HYDROGEN ON DEMAND

Onboard hydrogen storage can create headaches for naval architects and vessel operators. However, methanol-to-hydrogen systems could help operators to meet the looming emissions mandates while keeping design and logistical challenges to a minimum, writes Bryan Reid, chief sales officer, RIX Industries

The volumes of hydrogen required for vessel propulsion consume a colossal footprint, and are difficult to transport and manage

Environmental mandates have the shipping industry facing immense change – shipping operators must clean up their act on a global scale, aiming for a 40% cut in carbon emissions by 2030, and at least 50% by 2050. For the naval architect, understanding the options for clean, green propulsion may only be the starting point in this major shift: it's a challenge compounded by the potential for long-term impact on ship design.

While hydrogen is an appealing answer industry-wide, its deployment is deeply complicated by cryogenic temperature requirements and high-volume, high-pressure storage. The ability to generate hydrogen on demand is breaking through these barriers, tapping into safe, convenient methanol to eliminate complexity and enable decarbonisation. For shipbuilders, it's a big leap in establishing real-world usability of hydrogen as a commercially viable green propulsion option.

Eliminating the logistical challenges of onboard hydrogen storage is necessary for hydrogen to become a practical source of propulsion energy. The volumes of hydrogen required for vessel propulsion otherwise consume far too large a footprint and are not easy to transport, let alone manage. When stored as a liquid, cryogenic temperatures are required: think -253° Celsius. Storage as a gas would require potentially dangerous pressurised storage. Neither offers a safe, manageable, or cost-effective approach that can be reasonably deployed on an existing or modified ship infrastructure.

Steady stream

Here is where methanol fits into the equation, functioning as a feedstock for generating hydrogen on-vessel, on-demand. Hydrogen is not stored, but rather created as needed through a safe and efficient chemical process.

Methanol-to-hydrogen conversion occurs within a self-contained power system, creating a steady stream of high-purity hydrogen. Systems are modular, scalable, and commercially available – blending methanol-to-hydrogen generator technology and PEM fuel cells to support power needs ranging from 10kW to MW applications, while ensuring high energy efficiency (>80%) and meeting reduced space and weight requirements versus the heavy footprint of pure hydrogen storage.

For existing vessels, no major retrofit of ship infrastructure is necessary to deploy hydrogen on-demand. With proper cleaning, tanks currently used for diesel storage can instead store liquid methanol at ambient temperatures. Cryogenics are not required, and neither is high-pressure storage.

Tanks under pressure must be cylindrical in nature to safely hold their contents. Without pressure, tanks can be shaped more creatively for best fit. For new vessel designs, this characteristic helps naval architects redefine the footprint required for propulsion systems, freeing up premium deck space or cargo volume that might have previously been unavailable. Methanol tanks can be incorporated within any unique void in a ship's structure – custom fit to make use of otherwise unusable space.

This means the methanol-to-hydrogen propulsion strategy can be distributed across a ship's infrastructure. Instead of a traditional engine room, new ship designs may include a reformer area featuring a primary methanol-to-hydrogen cabinet-based system. Capacity can then be extended by capitalising on small spaces across the ship for additional reformers and methanol tanks.

Methanol vs ammonia

Versatile methanol is well-established in maritime settings, and already used as a feedstock on a global scale. It remains liquid at normal temperatures and requires handling similar to any other fuel. It's biodegradable, miscible in water and found in relative abundance in most seaports – factors that contribute to its comparatively low cost. All these values can be readily contrasted to ammonia, another feedstock option in generating hydrogen.

Ammonia, however, is more costly and is only available from centralised outlets with no convenient dispensing mechanism. Because of ammonia's inherent toxicity and ability to cause severe health hazards, supporting technology for its storage, handling, and transport must be improved to enable mass deployment.

As a toxic substance, ammonia has not been approved as a fuel resource by IMO, whereas methanol is approved for storage and handling, including bunkering in marine environments.

Grey or green?

In the reforming process, methanol is blended with deionised water at a ~2:1 ratio, then heated and pressurised. As the methanol/water mixture becomes hotter and transforms to steam, the pressure and heat applied within the self-contained cabinet separate molecules of carbon monoxide and hydrogen. The process is the same whether the methanol is grey or green, a reference to the carbon impact of methods used to produce the methanol itself.

Currently, the methanol most widely available is considered grey, produced with natural gas as a feedstock. Using grey methanol, current methanol-to-hydrogen reforming systems deliver 23-25% reduction in CO_2 versus a traditional diesel engine, and eliminate NOx, SOx and particulate matter (PM). The availability of green methanol will certainly evolve, meaning the amount of carbon created in its production will be equal to the amount of carbon released by its use. Yet this Net Zero goal is complex and must account for carbon in processes such as transportation and distribution as well.

It's a significant logistical footprint, and there is pressure on IMO to consider all these factors in evaluating carbon impact. Whatever the timeline, vessels with methanol-to-hydrogen systems will be poised for that Net Zero breakthrough. Grey and

Methanol-to-hydrogen reforming systems enable naval architects to distribute the means of hydrogen propulsion across the vessel's infrastructure

Meeting the mandates

Methanol-to-hydrogen reforming has a number of beneficial features, identified by RIX Industries:

- It leads to elimination of NOx, SOx and PM emissions, as well as a 23%+ reduction in CO_2 compared to traditional diesel engines (1)
- It has strong scalability prospects
- It is a relatively quiet (approx. 70dB) and mobile process
- Methanol-to-hydrogen reforming can be conducted with all PEM fuel cell systems, and meets ISO 14687 (2019) purity standards
- As the process requires no supporting infrastructure, it can result in low capex
- It takes just 7.1kg of methanol to produce 1kg of hydrogen
- 33% of product hydrogen is derived from water
- The cost of produced hydrogen is about US$4-5 per kg at the point of use (1)

1. White paper "*The Renewable Methanol Pathway To Green Hydrogen*", Webber Research & Advisory, 2020

green methanol can even be blended in the reformer, offering ultimate flexibility for evolving sustainability goals. For shipbuilders anticipating new fuels, immediate action primes them for what's next and positions them to avoid the carbon levies that come into play in 2023.

Cost considerations

Consider that ready availability of a pure hydrogen solution is unlikely – its chemical characteristics require high-pressure or freezing-cold storage. Tank filling is precarious and cannot be too fast or too slow for ideal safety, and only certain ports can handle hydrogen logistics at this level. Under these circumstances, transportation costs can jump from US$1 to US$16 per kg by the time hydrogen gets to the pump.

These factors are not subject to change and are present across the entire hydrogen supply chain. Methanol is benign to transport, available at seaports and commercial waterways, and stored at ambient temperature.

Net Zero CO_2

Decarbonisation may be a journey, but naval architects are tasked with designing assets that exist for decades. The propulsion systems they incorporate today need to meet a complex slate of features, including longevity in a changing world of global sustainability requirements. This may be a point of confusion among shipbuilders, with some reticent to embrace methanol-to-hydrogen systems until green methanol becomes a reality. However, methanol-to-hydrogen systems are flexible and simply use methanol, whether it's the grey methanol of today or the green methanol produced and transported with no carbon impact from end-to-end.

Most importantly, when systems are combined with fuel cells, they today produce power with no NOx, no SOx and no PM. When renewable methanol becomes available, they can reform it and readily achieve Net Zero CO_2 emissions.

Regulatory bodies and private industry are making steady progress in aligning sustainability policies with the goals of the Paris Agreement. Required monitoring and reporting will help evaluate efficiency of shipping operators worldwide, and even ship financiers are aligning to the Poseidon Principles, guidelines which feature climate considerations in financing decisions. While 2030 and 2050 represent decarbonisation milestones, shipbuilders are navigating to full decarbonisation of global shipping. Achieving carbon reduction this decade is essential – and hydrogen on-demand can play a powerful role today and in the future. **SBI**