GTT Inside
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Message from Anouar Kiassi, Chief Digital & Information Officer, GTT

As vessel design and propulsion technologies evolve rapidly to increase efficiency and to comply with the demanding environmental regulations, digitalisation is key in the transformation of the shipping industry by improving the overall environmental and economic performance.

To be effective, the digital transformation must be seen as a continuum: from the ship to the shore and from the sensors to the cloud. Digital tools must leverage maritime knowledge, recognised experience and on-the-ground expertise to deliver value to the users.

When it comes to the reduction of emissions, LNG as fuel is an effective solution to meet IMO 2020 environmental targets. Through specific digital solutions, GTT and Ascenz* aim to support the adoption of this cleaner fuel and facilitate the transition within the maritime industry.

GTT's commitment to become a global partner in the digital transition of the maritime stakeholders goes hand in hand with an increasing investment in research and digital innovation. The articles presented in this issue of GTT Inside have been drawn from our experience, publications and contributions to multiple conferences.

Anouar Kiassi

(*) In 2018, GTT acquired Ascenz, a Singapore-based maritime digitalization company.

DIGITAL

Digital solutions for LNG as Fuel (Shipulse LFS)

LNG is a clean and competitive fuel already chosen by major industry players, who have launched significant newbuild projects for LNG-fuelled vessels. These vessels can be carefully monitored to ensure a successful transition in an optimised manner, while taking into account the specific properties of LNG.

The digital solution Shipulse LFS is combining GTT's expertise in LNG with Ascenz's know-how on smart shipping solutions. The ambition is to support on-board and on-shore teams to ease operation of the fuel tank by gaining awareness from advanced LNG modeling capabilities.

LFS specificities

The development of dual-fuel engines and suitable LNG containment technology has initiated the market for LNG-fuelled ships. The environmental benefits of LNG as fuel play a major role in its adoption by the maritime industry.

To bring added value decision-making tools to the industry, an advanced understanding of LNG behaviour is necessary. These are a few example of the specific characteristics of LNG:

The **composition of LNG** is a key element. In fact, LNG comprises different molecules such as methane, nitrogen, ethane and heavier hydrocarbons. As each molecule has its own evaporation rate, the composition of LNG varies over time. This phenomenon is called **LNG Ageing**.

The indicator used to describe the quality of LNG as fuel is the **Methane Number (MN)**. The higher the content in methane in the LNG, the higher the MN will be. If the Methane Number goes outside the range recommended by the Engine Maker, the engine can experience knocking and operate in a suboptimal manner. Thus, **monitoring the Methane Number** and **predicting LNG Ageing** is very important, especially for voyages far longer than those of LNG Carriers (up to 80 days).

Boil-Off Gas (BOG) is initiated via the passage of external heat through the tank wall, as well as from internal heat sources such as fuel gas pumps. This Boil-Off Gas will be sent to the engines. However, the natural BOG will not always be sufficient to meet the engine energy requirements when at sea. There is therefore a requirement for forced Boil-Off. Hence, a holistic vessel energy management provides a clear operational breakdown between natural BOG and forced BOG. When, the ship is at berth for a long period, the Natural Boil-Off Gas leads to a continuous increase in tank pressure. When the design maximum pressure limitation is reached, the extra Boil-Off Gas is sent to the Gas Combustion Unit to reduce the pressure. The maximum time a ship can wait at berth with a closed tank is called the **Holding Time**. It is also important to be able to predict this parameter. It depends on the tank design and the quantity and quality of the LNG.

LNG Bunkering can take place at different places. Also, due to LNG Ageing, the density of the LNG in the tank can change overtime. Thus, during the bunkering operation, the density of the bunkered LNG and the LNG inside the tank can be very different. In this situation, the liquid inside the tank can be **stratified**, and if not dealt with properly can lead to a liquid **rollover**. The main risk of a rollover accident is the rapid release of large amounts of vapour leading to over-pressurization of the tank.

Data acquisition

The digitalisation of LFS is based on three main data sources: **navigation**, **consumers** and **tanks**.

A Data Acquisition System (DAS) will gather the data from several systems (AIS, IAS, sometimes with a direct connection to sensors), and different protocols (mostly NMEA and Modbus). Afterwards, this information can be used immediately on-board for decision-making systems, and/or sent securely on-shore for remote performance and security monitoring.

Precise LNG ageing measurement and simulation are key, as it affects BOG generation, Methane Number and energy content of the gas sent to the engines.

It is highly recommended to pre-equip LNG-fuelled ships with the following sensors:

Composition sensor

It helps measure the composition, recalibrate the prediction algorithms when required and brings transparency regarding the quality of the bunkered LNG.

Flow Meters

They allow a precise measurement of the quantity of the LNG or NG taken from the tanks.

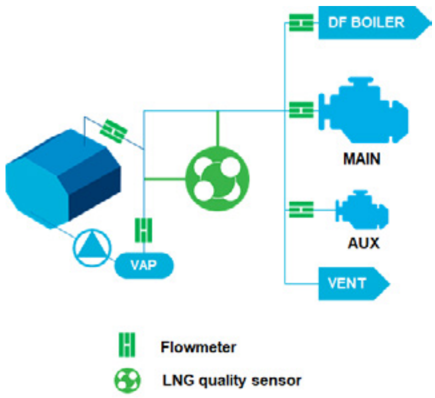

Fig.1 Recommended instrumentation for LFS

LFS Decision support system

Real time acquisition of data enables prediction of the bunker status thanks to advanced LNG modeling techniques developed by GTT.

First, the system offers useful insights into operational limits (tank pressure filling levels, bunker temperature and inventory).

Second, the systems predict the bunker thermodynamic evolution. For instance, the evolution of the Methane Number over time during the voyage to ensure it remains within the engine maker's recommendation, the pressure profile regarding engine demand for the next leg, or density prediction before a bunkering operation in order to prevent a possible rollover inside the tank.

Third, the system can measure and verify the quality of the bunker to make sure it fits the customer requirements. A deviation from the quality requirements has a direct impact on the operations and the economics.

Fig.2 Example of prediction capabilities of Shipulse LFS

As many maritime players are adopting LNG as a fuel, dedicated smart decision-making tools can help smooth this transition. In addition to the above operational and economic benefits, these systems provide a real help for the crew and the fleet managers, particularly if there are new to LNG.

DIGITAL

Reliable bunkering practices enhanced by new technologies

Fuel costs make up to 30% - 70% of the overall ship operating costs, depending on the ship type. Hence, it is important to accurately quantify the amount of bunker fuel used on the vessel using the Coriolis Mass Flow Metering (MFM) system.

Using Mass Flow Meters (MFM) is important as a starting point towards effective bunkering monitoring. Indeed, unlike measurement of volume, mass is not dependent on changes in temperature or pressure. Hence, measurement of mass flow is more accurate without the need for temperature and pressure correction. With its long experience and understanding of accurate bunkering monitoring, robust Data Acquisition and machine learning technics (i.e. classification problems), Ascenz has developed a new approach to automatically filter down operations which may have significant anomalies.

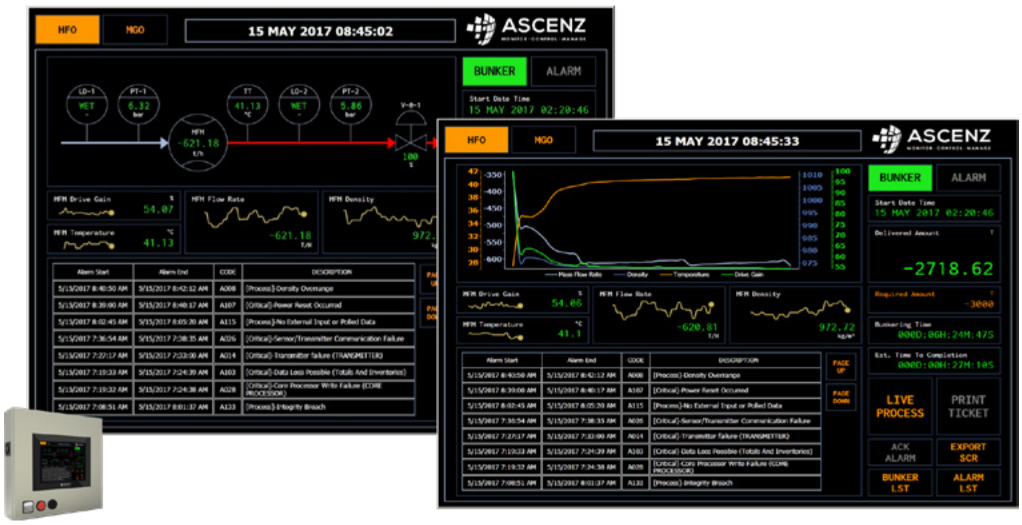

Fig.3 Shipulse BunkerXchange with real-time information from MFM

Path towards accuracy

Having completed several hundred projects of bunker measurement using MFM, Ascenz has identified three main sources of error: partially filled pipes, excessive aeration and the presence of dead volumes when quantifying amount of bunker.

Before leveraging latest digital advancements of its team, Ascenz looks at the most important steps critical for the path towards accuracy.

First, the credibility of bunkering measurements is ensured with proper meter selection. The meters are selected based on the required certification (marine approval among others), with careful sizing (with relevant process data). The quality of the sensor is critical. This is why Ascenz distributes its own Mass Flow Meter.

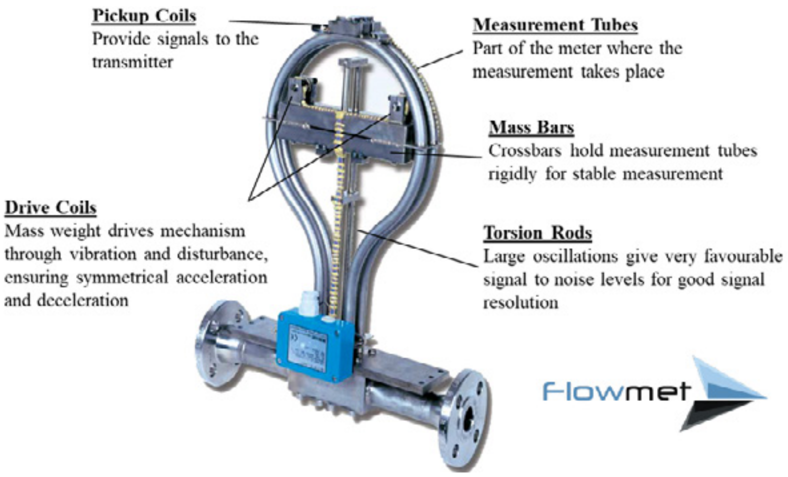

Fig.4 Coriolis Mass Flow Meter design

The second important parameter is the “art of installing” the sensor (pipeline layout, space constraints). This improves the line packing, consisting of having full pipes most of the time and as quickly as possible.

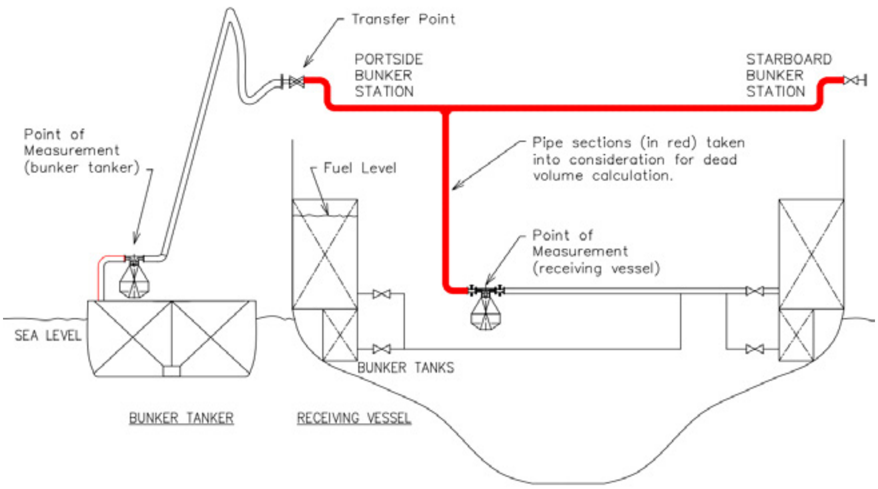

Fig.5 Schematic view of potential areas of dead volume during bunkering

The system integrity shall be ensured by completing the previous steps with acceptance tests and system monitoring during operations.

Smart Bunkering

Ascenz's digital solution, BunkerXchange, is designed to acquire the MFM key data (mass flow rate (t/h), density (kg/m^3), temperature (°C), drive gain (%), and totalising of the bunker fuel), store and display the data both on-board and on-shore. The team recently created and developed Smart Bunkering, an innovative way to analyse the bunkering profile data.

With the different combinations of data, automatic identification and classification of operations can be carried out throughout the entire bunkering process. The bunkering data are also used for predictive bunkering, where the flow rate, density and frequency can be modelled and compared to the actual data set of the bunkering process. Deviations between the predicted data set and the actual data set are used for alerting any possible safety breaches or malpractices.

Smart Bunkering also leverages machine-learning technologies to rate and score MFM bunker transfer operations. This solution allows operations and procurement staff to have automated analysis on each bunkering operation and on the overall performance and activity trends. All bunker events, including start and end of bunker, bunker abnormality, tank changes and entrapped air, are automatically classified. From there, further investigations can be raised for review.

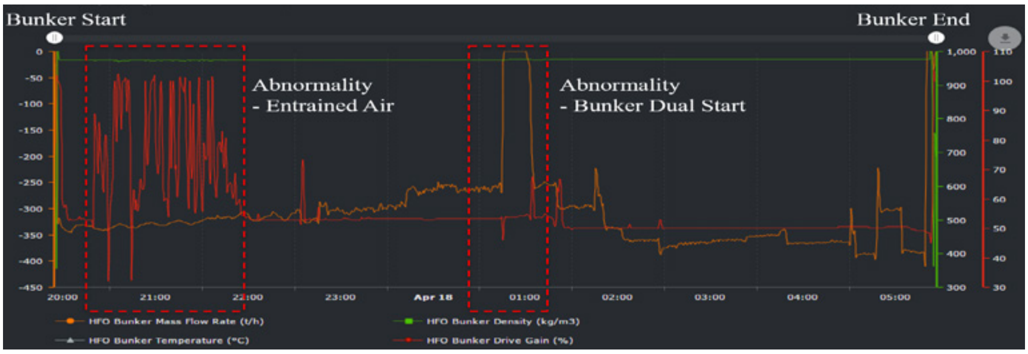

Fig.6 Examples of abnormalities detected using bunkering data

A real time evaluation of bunker profile helps to draw immediate attention and required actions when abnormalities are detected. A smart scoring system showing the overall bunker efficiency in complete transparency allows users to compare and evaluate numerous bunkers profiles and carry out procurement assessment.

