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Methanol, an Alternative Fuel in Maritime Industry

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Abstract: The satisfactory results of using methanol as a fuel in heavy machinery onshore, together with its numerous advantages in comparison with other conventional fuels in the maritime industry, such as HFO (Heavy Fuel Oil) and MDO (Marine Diesel Oil), have highlighted methanol as one of the possible alternative fuel options in this industry. Compared to other conventional fuels for ships, methanol has much cleaner combustion in a way that its emission rate of sulfur compounds is zero. Moreover, the nitrogen compounds produced by methanol during combustion are significantly lower and the amount of soot produced in the engine is at least 90% less than conventional fuels. In the present review article, the physical and chemical features of methanol to be used as fuel for ships are primarily explored. In addition, we will briefly go through the design considerations of methanol-fueled ships, and finally, we will review the practices of leading companies in the use of methanol fuel, as well as their implemented innovative measures.

Introduction

Global requirements aiming at reducing the emission of pollutants, especially greenhouse gases, are being increasingly developed, and the maritime industry is no exception to this rule, despite its 3% share in the total amount of greenhouse gas emissions in the world. This has caused the mega companies worldwide, which are connected to the maritime industry in one way or another, to gradually convert or replace their vessels with clean-burning ships by concluding joint contracts. The use of methanol as bunker fuel is highly intriguing due to its physical and chemical features as opposed to other alternative fuels.[1]

As one of the leading exporters of petroleum products, Iran enjoys a very well-equipped fleet in the sea, which subsequently exposes this country to abide by international regulations and requirements. However, after the passing of a regulation regarding the use of low-sulfur marine fuels devised by the International Maritime Organization in 2020, the negligence of the relevant organization in providing a timely response to this issue, and as a result, the insufficient production of low-sulfur bunker fuel domestically raised the need for Iranian maritime companies to import fuel from abroad. In addition, in the coming years, the law on levying exponential taxes on greenhouse gas emissions by vessels will be implemented by the International Maritime Organization and in case of any probable inattention to this law, Iranian maritime companies would be costly penalized.[2] It is noteworthy that the use of methanol as a fuel by internal maritime companies not only resolves the country's need to import fuel but it also causes the maritime companies to adhere to the laws enacted in the future and consequently minimize the due tax and on top of those, reduce the cost of transporting export goods. In the present article, the physical and chemical features of methanol to be used as fuel for ships are primarily explored. Then, we will briefly go through the design considerations of methanol-fueled ships, and finally, we will review the practices of leading companies in the use of methanol fuel, as well as their implemented innovative measures.[3]

1- The Ideal Physical and Chemical Features of Methanol as Bunker fuel

In this section, we will explore the properties of methanol, make a comparison between methanol and other conventional marine fuels, and review the environmental considerations of using methanol as an alternative fuel for ships.

1-1- Combustion Emissions of Methanol

As the simplest compound of alcohol, methanol is a light, volatile, and flammable substance that can be found in liquid form at room temperature and pressure, which reduces safety issues when it comes to using it as a marine fuel compared to other possible options such as hydrogen gas and LNG. When methanol is combusted, water and carbon dioxide are the only byproducts of the reaction. One of the advantages of methanol as a fuel is the lack of sulfur compounds emission during combustion due to the absence of sulfur in its molecular structure, which makes this substance efficiently compatible with the requirements set by the International Maritime Organization in line with IMO2020 to reduce the emission of sulfur compounds.[4] Furthermore, the emission of particulate matter is negligible given the absence of carbon-carbon bonds in methanol molecular structure. The adiabatic combustion temperature of methanol is lower than conventional fuels such as heavy fuel oil (HFO), leading to a decline in the temperature of the combustion chamber and eventually, a drop in the amount of NOx pollutant compounds.[5]

Based on the experiments carried out on marine engines, the amount of soot produced in ship engines is reduced by at least 90% when using methanol.[6] As mentioned earlier, one of the key reasons for maritime companies to pursue the use of alternative fuels such as methanol, LPG, hydrogen, etc. is reducing CO_2 emissions.[7] Cutting down on the amount of CO_2 has gained the attention of many companies related to shipping and marine transportation not only as an important social responsibility but also because of the regulations and requirements set by international organizations and institutions to levy taxes on the emission of this greenhouse gas.[7] Collecting taxes on CO_2 emissions from related companies in the upcoming years will be proportionate to the amount of this pollutant's production. The amount of tax collected annually will go up exponentially so that all pertinent companies will be obliged to devise various plans to downturn CO_2 emissions.[8] In case methanol is used as a marine fuel, the amount of CO_2 reduction would vary depending on the primary sources of methanol production and would be determined according to life cycle calculations for this substance.[9,10] Needless to say, using renewable resources such as biomass, as opposed to natural gas, to produce the methanol that is supposed to be used as marine fuel would also significantly bring down the CO_2 calculated by the supervisory bodies for tax collection. Besides, producing methanol using the carbon dioxide recovery method (CDR) can be another effective method to decrease emissions. In the West Asia region, QAFAC Company in Qatar, (Persian) Gulf Petrochemical Company in Bahrain, and Azerbaijan Methanol Company in Baku utilize this method to cut down their methanol production, which consequently reduces the released CO_2 per unit of produced methanol.[11,12]

Tapping on industrial experiences regarding using methanol as bunker fuel, the amount of SOx pollutants is quite negligible and the NOx pollutants are also significantly lower than conventional fuels used in the maritime industry. The amount of carbon dioxide reduction may vary depending on the primary sources of methanol production, which can be determined via life cycle calculations.[11-13] The amount of methanol's combustion emissions compared to conventional and non-conventional marine fuels is illustrated in Table 1.

Table. 1. Comparison of the pollutants emitted from conventional fuels. LSFHO, heavy fuel with low sulfur; MDO, marine diesel oil; LH_2, liquid hydrogen[14]

Fuel type	Energy (MJ/kg)	Pollutants Emitted (g/kWh)				
		CO_2	PM	NOx	SOx	N_2O
LSFHO	40.5	541	0.72	15.8	3.23	0.027
MDO	42.6	524	0.16	14.8	0.32	0.026
LNG	48.6	412	0.027	1.17	0.003	0.016
LH_2	120	0	0	0	0	0
Ammonia	18.9	0	N.A.	0	N.A.	0
Methanol	20	522	0	3.05	0	0

1-2- Environmental Effects

In case of any methanol leakage into the sea, this substance has significantly lower environmental effects than conventional fuels such as diesel or heavy fuel oil. Methanol quickly dissolves in water and only in high concentrations, it can cause hazards to living organisms. The methanol that is leaked into the water is continuously decomposed and consumed by the bacteria in the water. It is noteworthy that methanol is naturally produced in the ocean by phytoplankton and consumed by bacteria.[15,16] It must also be considered that the use of LNG is one of the most common alternatives to conventional marine fuels, with more than 250 ships using it worldwide. However, since LNG is one of the major pollutants in the climate change debate (with 80 times more greenhouse effect than CO_2) and also considering the high leakage of this fuel in LNG ships, methanol is a more favorable option when it comes to environmental considerations.[17]

1-3- Ease of Use as Marine Fuel

Methanol has no cryogenic complexity and at ambient temperature and pressure has the most physical similarity with conventional marine fuels such as diesel or heavy fuel oil in comparison with other alternative fuels. For instance, methanol density at a temperature of 20 degrees Celsius is reported as 3792 kg/m, which has a slight difference from the density of HFO with a density of 3780 kg/m and diesel with a density of 3830 kg/m. Moreover, methanol has long been widely transported by chemical tankers to all parts of the world, and therefore it would be less complicated to change safety tools and equipment after replacing methanol with conventional marine fuels in comparison with other alternatives such as hydrogen and LNG.[16-18]

2- Technical and Safety Considerations for Using Methanol as Bunker fuel

The safety rules and regulations provided by the IGC[(1)] and IGF[(2)] codes define the general framework for the use of low-flashpoint marine fuels. Many public safety considerations such as a safe location for the fuel storage tank, double wall containment pipe for fuel transfer, vapor and gas identification and ventilation system, categorizing different areas in terms of risk level, installation of anti-explosion systems, etc. are viable for all liquids with a low flashpoint as a maritime fuel. Each type of fuel has its own unique features, and therefore specific protocols for each should be considered. In this section, we will review the general framework and different aspects of using methanol as a ship fuel.[19-21]

2-1- Considerations regarding Methanol Bunkering

[(1)] International Code of Construction and Equipment of Ships Carrying Liquefied Gases in Bulk

[(2)] International Code of Safety for Ships using Gases or other Low-flashpoint fuels

When it comes to utilizing methanol as a fuel, one of the most critical issues is to create an efficient fueling system on the ship so that the ship, crew members, or the environment would not be exposed to any risk. Methanol bunkering includes a fueling station, fueling pipes, fueling connections, and also a pipe discharge system. There is no difference between the methanol fueling system and those of other types, however, only the standards pertaining to the ship's fueling station, such as proper ventilation and placement on the ship's deck, must be in place.[22,23] In the case of using closed and semi-closed fueling stations, the establishment of an effective mechanical ventilation system would deem necessary. A manual valve and a control solenoid valve must be installed in series on the fuel transfer line and in the closest spot to the connection point to cut off the fuel flow if needed, either manually or from the control room. Additionally, it is also required to install equipment to empty all fuel lines after fueling.[24]

2-2- Storage Considerations of Methanol Fuel

The use of fuels with a low carbon percentage such as methanol requires a larger fuel storage space given the reduction of their energy content compared to conventional fuels, and this is to compensate for the lack of fuel energy content. Considering the physical properties of methanol, it is much easier to store it on board with less complexity according to the regulations and standards defined for the storage of marine fuels. For storage on the ship's deck, fuels with a low evaporation point such as ethanol and methanol can be stored in conventional storage tanks with minor modification, and for this reason, they can be used easily.[25,26] Moreover, methanol can be stored on the lower decks of the ship. Even some ballast tanks can be converted into methanol storage compartments. Indeed, these storage tanks need a suitable internal coating employing anti-corrosion materials as per the considerations explained earlier. For example, in the Stena Germanica ship, the first ship converted from diesel fuel to methanol, a number of ballast tanks of the vessel were repurposed and redesigned as a storage tanks for the consuming methanol, which will be further explained in the following sections. Considering the low evaporation point of methanol, it is necessary to use neutral gases such as nitrogen to fill the empty space of the storage tank. Besides, the low viscosity of methanol compared to other fuels such as heavy fuel oil requires a proper technical design to prevent leakage.[27] It is also imperative to consider additional separation spaces in fuel storage compartments.[28]

2-3- Considerations regarding Methanol Corrosivity

As opposed to some chemicals, methanol is corrosive and hence its use as a marine fuel will need the design and use of appropriate materials and methods in the storage system, fueling, and combustion engine. Anti-corrosion additives to this substance or the use of appropriate insulators can reduce its corrosive effects. When exposed to some metals such as titanium and aluminum alloys, the conductivity of methanol increases its corrosive power. These materials are widely used in systems containing natural gas and gas condensate, however, they are not a good choice for tools and fittings that are in contact with methanol or fuels mixed with methanol because of their low corrosion resistance.[29,30] Methanol storage tanks must be made of stainless steel with appropriate grade or coated with materials resistant to methanol corrosion. With regards to coating materials, it must be considered that any acidic impurity will quickly cause the loss of the anti-corrosion coating and consequently damage the storage tank, which may lead to a disaster if no timely action is taken. The non-metallic materials used for storage tanks or methanol pipes must contain sufficient amounts of anti-corrosion materials resistant to methanol such as nylon or neoprene.[31,32]

2-4- Safety against Combustion

There are instructions for preventing, identifying, and extinguishing fires caused by methanol as fuel for ships that are devised by the safety department of the Methanol Institute and also the International Maritime Organization, which would be discussed briefly in this section. For more information, you can refer to the standard (MSC.1/Circ.1621) developed by the International Maritime Organization.[13] For instance, based on these instructions, all manifolds, drain valves, and ventilation systems must be placed in a proper spot in a way so as to prevent the outburst of sparks and fires. To prevent the combustion of methanol vapor in the fuel storage tank, neutral gas can be used. Nitrogen and CO_2 as two neutral gases, are widely used in industry.[19,20] The combination of methanol, CO_2 and humidity creates a corrosive condition that damages the storage tank, and for this reason, nitrogen is mainly suggested as a neutral gas to fill the empty space of the methanol fuel storage tank. If methanol is combusted, its flames would have low temperatures and no smoke make its identification difficult and delayed.[21] Consequently, soot detection sensors as well as heat detection sensors that are widely used in the industry are not a good option for detecting methanol combustion given the mentioned features. Hence, fire and smoke detection cameras or thermal cameras with infrared waves are an ideal option for quick detection of methanol combustion in ships as per the recommendation of the instructions.[33]

3- Methanol Engines

MAN[(3)] and Wärtsilä[(4)] are leading companies in the design of methanol-fueled marine engines, and both have managed to redesign high-pressure diesel engines to use methanol as a fuel. At the moment, the dual-fuel methanol engines manufactured by these companies have been commercially utilized in the market.[21]

3-1- Methanol Engines of MAN Company

The design undertaken by MAN is based on ME-GI engines (dual-fuel diesel and gas) however, instead of injecting high-pressure natural gas as a secondary fuel, a liquid fuel is injected with high pressure into the engine through the installed lines (Fig. 1). New engines are designed to use a liquid fuel such as

(3) https://www.man.com/

(4) https://www.wartsila.com/

methanol, ammonia, LPG, or dimethyl ether as a secondary fuel, in addition to diesel as a primary fuel. These engines will be able to operate similarly to conventional diesel engines in terms of maximum continuous rating (MCR) and transient response preference and work with a wide range of methanol and diesel combination ratios.[13]

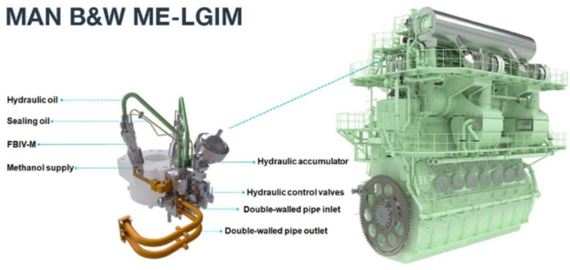

Fig. 1. MW-LGIM dual-fuel methanol combustion engine of MAN Company (man-es.com)

3-2- Methanol Engines of Wärtsilä Company

The Wärtsilä engine design is based on high-pressure natural gas injection technology, which has been used by this company in marine and land engines for many years (Fig. 2). The modifications that this company made on the engine involve the installation of a new cylinder head with a special injector system, in a way that allows the injection of mixed diesel and methanol fuel. Since this type of engine is a compression ignition engine, the fuel for starting the internal combustion of the engine must have a low octane. Accordingly, the injectors installed in the first stage direct the low-octane diesel fuel into the engine through a hydraulic system to initiate the ignition, and subsequently, methanol with high octane number is injected and continues the combustion process. In other words, the dual-fuel engines designed by MAN and Wärtsilä operate with two fuels, one with a high cetane number and the other with high octane number, as explained. Fuel with a high cetane number (diesel) is used as an ignition starter and fuel with a high-octane number (methanol) is used as a continuation of the combustion following the first fuel (Fig. 3).[34,35]

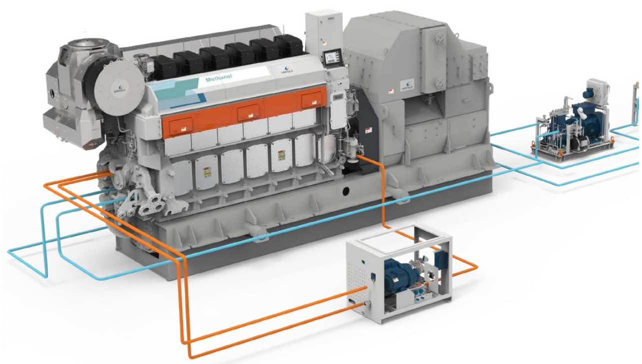

Fig. 2. Wärtsilä32 engine made by Wärtsilä (Wärtsilä.com)

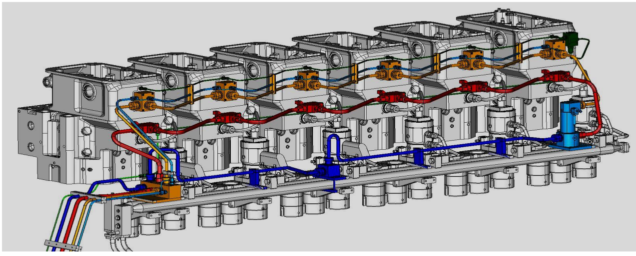

Fig. 3. Methanol fuel transfer lines in red, diesel fuel in orange, and return methanol in blue in the Wärtsilä 32 fuel-flexible methanol engine

In 2015, dual-fuel technology was first carried out on the Stena Germanica ship successfully, and its medium-speed four-stroke engine was re-designed and modified to burn methanol as a secondary fuel (Fig. 4). Moreover, some of the ship's ballast tanks were customized and utilized under technical and safety protocols to store methanol. Other modifications included the installation of a high-pressure fuel pumping station (600 bar), using two-layer fuel transfer lines and inserting suitable safety systems for methanol.[24-31]

Fig. 4. Stena Germanica ship (stenaline.com)

4- Pioneers of Using Methanol as a Fuel for Ships

In this section, we are going to name some of the world's greatest companies that have taken measures to burn methanol in part of their fleet.

4-1- Waterfront Shipping Company

As the logistics subsidiary of Methanex Company, Waterfront Shipping Company which is fully owned by the mother company was recognized as the first enterprise to use this new technology on an industrial scale by ordering and deploying three methanol-fueled ships in 2016. Methanex, as the world's largest decentralized methanol producer, has methanol production units in various countries including but not limited to the US, Canada, Chile, Egypt, Trinidad, and New Zealand, and therefore Waterfront Shipping Company is responsible for shipment of the company's produced methanol to all parts of the world using its fleet of 30 vessels. From 2016 to 2020, Waterfront Shipping Company increased the number of its methanol-fueled ships to 11 by adding 8 more methanol vessels to its fleet in 4 years.[24] Paul Hexter, the CEO of Waterfront Shipping Company[36], explains that the addition of these 11 methanol-fueled ships has not only been in line with the requirements of the International Maritime Organization devised in 2020 to reduce the emission of sulfur compounds, but also will align the company with the requirements of IMO2030 obligations to reduce the carbon dioxide emission. The successful experience of using methanol ships for 4 years, as well as the business advantages of using methanol as a fuel for ships based on the requirements set by the legislative authorities, have convinced the executives of Waterfront Shipping to manipulate 8 more methanol ships for delivery by the end of 2023.[37] Hence, the number of methanol-fueled ships owned by this company raised to 19 ships by the end of that year. All those ships were built through joint venture projects between Waterfront Shipping Company and other companies active in the field of marine transportation. It is to mention that the engines used in all 19 methanol ships are two-stroke and dual-fuel methanol-diesel manufactured by MAN Company, whose operation was discussed early on. Table. 2 indicates the characteristics of 11 dual-fuel methanol vessels of Waterfront Shipping Company, which have been delivered to and used by this company until October 2020.[38]

Table 2. Ships owned by Waterfront Shipping until the end of October 2020[24]

Name of the Ship	Shipbuilding company	Business partner in ship ownership	IMO Vessel Code
Creole Sun	HMD	IINO LINES and Mitsui	9850214
Takaroa Sun	HMD	NYK	9850202
Mari Kokako	HMD	Marinvest	9848687
Mari Couva	HMD	Marinvest	9848584
Lindanger	HMD	Westfal-Larsen	9725299
Leikanger	HMD	Westfal-Larsen	9725304
Leikanger	HMD	Westfal-Larsen	9725304
Cajun Sun	Minami Nippon	MOL Mitsui OSK	9724025
Taranaki Sun	Minami Nippon	MOL Mitsui OSK	9751406
Manchac Sun	Minami Nippon	MOL Mitsui OSK	9724013
Mari Boyle	HMD	Marinvest	9732979
Mari Jone	HMD	Marinvest	9725316

4-2- Proman Shipping Company

Known as the world's second-largest methanol producer with 6 million tons of methanol produced annually, Proman Company has been pursuing two general plans in line with the CO_2 emission reduction policy. The first plan is the production of Green methanol (bio methanol) and the second is deploying dual-fuel ships with methanol as the secondary fuel. Proman Shipping, as the logistics arm of this methanol-producing company, has ordered and manipulated 6 dual-fuel methanol vessels through a joint venture with Stena Bulk shipping company. Weighing 49,000 tons, Stena Pro Patria was the first of the 6 purchased vessels, which was built by Guangzhou Shipyard International (GSI). Two other dual-fuel methanol vessels, known as Stena Pro Marine and Stena Prosperous, were also built by the same company (i.e. GSI) and delivered by the end of 2022. remaining 3 ships were delivered between 2023 and 2024 (Fig.5).[39]

Fig. 5. Stena Pro Patria, a dual-fuel methanol vessel owned by Proman and Stena Bulk[40]

4-3- Maersk Shipping Company

When it comes to marine transportation, Maersk Shipping Company is regarded as the world's largest shipping company with more than 700 active ships. With regards to the requirements imposed to levy taxes on greenhouse gases emitted by ships (IMO 2030), this company has ordered 18 container vessels that can burb methanol as a fuel, and the old ships of the company's fleet are supposed to be substituted with these methanol-fueled ones. 9 of these gigantic ships, with a nominal capacity of 16,000 twenty-foot equivalent unit (TEU) containers, are delivered and remaining 9 vessels will be delivered by the end of 2025. Furthermore, Maersk Company plans to purchase 100 to 150 thousand tons of green methanol (bio-methanol) for its dual-fuel methanol ships through an agreement with the methanol-producing company, Proman. It is remarkable that the green methanol production project by Proman Company is to be carried out in North America using municipal solid wastes as well as forestry residues. The objective of Proman Company in the project of green methanol production is to produce up to a nominal capacity of 200,000 tons per year by 2025. As Maersk has proclaimed, it will prevent the annual emission of 1 million tons of CO_2 by replacing new dual-fuel methanol ships in its fleet. Given the numbers proposed by the member countries of the International Maritime Organization to levy taxes on greenhouse gas emissions, it is expected that this company will save 100 million dollars annually from tax exemptions related to this issue.[41]

5- Research Projects regarding the Methanol Usage

Concerning the criticality of utilizing alternative fuels to downturn greenhouse gas emissions, various research projects have been defined and undertaken in this regard by industrialized countries, and we will explore some of the most influential ones pertaining to methanol in this section.

5-1- HyMethShip System

A consortium consisting of 13 European industrial companies, universities, and research centers that have been cooperating since 2018, has proposed an offshore-onshore system under the name HyMethShip, aiming at reducing GHG emissions in the maritime industry. The ship's required energy is provided through hydrogen. One of the most important methods of chemical storage of hydrogen is through its conversion to methanol. In the land part of the system, hydrogen is produced via renewable energy and in the form of water electrolysis. In concordance with the safety considerations regarding the physical storage of hydrogen both onshore and on board, the hydrogen produced during the chemical process is combined with CO_2 and turns into methanol. Then, the methanol produced onshore is converted into hydrogen and CO_2 in a reverse process once transported and stored on the ship. Finally, hydrogen is transferred to the ship's engine for burning, and CO_2 which is stored so that it would be transported to land and used to produce methanol from hydrogen (Fig.6).[24]

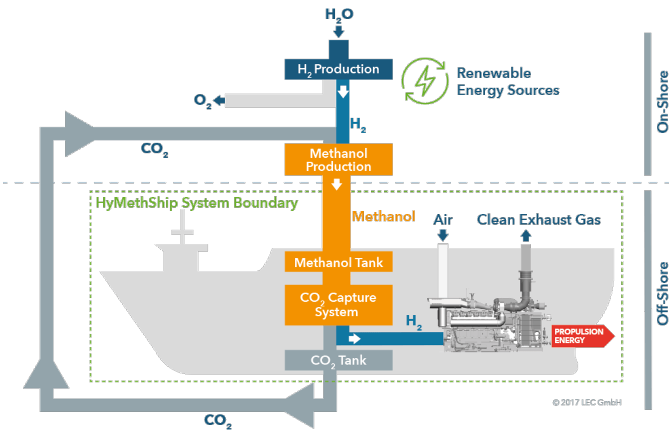

Fig. 6. Functioning of HyMethShip (hymethship.com)

5-2- Green Maritime Methanol Consortium

A consortium consisting of the most imminent shipping companies, methanol-producing companies, and industrial equipment manufacturing companies was formed to explore and investigate all available solutions for using renewable methanol as a maritime fuel, and in this part, we will take a look at some of the conclusions this consortium has reached. In early 2020, Pon Power launched a project intending to change Caterpillar 3508 gas engines so that they can burn pure methanol as fuel. As one of the other members of this consortium, the Nederland's Defense Academy (NLDA) has conducted various tests on how to integrate fuels so they can be used in dual-fuel engines. In the conducted research, the efficiency of the engine has been studied in correlation with the type of fuel combination, the mechanical method of integration, and also the relative percentage of combined fuels.[42]

5-3- Testing of Methanol Additives, Danish Energy Agency

Utilizing methanol as a fuel additive is commonly practiced in the industry. Combining methanol with engine fuel is done directly up to 3%, however, for mixing with higher percentages, other chemicals must be added as well. This agency intends to test various chemical additives to methanol to optimize its direct usage as fuel by making minor improvements in the engine. Chemical additives together with the required modifications on the engine can be proposed as a collective solution to companies for turning their ships' conventional engines into dual-fuel ones.[11]

Conclusions

Having characteristics such as low combustion and environmental pollution as well as easy transportation and storage, methanol has been considered as one of the most important alternatives to conventional fuels in the maritime industry. During recent years, methanol has been used as a maritime fuel by several key shipping companies, and this trend will certainly continue as the number of methanol ships and the companies using these types of ships surges in the upcoming years. Since methanol is traditionally produced by fossil fuels, this process causes a significant amount of greenhouse gas. Therefore, it is better to produce methanol as a fuel for ships from renewable methods, or use carbon capture systems in its production process to produce additional methanol. This way, based on life cycle calculations, the amount of produced CO_2, which is the basis for calculating future taxes for maritime companies will decline. Moreover, the taxes levied by international organizations will be exponential and incremental, in a way that the subjected companies are forced to cut down on the amount of emitted CO_2. The high cost of producing methanol through the renewable method on the one hand, and the low production capacity on the other, has made green methanol production not much attractive to date. However, considering the comprehensive plans to produce methanol from renewable sources in the coming years, this option will gain attractiveness. Among these plans, the plan of green methanol production in North America by Proman Company can be highlighted, in which its production will start in 2025 with a nominal capacity of 200,000 tons per year. To use methanol as a fuel for ships, the redesign of various parts of the vessel, including the fueling system, fuel storage, and the ship's engine is required. All the modifications and redesigns must be undertaken in accordance with the protocols defined for the use of low-flashpoint fuels. Moreover, some natural characteristics of methanol rises the need for special safety considerations to be considered. There have been several projects to use methanol as a ship fuel that were implemented successfully, among which the dual-fuel methanol ships of Waterfront and Proman companies can be pinpointed. All these projects have been undertaken using dual-fuel engines with high and low-octane fuel. Besides, the world's major methanol producers, maritime companies, heavy industrial equipment manufacturers, and academic and research centers have established several consortia to explore and test all possible methods to use methanol as a maritime fuel, and the achieved results have been quite promising for the increasing use of methanol as fuel in near feature.

Conflicts of interest

There are no conflicts to declare.

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