Azimuthal Pod Propulsion for Energy Conversation and Better Manoeuvarability

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***Abstract*— In the present era of shipping where ports are much busier than the roads, manoeuvring of the ship plays an important role. Not only manoeuvrings important, but when seen from an owner or charterer's perspective, fuel consumption plays a bigger hand. The greater the efficiency, lesser will be the fuel consumed, so, lesser will be the emission, and ultimately a greener tomorrow for the future generations, without burning a hole in the owner's pocket. Azimuthal Pod Propulsion System which shrouds off the existence of rudders, is composed of a pod which is capable of rotating about its mount axis, hence providing the vessel with thrust in any direction, which the convectional propulsion systems lacks. This system incorporated an electric motor, mounted directly on extremely short propeller shaft. The electric motor inside the pod, drives the propeller, controlled by frequency converter, which controls the frequency of the supplied power, so as to vary the speed as per the demands. For this reason, it is also known as POD or Propulsion with Outboard Electric Motor. The advantages of this system include the increase in cargo space due to the saving in space of the engine room. The side-thrusters are not needed anymore, as the Pods can be used for providing side thrust. The fuel consumption is reduced by about 10-15% thus reducing the amount of emission being exhausted into the environment. Although, the initial cost and the number of generators required are high, these are a viable option for a greener tomorrow.**

I. INTRODUCTION

An azimuthal pod thruster is a configuration of ship's propeller placed in pods that can be rotated in any horizontal direction making the rudder unnecessary. The pods propeller usually faces forward because in this configuration the propeller is more efficient. Since it can rotate about its mount axis the pod can apply its thrust in any direction. Azimuth thrusters allow ships to be more maneuverable and enable them to move astern nearly as efficiently as they move ahead.

The pod incorporates an electric single or double wound A.C motor mounted directly on an extremely short propeller shaft. The electric motor drives a fixed pitch propeller. The motor is controlled by a frequency converter which produces full nominal torque over the entire speed range.

The pods are in the power range of 0.4MW to 30MW. The pods in the power range of 0.4MW to 5MW are referred to as "small pods", whereas those which are in the range of 5MW to 30MW are referred to as 'large pods".

This concept has a great potential for container vessels, Ro-Ro vessels, shutter tankers, chemical tankers and LNG/LPG.

Most of the pods sold today generally have the same design. However there are two major variants, based on the location of the motor:

- *Mechanical transmission*, where a motor inside the ship is connected to the pod by gearing. The motor may be diesel or diesel-electric.
- *Electrical transmission*, where an electric motor is in the pod itself, connected directly to the propeller without gears. The electricity is produced by an onboard engine, usually diesel or gas turbine.

Main suppliers of these Pod Propellers are Rolls Royce Kamewa/Alstrom, Finland ABB Industry, Siemens-Schottel, and STN Atlas Marine/ John Crane-Lips.

II. ELECTRICAL TRANSMISSION

The conventional pods which are being manufactured use electrical transmission where motor is placed inside the pod, the rotor is placed on the same shaft as the propeller which eliminates the use of gears. The shaft is held in place by a thrust bearing arrangement at the non-drive end and a radial bearing arrangement at the drive end.

Electrical systems in pod propulsion usually consist of Transformers, Frequency converters and Propulsion motors.

Transformer

The transformer is used to divide the system into several parts in order to obtain different voltage levels but also for phase shifting. The transformer isolates the two sides electrically. In pod propulsion two types are most common, wet and dry type.

The output of a transformer, supplying a pod system, is adjusted to the input rectifier stage of the converter.

Frequency converter

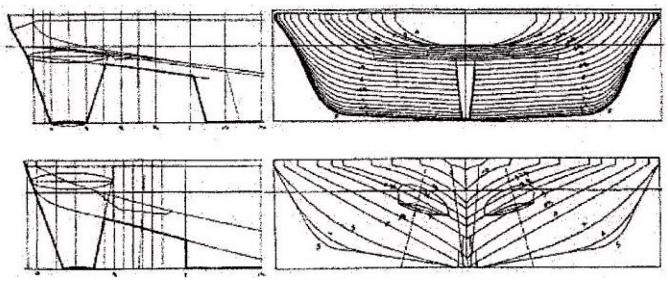
The purpose of the frequency converter is to control the speed and torque of the motor by changing constant frequency into variable frequency. The technical development of semiconductors has been important and made many different designs of converters possible

Electric motor

The electric motor is used for conversion from electrical to mechanical power. In pod propulsion three motors are used: synchronous-, permanent magnet- and induction motors. The by far most common motor is the synchronous motor (SM), because of the high efficiency in high power range. The motor is called synchronous because the rotor runs at synchronous speed, meaning that the rotor is spins at the same rate as the oscillating field which drives it.

III. ANALYSIS ON INSTALLATION OF POD SYSTEMS

Installation of AZIPODs has important impact on the design features of the ship. In particular as diesel-electric propulsion system is required, internal space of the ship may be arranged differently as in conventional ship, in general more convenient and saving in space. The other consequence is the form of the stern part of the hull that with the AZIPOD propulsion units installed must be flattened in order to accommodate PODs.



Recommended form of Hull (Stern Part View)

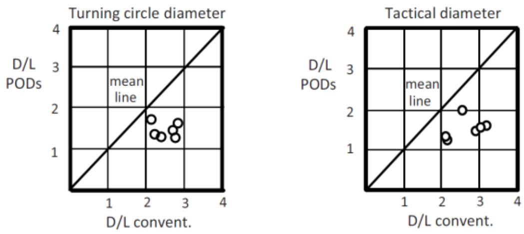
IV. ANALYSIS OF MANEUVERABILIITY OF SHIP UPON INSTALLATION

One of the most important advantages of AZIPODs is that manoeuvring characteristics of POD propelled vessels are different, and in general much better than of vessels fitted with conventional propellers. There are three basic manoeuvring characteristics that must be taken into account when designing a ship, namely:

1. Turning ability
2. Course keeping ability or dynamic stability on straight course, and
3. Stopping ability

Turning ability of AZIPODs driven ships is much better than turning ability of conventional ships fitted with conventional rudder. This is obviously the result of high steering forces created by AZIPOD rotated up to 360 deg with the result that the ship may turn even around of its own centre of gravity. Comparison of turning ability characteristics of average conventional and POD propelled vessels is shown.

The course keeping ability for AZIPOD driven ships is known to be worse than for conventional vessels. The reason of this effect may be attributed to the different form of the stern that is flat in order to accommodate AZIPODs. The course keeping ability is usually assessed by overshoot angles obtained in so called zig-zag test. The same source shows that overshoot angles obtained are in average larger for AZIPOD propulsion than for conventional propulsion, but still seem to satisfy manoeuvring standards adopted by the IMO Resolution. With AZIPOD propulsion however, this characteristic depends on the proper installation of fins at the loaf-shaped stern, otherwise course keeping ability would be inadequate.



This was clearly shown during the tests of manoeuvring characteristics performed of AZIPOD propelled vessel in SHRTC Ilawa (Ship Handling Research and Training Centre)in the years 2003-2010. Within the scope of the project large model of gas carrier equipped with one or two AZIPODS was built and tested on the lake.
Stopping ability is an important element of manoeuvring characteristics of the ship and stopping distance according to IMO criterion should be not more than 15 ship lengths when crash stop test is performed. With AZIPOD driven ships there are several possible modes of stopping the ship. Main three modes are:

- Conventional crash stop manoeuvre when engines are ordered full astern
- Stopping (called POD WAY) by turning AZIPODs 1800 inwards (or outwards) in opposite directions while maintaining constant shaft torque.

- Stopping by turning AZIPODs 900 inwards in opposite directions while maintaining constant shaft torque.

V. MAIN ANALYSIS

The purpose of this thesis is to compare the Azimuthal pods to the conventional propeller and rudder system. This will be done on various parameters.

Apart from this, the thesis aims at doing an analysis of pod propulsion, its chances of being used in practical and, the future scope.

COMPARISONS:

Efficiency of Propulsion Unit

When compared with the efficiency of a propeller alone, the propulsion efficiency of a single pod unit is lower. A realistic conclusion can only be drawn if the unit efficiency of the pod is compared with the unit efficiency of the conventional propeller with rudder.

A gain in propeller efficiency can be expected for twin pod arrangements because the inflow to the propeller is more uniform (absence of shafts and shaft brackets). This leads to better design conditions for the propeller and therefore to higher propeller efficiencies.

Maneuverability

Since it can rotate around its mount axis, the pod can apply its thrust in any direction. Azimuth thrusters allow ships to be more maneuverable and enable them to travel backward nearly as efficiently as they can travel forward.

The M/S Elation which uses Azimuthal pods can travel:

- 17 knots astern
- 25 knots ahead
- 5 knots sideways.

Also, ships working on azimuthal pods do not require tug boats to dock thus proving to be economical to use. Full scale comparison of turning circles of M/S Elation and Paradise with conventional propulsion with rudder is shown.

The main key points hence can be laid out as,

The advantages of AZIPOD drives in comparison with traditional diesel propelled vessel with fixed propellers are:

- Elimination of shaft line, steering gear, rudder and stern thrusters.
- More cargo space because of possible re-arrangement of machinery space and utilization this space for other purposes.
- Better manoeuvrability.
- Better reversing capability and low speed and astern performance.
- Lower noise level and less vibration.
- Smaller power required in twin AZIPOD driven ships.

The disadvantages are:

- Higher capital cost.
- Generally slightly lower propulsion efficiency and loss of power because of diesel electric propulsion.
- Stern part of ship must be re-designed in order to accommodate AZIPODs.
- Limitation of power available for single AZIPOD (up to about 25 MW).

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