LNG THE NEW FUEL FOR FAST FERRIES

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ABSTRACT

As worldwide environmental concerns increase and the IMO legislative process creates greater restrictions on emissions, liquefied natural gas (LNG) will become a very important new fuel in the economics of efficient, cost effective and environmentally sustainable shipping. To meet future Tier II environmental guidelines in certain coastal areas the only practical way may be to use LNG.

Current predictions are that the price of distillate fuel will increase as the world economy picks up and demand exceeds supply during the mid part of this current decade, but it is expected that LNG will not due to high world reserves and world wide efforts to develop natural gas infrastructure and markets that will ensure that supply will exceed demand for the foreseeable future.

The latest Revolution Design/Incat Wave Piercing catamaran is a gas turbine powered, LNG fuelled, 99m vessel capable of speeds of 50 knots or more.

This paper will explain the mechanism of operating with LNG, its advantages and disadvantages as well as future applications.

Keywords

LNG, Fast Ferry, Wave Piercing Catamaran, Gas Turbine, IMO.

1 INTRODUCTION

Natural gas is mainly Methane; it is lighter than air and is liquid at approximately -163^{0}C.

It is flammable but self ignition temperature is 595^{0}C compared to 210^{0}C for distillate.

Natural gas contains no sulphur therefore no Sox emissions and burns a lean mixture in a combustion engine.

There is an 80-90% reduction in NOx emissions compared to distillate and combustion is cleaner than distillate fuelled engines.

The CO2 emissions are improved compared to distillate with a 15-20% improvement.

2 LIQUIFIED NATURAL GAS

Natural gas is liquefied for efficient storage. As a gas it would take up too much volume for efficient storage or would have to be compressed (CNG) meaning pressure vessels which are expensive and heavy.

As a gas it has 600 times the volume than as a liquid.

It is cooled to approximately -163^{0}C to liquefy. This is done in shore side cryogenic plants.

The LNG is generally stored on board ship in double skin vacuum insulated tanks.

3 SAFETY CHALLENNGES

The main challenge is the explosion risk from a gas leak.

Natural gas is flammable at between 5-15% mixtures in air. There is a large energy content associated with a storage tank.

The liquid at -163^{0}C in contact with normal steel will cause that steel to be brittle, materials for the tanks and pipe work are therefore normally stainless steel. If there is a spill aluminium hulls will be better off than normal steel.

On the plus side LNG has an excellent safety record with tankers in operation over a 40 year period with 350 ships currently in service.

As a marine fuel LNG is used in approximately 20 ships mostly in Norwegian waters but interest is high in most regions, DNV (2010).

4 COMMITTED ENVIRONMENTAL LEGISLATION

In 2016 Tier III restrictions come into force in Emission Control Areas (ECAs) with strict limits on NOx emissions, there being some 75% less than Tier II levels, Osberg (2010).

Three possible choices for ships to sail in ECAs in 2016:

1. Low sulphur fuel with sulphur content less than 0.1%.
2. LNG
3. Scrubbers.

There are disadvantages with each option; although low sulphur fuel can be supplied, it is already severely limited in availability meaning the price will be driven up with rising demand.

Scrubbers are expensive, add weight, reduce available space and there is special waste to be disposed of.

LNG requires extra tanks and associated equipment which adds to the cost, weight and reduces available space.

Figure 1. ECA's world wide.

5 DESIGN CHALLENGES

One fifth of beam or B/5 rule for risk of collision; this requires the LNG tank to be inside B/5 of the hull, which is reasonable on a mono-hull but quite onerous on a catamaran. The compromise for the first catamaran vessel was to take B as the combined hull beam as opposed to overall beam. This still needs to be ratified in legislation for future vessels in other parts of the world.

Natural gas has a low flashpoint, lower than normally acceptable for a HSLC so equivalent safety must be proved.

The gas is delivered to the ship as a liquid and before use in the engine must be evaporated. A heat source is required for this and in general this is a heat exchanger from jacket water or exhaust gases. This requires heat exchangers, glycol circuit, etc.

Figure 2, 99m WPC

6 STORAGE TANK TYPES

Two options are available, either a pressurised tank or a tank and cryogenic pump.

With a pressurised tank the LNG is heated until the tank pressure reaches the required feed pressure for the engine. LNG flows though an evaporator which converts it to gas. For a diesel type engine this pressure is generally around 10 bar, Arthur (2010).

With the cryogenic pump option LNG is pumped out of the tank at engine feed pressure through the evaporator then to the engine. For a gas turbine this pressure may be up to 37 bar.

Figure 3. LNG tank delivered to yard

7 ENGINE OPTIONS

Gas can be supplied in a number of ways, liquefied, LNG, Compressed, CNG or LPG.

Engines could be reciprocating or gas turbine.

The engine is generally dual fuel although some makers do have gas only. With the reciprocating engine a small amount of distillate is required, around 1%. With a gas turbine none is required but the gas is at a much higher pressure.

With the gas only engine the gas is spark ignited.

Other diesel engines run on various gas/distillate mixtures typically 70/30 with add on kits to standard engines.

8 GAS SAFE

In the gas safe system all pipe work must be double walled with inert gas in the outer annulus and fitted with a gas detection system. This is mandatory if gas pressure is greater than 10 bar.

9 ESD

Emergency shut down or (ESD) can be used for smaller low pressure engines where it is difficult to arrange ducted piping. A minimum of three gas detectors are required in the engine room with redundant fuel supply. The gas shuts off and distillate takes over at 20% LEL (lower explosion limit) and all electrical equipment explosion protected or disconnected. Ventilation is required at 30 air changes per hour for all spaces where gas leakage is possible.

10 A PRACTICAL APPLICATION

INCAT's 99m Wave Piercing Catamaran delivered to Buquebus early 2013 is classed to the HSC code and DNV HSLC rules and is the first HSC to use LNG.

For LNG storage non-integral tanks each with a cold box are located in each hull.

The cold box is ventilated and the tank has relief valves to a vent mast higher than the passenger roof level.

Road tankers will provide bunkering. The ships internal bunker lines are vacuum insulated stainless steel pipes with ventilated ducts.

A heat exchanger in the gas turbine exhaust provides heat to a glycol circuit which transfers that heat to a vaporiser in the cold box. A cryogenic pump draws the liquid from the tank and pumps it through the vaporiser to the engine at high pressure.

The engine runs on distillate at low power and gas at medium and high power.

The engine can only start on distillates as until there is sufficient exhaust gas heat to vaporise the LNG there is no gas available.

Inert gas is required to purge gas lines, in this case nitrogen. Ventilation is required for gas hazardous areas with redundant supply for the gas turbine enclosure.

The definition of external hazardous areas where gas may vent or escape was required and vent exhausts had to be carefully located to meet these criteria.

Risk analysis, safety, cause and effect assessments were all required for the gas system to approve and equivalent level of safety to a conventionally powered vessel.

The main driver for the design of this vessel was speed where the operator has to meet a minimum voyage time to be competitive against other forms of transport such as aircraft. Gas Turbines were the only choice to meet that requirement. To improve fuel efficiency and running costs LNG was chosen as a fuel. As the expected specific fuel consumption of natural gas is less than distillate then savings in running costs are possible. Maintenance costs are expected to be reduced with LNG as well. In service experience will give a better idea of the savings to be made.

Figure 4. Cutaway of 99m vessel

11 CONCLUSIONS

LNG is a viable option for a HSC classed vessel. The environmental improvements are unchallenged and there is certainly operating cost reductions through cheaper fuel and reduced maintenance but the initial capital cost is higher.

Larger medium speed vessels using reciprocating engines or high speed using gas turbines have been assessed to a preliminary design level by Incat/Revolution design and are technically feasible.

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Figure 5. 130m WPC Catamaran.