Green Energy Automation

Powered by Fuel Cells

The International Maritime Organization (IMO) is the United Nations' specialist agency responsible for maritime safety as well as the prevention of marine and air pollution. Their current proposed amendment to the International Convention for the Prevention of Pollution from Ships (MARPOL) introduces a combination of technical and operational measures to further reduce CO2 and other greenhouse gas emissions, with a targeted reduction of 40% between 2008 and 2030.

Thyssenkrupp Marine Systems, one of the world's leading maritime organizations with about 6,000 employees, has taken on the challenge to develop a solution based on fuel cell technology.

For seagoing vessels, the direct use of hydrogen is not usually an option, as the storage requirements are nine times higher than for diesel. For liquid natural gas, that factor is three (calculations based on the total space requirements of the tank system, possibly including insulation or dead zones).

This relates to an issue currently under discussion at the IMO; the assessment of fuels and emissions – local vs. global.

The task facing Thyssenkrupp Marine Systems is to achieve a reduction in global emissions, which will eventually become CO_2 neutral or negative. Achieving this task requires both renewable fuel sources and extremely efficient energy conversion.

Fuel cells with reformers present a major advantage because, within a mechanically simple system, they generate no additional pollutants (such as nitrogen oxides or NOX, fine dust, polycyclic aromatic hydrocarbons) apart from CO_2. The absence of methane slip prevents the release of unburned methane. Lower operating temperatures than those of an internal combustion engine makes the release of NOX negligible.

Furthermore, fuel cells are not a source of vibration or noise. Seagoing ships, ferries and feeder vessels, as well as large riverboats and yachts, are all suited to the application of fuel cells.

To prove the concept, Marine Systems designed and built a 50 kWnenn prototype, including energy storage, which serves to demonstrate the safety concept developments in its size class, the functioning processes and seaworthiness.

Advantages of power generation using fuel cell technology

The advantages of fuel cells are derived from the way in which fuel is converted. Systems such as the SchIBZ® (Schiffsintegration Brennstoffzelle or Ship Integrated Fuel Cell) usually work with a hydrocarbon fuel source. With the addition of water (H_2O) from the exhaust gas, the reformer catalytic converter splits the hydrocarbons into a synthesis gas.

This synthesis gas then recombines to form methane (CH_4) and hydrogen (H_2). Excess water vapor can remain in the gas mixture as an inert component. The gas that is formed and fed into the fuel cell is referred to as reformate.

Noise, vibrations and pollutant emissions are avoided through the features of the reformate conversion in the fuel cell, namely:

- no oscillating components
- low working temperatures that reduce NOX formation
- no soot / fine dust formation due to regulated oxidation

Odor and methane emissions are also prevented, in contrast to a (gas) engine.

The resulting greenhouse gas balance is at least 25% better than that of an engine (efficiency approx. 40% for motor generators vs. >50% for fuel cells).

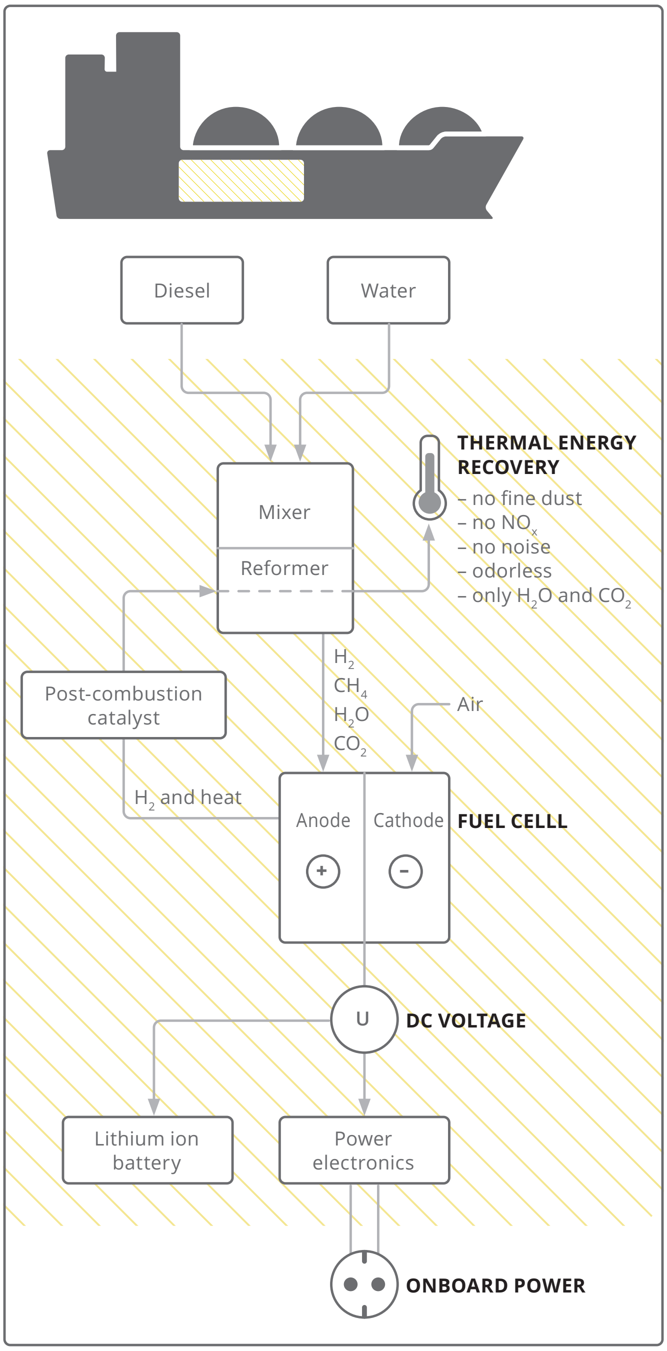
In order to comply with emission regulations, however, diesel generators also require various auxiliary units:

- particle filter
- catalyst
- exhaust gas monitor
- elastic mounting to reduce vibration
- silencer (optional)
- sound capsule to reduce noise (optional) None of which are required by fuel cells.

In terms of overall space requirements, a fuel cell is not significantly larger than a diesel engine. When it comes to cost, a modern engine including all emissions-reducing components costs about 22 cents per kWh of electricity; a fuel cell system in series production costs 26 cents per kWh.

The 20% difference has not yet been adjusted for maintenance fees or the operational costs of a motor generator.

Reformer



Operating principle

Challenging control aggregation

Up to now, automation has been decentralized and structured according to existing classification rules. In future, Marine Systems is planning an integrated automation system within the fuel cell, with optional energy storage. This system will also manage safety functions via the operational bus. For international use, the controller system must hold all standard shipbuilding certifications such as DNV GL, BV, LR, ABS, RINA, KR, and NK.

In contrast to other industries, integrated automation solutions are not currently permitted in shipping. Bachmann electronic GmbH, automation system developer, therefore drafted a proposal together with classification society DNV GL, which was then submitted to the IMO by the Federal Ministry of Transport and Digital Infrastructure.

Implementation will proceed as soon as the proposal is accepted by the IMO. A current fuel cell unit is made up of six subsystems: a reformer, fuel cell and an energy management system, each with its own automation components; namely a standard controller and safety system.

Furthermore, a higher-level control system is necessary to communicate with the ship and feed the generated energy into the onboard network. Each subsystem has its own control system with alarm handling and, in some cases, additional safety controls. The six subsystems work independently and exchange data in a complex network via interfaces.

Challenging application programming

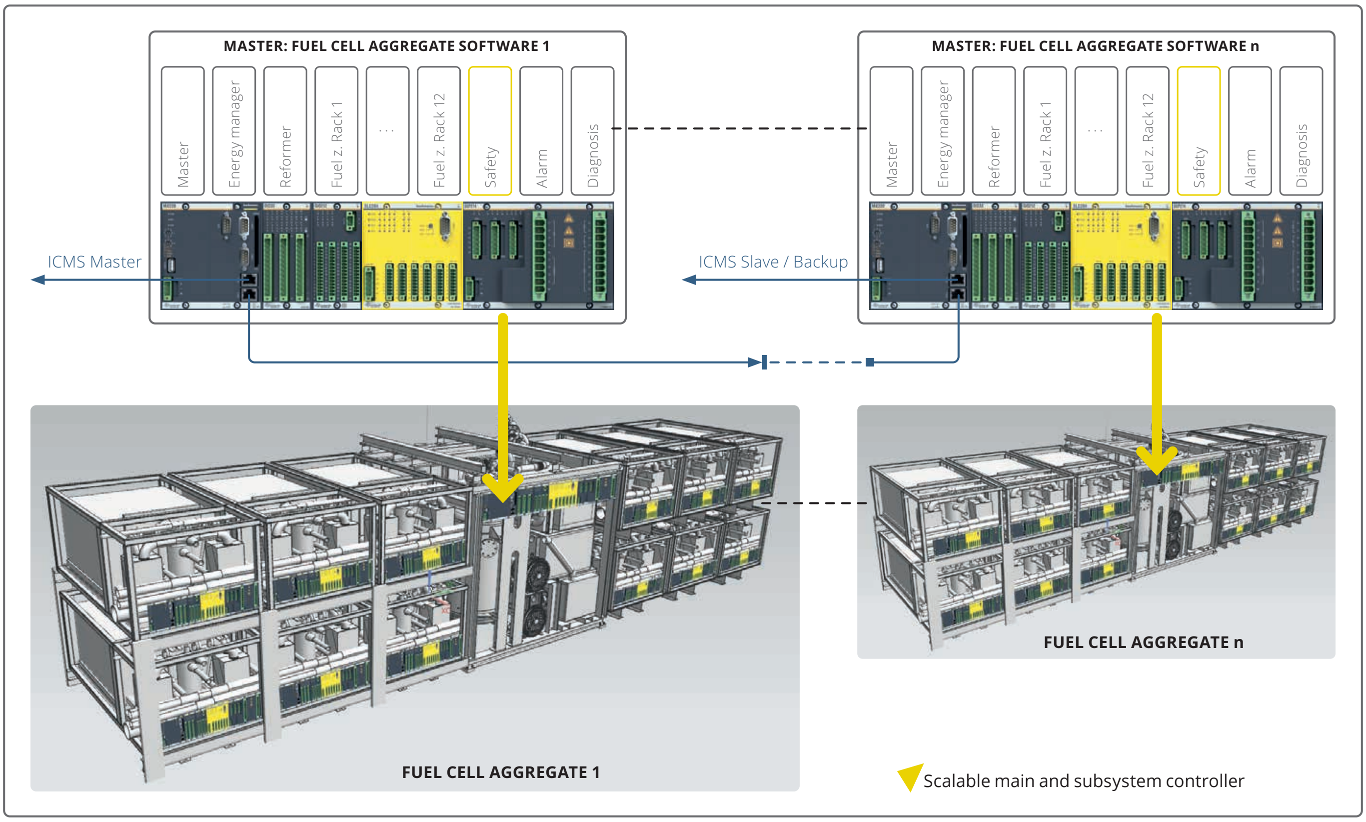
Programming of the energy management system as well as the higher-level controller function was undertaken by Bachmann's M1 controller in the "C" programming environment.

The prototype's reformer application was developed on a model-based system in the laboratory and reprogrammed for PLC use. Errors often arise at this stage, and identifying the cause can be a challenge, as continuity from model to system is not always guaranteed.

In order to ensure future consistency and to avoid potential errors, an integrated solution based on the Bachmann M1 controller was developed for series use.

The need to implement of various programming tools must also be considered. From an external perspective, there should only be one alarm system and one remote maintenance connection point for all subsystems.

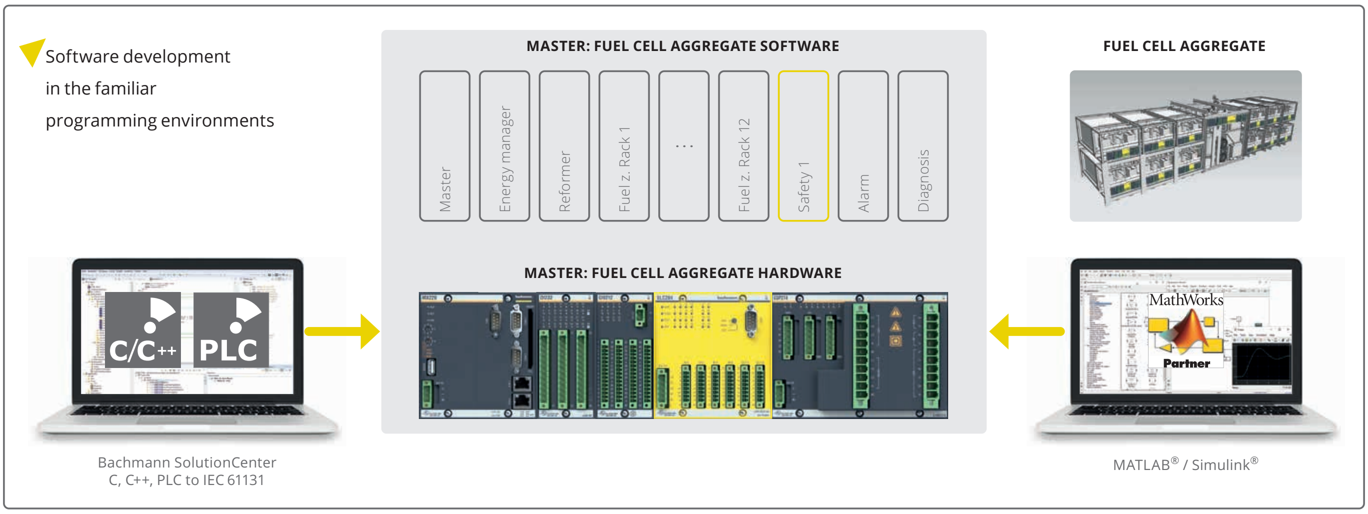
Important for software developers: projects can be implemented in familiar programming environments such as IEC 61131-3, C/C++, HTML5, MATLAB®/Simulink®. Commissioning engineers can operate on an abstract level with the CFC editor or component manager.



All applications can be processed in parallel on the M1 controller. Safety control can also be integrated as an extra hardware module and implemented via a certified "black channel" on the existing network tunnel.

All applications, such as reformers, fuel cells, energy management, higher-level systems and auxiliary units, are independently executed by the controller. If energy generation output should increase, then all required hardware can be added either centrally or remotely. Additional software modules are then deployed accordingly and assigned to the hardware. Therefore, it is only a matter of scaling up the pre-tested system for a smooth integration into the operation.

In addition to increased application security and scalability, this integrated solution requires fewer interface modules and cables. This is advantageous because it reduces the required space in control cabinets as well as cost-intensive cable laying.



Interview with Keno Leites,
Project Manager Fuel Cell Application, Thyssenkrupp Marine Systems

Mr. Leites, you ultimately decided on an integrated automation solution from Bachmann electronic. What were the main reasons for this?

Mr. Leites: It was important for us that our automation partner had all the required certifications in shipbuilding, and that they could guarantee robust products (up to +60 degrees Celsius) and long-term availability.

Which modules are in use for the project?

Mr. Leites: We use universal IO modules (GIO212), multicore-capable CPU modules from Bachmann's "MC" series. These modules work with the most important signal types, such as the detection of pressure, speed and temperature. In addition, we use the ERS202 "head module" for network redundant substations, and the GSP274 for synchronization and network analysis.

Safety modules SLC284, SDI208, SDO204, and SAI205 process digital and analog safety-related signals. For visualization, we used the 100% web-based system atvise®.

What are the main achievements of the solution?

Mr. Leites: Together with Bachmann, we developed an automation solution that enables us to integrate all subsystems onto one control system. This enables a transparent software architecture with a single alarm system, hardware diagnosis for the entire system, as well as simple communication between subsystems.

This structure provides a clear system overview and facilitates targeted remote maintenance. The diverse interface allows us to integrate our system into a wide variety of ship automation systems.

Can ship owners rely on this form of energy generation on board their vessels?

Mr. Leites: If we assume that our technology will be mass-produced, then the current cost advantage of diesel generators be significantly reduced.

Fuel cells generate enough energy to supply the onboard network and are even sufficient for low propulsion. Due to lower emissions, ships with a fuel cell can also dock in ports with strict pollutant compliance rules.

The same applies to certain stretches of water, fjords, etc. and is therefore particularly interesting for cruise ships. The solution is also appealing for commercial ships sailing in controlled waters, because it allows them to avoid using port electricity. Areas of water subject to such regulations will only increase in future.

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