Volatile Organic Compounds as Fuel

20 December 2018

In recent years, the shipping industry has seen the introduction of many new technologies with the aim of making shipping “greener”.

They range from techniques to increase the overall energy efficiency, to the treatment of ballast water, to methods to abate exhaust emissions such as the use of clean fuels like LNG.

Such measures are related to stricter environmental legislations and have helped to move the shipping industry towards a more sustainable, “greener” profile.

Crude oil tankers, however, haven’t always had the most favourable perception in the public eye. This perception could now change through the introduction of a new technology offering both fuel savings while avoiding hazardous and environmentally harmful emissions at the same time.

WIN GD

Motivation

The use of VOCs as fuel, has been a goal within the maritime business for decades. VOCs, volatile organic compounds, are vapours which are released from crude oil during loading, storage and transport. Shuttle tankers, with their short voyages and frequent on and off-loading, have to handle especially large amounts of VOC. With reported evaporation rates of around 1kg VOC per ton of cargo, a shuttle tanker of 125'000 dwt is estimated to produce roughly 100 tons of VOCs per voyage.

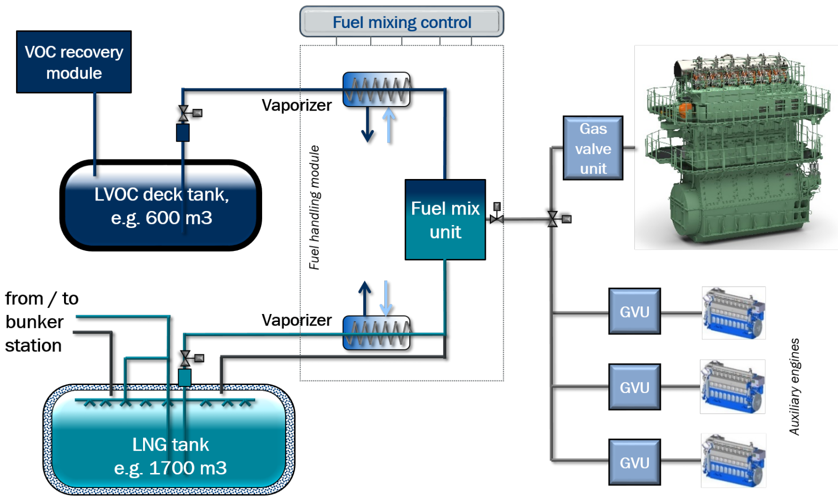
In the past, VOCs were treated as a waste product and were released into the atmosphere or flared off. The venting of VOCs resulted in significant air pollution. One of the VOC components, methane, is a greenhouse gas with a high global warming potential. The heavier compounds react with nitrogen oxide and UV radiation and form ozone – the photo smog which is hazardous to health in many ways. Venting and flaring of VOCs also meant a loss of cargo and thus revenue.

Technical execution

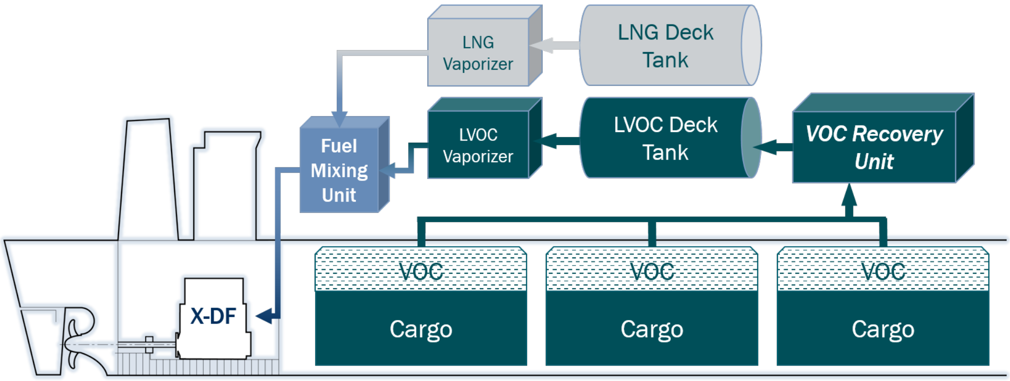
The VOC recovery uses a two-stage condensation process. It was developed and tested to achieve the optimum combination of a high recovery rate and output composition to best suit the engine. In the first stage the heavier fractions from C7 upwards are removed. The medium fractions from propane to hexane are condensed to liquid state in the second stage, forming the liquefied VOC (LVOC). What remains are the so-called non-condensables which are mainly methane and ethane plus the inert gases from the cargo hold. This gas can be stored and used as an energy source in on-board processes like burners.

LVOC is a light hydrocarbon fuel which is kept in a pressurized storage tank on the deck of the vessel. With the main components being hydrocarbons that are heavier than methane, LVOC has a significantly lower methane number (MN) than LNG. The lower the MN of a fuel, the lower its knocking resistance (knocking: uncontrolled self-ignition). To avoid knocking, when using LVOC as a fuel, it is advisable to blend it with the LNG fuel. With this method, it can be assured that the MN of the fuel blend always stays above the limit required by the engine.

The fuel supply line for LVOC consists of the pressurized storage tank (type C), the evaporator, a mixing unit and the mixing control. The evaporator turns the LVOC into vapor with a temperature of about 120 – 140°C. This temperature ensures that the VOC does not condensate in the downstream piping and that the temperature of the LNG/VOC-mixture is within the limits. The mixing control governs and adjusts the fuel mix ratio. This is done to keep the methane number above the target value for the current engine operation point, and to keep the fuel mix temperature and pressure within the given limits.



The VOC recovery system captures VOC emissions during loading and turns it into a valuable fuel



Successful tests

This fuel mix control was successfully demonstrated on WinGD's test engine in Trieste, Italy, in Spring 2018. The test validated that the control system maintains a stable fuel supply pressure and fuel mix ratio at all times. Just as well as keeping the mix ratio stable at varying engine loads, the test demonstrated the precision of the dynamic mix ratio adjustment depending on the MN. This, of course, is only possible due to the reliable dynamic online calculation of the fuel mix' MN.

On hand to witness the test were representatives of the ship-owner, charterer, operator, shipyard and engine builder of a new shuttle tanker project. The test results proved that both engine performance and fuel handling, under dynamic load conditions, absolutely meet expectations.

A pair of new shuttle tankers is currently being built at Samsung shipyard for a Singapore based tanker owner. They have signed a long-term charter agreement with a Norwegian oil major who will deploy them on their shuttles from the North Sea oil fields to land-based terminals.

Each ship will be equipped with the VOC recovery system and two WinGD 7X52DF low-speed dual-fuel engines as prime movers. In contrast to the high-pressure system, the low-pressure gas admission of the X-DF engine is beneficial for blending VOC into the LNG fuel, since a condensation of heavier hydrocarbons can be avoided.

Engine

To avoid the condensation of VOC in the gas feed piping, a few precautionary measures are taken. These comprise the lifting of the lower gas inlet temperature limit, the reduction of gas feed pressure at part load and allowing the gas pipes to heat up in operation before adding the LVOC. Apart from additional insulation around the gas manifold, the engine remains virtually unchanged when operating with a VOC/LNG mix.

The engine is set with the same tuning as an engine running on LNG only. Likewise, no modified parts or additional parts are needed. Consequently, neither the performance nor the emissions are subject to any change due to the use of LVOC in the fuel.

Outlook

First calculations indicate an annual fuel saving potential of around 3'000 tons from burning LVOC in combination with other technologies. This adds to the environmental benefits of keeping the hazardous potential of VOC out of the atmosphere. On top of that, the NO_x emission of the X-DF engine is still well below IMO Tier-III limits while operating on a VOC/ LNG mix.

As the first to successfully use cargo vapour as fuel, this project is likely to blaze a trail for future use of this environmentally sustainable technology. The first of the two shuttle tankers is due for delivery in the second half of 2019.

The concept of recovering VOC for use as a fuel in a low-pressure gas engine has just unveiled its potential.

The fuel savings and consequent CO_2 reduction, full IMO Tier-III compliance and the prevention of hazardous pollutions make this package a cutting-edge technology for environmentally sustainable tankers.

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