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Thruster Session

Electrical Voith Schneider Propulsion (eVSP) - Efficient and Safe DP through a gearless Thruster

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Abstract

Efficient Dynamic Positioning (DP) requires a fast and safely reacting propulsion system. The Voith Schneider Propeller (VSP) has proven itself for decades as a safe maneuvering device for DP vessels. Currently, Voith is taking the VSP one step further and introducing the electric Voith Schneider Propeller (eVSP) to the market.

This opens new options for Dynamic Positioning: Because in addition to the fast control according to an XY-logic of the VSP, the RPM can also be changed extremely quickly. This is made possible by the fact that a permanent magnet synchronous motor (PMSM) directly rotates the thrust-generating blades. Gearboxes are completely dispensed with, which has a very positive effect on efficiency and maintenance costs.

1. Introduction

The Voith Schneider Propeller (VSP) has been known for almost 100 years as a highly maneuverable, safe, reliable, and efficient propulsion system. The igniting basic idea came to the Austrian engineer (when he had the idea, he was still a student) Ernst Schneider (1894-1975), who saw a copy of a fish-like propeller. Thus, in the broadest sense, the VSP is also a bionic development.

With the electric Voith Schneider Propeller (eVSP), Voith has further improved the classic Voith Schneider Propeller. It is a gearless propeller, the rotor (i.e., the blades) is driven directly by an electric motor integrated in the housing. The advantages of this new design are that the efficiency is increased, especially because losses are reduced and the integration into the ship is very simple and compact.

The first ships are successfully sailing with the electric Voith Schneider Propeller (eVSP). These are the Edda Breeze and Edda Brint, two Service Operation Vessels (SOV) of the shipping company EDDA WIND (Ostensjö) and the passenger ship Viking Mississippi.

Figure 1 shows the SOV Edda Breeze, which is powered by two eVSP 26. The two propellers each have an electrical input power of 1850 kW.

Figure 1: SOV Edda Breeze propelled by two electrical Voith Schneider Propeller eVSP 26/230 (1850 kW)

2. Voith Schneider Propeller - Operating principle and integration into the ship

The Voith Schneider Propeller, a controllable pitch propeller, generates thrust by means of profiled blades that protrude from the vessel hull and rotate around a vertical axis. The blades are mounted in a rotor casing which is flush with the hull of the vessel. A local oscillating motion of the individual propeller blades around their respective axis is superimposed on the rotary motion of the blades around the common vertical axis. Generation of this oscillating motion is done via a kinematic mechanism. This working principle enables the propeller to adjust thrust continuously, both in amplitude and in direction (Figure 2).

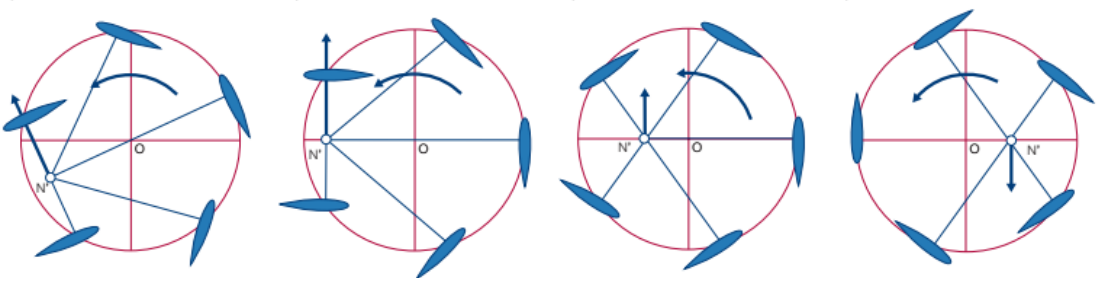

Figure 2: Easy and fast thrust variation through alteration of the steering center N'

More details on the VSP principle can be found in [1], [2].

A technical detail that is relevant for DP applications lies in the inherent way of thrust variation. Unlike with Azimuth thrusters, the thrust control of the VSP occurs according to Cartesian coordinates, so that a thrust reversal takes place via the neutral position instead of turning the thrust vector in polar coordinates as performed by the azimuth thruster (Figure 3) [2].

Voith Schneider Propeller (VSP)

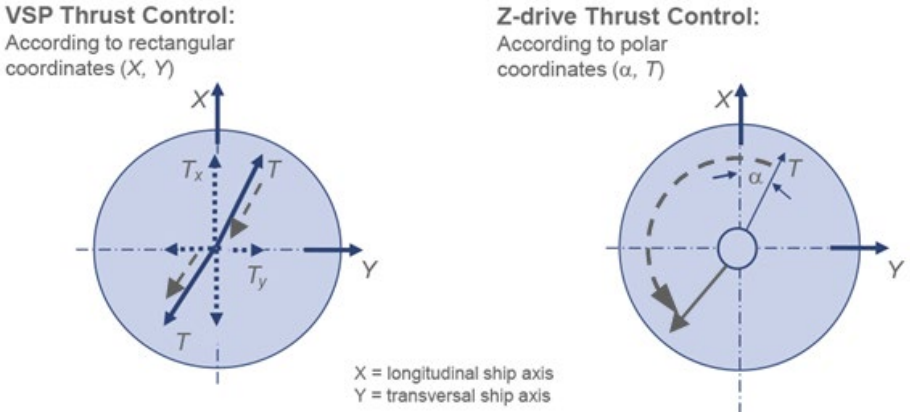

Figure 3: Thrust control principles of VSP and Z-drive Thrusters

3. Description of the technology of the electrical Voith Schneider Propeller (eVSP)

As a first development step of the new eVSP, a suitable electric motor principle was selected and adapted to the special features of the VSP. It was considered that the Voith Schneider Propeller operates at very low rotational speed, requires a high torque, and is often used in the partial load range.

Therefore, the highly efficient technology of the permanent magnet synchronous motor (PMSM), also known as torque motor, is the ideal solution. This modern electric motor technology is characterized by a very high efficiency in the entire motor map.

For this purpose, the PMSM was integrated directly into the housing of the Voith Schneider Propeller, and a special PMSM was developed for this purpose. The result of the development is shown in Figure 4.

The PMSM was realized with the innovative, space-saving toothed coil technology and the buried magnet method. The buried magnets guarantee a very high functional reliability.

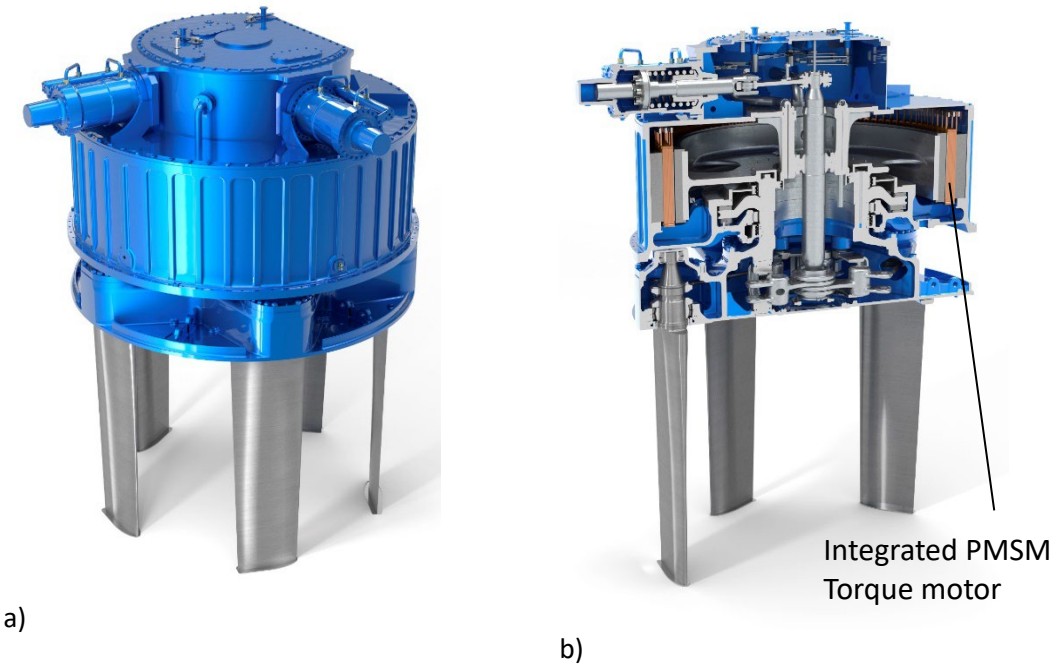

Figure 4: Electric Voith Schneider Propeller, CAD model a) in full view and b) in sectional view.

A comparison of both concepts - eVSP vs. classical VSP - can be seen in Figure 5. The PMSM torque motor of the eVSP substitutes the following elements of the classical VSP:

- bevel gearbox,
- primary gearbox,
- asynchronous machine,
- shaft line,
- cooling/controls of the primary gear unit and the asynchronous machine and
- foundations in the ship for the primary gearbox and the asynchronous machine.

In addition, the PMSM torque motor uses the same bearing as the hydromechanical part of the VSP.

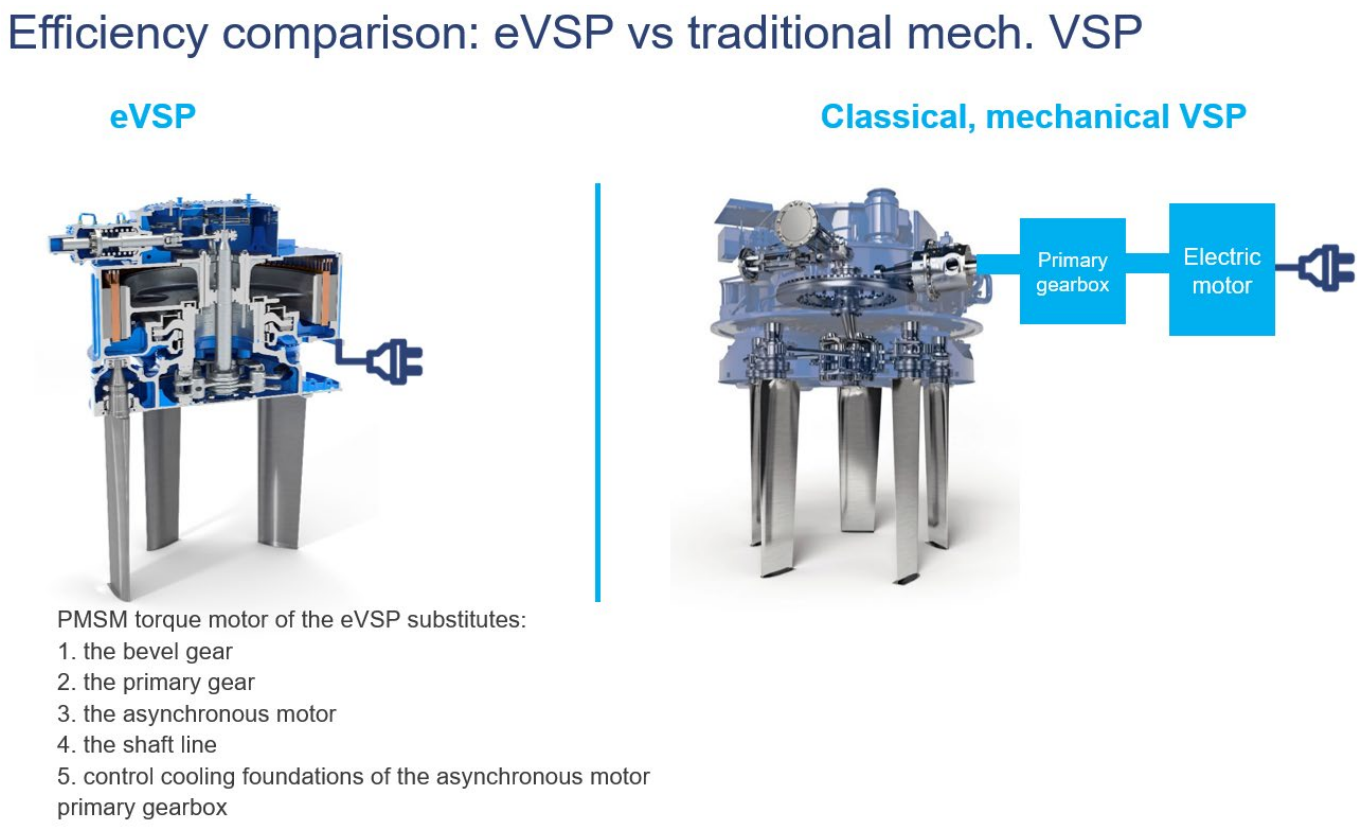

Figure 5: Comparison of concepts: eVSP vs. classic VSP

The high efficiency of the PMSM torque motor and the elimination of gearbox and shaft line losses are the basis for the efficiency increase in the range of 4% to 12% depending on the load. With the agile PMSM torque motor, variable-speed new dynamic positioning controls can be realized for offshore vessels.

To ensure development, a test machine with an input power of 260 kW was developed and accurately measured. Figure 6 shows the PMSM test machine in the Voith assembly hall.

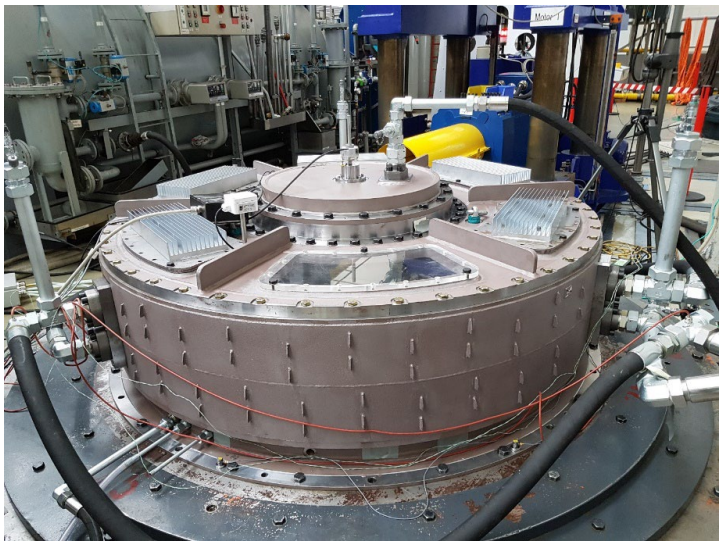

Figure 6: PMSM test machine for the eVSP with 260 kW input power

The first eVSP 26 was manufactured on schedule and in high quality. To get an impression of the size of the eVSP 26, it was photographed in the assembly hall before delivery (Figure 7). Next to the eVSP 26 stands a 170 cm tall development engineer.

Figure 7: eVSP 26 before delivery in Voith's assembly hall

The electric Voith Schneider Propeller (eVSP) offers advantages over the classic mechanical VSP in terms of compactness, energy efficiency and comfort (acoustics and vibrations). Since the eVSP does not require a separate drive motor, it can be integrated very easily and advantageously into any electrically designed ship concept. Figure 8 summarizes the advantages of the eVSP.

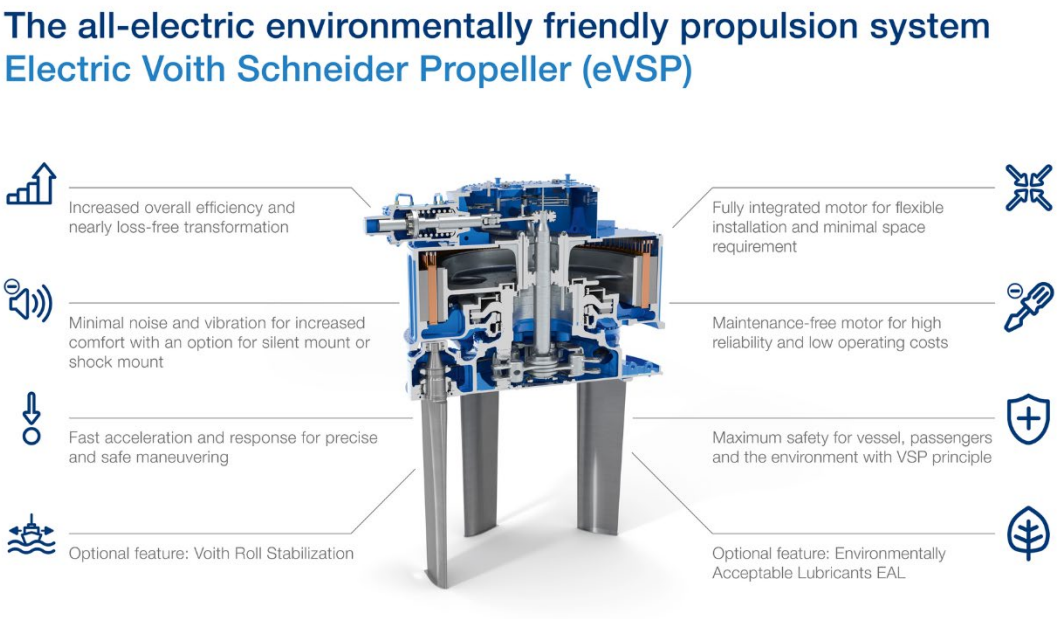

Figure 8: eVSP - summary of its special features

The fast response time provided by the high-torque PM motor also continues to improve the DP capability of eVSP-powered vessels. It is now possible to develop new ways of efficient thrust creation that incorporate the fast element of RPM adjustment, in addition to the classic pitch adjustment and a classic combination of pitch and RPM adjustment (combinator curve).

Figure 9 shows the advantage provided by a Voith Schneider propeller in a DP plot (dynamically calculated) for conditions typically for SOVs.

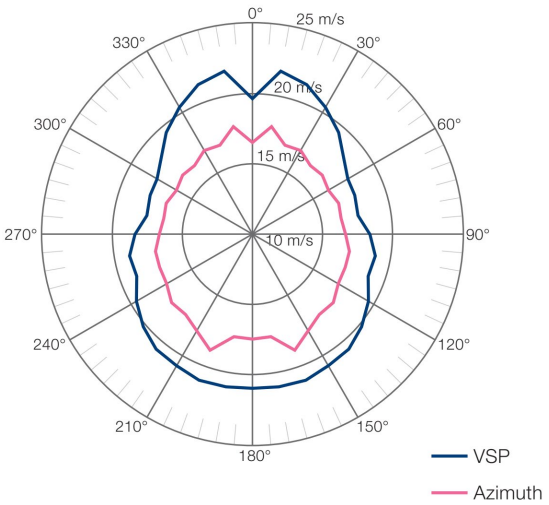

Figure 9: Comparison of limiting wind speeds by means of a dynamic DP capability plot [3]

The ability to significantly reduce rolling motions - Voith Roll Stabilization (VRS) - has also been further improved by the eVSP. Since the Voith Schneider Propeller can vary the thrust very quickly (according to an X/Y logic), it is possible to reduce the rolling motions of ships at speed, at standstill and especially also in DP (Figure 10).

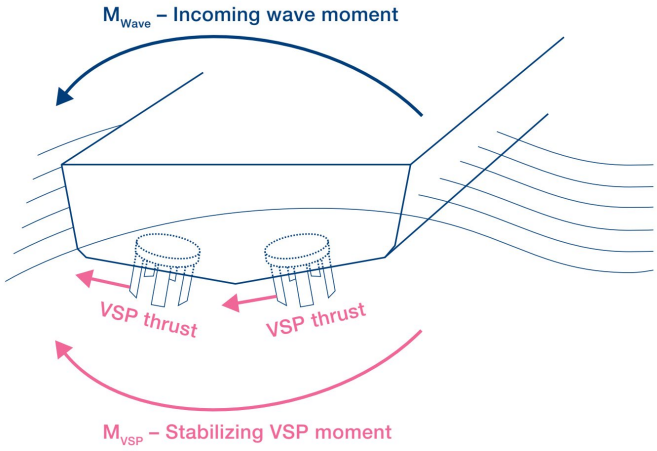

Figure 10: Moments and forces during ship's rolling

When the vessel encounters the effect of incoming wave, sensors measure the angular acceleration and the system immediately, then applies the restoring forces to counteract the rolling motion of the vessel.

As the feature of roll stabilization is incorporated into the propeller, it requires no additional equipment.
Roll stabilizing tanks are no longer required and thus no reduction of payload has to be encountered. While aboard numerous offshore vessels during harsh weather conditions, the VRS has shown its improved operational capability.

Depending on the vessel dimensions, a high level of reduction of roll angles has been achieved. This prediction can be done already in early design stage (Figure 11).

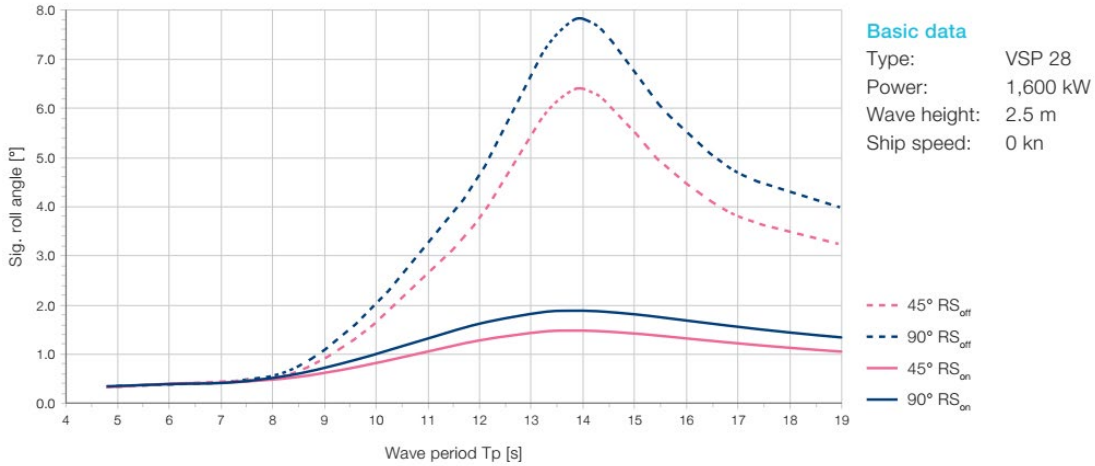

Figure 11: Typical result of achievable roll reduction for a wind park service vessel in the North Sea

Conclusion

With the electric Voith Schneider Propeller (eVSP), it has been possible to further develop the classic mechanical Voith Schneider Propeller. The first ships are sailing with the eVSP. The expectations placed on this new type of propeller have been completely fulfilled.
The propeller is characterized by very quiet running and efficiency is significantly increased because gear losses and bearing losses have been reduced. The permanent magnet excited motor also has a very high efficiency. This high efficiency is not only achieved in the design point but also at low loads, which often occur especially in DP operation.

The electric Voith Schneider Propeller can change speed very quickly due to the high torque PM motor. This offers additional advantages for dynamic positioning and for reducing rolling motion. Thus, a combination of pitch change (X/Y logic) and RPM variation in combinator curve can be used even more dynamically than before. The first experiences on board have shown that this results in a further reduction in fuel consumption and an improvement in roll reduction with the new eVSP.

Literature

[1] Jürgens, B.; Fork, W. Faszination Voith-Schneider-Propeller: Geschichte und Technik Koehlers Verlagsgesellschaft mbH, Hamburg, 2002
[2] Jürgens D., Palm M., Voith Schneider Propeller - An efficient propulsion system for DP controlled vessels, Dynamic Positioning Conference, Houston, 2009
[3] Jürgens D., Palm M., Voith Schneider Propeller - Influence of Thruster Response Time on DP Capability by Time-Domain Simulations, Dynamic Positioning Conference, Houston, 2017