



INVESTIGATION AN ENVIRONMENT FRIENDLY PROPULSION SYSTEM FOR LNG CARRIER

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1. Introduction

- + What is natural gas?
- + What is LNGC?
- + What is an environment friendly propulsion system?
- + Type of propulsion systems
- + Steam turbine propulsion system
- + LSRL
- + DFDE



2. Feature of Different Propulsion System

- ✚ **Steam turbine propulsion system**
- ✚ **Steam boiler with dual fuel burner**
- ✚ **Burning combination of gas and fuel oil**



2. Feature of Different Propulsion System

- ✦ **Low-speed diesel engine propulsion system plus re-liquefaction plant**
- ✦ **Extensively used for conventional cargo ship**
- ✦ **Extra cost for re-liquefaction plant**



2. Feature of Different Propulsion System

- ✦ **Dual-fuel diesel electric propulsion system (DFDE)**
- ✦ **Burning with 99% of gas and 1% of pilot oil**
- ✦ **30~40 cylinders for power station**

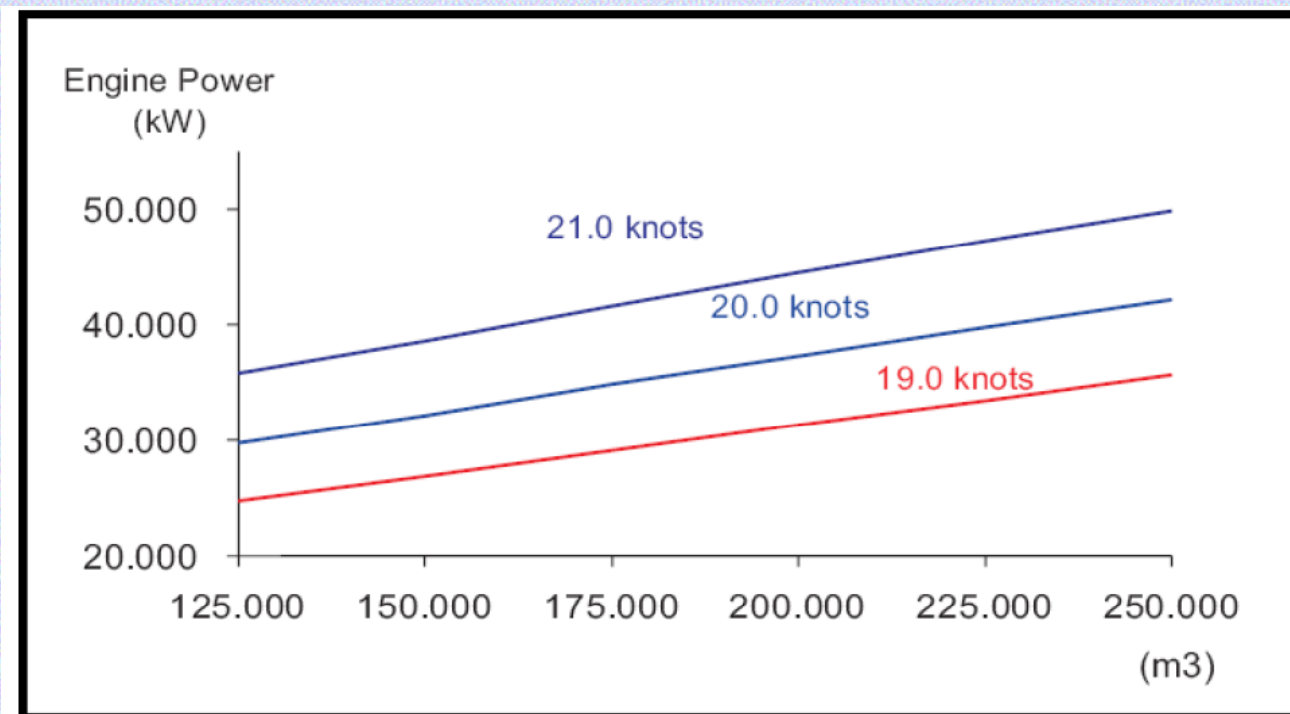


3. Relationship between PP and BOG

The largest feature of LNGC is the issue of BOG as it happened always. And for environment protection, BOG shall be utilized as far as possible instead of burned by GCU directly or other means of energy wasting.



Relationship between engine power and cargo volume



Source from MAN B&W



Power balance of different size of LNGC

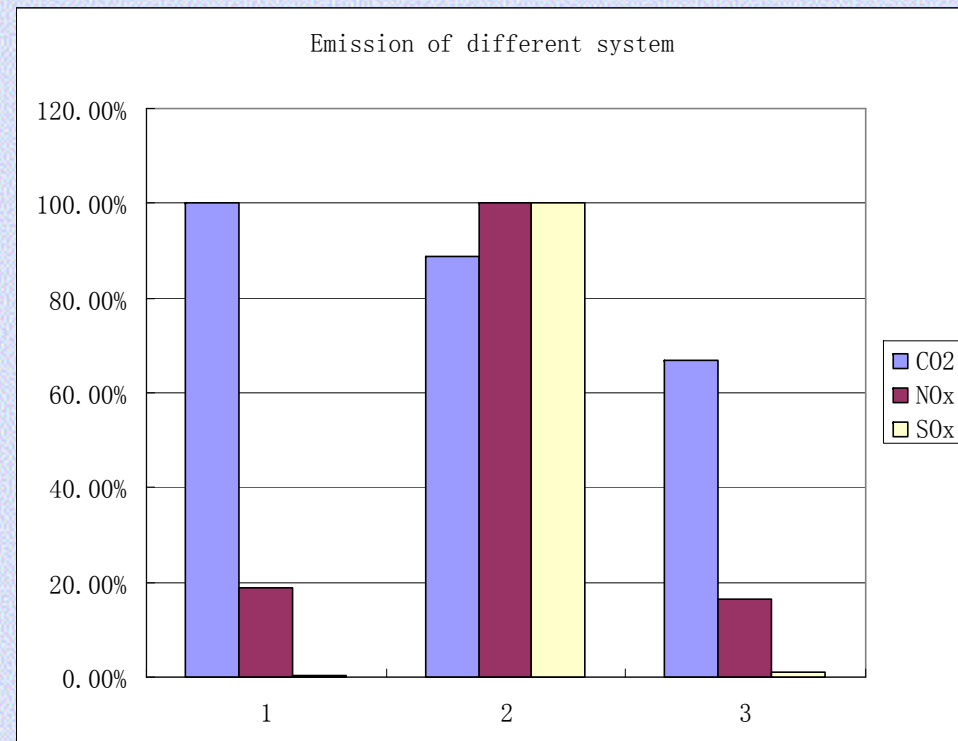
| Class of Vessel | Small (Med-max) | Large Conventional | Q-flex | Q-max |
|---------------------------------------|--------------------|-----------------------|---------|----------|
| Number of Screw | Single | Single | Twin | Twin |
| Cargo Capacity | 75,000 | 150,000 | 216,200 | 255,000 |
| BOR (%) | 0.21 | 0.15 | 0.14 | 0.135 |
| BOG (kg/h) | 2789.1 | 3984.4 | 5360.0 | 6096.1 |
| Available steam (kg/h) | 46484.4 | 66406.3 | 89332.6 | 101601.6 |
| Available power for ST (kW) | 14,481 | 20,687 | 27,829 | 31,652 |
| Available power for DF Engine (kW) | 16,865 | 24,093 | 32,411 | 36,862 |
| Speed (knots) | 17.5 | 19.5 | 19.5 | 19.5 |
| Installed MCR (kW) | 14,200 | 28,500 | 33,400 | 38,000 |
| Installed CSR (85% of MCR) | 12,070 | 24,225 | 28,390 | 32,300 |
| Power Balance (kW) | 4,795 | -132 | 4,021 | 4,562 |

It is clearly, a certain balance point is existed for different Class and cargo volume of LNGC where power are produced by BOG and no more other fuel is needed and eventually none excess BOG is needed to be treated by GCU.



4. Emission calculation of air pollution

✚ The amount of air pollution represents whether a vessel is environment friendly or not. Take a standard size of 150,000m³ LNG carrier for example, on the basis of applying three different propulsion system, CO₂、NO_x and SO_x emission is to be calculated separately for environmental analysis.



1- Steam turbine propulsion system

2- Low-speed diesel engine propulsion system + RL

3- Dual-fuel engine propulsion system



4. 1 Emission for steam turbine propulsion system

- ✦ **Power efficiency is ~29%**
- ✦ **Equivalent SFOC is 294g/kW.h**
- ✦ **CO₂ is highest**
- ✦ **SO_x is minor with gas mode**



4. 2 Low-speed diesel engine propulsion system plus Re-liquefaction plant

- ✦ **Power efficiency is 48%.**
- ✦ **Re-liquefaction plant needs electricity**
- ✦ **NOx is 14.4g/kWh for main engine**
- ✦ **NOx is 9.7g/kWh for auxiliary engine**
- ✦ **Sulphur content is 3.5% m/m**



4. 3 Dual fuel diesel electric propulsion system (DFDE)

- ✦ **Power efficiency is about 43.4%**
- ✦ **99% BOG and 1% pilot oil**
- ✦ **NOx is 1.4 g/kWh (below Tier III).**
- ✦ **SOx is minor with gas mode**



5. Other issues for consideration

- ✦ **Environment-friendly propulsion system not only need to control emission , but also need consider other factors:**
 - ✦ **Ship's speed**
 - ✦ **Redundancy of BOG process equipment**
 - ✦ **Balance of BOG and propulsion power**



6. Conclusion

- ✦ **New regulations for the Prevention of Air Pollution from Ships is always expected.**
- ✦ **A propulsion system burning with clean energy (natural gas) is preferred.**
- ✦ **LNGC with BOG_{\max} is the final solution.**



Thank you!