6.11. Azipod® propulsion

Efficiency and availability

Azipod technology was introduced in 1990. The first cruise vessel installation on the Fantasy-class vessel Elation in 1998 showed remarkably positive results with high efficiency and excellent maneuverability. The new technology provided ship designers with greater freedom to optimize the ship's general arrangement.

After processing further knowledge from experience and getting a better understanding of the system's behavior in operation, the scope of development was widened to cover larger systems.

Design improvements

At first the improvements were mainly concentrated on shaft bearings and seals. While the basic mechanical design remained the same, the focus was to provide improved lubrication conditions and to improve seals to prevent any leakages into the lube oil or into the sea.

After collecting several years of operational experience with wider knowledge of system behavior, improvements were broadened to include processes like better control of manufacturing, delivery and operational processes, and general quality control.

Time for redesign

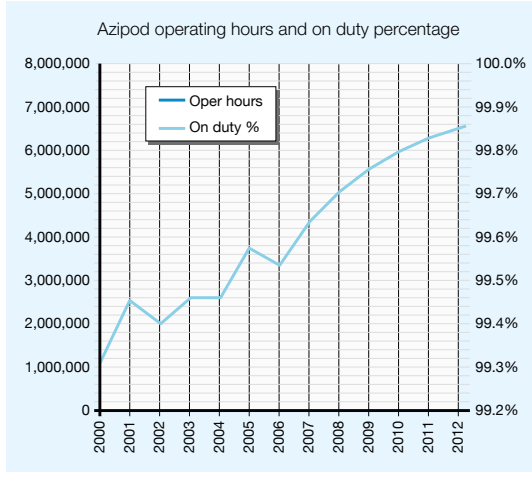
After several generations of updates from the original design, it was seen that a concurrent redesign would be necessary to be able to combine all identified improvement ideas. The first such development project addressed the larger open water unit series, which was subsequently given the identifying type code Azipod XO where X stands for "next generation Azipod" and O means that it is mainly made for vessels that will operate in open water conditions. In this research and development project ABB Marine decided to utilize well-known, proven technologies for components and design. As an example of the latter, sliding bearings were selected for thrust bearings.

The outer shaft seal was also completely redesigned to provide similar benefits: reliability and maintainability. The seal system enables advanced condition monitoring to a degree not seen elsewhere in the market.

For larger models the seal can be changed from inside the pod. The seal is designed for a five-year lifetime and to be replaced during normal dry-dockings, but in case of an emergency situation this can also be done with the vessel afloat.

The fully electric steering gear was originally designed for smaller Azipod sizes, but it was the right time to introduce it for larger open water unit sizes to replace conventional electro-hydraulic steering gear. The main reasons for this step were that it reduced energy consumption and noise, as well as cutting the amount of oil in the installation, in order to make it more environmentally friendly. Electric steering gear is now installed on recent Azipod deliveries for open water conditions.

Figure 1: Azipod operating hours and on duty percentage



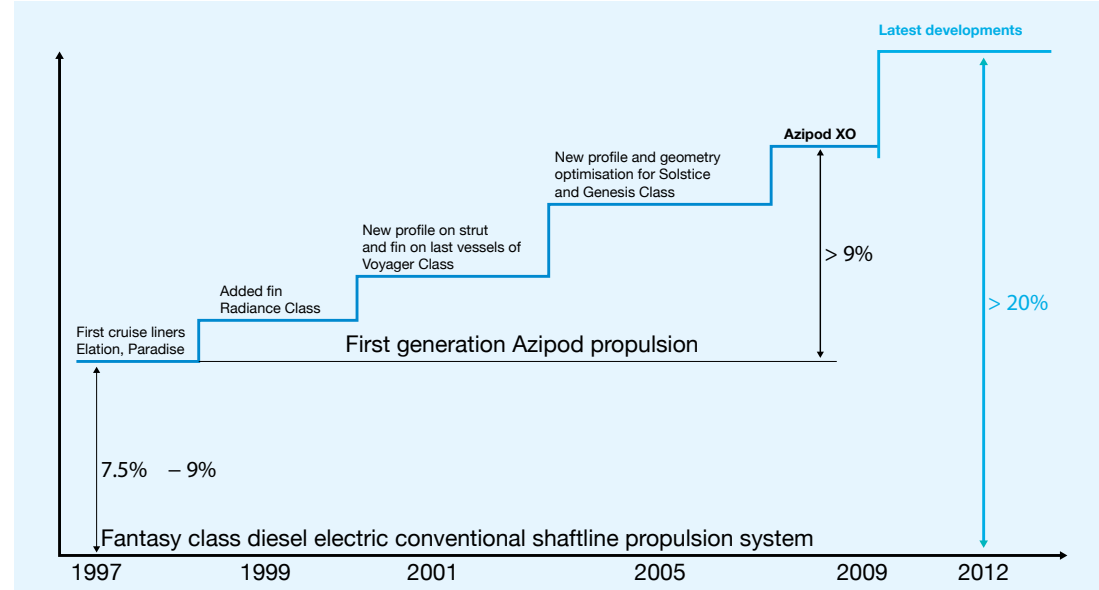


Figure 2: Propulsion efficiency has been improvedby several steps in design optimization

Improved fuel efficiency

The propulsion efficiency of Azipod propulsion, when originally installed on cruise ship Elation back in 1997, improved by some 9 percent, when comparing identical sisterships with traditional shaftlines. Since then, the propulsion efficiency has been improved by several steps in design optimization (Figure 2).

One major hydrodynamic improvement was gained early by installing a fin under the Azipod to reduce rotational flow losses generated by the propeller. In the next steps, the Azipod strut design was modified by making it slimmer and more optimal for operation in the propulsion environment. Finally, with the Azipod XO, the propeller hub and motor module diameters were reduced and the unIt is entire hull was optimized with the help of CFD and model testing.

During 2011, ABB introduced an additional package to improve Azipod propulsion efficiency further. This package consists of an asymmetric lower fin and crossed plates (X-tail) that are integrated in the aft cone. The asymmetric lower fin will improve efficiency up to 1 percent by reducing the losses from the propulsion system and the X-tail will further increase efficiency by up to 1.5 percent by reducing the rotational flow losses at the aft cone section. These changes can also be made as a retrofit installation on open water units. The first retrofit work with asymmetric fin and X-tail was done in 2011 during the vessel's normal dry docking.

Also in 2011, ABB launched a method of optimizing the energy efficiency of Azipod installations on board vessels. This was based on the finding that further fuel consumption savings can be reached by optimizing the toe (steering) angle of the Azipod units dynamically, in addition to the angle optimization already undertaken at the vessel design stage. This package has the acronym ADO from the words

The propulsion motor technology in Azipod units is selected so that it will achieve high efficiency throughout the entire propeller speed range.

“Azipod Dynamic Optimizer”. Fuel consumption is estimated to be reduced further by up to 1.5 percent using ADO.

The overall improvement in propulsion efficiency has been above 10 percent over the course of the existence of the Azipod, with a more than 20 percent gain when compared to the shaftlines being used back in the mid 1990s. However, it is fair to acknowledge that there have also been improvements in shaftline propulsion during this time. Even so, a recent comparison test at

Marin showed that Azipod propulsion compared to a fixed shaftline propulsion design still had a 6-8 percent lead what regards to propulsion efficiency. Furthermore, these tests were made before the introduction of asymmetric fin, X-tail and ADO, which can improve the efficiency of the Azipod system overall by up to four percent.

Operation experience

With regards to fuel savings and ship maneuverability, the expectations set by ship operators have typically been fulfilled or exceeded by the Azipod. Ship captains in particular have expressed satisfaction with the ease of operation and the maneuverability of their ships. Concerning energy efficiency, some operators have claimed fuel savings of more than 20 percent, compared with their vessels operating with conventional propulsion.

Seven million operating hours with Azipod propulsion have resulted in the largest pool of experience in how podded propulsion systems should be designed, used and maintained for trouble-free reliable operation.

During the two decades ABB has established a unique position being the only company that has in-depth and in-house product and integration knowledge, with a responsibility covering the whole concept from hydrodynamics, mechanics, electronics, cooling to operating, maintenance and services, as well as the integration of the complete electrical and control system.

Nowadays, Azipod propulsion and thruster units are designed for five years dry-docking and maintenance intervals. For some applications a longer maintenance interval of even up to 10 years has proven supportable. This conclusion is based on results drawn from a well documented operational and maintenance history. Today, there are some 100 vessels using Azipod propulsion. It has been selected for a wide range of ship types and operations; such as cruise ships, icebreakers and ice-going cargo vessels, ferries, megayachts, offshore supply vessels, research vessels, wind turbine installation vessels and drilling rigs.

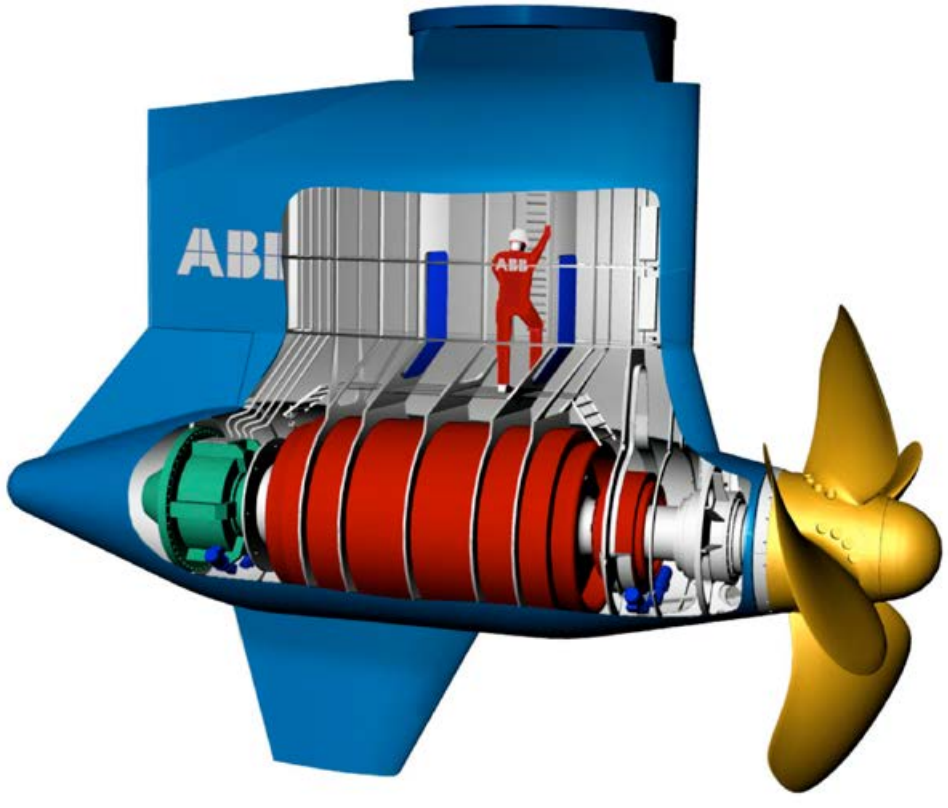
The advantage of having data available from a large number of operating units as well as a wide range of test results from models and full size units has been essential for continuous development.

Azipod XO

Currently, there are more than 60 passenger vessels equipped with Azipod® units in operation. Cumulative running hours for the total fleet is above 6 million.

Our premium propulsion solution for the medium voltage propulsion system – the Azipod® propulsion – has been improved. The old open water VO generation has faced improvements in the total efficiency, maintainability of the unit and safety of the operation and work inside.

Special attention in the new-generation Azipod® has been paid on the reliability and efficiency, which have already been in a class of their own. The target has been to extend the docking interval and increase the maintainability from inside. The thrust pad and propeller seals can be changed from inside in models XO 2100 and above.



The unique efficiency of Azipod® units is based on the following characteristics:

1. The pulling propeller eats from the homogenous field of water. The propeller is therefore loaded equally and there are no disturbing and resisting components in front of the propeller. Also the wake field behind the propeller is close to optimal.

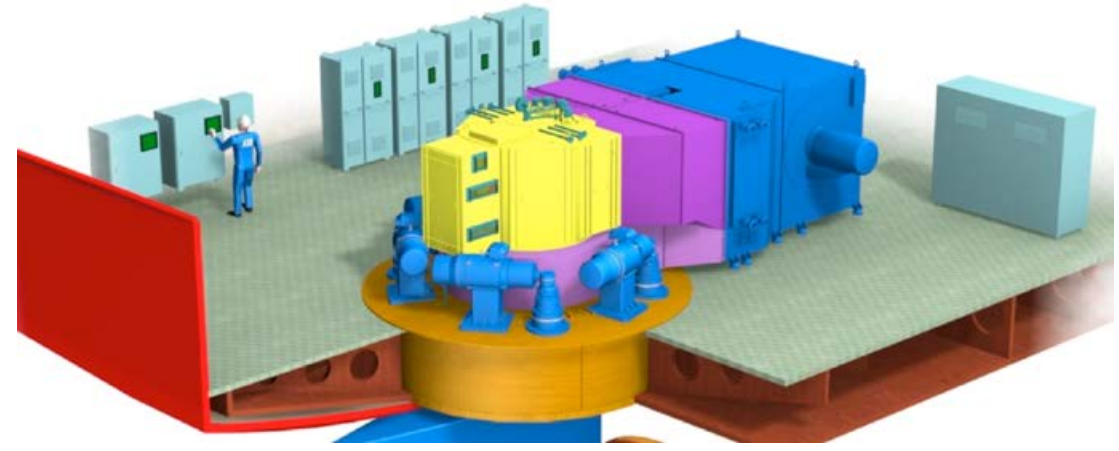
2. The propeller positioning is optimized to the hull shape. In this aspect, the hull form of an Azipod® vessel differs from the shaftline hull, since this optimal positioning of the propeller allows more hull optimization based on the hydrodynamic evaluation. The propeller positioning and the hull form are designed together with the shipyard or design offices. The Azipod® projects are always evaluated case-by-case for the best final result.

3. The propulsion motor is a synchronous motor which meets the requirements of the ship's propulsion motor in large passenger vessels.

4. The propulsion drive is a voltage source inverter, which brings in the unique level of efficiency on the system level and combines with the ship-level requirements of the total vessel energy management.

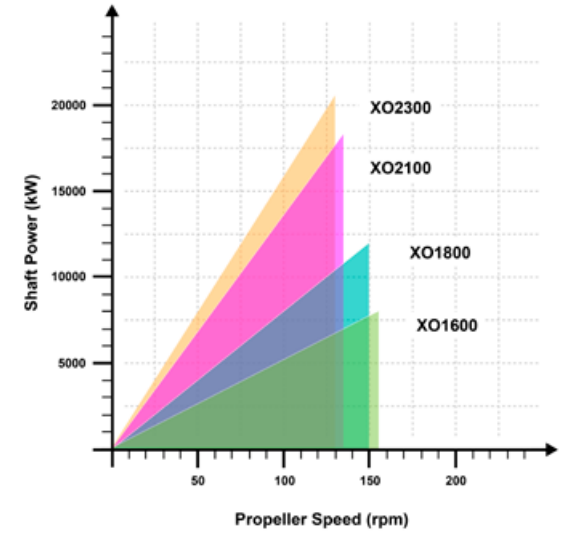
For a project with ABB Azipod®, contact us for the assistance and information or visit our website for more information.

The steering system in the new design is electrical. This eases the yard work by leaving out the piping and flushing, and increases the comfort onboard.



The efficiency of the Azipod® is on a unique level. Compared to a similar shaftline vessel, the ship's resistance is 10 percent lower in the design optimized for Azipod®. The unique hydrodynamic efficiency is finalized with the top-performance technical solutions inside the vessel and Azipod® unit – the synchronous motor controlled by modern drive technology.

Azipod® XO family ranges with main rating.



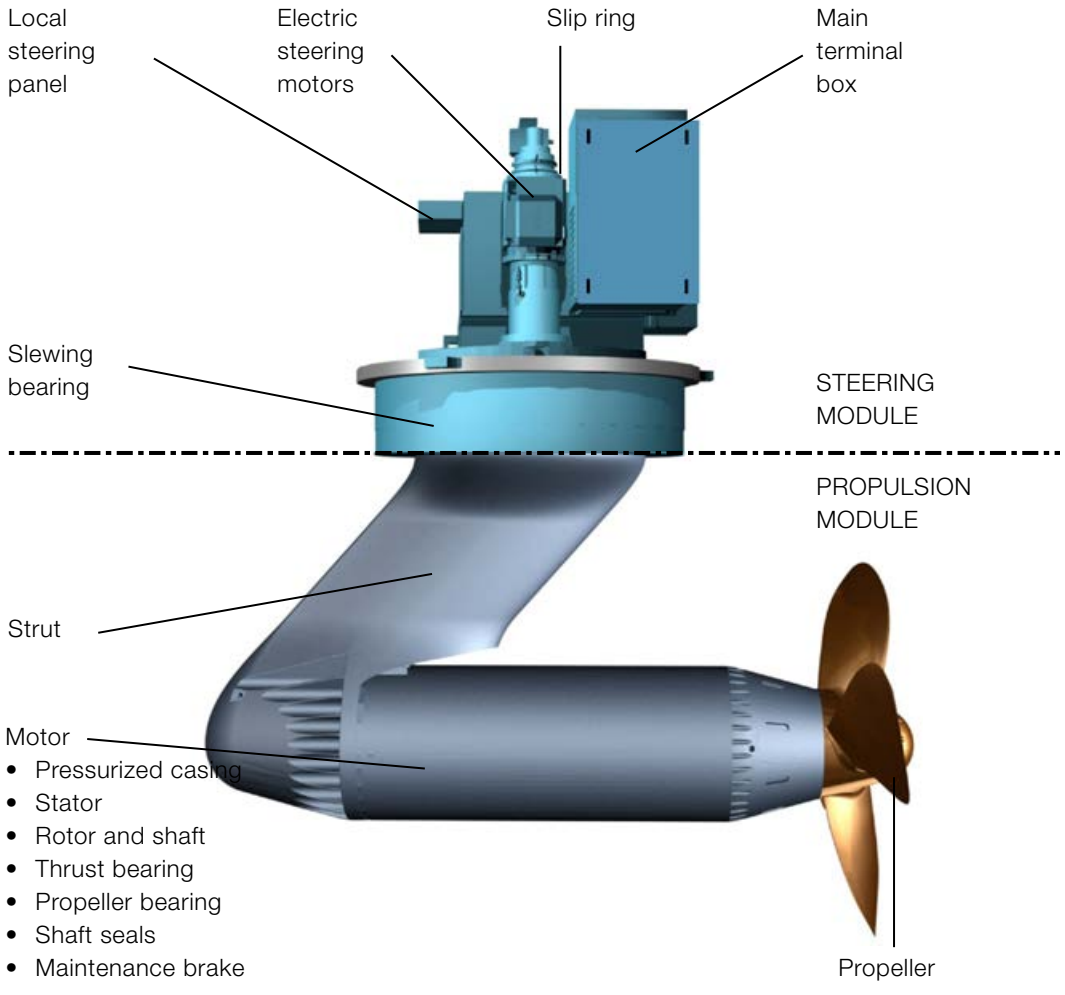
Azipod CO

The efficient low voltage permanent magnet synchronous motor is cooled directly to the sea. Additional cooling arrangements are not needed. On the power range of 1300 – 4500 kW, the Azipod® CO is the easiest and most efficient propulsion selection for small and medium size passenger vessels that are operated below the speed of 21 knots.

The standardized manner of production and simplicity of the installation allow the pulling propeller to be located optimally. This results in the best efficiency of the unit.

The installation work is easy and alignment work at the yard is not needed. Azipod® CO is delivered in two modules which are bolt-connected to the hull. The propeller is designed for each project individually to meet the hull form requirements.

For a project with ABB Azipod® CO, contact us for the assistance and information or visit our website for more information.



Azipod XO as CRP

The Contra Rotating Propulsion (CRP) principle is a very efficient way to place an additional propeller behind the main propeller and gain hydrodynamic benefits from this arrangement. The main propeller is either diesel-mechanical or diesel-electrical.

In the 'sea-highway' type of operational profile, this arrangement has proven to bring energy savings in a scale which does not have a comparison.

The propellers are designed as a pair and therefore each project is always of individual design.

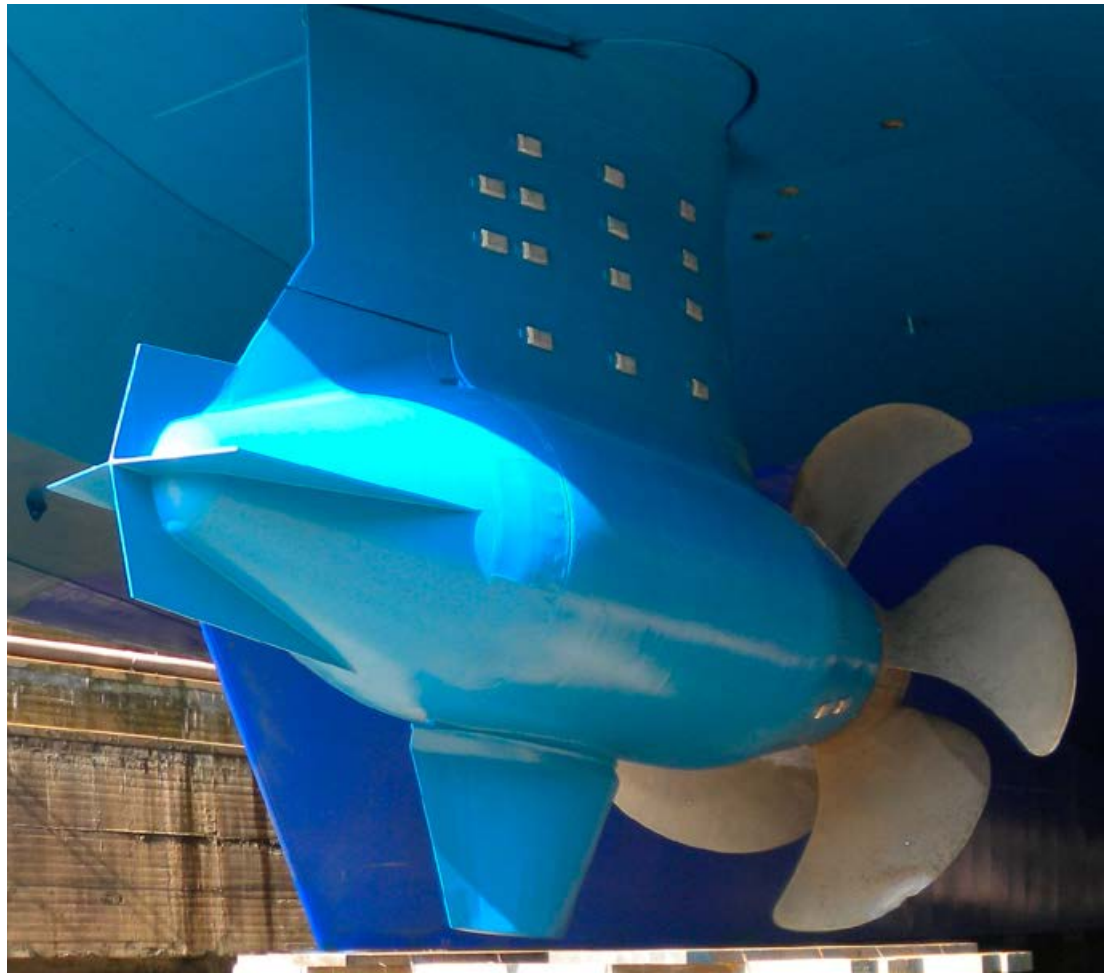
For a project with ABB Azipod® CRP, contact us for the assistance and information or visit our website for more information.

6.12. Azipod® hydrodynamics upgrade

Background of Azipod

The ABB Azipod is an azimuthing electric podded drive used in diesel-electric vessels. The Azipod unit is fixed in a pod outside the ship, and combines the functions of a propulsion motor, main propeller, rudder and stern thruster. This innovation was introduced in 1990, in a pilot installation for a Finnish fairway maintenance vessel, and was later installed in some ice-going vessels and ice breakers. The first cruise vessel installation was performed in 1998 on a Fantasy-class cruise ship, the "Elation". Compared to previous Fantasy-class vessels, the "Elation" displayed remarkably positive results, including high efficiency and excellent maneuverability. The technology also provided ship designers with greater freedom to optimize the ship's general structure.

Figure 1: X-tail and asymmetric fin installed during dry docking in 2011. The tests confirmed a 2.8% improvement in efficiency.



The first Azipod units installed in the "Elation" yielded an approximately 7–9 percent reduction in the required propulsion power, compared to older Fantasy-class vessels equipped with the more traditional shaftline arrangement. A major hydrodynamic improvement was gained early on, by installing a fin under the Azipod to reduce rotational flow losses generated by the propeller. The lower fin also provided an efficient way of reducing steering system loads, by decreasing the azimuthing counter torque. In the subsequent steps, the Azipod strut design was modified by making it slimmer and more optimal, for operation in a propulsion environment. Finally, with the introduction of the new Azipod XO product family, the propeller hub and motor module diameters were reduced and the entire hull optimized with the help of CFD and model testing. All in all, Azipod hydrodynamic improvements, from the first units to Azipod XO, have represented an improvement of 9 percent on the "Elation" results.

Azipod hydrodynamics upgrade

During 2011, ABB introduced an additional retrofit package to further improve the Azipod's propulsion efficiency. This package consists of an asymmetric lower fin and crossed plates (X-tail) integrated with the aft cone.

The asymmetric lower fin improves efficiency up to 1 percent, by reducing losses from the propulsion system, while the X-tail can further increase efficiency by up to 1.5 percent, by lowering the rotational flow losses from the aft cone section. These changes can be performed as a retrofit installation for open water units during dry docking. Due to different design and load conditions, such modifications are not applicable to ice-going vessels.

The total savings potential of the Azipod hydrodynamics upgrade can be up to 4 percent in propulsion power

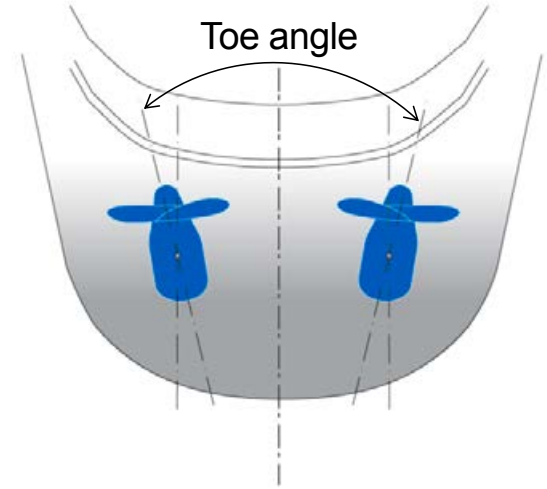


Figure 2: The optimal toe angle between the Azipod units varies dynamically, depending on the operating conditions. The Azipod Dynamic Optimization system has a savings potential of up to 1.5 percent.

Azipod hydrodynamics upgrade

The already high hydrodynamic efficiency of the Azipod propulsion system can be improved with an upgrade package. Power required for propulsion can be reduced by up to 4 percent, by installing the Azipod hydrodynamics upgrade – a system which reduces rotational losses from the propeller flow and optimizes the toe angle between the Azipod units. The reduced power requirement applies to the vessel's entire speed range, not only its top speed. The Azipod hydrodynamics upgrade consists of:

- An asymmetric fin
- An X-tail
- The ADO – Azipod toe angle dynamical optimization system

The first retrofit work with an asymmetric fin and X-tail was performed in 2011, on the "Radiance of the Seas" during the vessel's normal dry docking. In order to achieve a firm verification of the results, the same measurements were performed for two similar vessels before and after dry docking. The first vessel was refitted without the modifications and second one was equipped with them. Both vessels were subjected to the same scope of hull cleaning and painting during dry docking. Finally, the figures were verified and approved, together with the customer and a third party. The results confirmed a 2.8 percent reduction in fuel consumption for propulsion.

In 2011, ABB also launched a system called the Azipod Dynamic Optimizer (ADO). This is a method of optimizing the energy efficiency of Azipod installations onboard vessels. The system is based on the finding that further fuel consumption savings can be achieved by dynamically optimizing the toe (steering) angle of the Azipod units, in addition to the static angle optimization already performed at the vessels' design stage. Because the optimum toe angle depends on the vessel's trim, ballast, speed, weather conditions etc., it varies dynamically. The ADO can be installed during the new building phase or as a retrofit when the vessel is afloat. It is estimated that using the ADO represents a savings potential of up to 1.5 percent.

The ADO was installed on "Noordam" in 2010. After the commissioning phase, the system's performance was tested and a 1.5 percent reduction in propulsion power achieved with the system switched on, compared to when it was switched off.

The total savings potential of the Azipod hydrodynamics upgrade, including an asymmetric lower fin, X-tail and ADO can be up to 4 percent, the savings effect covering the entire speed range of the vessel, not only its top speed.

Benefits

- Lower fuel consumption due to reduction in required propulsion power
- Lower emissions due to reduction in fuel consumption

Savings and payback time

The improvement in hydrodynamic efficiency reduces the required propulsion power, with the savings effect occurring across the vessel's entire speed range, not only when it is operating at top speed. The typical payback time for the Azipod hydrodynamics upgrade is less than 24 months.