

Nanyang Technology University
Semester 1 2019-2020
MT2003 Maritime Technology

1. (a) Important fuel oil characteristics:

Special attention in the quality of the fuel is to be paid for density (if no mass flow meter is used), as the fuel is supplied in volume and paid as per the weight and hence density lower than the declared one will mean there is a small change.

CCAI is important as it indicates the ignition and combustibility of the fuel.

Cat Fines are very hard and important in a sense that they may get trapped between the piston rings and the liner and cause damage to the components.

Calorific value is important because this indicates how much energy is there in the fuel, which would be converted to the mechanical energy.

Sulfur content is important as it should not exceed the regulatory limit and high sulfur cause corrosion.

(b) SO_x Management & Impacts:

0.5%S Fuel – Commercially, this compliant fuel will be more expensive as to produce these low sulfur fuel, the suppliers need to blend with high value distillate fuel. The technical impact of these fuel is of concern, as they may be unstable, not compatible (when mixed between two fuels) and wide range of viscosity, which will affect the injection and combustion. Environmentally, they will be better as the sulfur content of the fuel is low.

LNG – LNG has very long sustainability like a few hundred years. The price of LNG will even be lower than the high sulfur fuel in the long run. Commercially, it is viable. However, the infrastructure of LNG is not available in many parts of the world. On top of that LNG tanks are very heavy. LNG cannot be stored in the existing bunker tanks. So, this additional CAPEX and weight of the tanks are the hindrance for retrofitting LNG for the existing ships. Environmentally, LNG is much cleaner as it doesn't have sulfur and it also produces less NO_x and CO₂.

(c) Comparison between Positive and Centrifugal Pumps:

In general, for centrifugal pumps the water flow is continuous and the head and the flow rate are inversely proportional. In reciprocating pump, the flow is pulsating and a fixed amount of water is trapped and pressurized.

There are considerable advantages of positive displacement pumps. They are self-priming, thus automatically mixing water with steam being passed into the cylinder; secondly, high delivery head is possible for positive displacement pumps; they can also be used for viscous fluids such as lubricating oil, fuel oil, sludges and high temperature fluids. However, their disadvantages exist. A positive pump needs gear to reduce the flow speed. Secondly, the pulsating effect might damage the machinery and reduce the working efficiency. It is not suitable for high flow rate. Particularly, safety valves are mandatory.

In comparison, advantages of centrifugal pumps include continuous flow, high flow rates possible, multi-stage arrangement for higher pressures and no safety valve or gear is required for safety issues, which is opposite to the positive displacement pumps. Nevertheless, normally a centrifugal pump is not self-priming thus requiring more energy for pumping. It is also prone to cavitation, under which small air bubbles collapse on the discharge side and eventually cause implosion.

(d) Purifier Description:

The purifier contains a shaft and discs and a bowl. Purifier rotates at a very high speed and it works on the principle of centrifugal force. Water is fed to the purifier to form a seal against the extreme boundary of the bowl. Fuel is lighter than water and solid particles.

About self-cleaning function, when fuel with unwanted water and dirt in the fuel is fed onto the purifier, the rotational energy throws out the water and dirt at the extreme boundary of the purifier bowl and they overflow against the sealing water. The oil is squeezed over the discs and flow out from the inner passage. Once a while, the bowl is brought down and flushed with wash water to de-sludge the accumulated dirt around the bowl.

2. **(a) Energy Content**

In an internal combustion engine (ICE), the ignition and combustion of the fuel occurs within the engine itself. The engine then partially converts the energy from the combustion to work. The engine consists of a fixed cylinder and a moving piston. The expanding combustion gases push the piston, which in turn rotates the crankshaft. Ultimately, through a system of gears in the powertrain, this motion drives the vehicle's wheels. Generally, the working efficiency is around 50% and the typical energy content of HFO is 41 kJ/g.

(b) Comparison between 2- and 4-Stroke Engines:

In 2 stroke engines, when the piston is near the top dead center, the compressed or trapped air is injected with fuel. Advantages of 2-stroke engines for marine use include: firing every revolution; high degree of efficiency, up to 55%; simple, robust design; low

speed engines thus no reduction gear required and they are mainly used as big main engines. Meanwhile, their disadvantages are substantial factors to consider in the real-life mechanical engineering. Firstly, Air is lost in scavenging and hence combustion is not as efficient. Secondly, power to Weight Ratio is not as good as 4-stroke engines.

In comparison, 4-stroke engines for marine applications have better gas exchange and more efficient combustion, as well as better power to weight ratio and compact design. They are mainly used as auxiliary engines or small / medium sized main engines. However, their disadvantages include reduction gears required for main propulsion and incapacity of running with unit cut-off.

(c) Savings calculation

For 30 years' original plan: $6000 * 30 * 0.024 / 1000 = 4.32 < 4.80$, no replacement

Thus, savings of the new plan will be:

$$\$135,000 * (30/5) + (1.3 - 0.6) * 6000 * 30 * 15,200 * \$2 / (0.95 * 1000) = \$4842000$$

3. (a) SOLAS

The intervals between inspections of the outside of the ship's bottom are specified in SOLAS, IACS Regulations and Classification Society Rules and require a minimum of two inspections to be carried out during the 5 year validity period of the Safety Construction Certificate/Special Survey period.

(b) EDD

Ships eligible for the Extended Dry-Docking (EDD) scheme should meet the provisions and conditions described in this document. Qualifying ships may be permitted to carry out two consecutive in-water surveys, subject to the conditions described in this document. A minimum of two inspections of the outside of the ships bottom should be carried out during the renewal period of five years and the intervals between any two inspections shall not exceed 36 months.

(c) Digitalization Initiatives:

5G Network --With the development of 5G, which is designed to improve the flow of information and enable automation and artificial intelligence (AI). Communication will be more flexible and faster, achieving a seamless Wireless network efficiency. 5G will support engineers on site to monitor and optimize construction planning.

Internet of Things (IoT) --Connection point between the physical world and the digital world; Network of physical objects embedded with the computing power required to collect, process, and transmit data. Consequently, IoT enables ship owners and managers

to deal proactively with preventative maintenance and monitor shipboard equipment and machinery in real time. Besides, it helps pinpoint issues, prevent potential failures, reduces downtime and also improves crew safety.

4. **(a) AIS:**

Automatic Identification System (AIS) is an automated tracking system that displays other vessels in the vicinity. It is a broadcast transponder system which operates in the VHF mobile maritime band. AIS consists of transmitter, receivers, and a standard marine electronic communications link to shipboard display and sensor systems. Distinctly, it stands out for easy installation and decent integration with bridge systems and multifunctional display.

(b) AIS Applications:

AIS has been broadly applied by worldwide authorities for multiple purposes. Essentially, AIS prevents marine collision accidents significantly. Besides, it applies to fishing fleet monitoring and control; maritime security; aids to navigation; search and rescue; accident investigation; ocean currents estimation; infrastructure protection. Last but not the least, AIS provides reliable real-time data for efficient fleet and cargo tracking.

(c) AIS Transmission:

COSPAS-SARSAT is a satellite-based monitoring system that detects and locates emergency beacons. Professional operators then notify search-and-rescue (SAR) authorities. The beacons comply with internationally agreed standards for radio communication and identification of beacon owners.

The system includes emergency beacons that transmit the distress signals; satellites that detect the distress signals; ground receiving stations that receive and process the satellite signals to generate distress alerts; and Mission Control Centers (MCCs) that receive the alerts and forward them to SAR bodies.

5. **(a) Challenges:**

Firstly, the definitions issue regarding an autonomous or unmanned ship is on the global front. Whether an autonomous ship is considered as a 'ship' by international law is yet to be clarified.

Secondly, there are absence of crew issues. Various international regulations define that all ships must be "in the charge of a master and officers who possess appropriate

qualifications". In the case of a MASS, the absence of crew issues might bring substantial uncertainty to circumstances such as dealing with marine pollution at sea.

Thirdly, in the aspect of insurance and law sectors, the definition of seaworthiness and error in navigation actually implied warranty that the vessel is "reasonably seaworthy in all respects". This warranty fundamental and basis of all policies in marine insurance at the commencement of a voyage. As per Hague Visby Rules, all ships are required to be seaworthy, which is a very fundamental prerequisite.

Last but not the least, cyber risks can be destructive, considering the environment of high dependency on computers and other robotic equipment, which could escalate in a cyber-attack.

(b) Green Shipping Technologies:

No Ballast System reduces the transit of sediments and micro-organisms of one territory to another through the ballast of ships. LNG fuel for propulsion helps in reduction of air pollution from ships, resulting in fuel saving. LNG fuel for auxiliary engine drastically reduces air pollution from ships. Sulphur Scrubber System ensures that sulfur is washed out from the exhaust gas of the engine resulting in the reduction of SO_x as well as other harmful particles. Waste Heat Recovery System use waster heat to generate steam, which in turn can be used for heating cargo area, accommodation, fuel oil etc. In addition, part of the exhaust air can be re-circulated and added to scavenge air of the engine which reduces the oxygen content of the scavenge air along with temperature of combustion cylinder.

(c) C.G. & C.B.:

Center of Gravity is the point in a body where the gravitational force may be taken to act. Center of Buoyancy is the center of the gravity of the volume of water which a body displaces. By definition, the center of buoyancy is determined by the summation of the densities of each tiny piece - where the center of gravity is the summation of the masses of each tiny piece.

Nice to meet you here 😊 Wish you a bright future!

A handwritten signature in black ink, appearing to read 'ShwN', located in the bottom right corner of the page.