【欧州】【海事】

Maritime Issues – Utilisation of LNG and Hydrogen as fuel: The decarbonising challenge in maritime transport: Hydrogen fuel cells as a ship propulsion option

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【概要：Summary】

The maritime sector will need more environmentally friendly fuel sources in order to meet the requirements of the IMO's plan to reduce GHG emissions from shipping by 50% by 2050, compared to 2008.

The type of propulsion and alternative fuel selected will have a direct impact on the vessel's emissions, including GHG, NOx, and SOx. Accordingly, the focus will be on the development of potentially low and zero-emission propulsion systems and fuels.

However, ocean-going vessels might need different solutions from coastal and short-sea shipping or ferry transport. Currently, in the deep-sea maritime transport, which accounts for 80% of the global CO2 emissions from shipping, the majority of new vessels are still being planned and built to use traditional fuels. However, due to the fact that vessels typically have a life span of about 25 years, vessels that use new low to zero-carbon emission biofuels, hydrogen or other potentially CO2 emission neutral fuels would have to be already available by 2030 in order to achieve the IMO's 2050 target.

Currently, the ship-owners are facing the replacement of Heavy Fuel Oil (HFO) by other fuels that comply with the maximum of 0.50% sulphur limit as of 1 January 2020. However, in the long term, they will have to replace also very-low sulphur fuel oil (VLSFO) with low or zero GHG emission fuels. Hydrogen based fuel cells propulsion is considered being one possible option besides other alternative fuels to achieve a decarbonisation of maritime transport, provided that renewable energy sources are used in the hydrogen production.

【記事：Article】

1. The IMO's GHG emission reduction measures

According to the International Maritime Organization (IMO), maritime shipping is responsible for 18 to 30% of NOx, 9% of SOx, and 3.5 to 4% of CO2 emissions worldwide. In the past decades, the IMO and the shipping industry had been postponing measures to deal with the problem of GHG emissions in maritime transport. However, since the maritime transport's CO2 emissions remained excluded from the UNFCCC's Paris Agreement, the IMO is responsible to taking measures for reducing the international maritime transport's CO2 emissions. Accordingly, in April 2018, the IMO's Marine Environment Protection Committee (MEPC) 72 adopted the initial IMO strategy on reduction of GHG emissions from ships, RESOLUTION MEPC.304 (72). This resolution refers to a range of short-, mid- and long-term measures and supports a three-step approach towards addressing CO2 emissions from international shipping. The IMO's MEPC 74 committee confirmed the IMO's commitment to reducing GHG emissions and approved amendments to strengthen existing mandatory requirements for new ships, It also agreed on the terms of reference for the 4th IMO GHG study and considered proposals for short-term measures, but no final decisions were taken.

At the 6th session of the IMO MEPC's Intersessional Working Group on GHG Emissions (ISWG-GHG6) from 11 to 15 November 2019, the working group considered proposals for short-term measures to tackle shipping's climate impact, including proposals to reduce ship speeds. However, environmental organisations criticized the IMO for showing a concerning lack of progress and low ambition. They criticized that one and a half years after agreeing on the IMO's initial GHG strategy, the ISWG-GHG6 meeting resulted in little more than a review of options already considered and did not deliver tangible results. IMO will have to decide by summer 2020 on the implementation of immediate measures in order to be able to achieve short-term GHG reductions.

Meanwhile, the European Community Shipowners' Associations (ECSA) rectified the criticism regarding the IMO's the lack of progress and low ambition at the ISWG-GHG6 meeting. In a recent statement, ECSA pointed out that a majority of ambitious member states from Europe decided to cooperate closely with core states from Asia and South America in order to be able to adopt concrete CO2 reduction measures next spring for the MEPC 75. The ECSA also underlined that it was not the aim of the IMO MEPC's ISWG-GHG6 meeting to make any decision, but to prepare for the MEPC 75 in March 2020.

However, in fact, the IMO's initial GHG strategy does not give a schedule for the set up of legal restrictions on CO2 emissions. It is a framework for IMO member states to set levels of ambition to reduce GHG emissions. Accordingly, the EU is waiting for the IMO's presentation of GHG emissions reduction measures for the period after 2023, in order to eventually decide on the introduction of unilateral GHG emission reduction measures in the EU.

2. Alternative fuels for maritime transport

Besides the introduction of the IMO's 2020 global sulphur limit, the maritime industry needs to consider the implications of the 50% reduction of GHG emissions from shipping by 2050, compared to 2008. Therefore, also in maritime transport, the focus will be on the development of potentially low and zero-emission propulsion systems and alternative cleaner fuel solutions. In the mid- and long-term, also ship owners will have to consider a switch to vessels with alternative fuels like LNG, methanol or biofuels, or low to zero emission propulsion systems like hydrogen based fuel cells and electricity, among others. In fact, hydrogen or electricity based prolusion systems offer a low to zero carbon emission solution as these systems can operate without GHG emissions during operation. Furthermore, the shipping industry will have to consider different solutions depending on the utilisation of a vessel. In short-sea shipping or in ferries, electrification is a viable solution and hybrid or fully electric ferries already are on trial or operation in Norway, Denmark and Sweden. In long distance transport like ocean transport, any kind of low to zero carbon emission liquid fuel could replace heavy fuel oil. Currently, there are three options in consideration, including carbon neutral biomass-derived fuels, hydrogen and synthetic non-carbon fuels, like ammonia. Each of these three solutions has its challenges. Biomass-derived fuels are being tested as drop-in fuels on certain routes, but they are considered being only a transition solution. They have capacity constraints as production of biomass is in competition with food production and therefore, hydrogen or synthetic non-carbon fuels seem to have the highest potential as a long-term solution for maritime transport. Furthermore, since a vessel's life span is about 25 years, any new orders for the next decade will already have to be for vessels with new designs that will be able to use biofuels, ammonia, hydrogen, batteries or another form of alternative fuels for propulsion. The shipping industry will soon need solutions of shipbuilders and engineers to achieving the transition towards zero-carbon emission technologies by 2050.

3. The shipping industry' efforts regarding the decarbonisation of the maritime transport

In 2018, A.P. Moller – Maersk established an ambitious goal for reducing CO2 emissions towards having net-zero CO2 emissions with its operations by 2050. Maersk is convinced that the climate change problem can only be solved by becoming carbon-neutral as efficiency will not be enough. So far A.P. Moller – Maersk has not decided how it intends to reach this target of net-zero CO2 emissions in its operations by 2050. However, by setting the target, Maersk hopes to create a certain momentum to inspire researchers, technology developers, investors, cargo owners and legislators to come up with sustainable solutions for the maritime industry.

During the UN Climate Action Summit on 23 September 2019, the Danish Minister for Foreign Affairs, and CEOs from Maersk Container Industries, as well as about 80 companies from the maritime, infrastructure, energy and finance sector, including Shell, Citibank, Cargill, Kuehne + Nigel, Unilever, the Antwerp Port, and Sustainable Energy for All, among others, launched the so-called "Getting to Zero Coalition". The GtZ Coalition highlights the need for collective action to decarbonise shipping. The Coalition is committed to getting commercially viable deep sea zero emission vessels powered by zero emission fuels into operation by 2030. The shipping industry considers zero emission fuel cells as a long-term solution, which was also discussed at this year's Maritime Hybrid & Electric Conference in Bergen, Norway in September 2019. There is an increasing interest from the merchant shipping fleet in the uptake of hydrogen fuel cell technology in the next five years. Currently, in the deep-sea segment, which accounts for 80% of the global CO2 emissions from shipping, the majority of new vessels are still planned and built to use traditional fuels. However, according to A.P. Moller-Maersk, when considering the 20-25 years lifetime of vessels, realistically, in order to achieve the IMO's 2050 target it would need vessels with alternative new propulsion technology available by 2030. The shipbuilding industry and naval architects would have to develop zero emission vessels with new propulsion systems in less than a decade and to make the entire shipping industry utilise them, because ships that will enter the global fleet in 2030 will still operating in 2050. Accordingly, the future demand for liquefied hydrogen can be expected to rise in the entire transport sector and also in maritime transport.

This will require specific vessels tailored to transporting and bunkering liquefied hydrogen as well as the construction of the necessary bunkering infrastructure. Consequently, the further challenge around commercially viable zero emission vessels is not primarily seen as a technological challenge but a challenge of the necessary collective action, since decarbonizing shipping requires a systemic transformation of the entire maritime industry.

4. Challenges in the hydrogen fuel cell utilisation in maritime transport

Hydrogen-based propulsion technology has the potential to supply clean and efficient power in maritime transport. Hydrogen fuel cells emit only water vapour and warm air, so there are no CO2 emissions and no direct air pollutants at the point of operation. Therefore, hydrogen based fuel cell propulsion is potentially a propulsion system with zero CO2 emissions at operation, but only if the hydrogen is produced using a natural energy sources, such as solar energy, wind power, or biomass. However, if the hydrogen used in fuel cells is derived from non-renewable natural gas or petroleum, then CO2 emissions from hydrogen production could even exceed the CO2 emissions of diesel-fuelled propulsion systems. Therefore, it is critical how the hydrogen is produced. Another challenge is that hydrogen fuel cells have never been used for ship propulsion for ocean going vessels and trials are only starting for short-sea shipping and ferries. The use of hydrogen-powered fuel cells for ship propulsion is still at an early design and trial phase, with applications in smaller passenger ships, ferries or recreational craft.

On 24 January 2017, the European Maritime Safety Agency (EMSA) released the study entitled "Study on the use of fuel cells in shipping", prepared by DNV GL. The study identifies the leading fuel cell technologies with potential for maritime applications and shows technical challenges related to the use of hydrogen as ship fuel. One key factor is the weight and volume impact of the hydrogen fuel storage system required on board, presenting even tougher handling and storage challenges at sea than LNG. Furthermore, regarding the regulatory framework, the EMSA study notes that the IMO's International Code of Safety for Ships using Gases or other Low-Flash-Point Fuels (IGF Code) does not yet cover fuel cells or hydrogen as fuel. Having entered into force on 1 January 2017, the IGF Code is a mandatory instrument applicable to all ships using gases and other low flashpoint fuels, built or converted after the entry into force of the Code. The IGF Code provides specific requirements for ships using such fuels, but presently, it only contains detail requirements for LNG or CNG as fuel. There are several initiatives, which will eventually lead to an amendment of the IMO IGF Code for including rules for hydrogen on-board of ships.

In the EU, the development of hydrogen as alternative fuel has political support in the form of a EU commitment to invest in a new fuel cell system for marine purposes, as part of the Fuel Cells and Hydrogen Joint Undertaking (FCH JU).

5. Recent projects of the utilisation of hydrogen fuel cells in maritime transport

The new generation of vessels that utilise hydrogen or other CO2 emission neutral fuels need to be developed in the next decade in order to be ready and available for deployment by 2030 in order to achieve the zero net carbon emissions target by 2050. Although at an early stage of development for the shipping market, hydrogen based fuel cells could become a truly low-carbon propulsion solution for the shipping industry. Without claiming completeness, there are several projects underway in Europe to develop and deploy hydrogen fuel cells as propulsion system in vessels. The use of hydrogen by ships includes a number of demonstration projects like H2SusBuild, HySafe, HyApproval, the European Integrated Hydrogen Project (EIHP2), HyWays, Zemships and FellowSHIP.

In Europe, Norway is one of the pioneers in developing and testing hydrogen-fuelled ferries. The Norwegian government is supporting a wide range of hydrogen fuel activities involving players ranging from the Norwegian Maritime Authority (NMA), the Directorate for Civil Protection (DSB) and the Norwegian Public Roads Administration (NPRA), to DNV GL, shipyards and ship-owners. The Norwegian Maritime Authority is increasingly involved at an early stage in innovative projects. With the backing of the government, the NPRA established a project in 2017 with the ultimate goal of building and operating a hydrogen-electric ferry on the Hjelmeland-Nesvik route on the southwest coast. The project aims at developing hydrogen technology in order to achieve zero emissions on ferry routes not suitable for full-electric operation. A second project, called HYBRIDShip (Hydrogen and Battery Technology for Innovative Drives in Ships), was initiated by Fiskerstrand Holding AS in 2016. It aims at converting an existing diesel-powered ferry to hydrogen. The goal of the HYBRIDShip pilot project is a hybrid-powered ferry to start operation in 2020. The ferry's main propulsion will be hydrogen fuel cells, supplemented with batteries. Both the NPRA and HYBRIDShip projects ultimately aim to make zero-emission technology feasible for routes that are too long for pure electric propulsion. Once the technology is refined on shorter routes, the plan is to expand into longer and more demanding trips and larger vessel types.

Furthermore, MAN Cryo, ship-owner Fjord1 and designer Multi Maritime in Norway announced the development of a marine fuel-gas system for liquefied hydrogen. The system is designed for vessels, such as ferries, employed on relatively short routes, and it has been granted preliminary approval in principle by DNV GL. DNV GL predicts significant long-term rises with low-carbon hydrogen becoming an effective decarbonisation agent to mitigate climate change.

Another Norwegian government-funded project aims at developing a hydrogen propulsion system for large maritime vessels. Havyard intends to develop a pilot hydrogen system that could help large ships sail emission-free over long distances. Havyard's project is part of the government-financed initiative Pilot-E project. With the first phase of development completed, the company is now entering into the approval stage for its hydrogen system, together with Linde Engineering as tank supplier and PowerCell Sweden AB as supplier of fuel cells. According to Havyard, the regulations for these solutions have not yet been developed, and based on Linde's experiences, they intend to gain approval for the system. The vessels are scheduled to start operation in January 2021.

Furthermore, the design and engineering services company Moss Maritime, in cooperation with Equinor, Wilhelmsen and DNV GL, have developed a design for a liquefied hydrogen (LH2) bunker vessel. The LH2 bunker vessel has been designed to permit transport and bunkering of liquefied hydrogen to merchant ships and to open sea transport.

Another company involved in the development of new zero-emission solutions is ABB Marine & Ports. In June 2018, ABB and Ballard Power Systems signed a Memorandum of Understanding (MoU) on developing the next-generation fuel cell power system for sustainable marine e-mobility. They intend to develop together the next-generation fuel cell systems for sustainable electric mobility in shipping.

In another maritime hydrogen development, Ferguson Marine Engineering is building the world's first fuel cell ferry that will use hydrogen harvested entirely from renewable sources. The ferry will operate around Scotland's Orkney Islands, which are producing hydrogen in from renewable energy. The vessel is expected to be delivered in 2020.

Furthermore, Ulstein ship manufacturer has unveiled its first hydrogen-powered ship design which is now market-ready, offering zero emission marine operations. The Ulstein SX190 Zero Emission DP2 construction support vessel features a Nedstack fuel cell power system. At present, the Ulstein SX190 design is capable to operate for four days in zero emission mode, however, with rapid developments in hydrogen storage and fuel cell technology, the company is aiming at reaching a future zero emission endurance of two weeks.

In November 2018, ABB also partnered with SINTEF to test the viability of fuel cells as an energy source for ship propulsion. ABB and SINTEF's project is still in its early stages, but the parties hope to see positive results soon.

Also cruise operator Royal Caribbean has announced plans to use hydrogen fuel cell technology as a means of additional power on their new LNG-powered Icon-class vessels, which are expected to be delivered in 2022 and 2024. However, despite the growing number of hydrogen-related marine projects, the shipping industry's opinion on the suitability of hydrogen remains divided. This is an indicator that any significant uptake of hydrogen fuel cell vessels could be delayed for several years.

6. Conclusion

There are some alternative fuels that could potentially help to decarbonise the shipping industry. The hydrogen based fuel cells propulsion technology has been identified as a potential solution to reducing the GHG emissions and to reach the IMO's target of halving GHG emissions in the shipping industry by 2050. A number of different hydrogen fuel cell propulsion systems are in development and trial stage. However, since the production of hydrogen itself can lead to pollution, including GHG emissions, the only way to reach a zero carbon emission utilisation of hydrogen fuel cells is to produce hydrogen from renewable energy sources. Consequently, in order to utilise hydrogen fuel cells for decarbonising maritime transport, it will be crucial to use hydrogen, which is produced by using natural energy sources.

Furthermore, the codes and standards for hydrogen fuel cell powered ships have repeatedly been identified as a major barrier for the deployment of the hydrogen technology. Rather than the development and deployment of this relatively new technology itself, it is the lack of amendment of international codes and standards, which could hold back the utilisation of hydrogen fuel cells beyond a state's territorial waters. So far, fuel cells have been scaled for and are being used in a country's territorial waters.

Furthermore, the necessary infrastructures at land and on board of ships need high investments and the financing of the promotion of fuel cells is a major hurdle that has to be overcome. Since there exist less complicated alternatives, it remains open whether hydrogen will become an important fuel for future shipping. However, part of the solution could be to develop short-sea shipping based on FCH propulsion, which can work as important test ground for the introduction of FCH fuels on a higher level. It would be a valuable stepping-stone for getting both, technology and infrastructure, ready for larger deep-sea vessels. Starting with FCH powered ferries sailing on fixed routes in territorial waters simplifies legal, administrative and logistic requirements and allows stakeholders to begin expanding the infrastructure besides collecting valuable experience in operating FCH powered ships. In this respect, the Norwegian projects are very valuable steps towards a wider introduction of FCH propulsion in maritime transport. Although currently not economically competitive, in the medium- to long-term, hydrogen could become viable as zero carbon emission fuel.

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