



## Brunvoll presents a "Rim driven thruster" (RDT)

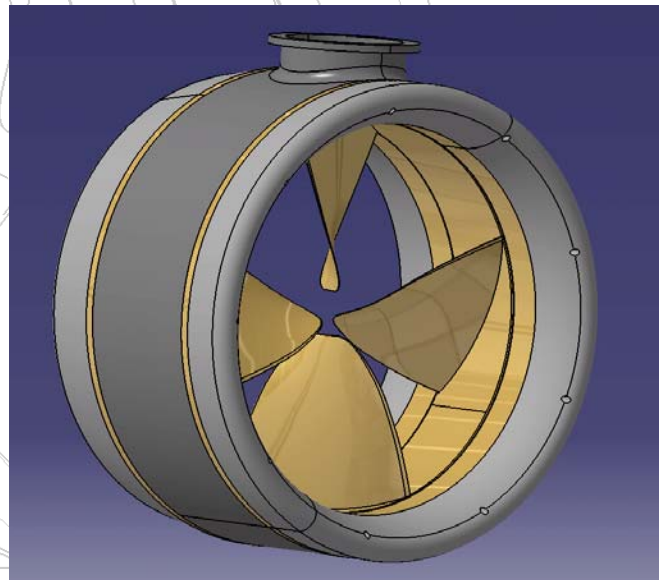
Brunvoll A.S has since 2002 worked on the development of so-called rim driven thruster units. The development work has been carried out in co-operation with the company Norpropeller AS, which is also partly owned by Brunvoll.

The work has included the building of a 100 kW azimuth thruster. This thruster unit, which is believed to be the largest RDT built so far, has undergone extensive testing.

The RDT is electrically driven with a permanent magnet (PM) motor, where the motor windings are in the stator and where the rotor has a number of permanent magnets. The rotor bearings are located at the periphery of the rotor. The fixed pitch propeller is directly connected to the rotor and hence the thruster unit has no central shaft.

The development of the RDT has been triggered by the market demand for an increased number of ships where both the main propulsion units and the manoeuvring thrusters have electric motors with variable speed drives. In this context the RDT offers a number of advantages.

- The motor is an integral part of the propeller nozzle in a ducted azimuth thruster and an integral part in a section of the tunnel in side thruster. This frees space on board the ship and gives greater arrangement flexibility.
- The motor design utilises permanent magnets. This gives greater flexibility in selection of motor speed (number of motor poles) and a motor with high efficiency.
- The bearings of the RDT are designed to eliminate the need for lubrication oil and there are no dynamic seals. Hence, the bearings, which are both magnetic and hydrodynamic bearings (with patents pending), are designed to minimise maintenance costs and eliminate any oil pollution.
- The Brunvoll RDT, as presented so far, has no central shaft and no shaft supporting struts. The inflow to the propeller is therefore undisturbed which is beneficial both with regard to propeller efficiency and propeller induced noise and vibration.
- The lack of a central shaft and shaft support stays, and the fact that there are no dynamic seals, is also beneficial with regard to damages due to line and rope entering the thruster.
- The fact that an RDT for main propulsion has a nozzle, which may be of the accelerating or decelerating type, is an advantage when the thruster operates with a rudder angle since the duct will reduce the negative effect on noise and vibration due to an inclined inflow.
- There is no gap between the propeller tips and the duct or tunnel. The elimination of the propeller tip gap gives higher propeller efficiency and a lower noise levels. Additionally, the propeller blade thickness may be reduced, and the radial thickness distribution as well as the radial load distribution may be changed to enhance propeller efficiency.



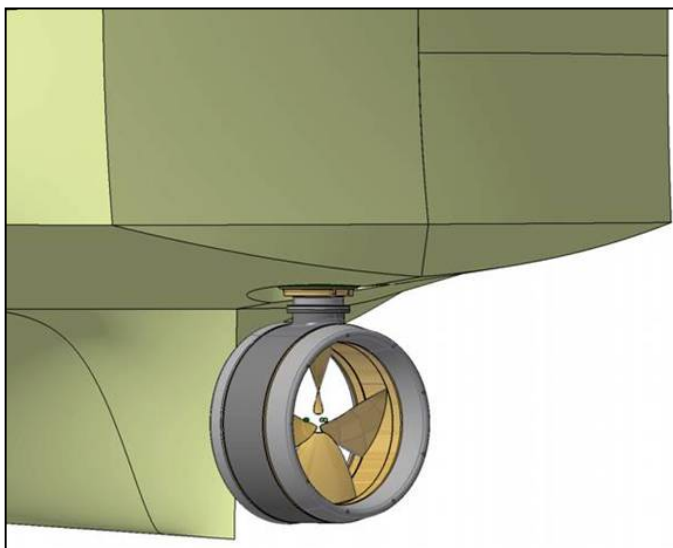


## The RDT may be applied for various thruster configurations

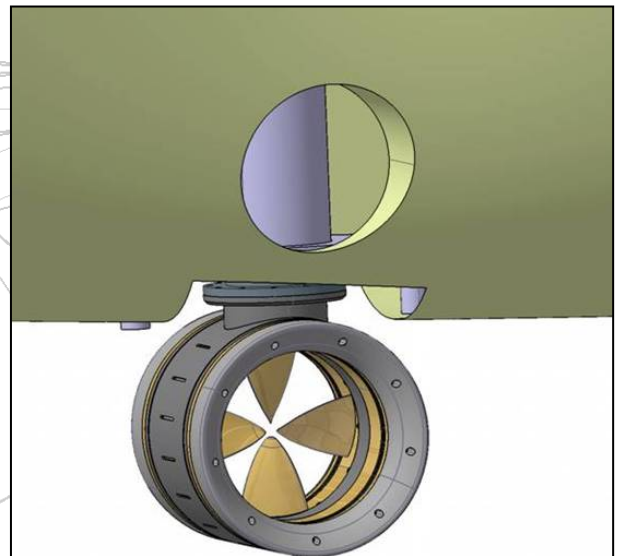
The RDT may be applied for virtually all thruster applications with a variable speed drive. Hence, as:

- A azimuth main or auxiliary propulsion thruster
- A retractable azimuth thruster
- A combined tunnel and azimuth thruster
- A tunnel thruster

The illustrations show the RDT designed as a main propulsion unit, as a combined retractable azimuth and tunnel thruster, and as a super silent resiliently mounted thruster (patents pending).



A RDT for main propulsion



A combined tunnel and azimuth RDT.

## The RDT drive system

The application of frequency converters

- The RDT may be applied directly on board ships equipped with diesel electric power systems and variable speed electric motors provided by frequency converters. Diesel electric variable speed drives have become more common over the latest years even for smaller ships. It is though observed that the interest in variable speed electric drives, and hence the application of RDT's with fixed pitch propellers, relies on several factors involving both consideration of cost-benefit and system complexity. E.g. from a cost-benefit consideration variable speed drives are of particular interest where the power needed for propulsion are minor as compared to power demands for other purposes, and/or for ships with an operating profile implying considerable periods with low-load operation.

A novel electric shaft system

- Based on the above considerations Brunvoll has also worked together with the company Norpropeller to test a novel drive system for variable speed electrically driven propellers. This system, which is patented by Norpropeller, involves the use of variable speed permanent magnet (PM) generators and PM motors.



The design implies that the prime mover, the diesel engine, may be run as in a traditional system, as if the engine was direct mechanically coupled to the propeller. A reduction gear is not required, since optimum speed for both engine and propeller can be obtained by selection of appropriate number of poles for the generator and propeller motor.

For operation a low power, idling and reversing a small frequency converters is used. That is, a much cheaper frequency converter than normally applied. The system may also involve the connection of a novel variable speed generator (VAR-G) that is capable of feeding constant frequency power to the ship net.

The system implies that the diesel engine (or other prime mover) may be operated with variable speed. This in turn gives lower noise and vibration levels and reduced fuel consumption as compared to the conventional diesel-electric systems.

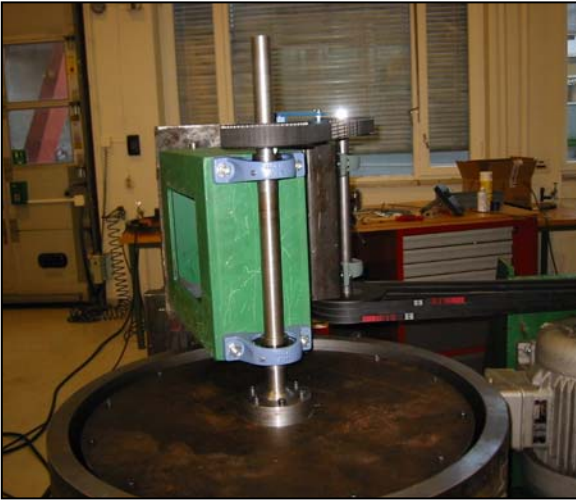
## Testing and verification

- The design of the PM motor, the bearings, and the propeller, has been verified by the building and testing of a 100 kW azimuth RDT. This RDT has entirely been built by Brunvoll, with the exception for the stator windings. The motor windings have however also been manufactured locally.
- The RDT has been subject to extensive testing in a test bed, as well by installation on board a test boat. The tests have e.g. included;
  - Testing of alternative novel rotor bearings (magnetic and hydrodynamic) both in test bed and on board the test vessel,
  - Determination of PM motor characteristics in test bed and on board the test vessel,
  - Bollard pull tests for different RDT configurations,
  - Measurements of noise and vibration levels,
  - Instrumented long term tests on board the test vessel.
- Further alternative thruster drive systems have been demonstrated and tested:
  - Operation with a conventional frequency converter
  - Operation with a PM generator directly coupled to the thruster PM motor, and where the motor speed follows the generator synchronous from zero to full speed.
  - Further, the tests has included a drive system configuration with a PM generator for the propeller PM motor and a variable speed generator (VAR-G) giving constant frequency power to the ship net. Both starting of the thruster PM motor using a reduced size frequency converter and synchronization towards the VAR-G has been demonstrated.

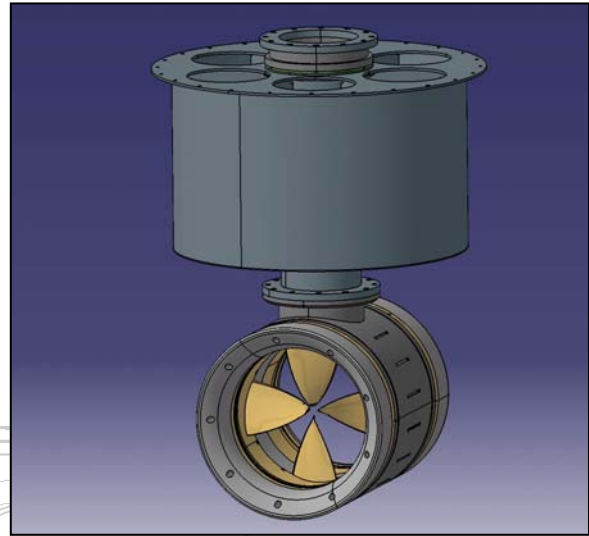


In the development and design work on the RDT and alternative drive systems a number of patent claims have been filed and several of these have already been granted.

As a result of the successful tests that have been conducted, Brunvoll AS is now working on the realization of the development and production of larger RDT units for the commercial market.



**Testing of rotor bearings in laboratory**



**The motor stator and rotor.**



**The 100 kW prototype have a flange mounted trunk to enable installation with the ship afloat.**



**Pictures during and after long run testing.**





Demonstration of thruster



Test boat



## Brunvoll A.S

Brunvoll develops and manufactures thruster systems for manoeuvring and propulsion of ships and mobile offshore units. The company was founded in 1912 and is represented in 22 countries.

Brunvoll has delivered more than 4800 thruster systems to world wide customers. More than 2500 ships have thruster installations from Brunvoll.

Brunvoll thruster systems includes tunnel thrusters, resiliently mounted super silent tunnel thrusters, azimuth thrusters, retractable azimuth thrusters and combined tunnel and azimuth thrusters.

[www.brunvoll.no](http://www.brunvoll.no)



## Norpropeller A/S

Norpropeller is a product development company founded in 2001 and is focusing on system design for power generation for maritime and land based industry and propulsion solutions for ships.

The Norpropeller solutions are based on application of permanent magnet technology and in-house developed motor/generator bearing designs and electrical generator and motor system designs.

[www.norpropeller.no](http://www.norpropeller.no)

