

Rotterdam Mainport University of Applied Sciences - RMU

Hybrid Propulsion

Electrical Installations

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Contents

- Preface:..... 4
- Introduction:..... 5
- 1. What is hybrid propulsion, and what types of hybrid propulsion exist? 6
 - 1.1 Azimuth thrusters..... 6
 - 1.1.1 Azipod/ Azipull:..... 6
 - 1.2 Diesel-electrical 7
 - 1.3 Gas-electric..... 7
- 2. On what types of ships would hybrid propulsion actually be useful?..... 8
 - 2.1 Ship types 8
 - 2.2 Practical examples..... 9
 - 2.2.1 Green tug project - Hydrogen Hybrid Harbour Tug (HHHT):..... 10
 - 2.2.2 Ecolution:..... 11
 - 2.2.3 Japan’s super eco ship:..... 12
 - 2.2.4 Siemens Marine Introduces New Hybrid Propulsion Solution for Smaller Vessels:..... 13
- 3. What types of hybrid propulsion would add a substantial amount of speed? 14
 - 3.1 Azimuth Thrusters 14
 - 3.1.1 Azipush/ Azipull: 14
 - 3.1.2 Z-Drive/ L-Drive: 15
 - 3.2 Diesel-electrical 15
- 4. What type of hybrid propulsion combines most advantages for a ship? 16
 - 4.1 Advantages 16
 - 4.1.1 Fuel efficiency:..... 16
 - 4.1.2 Easy to upgrade: 17
 - 4.1.3 Arrange ability: 17
 - 4.1.4 Operational flexibility: 18
 - 4.2 Disadvantages: 18
- 5. Field research; J. Pinksteren and Alewijnse. 19
 - 5.1 J. Pinkster..... 19
 - 5.1.1 Azipods: 19
 - 5.1.2 Azipush: 19
 - 5.1.3 Azipull: 20
 - 5.1.4 Future developments 21
 - 5.1.5 Azimuth: 21

5.1.6 L- and Z-drive:.....	22
5.2 Alewijnse	23
5.2.1 Experience and projects:	23
5.2.2 Benefits:.....	23
5.2.3 Disadvantages:	24
Conclusion desk research:.....	25
Conclusion Field research:.....	26
Recommendation:	27
References:.....	28
Sites:	28

Preface:

In this report, project group 2 wants to bundle all relevant information they have found so far. Although some information seems basic but all information can be relevant for this project. As references, books and the internet are used. All information is analyzed and checked by all project members.

In this report project group 2 will show their information per sub question, in the same order those sub questions were put in the plan of approach.

Introduction:

This project is about the theme speed. Within this theme our topic has to be related to electrical engineering. After consulting mister Voeselek, we decided to choose the subject "Hybrid propulsion". In this research we want to find out whether any kind of hybrid propulsion might help increase speed of (certain types of) ships.

This extra bit of speed is basically generated when sailing at a speed at which the main engine is working less efficiently. One could make the main engine run a bit faster (and thus more efficiently), and store the extra power using a PTO (shaft generator). Except the speed, hybrid propulsion has the great advantage that it is environmentally friendly.

We summarize this research subject in the question "What type of hybridization would have the most favorable influence on a vessel's speed?"

To answer this main question we have to investigate the subject while using sub questions. We decided to use four sub questions:

- Sub question 1: "What is hybrid propulsion, and what types of hybrid propulsion exist"
- Sub question 2: "On what types of ships would hybrid propulsion actually be useful?"
- Sub question 3: "What types of hybrid propulsion would add a substantial amount of speed?"
- Sub question 4: "What type of hybrid propulsion combines the most advantages for a ship?"

We specifically ask these questions, so we investigate everything important to answer our main question. The first question is basically the question that is going to provide most information needed to answer the main question. The main question is about "what type", after all. The second question may seem a bit unrelated to our main question, but actually it is quite important. We want to investigate if hybridization could add more speed to a vessel.

Now we know already that some different kinds of vessels are usually already capable of sailing at the hulls maximum speed (The speed that the hull can handle maximally). For other ships it takes way too much power to generate this little bit of extra speed. The last question is about the same, but then looking into it not from the vessels side, but from the side of the hybridization.

Because the project is about speed and electrical engineering our research and investigations will be focused on these two subjects. Therefore it is important to know which parts will be discussed in the final report and which will not.

We will investigate: the hybrid principle, what types of hybrid propulsion exist and on board of what types of ship might hybridization be useful on.

We will not investigate: the execution of hybrid engineering in a ship (practical part) is the border.

1. What is hybrid propulsion, and what types of hybrid propulsion exist?

Hybrid propulsion is a type of propulsion in which 2 types of propulsion are combined to propel a ship (or car or whatever is using the propulsion). All hybrid propulsion systems that exist at this moment combine a conventional propulsion system (combustion engine, turbine by example) with electrical propulsion (Azipods, Azipulls by example). Usually a hybrid propulsion system is just known by the electrical propulsion part. The part which generates the power doesn't really matter. In the following paragraphs we will discuss the currently known hybrid systems.

1.1 Azimuth thrusters

1.1.1 Azipod/ Azipull:

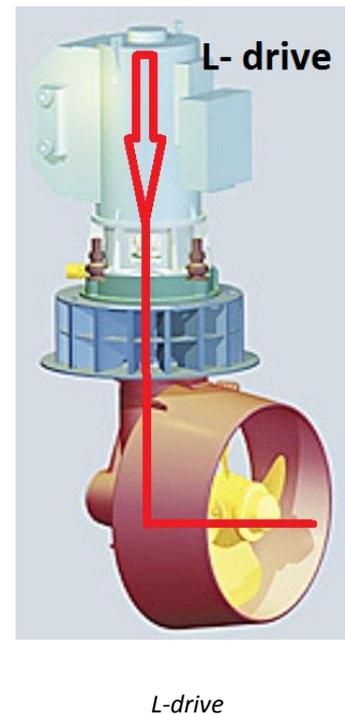
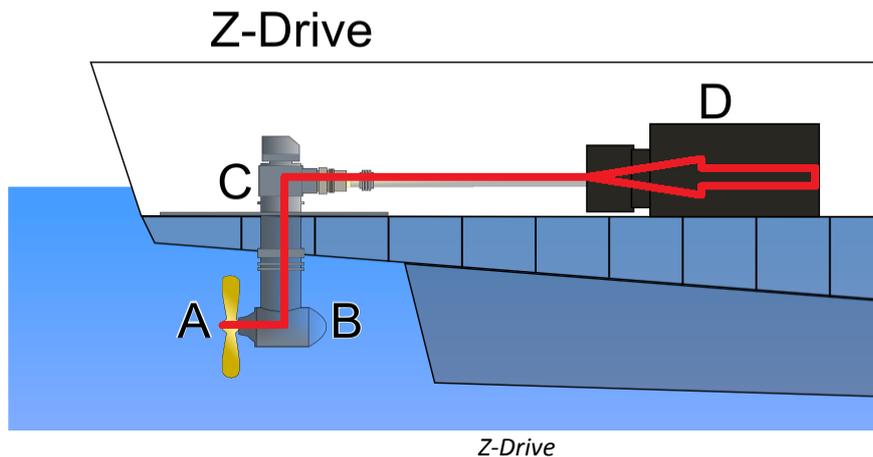
Azipod is a registered trademark by the ABB Company. It is mostly used in ships to make them more maneuverable. It is a system where a unit is placed under the ship, in which an electrical engine is placed, and to which the propeller is connected. The electrical power is generated by whatever conventional engine the shipbuilder decides, and conducted through slip rings, so that the Azipod can rotate 360 degrees. This makes the ship a lot more maneuverable, and thus more efficient.

An Azipod doesn't have (or need) a reversing gear, since the whole pod can be rotated. An Azipods propeller is powered and directed in such a way, that the Azipod "pushes" the ship forward.

Azipull is a system that is quite similar to the Azipod. The main difference is that an Azipull pulls the ship, instead of pushing it.

1.1.2 Z-drive/L-drive:

A Z-drive or Z-drive type of azimuth thruster is a propulsion system that is installed in a special way. L-drive means that the motor is placed vertical above the propeller. From the motor to the propeller is a straight way. Z-drive means that the motor is placed horizontal above the propeller. From the motor to the propeller is a combination of a horizontal and vertical way.



1.2 Diesel-electrical

Diesel-electrical propulsion is a collective noun for all propulsion systems in which, as the name says, combines a diesel engine with an electrical propulsion system. The previously mentioned azimuth thrusters are also an example of diesel-electrical propulsion, but they are mentioned separately because they are quite commonly known, and more developed than different systems in this same category. The diesel-electrical propulsion system is commonly used in non-nuclear submarines. Early diesel-electric submarines had to switch between electrical and diesel propulsion. Nowadays they are usually electrical powered. The switch is now to switch the source where the power comes from, direct from engine or from batteries.

1.3 Gas-electric

A gas electric propulsion system combines a gas driven engine with electrical propulsion. Usually this gas driven engine is a gas-turbine or even a normal (two stroke) gas engine. This principle is possible to be used in LNG or LPG tankers, and may already have been implemented (however we have no proof of that (yet)).

2. On what types of ships would hybrid propulsion actually be useful?

With this sub question we want to find out what ship types exist and on which of those types hybrid propulsion can actually be useful. This is an important factor because every type of ship has a different hull or operates at a different speed. Container ships for example are designed to sail at a high speed while crude carriers are designed to transport as much oil as possible.

2.1 Ship types

Vessels can be classified in different types which are shown below. The principle of hybrid propulsion is to store energy in batteries while using the diesel engine. This stored energy can later be used for entering a port, so there is zero emission of NOx and CO2. Theoretically this could be supplied on any vessel; the only disadvantage of this system is that a huge number of batteries is required to maintain the vessel's speed. A good example is a seagoing tug. When maneuvering in the port the tug is only using a small amount of the power the engines can deliver. If this small amount of power can be replaced by using the batteries which are charged while the tug is on open sea, this will reduce the emissions and higher fuel efficiency is achieved.

Type	Example
Dry cargo	Container, multipurpose
Liquid cargo	Crude carrier, product tanker, chemical tanker
Passenger ships	Passenger ships, car and passenger ferries(RO/RO) cruise ships
Work ships	Cable layers, buoy layers, crane vessels
Auxiliary vessels	Seagoing tugs, icebreakers, pilot vessels
Offshore equipment	Pipe layers, drill-ships, drilling rigs

2.2 Practical examples

Hybrid propulsion on ships is nowadays an interesting subject due to the environmental changes. Most of the vessels are still powered with diesel engines which provide a huge amount of NO_x and CO₂ emissions.

With a ship that uses the hybrid principle as a propulsion system the emissions of NO_x and CO₂ can be reduced dramatically. Also the noise can be reduced and a higher fuel efficiency can be achieved.

A number of companies have already been experimenting with this type of propulsion. Some examples of the principles are shown on the next 4 pages. This text is directly from the internet. The sources can be founded later in this report by references.

2.2.1 Green tug project - Hydrogen Hybrid Harbour Tug (HHHT):

The HHHT will be able to remain on standby, be mobilised and deployed where it is needed with zero emissions, and will save up to 98 per cent of SO_x, NO_x and particulate matter and 30 percent of CO₂ emissions in total compared to a conventional harbour tug over the whole employment cycle. The 60 tonne bollard pull tug is fitted with fuel cells and hydrogen tanks, where hydrogen is stored under a pressure of 430 bar.

Fuel cells

The fuel cells, in combination with batteries, are able to provide sufficient power to operate the tug during standby and mobilisation/demobilisation periods. Only when substantial bollard pull is required to actually perform a berthing operation are the diesel generator sets used. Eighty-five per cent of the time, the tug is powered by the fuel cells and achieves zero emission. The Proton Exchange Membrane (PEM) fuel cells, developed by NedStack Fuel Cell Technology B.V. of the Netherlands, deliver well-to-propulsion efficiency of 34 per cent, substantially better than the efficiency of conventional diesel direct drive installations.”



Green tug

2.2.2 Ecolution:

Also there is the ecological project “ecolution”, driven by the former Dutch astronaut Wubbo Ockels. The ecolution is a yacht based on a design by Gerard Dijkstra. He supervised all changes applied to the Ecolution. The yacht looks quite classic on the outside, but below water level it really is modern.

The vessel is meant to be as much autonomous as possible while sailing, and that means the vessel provides its own power. The vessel is depending as little as possible on fossil fuel. The vessel does need 4 days of sailing in a moderate climate to be able to live comfortably for a month. In areas where more power is used, such as the polar region, diesel engines could be used for heating. Those engines are powered by bio-diesel.

Most interesting point for this project are the batteries. For power storage the yacht uses 120 so called gel-lead-acid-batteries. In the future other types of batteries could be applied, such as nickel-metal-hydride or lithium polymer.



the yacht

2.2.3 Japan's super eco ship:

The Nadeshiko Maru is a 70 meter, 749 ton next-generation tanker that achieves much higher fuel efficiency than conventional tankers, enabling dramatic reductions in emissions of carbon dioxide and nitrogen oxides.

The Nadeshiko Maru is equipped with four 410 kW diesel generators and adopts an electric propulsion system enabling it to reduce carbon dioxide emissions by more than 20% and nitrogen oxide emissions by more than 40% compared with conventional diesel-powered ships. Noise is also reduced by 5 decibels.

The tanker achieves its superior energy efficiency by unifying power management, in contrast with conventional ships that run diesel engines to power the screw but must also run separate generators for power used onboard for cargo handling, lighting, and other needs. An improved hull design and adoption of stern valves and counter-rotating propellers have enhanced fuel efficiency by more than 20%.

In addition, a double-hull structure has been adopted to comply with a general ban on the transport of heavy oil by single-hull tankers, announced by the International Maritime Organization (IMO) this year. And while a conventional 749-ton, single-hull tanker can generally carry 2,000 kiloliters; the same capacity has been achieved with a double hull design due to the high degree of freedom in the placement of engine room equipment, as the propeller and diesel propulsion equipment do not need to be directly linked. Taking advantage of this feature, equipment can be arranged on electric propulsion ships so as to minimize engine room dimensions, and cargo pump rooms can be eliminated by adopting electric deep-well pumps.

One drawback of super eco-ships is the cost of construction, which is 10% to 30% higher than for conventional diesel ships. To popularize these ships, the Ministry of Land, Infrastructure, Transport, and Tourism is providing long-term, low-interest loans through the Japan Railway Construction, Transport, and Technology Agency, using the same system as that to support the development of new technology. The five ships that will be in operation, including the one now under construction, have all taken advantage of this system for their construction.

The development of super eco-ships has advanced research into next-generation coastal vessels, including new hull designs able to accommodate gas turbines and electric propulsion systems with contra-rotating podded propulsors. However, because of cost barriers, none of the ships in actual service, including the Nadeshiko Maru, use gas turbines. Experimental ships have been completed that use gas turbine systems, but no ships intended for practical uses have yet been constructed with this system.

2.2.4 Siemens Marine Introduces New Hybrid Propulsion Solution for Smaller Vessels:

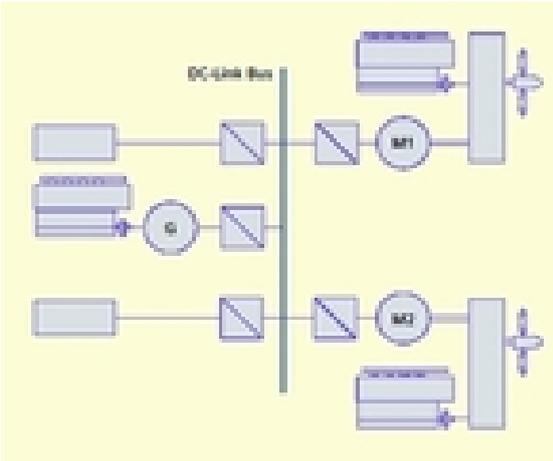
Siemens Marine Solutions has developed a very compact hybrid propulsion system for small vessels, using a combination of standard commercial generators, motors and mechanical gear package.

The main diesel engine runs at a constant speed, driving an electrical generator that feeds a propulsion motor through a switchboard and converters. This system exploits the optimized efficiency resulting from operating the engine as close as possible to its design point. The intelligent hybrid control and the diesel-electric system continuously drives the engines within the desirable speed and load ranges.

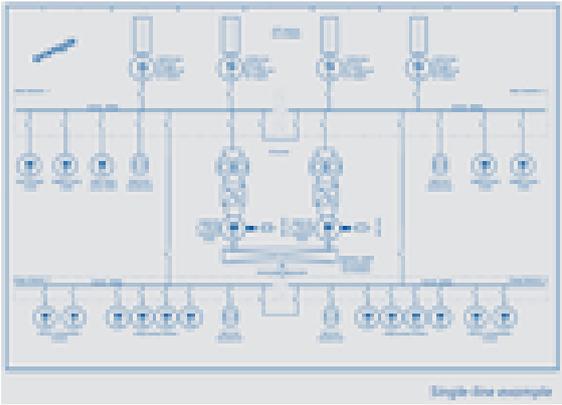
With Siemens’ new SISHIP EcoProp, the ship can be operated in 4 different modes:

- Diesel mode: Power from propulsion diesels, driving a geared generator.
- Battery mode: Electrical power from batteries feeds the ship service net and propulsion.
- Electro mode: Power from harbor generator charging batteries, supplying the ship service net.
- Hybrid mode: Propulsion diesels driving the vessel with additional power from geared electrical motors.

The SISHIP EcoProp systems offer power ranging from 100 kW to 800 kW. This type of system has been used for years in cruise liners and specialized ships, such as offshore supply ships, patrol boats, ice breakers and research vessels, according to Siemens Marine. Cost, weight, required space and complexity prevented vessels under 40 meters from taking advantage of a similar system, according to Siemens. The SISHIP Eco Prop is an integrated solution which provides the benefits of Hybrid Diesel Electric Propulsion systems for smaller vessels traditionally powered by conventional mechanical propulsion systems.



One configuration of SISHIP EcoProp



single-line hybrid power train in a large LNG carrier

3. What types of hybrid propulsion would add a substantial amount of speed?

There are three types of hybrid propulsion, see also sub question 1:

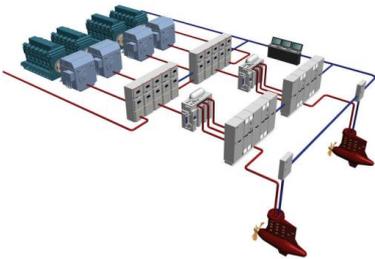
- Azimuth thrusters (Azipod/ Azipull and Z-Drive/ L-Drive)
- Diesel-electrical
- Gas-electrical.

But what type would add a substantial amount of speed?

3.1 Azimuth Thrusters

3.1.1 Azipush/ Azipull:

The Azipush/Azipull system is especially designed to increase the maneuverability of a vessel. When a vessel has a better maneuverability it means that it is faster when maneuvering. The speed lost when maneuvering will be decreased. By the Azipush/Azipull systems will increase the speed when maneuvering but when it's not maneuvering the speed will be the same. So these systems don't add that much extra speed to a vessel but don't slow it down either. This is the same for the Azipod and the Azipull because the only difference between those two is that the Azipush pushes and the Azipull pulls.



Azipod



Azipull

3.1.2 Z-Drive/ L-Drive:

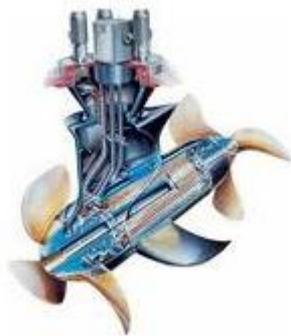
When using a Z-Drive/L-Drive there isn't a substantial change in speed. It is usually used to make a fast change in thrust. This can be convenient when there is thrust needed to avoid immediate danger. So the system gives a time advantage to the vessel, which can be related to speed. But it doesn't give the vessel a higher sailing speed. This is the same for Z- and L-Drive in the installation that is shown in sub question 1.



Z-drive

3.2 Diesel-electrical

The diesel-electrical propulsion system is usually combined with Azimuth thrusters. One of the advantages is that the screw propeller can turn very slowly, without the diesel-electrical propulsion system this wouldn't be possible. Because of this the vessel can sail slower what sometimes can be useful. For example when the vessel would arrive through circumstances too early it can now sail slower so that it will arrive at the planned ETA what saves money for too early berthing.



Diesel-electrical propulsion

4. What type of hybrid propulsion combines most advantages for a ship?

This sub question is actually divided into two parts, the advantages and the disadvantages of hybridization. By doing this a nice overview will be created of the advantages and disadvantages of hybridization which makes it easier to answer the sub question.

4.1 Advantages

4.1.1 Fuel efficiency:

By using hybrid propulsion the vessel can save a substantial amount of fuel. For example the vessel Makin Island of the American Navy saved 900,000 gallons (3 406 870.61 liters) on its maiden cruise. The Makin Island uses gas turbines and electric motors for propulsion. The gas turbines only start at higher speeds and the electric motors use the vessels electric grid for energy supply. This can also be done on larger passenger vessels. The auxiliary engines can provide enough energy for all persons aboard and the propulsion. And if there is too much energy they can store it in batteries.

It is important for the best fuel consumption that the engine that creates the energy runs at a constant load. This can be explained by the concept that if the engine runs at a constant load it only has to deliver a certain amount of power to overcome the water and air resistance on the ship to sail the same speed. If the same speed has to be achieved with a non constant load the vessel slowed down too much and has to be accelerated. The engine has to deliver more power which consumes more fuel. A constant load can be achieved by using an accumulator array. If the load of the engine suits the vessel's propulsion needs, all of the power can be sent to the propellers. When the vessel's propulsion needs are lower than the energy created, for example by low speed maneuvers, the energy that isn't needed for propulsion can be sent to an accumulator array. Here the power is stored for when there is a need for extra power. The stored power will then be added to the continuous output of the engine.



Makin Island of the American Navy

4.1.2 Easy to upgrade:

A typical hybrid system is easy to upgrade because it is modular. This means that the system is built with parts that work independent from each other. Which means you can change a part, for example the battery bank, without having to shut the engine down. This is possible because there are one or more diesel generators that can deliver the needed power to the propulsion engine when there is no battery bank in place.

Also when the part is replaced there will be less trouble shooting because it doesn't make any difference for the whole system if the old battery bank is in place or the newer one. So you can change components without disturbing the rest of the system.

A related advantage of the ease to upgrade is that upgraded parts are generally smaller, lighter and better than their counterparts.

4.1.3 Arrange ability:

Because the hybrid system is composed out of modules there is no limit on the design flexibility. This modular system makes it possible to put the components almost everywhere on the ship. So the placements of the components are not bound to the engine room. For example the diesel generator can be placed in the engine room and the battery bank in the bottom of the ship. So it doesn't matter where a component is placed for the working of the system.

4.1.4 Operational flexibility:

Generators on a hybrid ship don't have to be the same size. This is because the operator can then choose which generator should run to deliver the needed power. This can also be good for fuel efficiency.

Also because the ship's systems are run by a computer network that checks every component and alerts the sailor when there is something wrongs the amount of sailors can be decreased.

4.2 Disadvantages:

There are two major disadvantages of a hybrid propulsion system.

First of all the amount of batteries required for the system. You have to fill a big room with batteries that's space that is not available for cargo. The batteries often are also very heavy and the latest batteries are very expensive.

Second disadvantage is that the total system could be more complex than conventional propulsion systems.

5. Field research; J. Pinkster and Alewijnse.

After doing our desk research we went to two different persons to ask them a couple of questions to test our desk research and add more information to our report.

5.1 J. Pinkster

One of the visited persons was a member of stc-group called Jakob Pinkster. He's head of the research and development department. We asked him some questions about azimuth thrusters. An azimuth thruster is a big group of thrusters that can rotate 360 degrees. In this group you can find the azipull, azipush, L- and Z-drive systems.

5.1.1 Azipods:

The azipod is a group of propulsion systems. A feature of the azipods is that the engine is in the pod itself. The engine is surrounded by the so called pod or nacelle.

The following azimuth thrusters are azipods:

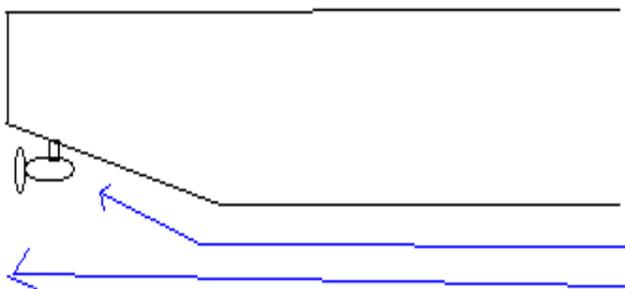
5.1.2 Azipush:

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

An advantage of this system is that the system is less vulnerable for damages then the azipull. This is because the propeller is being protected by the pod in front of it.

But there are also disadvantages, for example the pod decreases the water flow that flows through the propeller. Because of this, the system also causes more vibrations to occur. This is not wanted when installed on for example a cruise ship, because the vibrations can cause the soup to jump out of the plates when the dining room is above the engine room. So vibrations are not wanted because it can decrease the level of comfort the guests are experiencing.

Vibrations are also the number one cause of damage in the pods.

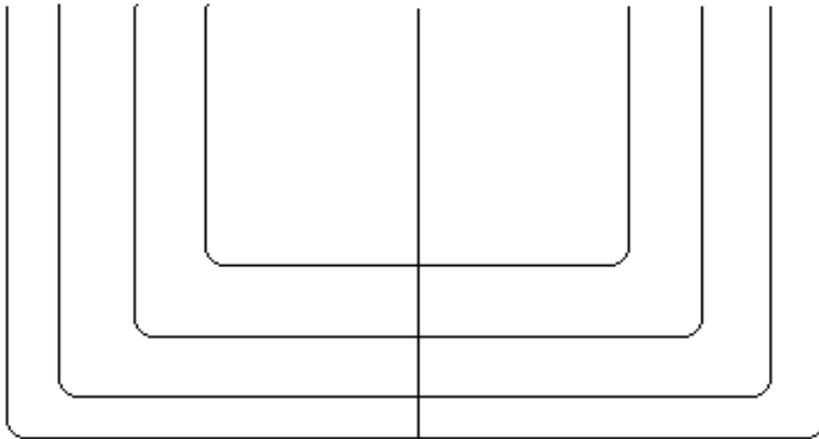


Example of the azipush

5.1.3 Azipull:

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

For this system it is important that the stern of the ship is prawn shaped. This is because this shape directs the flow to the propeller. When the propeller is installed in an angle the flow through the propeller will even be better.



Prawn shaped stern

Because of this homogenous flow through the propeller the vibrations will be less than with the azipush system. This is a great advantage because this also means that there is less cavitation on the propeller. There will also be less erosion of the system because there are fewer vibrations. This all means that the azipull system is more maintenance friendly than the azipush system.

But there are also disadvantages with this system. The stern of the ship has to be built in a prawn shape and when the pod is pulling the ship forward the system is more vulnerable than the azipush system.



Example of the azipull system

5.1.4 Future developments:

Even with all the advantages of the azimuth thrusters, the system isn't perfect. To make this technology more reliable and efficient it is important to solve the problems and disadvantages.

Experiences with this system teach us that there are a few points what have to be solved or improved.

These points are:

- Solving the problem with the mechanical forces that are being experienced and because of that there will be slack between the seals. When this is solved it will increase the reliability.
- Decreasing the forces that are working on the connection point from the pod and the ship. This will allow the master to work with more power and by doing this the ship will be more maneuverable.
- Better courses for the crews that are working with azimuth thrusters. This has to be done because the maneuvering of the ship is completely different than a conventional ship. Without this training the change that accidents will happen because of human mistakes will increase.

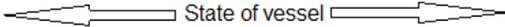
5.1.5 Azimuth:

Azimuth propulsion becomes more common on ships nowadays. This is because the system is well known for its maneuverability and it also decreases the amount of emissions. Because the high maneuverability of the system, the ship can enter a port without any help of tugs. This a huge advantage because the ship doesn't have to wait until the tugs arrive and the costs are also reduced. A ship with the azimuth system as propulsion doesn't need a rudder to maneuver because the azimuth can rotate 360 degrees. Although there are many advantages the system has also some disadvantages.

For example there are many mechanical problems with the shaft seal, which can lead to failure of the electrical part. Also when the ship is maneuvering with much power, like in a port, there will be a huge force working on the connecting part between the pod and the ship.

To prevent damage to the ship and system caused by this force, the manufacturers installed some limits. These limits concern the power used by the azimuth. The limit range depends on the state the ship is in. For example when the ship is sailing in the middle of the ocean it doesn't have to maneuver so there won't be a huge force on the connection part. The power limit will now be much higher than when the ship is close to shore or in port when it has to maneuver constantly.

Below a table is shown with some limits for the azimuth system.



	Ocean	Maneuver
Max angle of propeller	Maximum angle of 30°	360°
Max power	100%	35%

Limits

5.1.6 L- and Z-drive:

When the engine is not in the pod or so called nacell the system is not an azipod. But it is still an azimuth thruster because it can rotate 360 degrees.

An advantage of this system is that it can be placed on a conventional ship without having to change the whole stern of the ship.

So by placing the engine inside the ship it will be cheaper to place this system inside the ship than an azipod. This will be an argument for the shipping company to choose for this system when they want to place azimuth thrusters on their existing ships.

But an additional advantage of placing the engine inside the ship is that the engine is easy accessible for repairs. When the ship uses azipods they have to go inside a dry dock to repair the engine. This isn't necessary when using L- and Z-drive what also saves a lot of money.

But there are also disadvantages, because the engine is inside the ship there is a mechanical transmission needed. Because of this there will be losses in power. But that is not all; the engine also requires space inside the ship. This space is not available for cargo so the ship can transport less cargo then when there would be an azipod in place.

5.2 Alewijnse

We also visited Alewijnse. During this visit, we learned a lot about hybrid propulsion. It is important to know that the definition of hybrid propulsion may vary from person to person. At Alewijnse they say propulsion is hybrid when it combines power generation with an electrical engine, with a battery in between. So in our talk with them we will stick to the same definition.

5.2.1 Experience and projects:

Alewijnse has some experience equipping boats with hybrid propulsion. A few years ago Alewijnse has equipped the yacht "Itherion" with Hybrid propulsion. The owner of this yacht decided he wanted hybrid propulsion, because of its high reliability. On a previous yacht, he has experienced failing engines, and he never wanted anything like that again.

The hybrid propulsion in this yacht consists of a Power Take In/Power Take Off. The owner of this yacht is very satisfied with this configuration, and at Alewijnse they are satisfied with their project as well.

Besides this project, they are also working on the project "Ecotug". In this project they are going to equip a harbor tug with hybrid propulsion. The batteries in this tug are capable of a power output up to 1.5 MWh. Those batteries will be either of the Lithium-ion, or the Natrium-sulfide type.

In another project linked to hybrid propulsion Alewijnse has worked on a fuel-cell boat, which sails the Amsterdam Canals. This boat is not hybrid, but interesting because it also needs an advanced power management system.

5.2.2 Benefits:

Hybrid propulsion has a lot of benefits, but only for specific tasks. The spokesperson at Alewijnse told us that hybrid propulsion is very interesting for real specific tasks. Hybrid propulsion is good for tasks where a ship (or any other form of transportation) has a very variable power demand. For example a container vessel sails all of the time at maximum speed, and has an engine which has its optimal power output at that speed. That way it's not useful to install a hybrid propulsion system.

On the other hand a harbor tug sails most of the time just slowly, but once it's connected to a big vessel, it asks a lot of power. This is perfect for hybrid propulsion, because if the vessel sails slowly, the engine can deliver a bit more power as necessary, and convert that to electrical energy, storing that in the batteries. Once the tug is connected to the big vessel this electrical energy can be used to give the extra demanded thrust. Summarizing we can say that on vessels with an unstable power demand, hybrid propulsion is a lot more efficient.

Another advantage of hybrid propulsion is the adjustability. Where a conventional propulsion system (a combustion engine) has a minimum power output, does a hybrid system have no threshold? So a hybrid propelled vessel could have the propeller turn at every thinkable speed, where a conventional system has a minimum speed.

5.2.3 Disadvantages:

A big disadvantage of hybrid propulsion is the costs. It costs quite a lot more to install a hybrid propulsion system, and then it would cost to install a conventional propulsion system. This is easy to understand, because it has extra components. However, a hybrid system could earn itself back, as long as it is used in the right type of vessel.

Another drawback is that it's difficult to adjust the power management system just right. The system should have the engine running at the right speed all the time, and it shouldn't take too much power off. It also has to connect the power supply at just the right time.

Conclusion desk research:

-Sub question 1: “What is hybrid propulsion, and what types of hybrid propulsion exist Azimuth thrusters (Azipod/ Azipull and Z-drive/L-drive), Diesel-electrical and Gas-electric.

-Sub question 2: “On what types of ships would hybrid propulsion actually be useful?”

The main problem is the huge amount of batteries and place needed to provide the vessel of electric power. Most ships are build to carry as much cargo as possible so there will be Hardly any place to store the batteries.

However, some vessels such as tankers, which have to comply with the double –hull structure, may have enough space to store the batteries.

To provide a more detailed answer to sub question two, we need to visit some companies that are well known with the hybrid principle and ask them how they think about the idea of using it on ships and on which ships it will be realistic.

-Sub question 3: “What types of hybrid propulsion would add a substantial amount of speed?”

Every propulsion system has its own main function/advantage. For every ship there should be assessments made of which system can provide the best working conditions for the vessel. Thus the Azipod/Azipull systems are good for the maneuverability and the Z-Drive and L-Drive are best for a fast change of thrusting power.

-Sub question 4: “what type of hybrid propulsion combines most advantages for a ship?”

With the advantages and disadvantages of a hybrid system, we can conclude that every type has its own advantages and disadvantages. It depends on the type of vessel and the voyages the vessel makes on which type of hybrid propulsion should be implemented in the ship. So there is no type of hybrid propulsion that is perfect for a ship.

Conclusion Field research:

In this paper we discussed different kinds of hybrid propulsion. Our main question was which type had the most favorable influence on the vessel's speed.

By answering the sub questions we came to a several conclusions that led to the answer of our main question.

Because we came to the conclusion that hybrid propulsion will be useful on ships that have more than one electricity users. For example cruise ships: they have a big group for the hotel department and also for the propulsion. This will be more fuel efficient than when there is only one group for propulsion and a small group for the electrical grid on board.

Another conclusion that we came to is that there is no hybrid propulsion system that increases the ships sailing speed. Hybrid propulsion has no negative influence on the maximum speed, although it costs more fuel to sail that maximum speed in comparison with the normal diesel propulsion. However some of the systems, such as the azimuth thrusters, will increase the maneuverability of the vessel. This will save the company money because there's no need for tug assistance.

Hybrid propulsion is a topic where a lot of projects are busy with. But there is still a long way to go according to Alewijnse. Specially for vessel which are working with a lot of different powers, for example tugs.

Recommendation:

We recommend that companies will invest in hybrid propulsion. Not only for the environment but also for the economic and practical advantages that it gives. By implementing hybrid propulsion in their future build ships it will save more money then implementing it on their existing ships. This because the shape of the stern can be made directly in the right shape, instead of having to alter an existing stern.

Also when implementing it in new vessels the company can choose for azipods, such as azipull and azipush. This will create more space in the vessel for cargo, which is a main target for a shipping company.

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