A Review of Azimuth Thruster

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Abstract

This paper primarily concerns with the review of Azimuth thruster, its types, architecture, working along with its advantages and disadvantages. An Azimuth thruster is an arrangement of marine propellers placed in pods which can be rotated to any horizontal angle (azimuth). Joseph Becker, invented the Z-drive azimuth propeller first in 1950, whereas this kind of propulsion was first patented by Pleuger in 1955. The ships fitted with this system give better maneuverability than a fixed propeller and rudder system. This assembly consists of the podded propeller connected to a motor and an azimuth well to support the propeller. As thrust acts on the assembly, the well is supported by structures like brackets, struts etc. Furthermore, literature survey about the work doneon Azimuth Thruster till datehas been mentioned. There has been sufficient research on the optimization of design of propellers, performances and efficiencies at various parameters, but there is scope of improvisation in the design of supporting structures related to the assembly in order to optimize the weight and increase the efficiency of the working of the propeller, as well as to mitigate the problems faced while assembly.

Keywords: *Azimuth Thruster, Brackets, Propeller.*

I. INTRODUCTION

Azimuth Thrusteris the configuration, which is used in marine vessels to provide necessary thrust in desired direction which give ships better maneuverability than fixed propellers and rudder systems. Ship Propulsion system is changing rapidly and so is the propulsion mechanism system. These thrusters are primarily used in dynamic positioning of vessels to maintain the position by counteracting environmental obstacles such as wind and waves. Now days these are also used for propulsion.

Azimuth Thruster is an arrangement in which the propeller is placed in pods that can be rotated in any direction in the horizontal plane. Azimuth is an angular measurement in a spherical coordinate system. This thruster is capable of rotating itself in 360˚about its vertical axis, which provides more flexibility and optimal thrust in every direction to the system unlike fixed pitch thrusters. For a single vessel, there can be more than one thrusters mounted right underneath the hull of the vessel i.e. near bow and stern.

The azimuth thruster using the Z-drive transmission was invented in 1950 by Joseph Becker, the founder of Schottel in Germany, and marketed as rudder propeller [1]. Later on, relevant literature was studied and many modifications were suggested in the design of the thrusters. But, the work on the design of brackets of the azimuth thrusters is still in rudimentary stage.

II. TYPES OF AZIMUTH THRUSTERS

Based on the transmission used:

A. *Mechanical Transmission*

In this transmission,a motor inside the ship and is connected to an outboard propeller unit viabevel gears. The motor may be either a directly mechanically connected diesel engine, or an electrical motor getting its power from generators run by an electricity producing engine (usually diesel engines) situated elsewhere in the ship which is capable of delivering input power in the range of 330-3700 KW with RPM in the range of 1500-2100 and 720-1200 respectively[2]. Based on the arrangement these are further classified into,

1) L-drive

It means the motor is placed vertically above the propeller. The L-drive consists of a vertical input shaft and a horizontal output shaft. Power transmission between motor-axiswhich is connected to the propeller-axis is achievedby using a bevel gear arrangement. [3]

2) Z-drive

Z-drive means that the motor is placed horizontally above the propeller. A Z- drive's power transmission system consists of three shafts. A horizontal input shaft which is connected to a vertical intermediate shaft which is then connected to a horizontal output shaft with the help of two right angled gears (bevel gears) and thus making a Z shape.

B. *Electrical Transmission: [3]*

In this transmission, electric motor is installed in the pod itself which is directly connected to the propeller without gear arrangement. The energy used to drive the motor in the pod is produced by machinery inside the vessel, usually by diesel engines or gas turbines which drive electric generators, in a system comparable to that used by diesel-electric locomotives. Azipod thrusters belongs to this transmission system, which are further divided into, *1) **Azipush***

An azipush is installed so as to push the ship forward. The propeller is installed in the direction of the stern of the ship with the pod in front of it.

*2) **Azipull***

The azipull system is installed so as to pull the ship forward. The propeller is installed in the direction of the head of the ship with the pod behind it.

C. Retractable Thrusters

Azimuth thrusters can be retractable in horizontal and vertical direction. It is because azimuth thrusters are vulnerable to grounding damage in shallow water. Furthermore, thrusters can also be place higher on the ship, but in this case, they are closer to the surface and then they are less effective. Hence, retractable thrusters are highly recommended over non-retractable ones depending upon the applications. [2]

Retractable thrusters are thru-hull azimuthing thrusters using fixed pitch propellers at variable speed. Most commonly they use nozzled propellers and are used for dynamic positioning or slow speed course tracking applications. They are available with electric drive from 250 to 10,750 HP (185kW to 8.0MW) or with hydraulic drive from 75 to 3,000 HP. [4]

III. ARCHITECTURE AND WORKING OF AZIMUTH THRUSTER

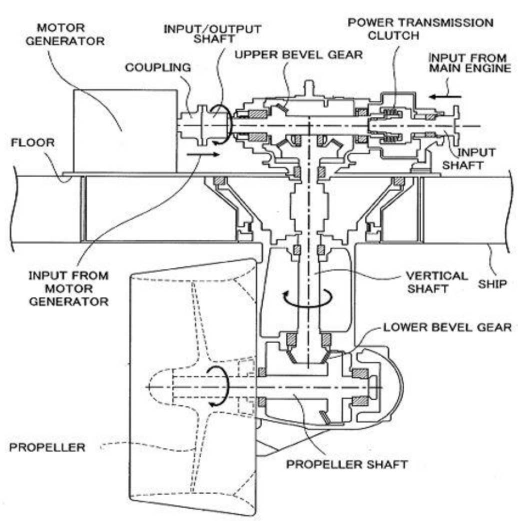

Fig 1. Components of Azimuth Thruster (Z- drive mechanical transmission)

Major components:

1. Propeller
2. Propeller shaft
3. Bevel gears (lower and upper)
4. Vertical shaft
5. Input shaft
6. Azimuth well and brackets
7. Motor

Azimuth thruster system including impeller, impeller shaft and vertical shaft which is fitted to the hull portion of the vessel by means of brackets by welding. Here, input from the main engine is given to the motor generator through the power transmission clutch [5].Output of the motor is given to the output shaft by a suitable coupling. The power from the horizontal shaft is then transferred to the vertical shaft through anupper bevel gear, as shown in fig.1. Further, this motion is transmitted to propeller shaft by lower bevel gear which results in the rotation of the propeller.

Azimuth thruster can provide thrusts in all directions. Because of this, the components of azimuth thruster experience thrust in every directions. So, for the analysis of thruster under variable load, all the directions are needed to be considered. It makes the analysis very critical.

IV. LITERATURE REVIEW

To achieve economical and effective modulation of the thrust and the direction of the Azimuth Thruster using the sequential quadratic methodso that it can be used in Platform Supply Vessels (PSVs) with dynamic positioning (DP) [6] system has been proposed. [7]

Failure in the thruster system can occur due to various reasons. There can be mechanical failure of generator, automatic engine shutdown, flexible coupling, and ventilation failure, etc. All factors responsible for failure of thruster operations, probability of failure, local and final effect, and criticality have been studied and results were obtained. [8]

A comparative analysis of different kinds of ship propulsion systems with azimuth thrusters and also constructional solution of an azimuth thruster destined for small vessel with diesel-hydraulic driving system. [9]

A fracture examination of the broken teeth of helical gear wheels in order to determine the damage root causes.An analysis through the scanning electron microscope (SEM) was carried out close to the crack initiation. [10]

Azimuth thrusters installed in a drillship are used not only as the thrust acting device in dynamic positioning mode when wind/current/wave load are applied but also used for the propulsion system in transit mode from drilling site to site.An alternative method is dividing 6 azimuth thrusters into several groups considering each thruster group'slongitudinal/transversal position in thruster's propulsion test is presented. [11]

The optimal structural design of the brackets for offshore structures was evaluated using ANSYS commercial Software. [12]

The pulling thruster under study was compared with a ducted pushing thruster for hydro-dynamic loads and the results are discussed in detail. [13]

The performance coefficients of the propeller and the pod unit showed a strong dependence on the propeller loading and azimuthing angle. [14]

V. ADVANTAGES

Azimuth thrusters are mounted on a 360˚ rotating shaft under the ship. The most important advantage of azimuth thruster is an optimal thrust in every direction. There is no rudder required in an azimuth system and hence, the underwater dynamics are improved which not only increase maneuverability, but also azimuth thrusters include the advantages of combined engine systems.

With the invention of azipod propulsion system, steering behavior has been increased. It can be built for pushing or pulling operation, at low or high speeds. Additional maneuverability may be attained by changing the azimuth elevation. Using azimuth thrusters, the crash stop distance can be halved compared to conventional propeller systems.

More advantages are electrical efficiency, better use of ship space, and lower maintenance costs. Ships with azimuth thrusters do not need tugboats to dock, though they still require tugs to maneuver in difficult places.

VI. LIMITATIONS

The azimuth thrusters can be retractable, horizontally or vertically in the hull, although the first one takes up less space. When the thruster is retracted it cannot be used.

Some azimuth thrusters are removable. This might be interesting for vessels where retraction of the thrusters is not possible (when there is not enough space for this for instance) or when it is too expensive to install. This is suited for ships that spend most of the time in deep water; when travelling to shallow water one can ’simply’ remove the thrusters.

An azimuth thruster can work in the ahead and the astern direction. In the astern direction the amount of thrust available falls to only 60%, but since sailing in reverse is faster than rotating the unit through 180˚ and since sometimes there is not enough space for rotation, this still is an interesting possibility.

VII.CONCLUSION

According to the literature survey, optimum control of azimuth thruster, failure modes, different propulsion systems, fracture examination, performance coefficient, and optimal design for brackets, etc. are studied till date. But, this technology is yet to be fully researched and optimized.

As there is requirement of more research to be done in the design and fabrication of brackets depending upon the shape of hull portions to mitigate the problems faced by the workers while welding, complete optimization of azimuth thruster is beyond the scope of this paper.

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