Ammonia as a Green Shipping Fuel: The Viking Energy Project

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Since 2003, Wärtsilä and Eidesvik Offshore (a Norwegian shipping company) have collaborated on the development of environmentally friendly technology.

With the addition of Equinor, Prototech and EU initiative ShipFC, they are working on the Viking Energy Project, which is a five-year demo project aiming to build the first zero-emissions supply vessel, using ammonia-powered fuel cells.

Their goal is to have the vessel up and running by 2023 for one year, where its emissions will be monitored for cleanliness.

Wärtsilä, a Finnish company, is engaging in large-scale testing of ammonia as a green shipping fuel. It sees ammonia as a key alternative fuel for future use in shipping vessels, one which will reduce the greenhouse gas emissions of the shipping industry as a whole. Tests are being conducted on dual-fuel and spark-ignition gasoline engines.

Following these tests, additional tests will be carried out in a real-world setting on ships, starting in 2022. According to Kaj Portin, general manager at Wärtsilä Marine, the first tests have shown promising results, and combustion parameters are continuously being optimized to improve performance.

The Use of Ammonia: Engines, Supply, and Efficiency

Wärtsilä is working on a whole range of solutions regarding the use of ammonia as fuel inside engines, along with fuel supply and storage capacity. This means that they are working with ship owners, shipbuilders, classification societies, and fuel suppliers to gain a thorough understanding of system and safety requirements, emissions, and efficiency, all while adhering to regulatory requirements as related to marine use.

The company already has significant experience with ammonia from the design of cargo handling systems for liquid petroleum gas carriers. Many of these carriers are used to transport ammonia.

Wärtsilä has extensive experience converting engines so that they can use other types of fuel, such as converting diesel engines to dual-fuel engines, or converting engines so that they can use methanol and volatile organic compounds as fuel. Wärtsilä is also investigating the use of several other fuels for future use, such as synthetic methane, ammonia, and hydrogen.

The company's goal is to provide engines and systems which allow for flexibility in the type of fuel used. For instance, internal combustion engines can be adapted so that they can burn any fuel. Engines that run on dual-fuels, or spark-ignition engines, are capable of burning liquified natural gas without alteration. Diesel engines can run on liquid biofuels, biodiesel, or e-diesel.

The Science Behind Using Ammonia as a Fuel

The main use of ammonia in the world is as a fertilizer in the agricultural sector. This has allowed for a greatly increased amount of food production to support a growing global population.

Ammonia has great potential as a carbon-free fuel because when it is burned, such as in an engine, it produces no carbon dioxide, as is the case with fossil fuels such as gasoline and diesel. The benefit of this is that the burning of this fuel in combustion engines does not contribute to the greenhouse gas emissions responsible for global warming.

Ammonia can also be used in fuel cells that produce electricity and can power an electric motor just as a battery can. Using ammonia in fuel cells also results in no carbon dioxide emissions. This makes ammonia-powered engines an attractive green alternative to engines powered by fossil fuels.

In the Viking Energy Project by Wärtsilä and Eidesvik Offshore, the prototype supply ship will run on ammonia fuel cells, which will power a 2-megawatt electric motor. This will provide important data on how well such a system will perform under real-world conditions.

On the molecular level, Ammonia consists of 1 nitrogen atom and 3 hydrogen atoms. Its chemical formula is NH_3. Nitrogen can be extracted from the air since air itself consists of 80% nitrogen. The hydrogen can be extracted from plentiful sources such as water (using electrolysis).

The energy required for the extraction of nitrogen and hydrogen, and their combination into ammonia, can, therefore, be provided by renewable energy sources such as wind and solar power. As a result, the process of producing ammonia can completely avoid the production of carbon dioxide.

As it currently stands, ammonia can be used as a fuel in internal combustion engines, such as car and truck engines, and can also be used as a fuel in fuel cells, which themselves generate electricity by oxidizing fuel, such as ammonia. This electricity then drives an electric motor that can power a vehicle just like a regular engine does.

Learn more about applications of fuels in clean technology

Hydrogen can also be used as a clean-burning fuel but it presents a challenge in the ability to efficiently transport and store it. Hydrogen is a gas at room temperature, and to make it economically competitive with other fuels such as gasoline and diesel, it must be stored in containers that have a size comparable to gasoline and diesel tanks/container.

The essence is that there must be enough hydrogen inside reasonably sized storage tanks/containers to provide an amount of energy comparable to gasoline or diesel. Since hydrogen is a gas at room temperature, this unavoidably requires that it should be placed in containers at very high pressure (700 atmospheres) or cooled to a very low temperature (-253 degrees Celsius) to convert it to liquid form so that it occupies as little volume as possible. Both of these situations present significant technological challenges.

Storing ammonia in liquid form at room temperature (25 degrees Celsius) requires a pressure of 9.9 atmospheres. Alternatively it can be stored at a temperature of -33 degrees Celsius at atmospheric pressure. This is easier to achieve than the requirements of hydrogen.

In terms of the ability to transport and store ammonia, it is very similar to propane. Since the boiling temperature and condensation pressure of ammonia are almost the same as those of propane, transport ships designed for propane can generally be used for ammonia.

However, there are currently significant technological challenges with using ammonia as a viable combustible fuel for engines, such as its low flammability and high levels of nitrogen oxide emission (which is a source of pollution).

Ammonia is already produced and transported in large quantities around the world, which means that shipping bunker supplies could be readily accommodated for additional ammonia production resulting from its use as a fuel.

The increase in ammonia production will have to be accommodated by expanding worldwide transportation capacity, such as in shipping with large marine vessels. Ammonia could be used as the fuel used to power ships that are actually carrying ammonia as cargo.

Wärtsilä and Eidesvik Offshore are playing a key role in testing this viability of ammonia as a shipping fuel, and there is a great deal of scientific information supporting this venture.

References and Further Reading

Wärtsilä Corporation (2020) *Leading the way towards the world's first zero emissions supply vessel*. [Online] Available at: https://www.wartsila.com/media/news/04-02-2020-leading-the-way-towards-the-world-s-first-zero-emissions-supply-vessel (Accessed on 12 April 2020).

Bond, M. (2020) *Wärtsilä advances future fuel capabilities with first ammonia tests*. [Online] Available at: https://www.seatrade-cruise.com/news/wrtsil-advances-future-fuel-capabilities-first-ammonia-tests (Accessed on 12 April 2020).

The Maritime Executive (2019) *New Research Shows Benefits of Ammonia as Marine Fuel*. [Online] Available at https://www.maritime-executive.com/article/new-research-shows-benefits-of-ammonia-as-marine-fuel (Accessed on 12 April 2020).

Kobayashi, H., Hayakawa, A., Kunkuma, K., and Okafor, E. (2019) Science and technology of ammonia combustion. *Proceedings of the Combustion Institute*, 37(1), pp. 109-133. https://doi.org/10.1016/j.proci.2018.09.029