fuel oil savings**

  The gain in power demand is generally high 10-15% fuel oil savings have been reported.

  Podded propulsion also calls for new thinking in hydrodynamic design.

  A ship equipped with podded propulsion does not have conventional shafts affecting the wake or rudder.

  On the other hand, the correct hydrodynamic balance between the pod shaft, the pod itself and the propeller, are important.

Performance low noise and vibration

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.

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 KT and KQ multipliers that reflect this. Based on published data, typical values in the normal design range would be KTmult=1.02 and KQmult=1.06.”

- **Safety**

Safety is something that cannot be compromised.

The growing size of the ships has caused some important new aspects to be taken into account, regardless of the size of the ships.

Risk based approach is a modern way to consider safety, whether it relates to fire, operational safety or stability.

Risk is the combination of the probability of accident or incident and its consequences. Preventive measures must be balanced by any risk.

- Fire safety is of course, of the utmost importance.
- New general arrangement solutions call for simulation of fire propagation.
- New fire extinguishing systems have been developed, especially for use in machinery spaces that have the biggest fire risk, where extensive fire testing of various new materials and structural solutions have been performed.

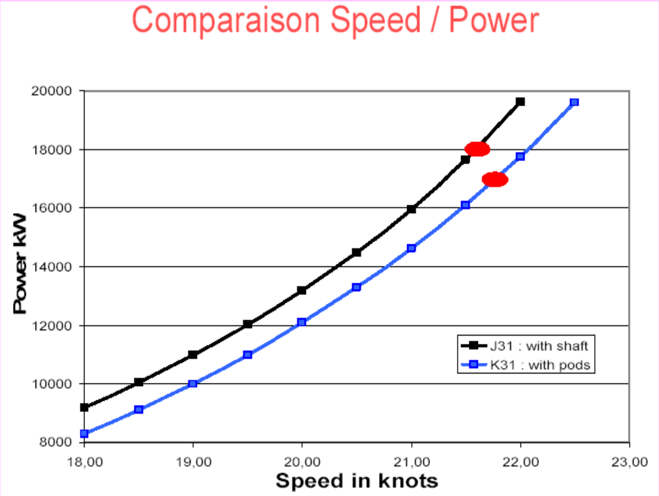
- Large new ships call for special operational safety measures.
- Podded propulsion offers extremely good maneuverability.
- On the other hand, modern cruise vessels have a very large wind area above the water line. Safe approaches to some harbors that are difficult to maneuver have been studied.
- This includes wind force coefficients for various wind speeds and directions for the ship model, which have been tested in a wind tunnel.

- A model of the actual harbors has also been tested in the same way, in order to get the local wind velocities under some nominal wind speeds.
- This data then goes in to a ship-handling simulator.
- The result is a calculation of the wind speed/direction combination for it to be safe to come into a particular harbors

- **High Speed**

the interest for the use of podded drives as the main propulsion system of ships is increasing due to the hydrodynamic characteristics and the advantages of the diesel-electric propulsion.

The main characteristic of podded drives is the integration of a powerful electric motor in a hydrodynamic optimised gondola below the aft body. The propeller is driven directly by the electric motor.



The following podded drive systems are available in this moment: AZIPOD® (ABB), MERMAIDTM (KaMeWa/Cegelec), SSP (Schottel/Siemens), DOLPHIN (John Crane Lips/STN).

The studies for podded drives with a pulling or a pushing propeller and with a twin propeller system include the design of propellers, pod housings and different model tests.

- **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.

Summary of the advantages of using podded propellers

Why to put Pods ?

- Power / Speed
- Comfort
- Manoeuvrability / Crabbing
- General Arrangement
- Assembling process / Replacement

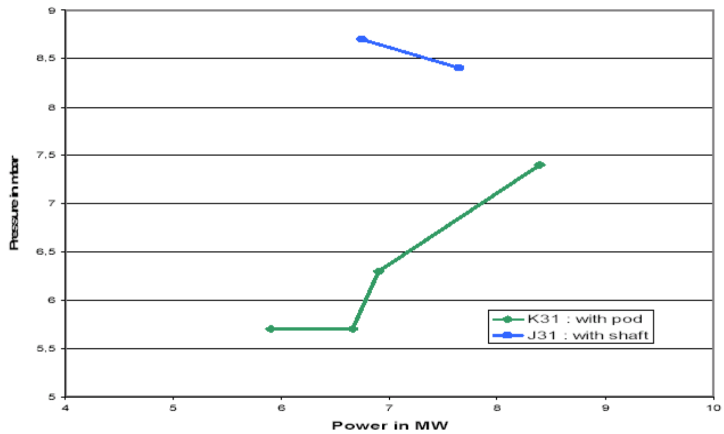
Other aspects

- Aftbody flatness / Angles
- Location of pods / Pod axis / Propeller axis
- Use of new freedom (no shaft)
- Check of seakeeping qualities
- Coursekeeping methodology

POD propulsion :

- Improvement in propulsion, manoeuvrability, environment, comfort, general arrangement, building process, operability
- Works are in progress for a complete control of qualities and limits
- Pods will be used for more ship types in the future
- Ship designs will be more adapted to pods in the future
- Excellent co-operation in European projects between industry, university, suppliers, model basins, classification societies, from all parts of Europe

Pressure Fluctuations



DISADVANTAGES

- As the concept is new, there have also been some negative experiences, mainly of a mechanical nature.

- The concept itself is great, however, and may just need refinements to some details, operating instructions etc…

- There are other challenging areas for research and development, such as electricity - how to get enough power to an electric motor that is slim enough to ensure that that the pod itself is not hydrodynamically incompetent.
- The structural design is also demanding.

- The weight of a unit may be over 100 tons hanging off a strut.
- All this calls for multi-technological research to support the design: dynamic analysis of the structure and hydrodynamics using as tools both model testing and computational fluid dynamics.

- **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.

- **Propulsive Coefficients Cont.**

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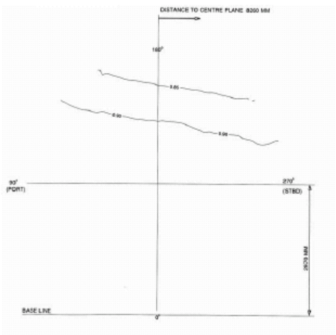
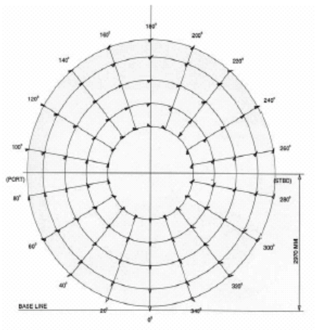
- **Overview**

  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., KT and KQ multipliers), propeller series and propulsive coefficients, you can reliably model an APD with standard propeller series data.

Ship Wake



Axial velocity component



Transverse velocity component

- **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%.

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.
- KTmult=1.02 and KQmult=1.06.
- As with all design data, this information is subject to a designer's own information or preferences