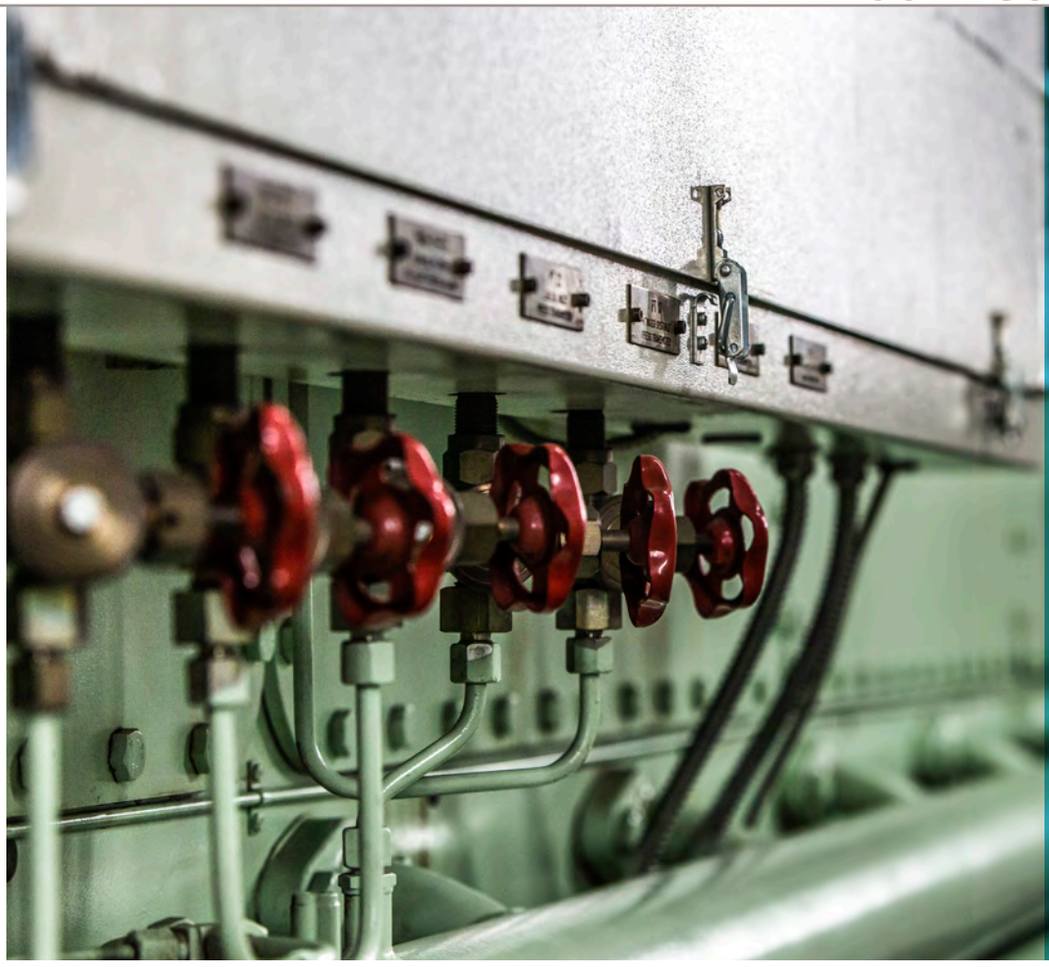
DRIVING MARINE DEVELOPMENT THROUGH TESTING

The use of gas and other non-diesel fuels is on the rise at sea. Liquid natural gas (LNG) tankers are at the forefront of this trend, quite simply because it makes sense to be propelled by the cargo on board. This poses new challenges and increases the focus on LNG as a fuel and as cargo. And that in turn places new demands on gas combustion technology. At the Alfa Laval Test & Training Centre in Aalborg, Denmark, development and testing are underway into the solutions that the marine industry will increasingly require.

TEXT: **PETER GODDARD** PHOTO: **JOHNY KRISTENSEN**

“This is a hands-on place where we cooperate to develop solutions that will bring the shipping industry forward.”

LARS SKYTTE JØRGENSEN,
VICE PRESIDENT PRODUCT CENTRE
BOILERS, ALFA LAVAL



Alternatives to marine oil

The shipping industry is currently dominated by the use of marine oils, mainly heavy fuel oil (HFO) and marine gas oil (MGO). According to Lloyds Registry, the share of HFO will be as low as 40% by 2030, due to environmental concerns.

Liquefied natural gas (LNG) represents the most viable alternative fuel to HFO for ships. LNG is an attractive, alternative because it reduces NOx by 85-90% and virtually eliminates SOx. By 2030, it is expected that 7,000 vessels will be sailing with LNG, compared with a mere 500 in 2015.

Marine engine manufacturers offer dual or triple fuel engines that can be operated with the above-mentioned fuel options. A number of other liquid fuels can be used in these engines, namely liquefied petroleum gas (LPG – a mixture of propane and butane), methanol, ethanol, and di-methyl ether (DME).

Gas is seen as one of the answers to future fuel needs as an alternative to oil, coal or nuclear power. Today natural gas accounts for around a quarter of global energy demand, of which around 10% is supplied in the form of LNG – compared to just 4% in 1990. To meet this developing need for gas there is a growing fleet of LNG carriers plying the oceans; there were 99 vessels in 1997, while by 2030 there are expected to be as many as 7,000.

At the same time increasingly stringent legislation on emissions enacted globally by the International Maritime Organization, as well as regional and national bodies, is putting new environmental demands on the shipping industry and driving interest for new technical solutions, and particularly around LNG. But the introduction of alternative energy sources takes place at a very slow pace because it takes time for technologies to mature and for the necessary production and distribution infrastructure to be built.

What is the best way to design new LNG carriers given that the gas on board can be used to propel the ship? One standard approach is to have a propulsion system of a dual type capable of using either diesel oil or the gas vapours coming from the cargo tanks. Another approach is to have a triple type for using heavy fuel oil, diesel oil as well as gas. Emissions of NOx (nitrogen oxides) can be cut by 80% or more, and SOx (sulphur dioxide) emissions can be eliminated by the use of sulphur-free gas in comparison to heavy fuel oil. Apart from environmental and efficiency gains, the amount of boil-off gas and the pressure in the tanks can be regulated by burning the gas in the

A unique testing facility

- The Alfa Laval Test and Training Centre is located in a construction hall of the former shipyard at Aalborg in Denmark. The equipment is steered from a dedicated control room and can also be steered remotely.
- Phase 1: Inaugurated in 2014. 250 m² testing space under actual operating conditions using a 2 MW marine diesel engine. Features major process lines: fuel line, steam line, exhaust gas line and ballast line.
- Phase 2: Construction began in May 2016. Testing began on full-scale GCU in September 2016. Combustion technology testing will commence in February 2017.
- Lifting capacity of cranes: 2x23 tonnes to a height of 12m.
- Major research collaborations: Aalborg University, Technical University of Denmark in Lyngby, and RWTH Aachen University in Germany, and marine engineering colleges in Denmark and Norway.

A natural fuel choice for LNG carriers

LNG carriers are usually fuelled in part by the natural gas they carry, as well as conventional marine gas oils (MGO).

The liquefied gas is transported at a temperature of -160°C in insulated tanks.

Inevitably, some of the gas kept in these cryogenic conditions evaporates and it can be redirected to fuel the engine. Any excess gas not burnt in the engine must be vented off and burnt in a combustion chamber under safe and controlled conditions.

A gas combustion unit must meet a challenging set of specifications. A unit designed for the largest of the Very Large Gas Carrier class has to be capable of burning off 4.5 tonnes of gas per hour (equivalent to 60 MW) at the drop of a hat in an emergency.

The temperature at the gas burner is around 1,400°C but by the time the exhaust leaves the stack, safety regulations state that the temperature must be down to 535°C. This is below the self-ignition temperature of natural gas in case of gas leaks. To achieve this rapid cooling, vast amounts of air are carefully blown into the combustion chamber on the GCU.

The Test and Training Centre features a full-scale gas combustion unit for simulating the largest units needed at sea.

engine as fuel. However, there are times when the main engines are not running, such as in harbour. Then the boil-off gas can build up and may need to be burnt off rapidly.

Vaporized gas is a huge safety issue on board LNG carriers. Emissions of the gas are a major environmental hazard, but Alfa Laval's Gas Combustion Unit (GCU) is an essential piece of safety equipment that secures that the gas is burned in a safe, controlled manner, securing minimum impact on the environment. This is done by burning the boil-off gas instead of releasing it into the atmosphere.

"As gas and multifuels grow, the demands on combustion technology and systems become more complex," says Lars Skytte Jørgensen, Vice President Product Centre Boilers. "This then drives demand for R&D and testing around these technologies to ensure reliability, safety and ease of operation."

Alfa Laval has a unique testing and training centre located in the former Aalborg shipyard in Denmark. The country has a long and proud history as a seafaring nation – from the Vikings to Maersk, the world's largest container ship operator – and the city of Aalborg is home to world-leading competence in the marine industry. This is the main site where Aalborg Industries was based when Alfa Laval acquired the company in 2011. Aalborg Industries has built ships since 1912 and boilers since 1919.

It was in Aalborg in 2015 that Alfa Laval tested its new generation of Alfa Laval PureSOx in-line scrubbers for exhaust gas cleaning. The next generation of waste heat recovery boilers was tested here in summer 2016.

The first phase of the Alfa Test & Training Centre, covering 250m² of the hall, was opened in 2014. It is a unique centre that can be likened to a functioning commercial vessel on land (see article on next page).

In January 2017 – exactly a century since Alfa Laval sold its first separator to the marine industry – Phase 2 was completed, representing a five-fold expansion of the testing and training area. The prime purpose of Phase 2 is to develop modern combustion technologies for multi fuels such as gas. These developments are expected to boost energy savings and support low emission technology.

Already a full-scale working gas combustion unit has been constructed here to simulate the largest units currently needed at sea. The reasoning is that it is easier to scale down the results from this large unit

Lars Skytte Jørgensen, left, in discussion with Test Centre Manager Kenneth Christensen. As gas and multifuels grow, the demands on combustion technology and systems become more complex.

than to scale up from a smaller unit.

The next step will be a combustion chamber for development of combustion technology, followed by an optimization of the boiler design to enhance and verify energy efficiency and environmental impact.

"Testing is important, but the ability to operate and optimize systems is vital for performance of the equipment on board," says Kenneth Christensen, Test Centre Manager. "The centre is used to train engineers to do just that. It also acts a showroom for Alfa Laval's equipment. On one day, the centre may receive a delegation from a tank fleet operator in China and on the next day, a group from a major ship-builder in South Korea."

"For me, it was an eye-opener that more than 1,500 people from outside Alfa Laval have come here since we opened. It attracts customers, universities, component producers, shipyards, ship-owners and ship designers," says Lars Skytte. "This is a hands-on place where we cooperate to develop solutions that will bring the shipping industry forward." ■

The Alfa Laval FCM one. "If you are unsure about purchasing a new product we say 'come here and we'll show you how it works'."

PUTTING NEW MARINE TECHNOLOGY THROUGH ITS PACES – ON DRY LAND

Testing new marine technology at sea is fraught with difficulties and constraints. But Alfa Laval's Test and Training Centre at Aalborg, Denmark, allows for running equipment in conditions similar to those at sea – without ever leaving dry land.

When Alfa Laval in Monza, Italy, developed a new type of fuel conditioning module (FCM) for marine applications, it was transported to Alfa Laval's Test and Training Centre in Aalborg for full-scale testing under conditions similar to those on board a ship.

The hub of the test site is a fully operational marine engine capable of generating 2MW of power, making the test and training centre the closest thing on land to the machine room of a full-sized commercial vessel.

One mode for the test engine is diesel or marine gas oil (MGO) and the other mode is heavy fuel oil (HFO). Sometimes, customers mix these two fuels to make a cheaper blend and comply with environmental legislation. The idea of the trial in Aalborg was to demonstrate to a potential customer that the FCM could mix the fuels in the right proportions to comply with the relevant emission regulations. The emissions were carefully measured and the trials convinced the customer that the module could deliver the low levels of SOx required in a reliable way.

Working with the defined fuels and a given sulphur target, the Alfa Laval FCM One can calculate the ideal blend and then mix the fuels accordingly. The first customer was already prepared to put in an order but was also keen to know how the new module worked in reality, as there was no reference list.

"We cleaned out the tanks here and purchased the same oils as the customer would have on the ship," says Kenneth Christensen. "Then we ran the engine so the customer could see the fuel conditions."

"With a test centre, you can really get closer to customers and show them that these are the alternatives. The customers are given the numbers for their particular vessel and can do the maths themselves," says Lars Skytte Jørgensen, Vice President Marine and Diesel Division. "In this case, we could first show that our equipment was reliable on marine gas and diesel. Secondly, we showed the same with heavy fuel oil. Then the third condition was to mix those two, put it through an engine and measure the content of the exhaust fumes. We could show that our module was capable of mastering all three conditions."

The product was a prototype that had never been used on the market before. "If you are a customer and you are faced with a completely new product, you are a little bit unsure about purchasing it. So we say: 'come here and we will show you how it works,'" says Christensen.