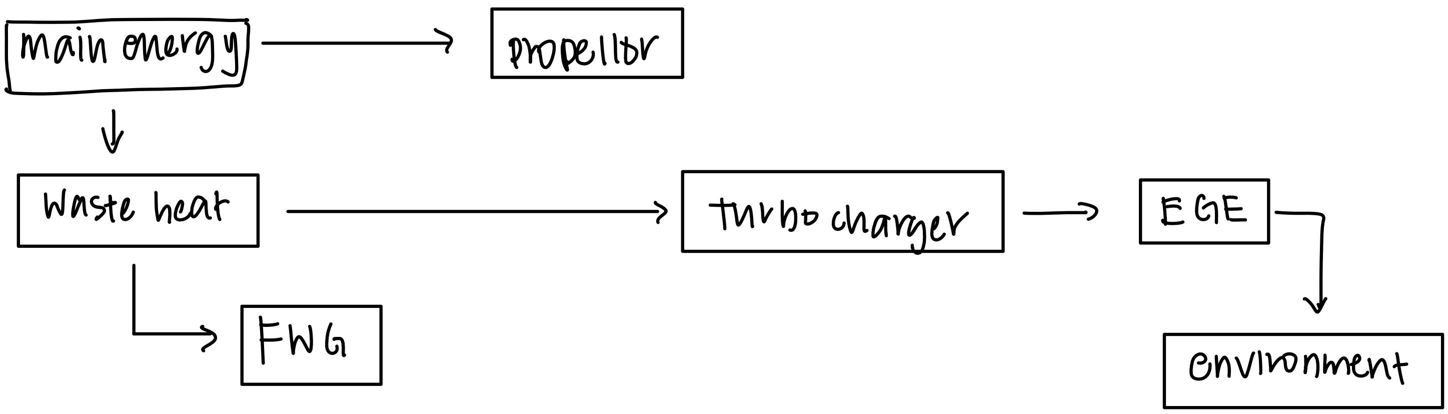
MT2003
mok shu yin

(a)



The principle of internal combustion energy is to convert the chemical energy of fuel to mechanical (kinetic) energy and thermal energy (waste heat)

waste heat recovery

→ Fresh water generator (FWG)

- sea water is supplied from the ejector pump
- part of this sea water is used as feed water to the FWG evaporator chamber and the remaining ones for the condenser to cool the evaporated moistures.
- jacket cooling water from engine outlet is used to heat up the sea water feed before it goes to the central heat exchanger
- when the ejector pump discharged water passes through the eductor, it removes the trapped air from the evaporator chamber and creates vacuum; at the same time, it also removes the excessive brine (salt) deposit from the chamber.
- owing to the vacuum creation, the boiling point of water drops to around 35°C and hence, the jacket cooling water inlet of 82°C is sufficient to boil the sea water

in the evaporator chamber

→ Turbocharger (220°c)

- supply more mass of air to engine for combustion
- driven by exhaust gas from cyclinder
- exhaust gas contain heat and kinetic energy which is converted to mechanical energy at the turbine of the turbocharger
- the turbine blade rotates as a gas turbine and it rotates the impeller
- the impeller draws atmospheric air from the atmosphere and pressurise it
- under pressure, the air is heated up to around 115°c
- this hot pressurised air is then cooled in the charge air cooler with cooling water
- the cooling effect increases the density of air and hence its mass
- cooled pressurised air is then used to supply the intake|scavenge air to the engine

→ Exhaust Gas Economizer (EGE) (160°C)

- Exhaust Gas Economizer is a boiler, which gets its hot water intake from the auxiliary boiler and produce steam or mixed steam|water through the heat exchange of the main engine exhaust gas after the turbocharger. The produced steam or steam|water mix is then passed back to the boiler, from where it is distributed to all consumers

→ afterwhich waste heat release to atmosphere (160°C)

- because of dew point limitation
- lower temperature can cause condensation and corrosion to materials in pipings

1b) $V = \frac{d}{t}$ (distance) (time)

consumption daily

$\frac{F_{CD}}{F_{CD}} = \frac{22^3}{20^3} = 1.332$

F_{CT} = Total fuel consumption

$F_{CT} = F_{CD\,22} \times D_{22} = V^3_{22} \times D_{22} \times K$

$F_{CT} = 22$

$22 = F_{CD} \times 22$

$F_{CT\,20} = F_{CD\,20} \times 20 = V^3_{20} \times D_{20} \times K$

$$\frac{F_{CT\,22}}{F_{CT\,20}} = \left(\frac{V_{22}}{V_{20}}\right)^3 \times \frac{D_{22}}{D_{20}} = \left(\frac{V_{22}}{V_{20}}\right)^3 \times \frac{\frac{d}{V_{22}}}{\frac{d}{V_{20}}} = \left(\frac{V_{22}}{V_{20}}\right)^2$$

$$F_{CT\,22} = F_{CT\,20} \times \left(\frac{V_{22}}{V_{20}}\right)^2$$
$$= F_{CT\,20} \left(\frac{22}{20}\right)^2$$
$$= F_{CT\,20} \times 1.21$$

percentage gain : 21%

1c) Turbocharger A as higher temperature difference, more efficient

possible causes:

- faulty impeller
- small amount of exhaust gas

2a)

① Air cavity system (ACS)

- incorporated during newbuilding
- air bubbles injected through the recess underneath the hull
- creates more or less a stable air film and lubrication effect

$R_f = fSV^n$

R_f = frictional resistance

S = wetted surface area

V = velocity

n = constant for the type of vessel

f = friction coefficient

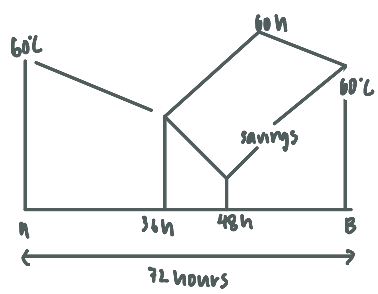
In ACS, the friction coefficient between air and water is far lower than the friction coefficient between steel and water
Hence, based on $R_f = fSV^n$, when friction coefficient, f, is reduced, the frictional resistance is also reduced
Fuel consumption ∝ frictional resistance of hull against water
With reduced frictional resistance, fuel consumption also reduced and hence energy saved

② use of bulbous bow

- facilitate streamline flow of water and reduce the impact of wave making resistance to hull therefore energy saving

2b)

① cargo heating



Cargo is loaded from port A and tobe discharged at port B after 72 hours at the same temperature of 60°C. If heating is on after 36h and it reaches to 60°C and maintain the temperature at 60°C until reached point B, there will be a lot of heating energy wasted. Instead, if the heating is on 48h and the temperature attained 60°C exactly after 72 hours, it will be the optimum.
Between the two scenarios, the area highlighted as savings is the saved energy for the latter option.

② slow steaming
- lowering the speed reduces fuel consumption
- slow steaming, the operational optimization, was the first wave of energy efficiency optimization for fuel saving, which achieved almost 25% savings owning to its exponential relationship with fuel consumption
- net savings can be computed as follows:

$$saving_{net} = \Sigma (\text{fuel saving} - \text{extra charter hire})$$

2c)

1. electro-chlorination system
- produces chlorine to kill the species

Advantage
- less energy intensive and produces chlorine from the sea water
- foot print of the reactor is also small compared to that of UV system

Disadvantage
- produces active substance, which means they produce DBP (disinfection by-product), some of which are carcinogenic
- IMO will set the DBP maximum limits to prevent those substances coming in our food chain through their accumulation on fish species
- chlorine may cause corrosion to the structures of the ballast tank and the system

2. UV system
- not an active substance system

Advantage
- doesn't produce any by-product

Disadvantage
- effectiveness of system is often challenged by the high turbidity of the water
- UV light cannot penetrate effectively through the water, if it is too dirty
- to make them effective in dirty water, more energy is needed and hence the energy consumption rises
- comprises of hundreds of lights and their footprint is huge
- effectiveness of light also deteriorates with time

container ship: less ballast is required (low ops expense, high capital expense — ops expense based on ballast based on the amount of ballast carried)
- total operation expense is less therefore owner does not mind if the ballast treatment system is more expensive as they will only need to treat small metric tonne of ballast water (eg 4MT)

big tanker / bulk VLCC: large amount of ballast is required (high ops expence, low capital expense)
- total operation expense is high therefore owner may not want an expensive ballast treatment system as they will have to treat large amount of ballast water (eg 150MT)

containership: UV system

VLCC: electro-chlorination system

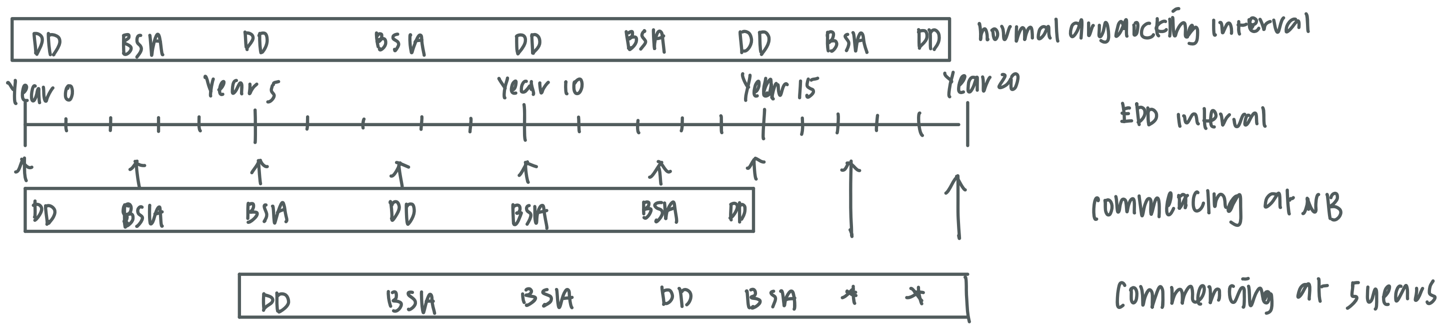
3a)

- break down maintenance : use up to no residual life ⁀ does not hinder the operations
- condition based maintenance : monitor the health of machinery, change before break down (requires some sensor
- planned maintenance : throw away some residual life

3b)

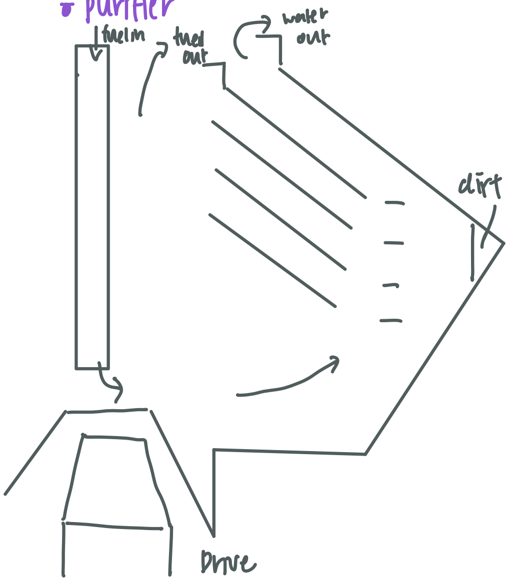
Prepare a ship for Dry Dock:

- The main objective in carrying out dry docking is to ensure ships are operational and to maintain their class license
- SOLAS requirements is to have two bottom inspection in every 5 years
- Class allows extended drydocking to 7.5 years against some conditions (eg new ship / ship < 5 years)
- Structural, machinery and various components are subjected to inspection and maintenance to ensure sea worthiness
- Dry docking is also required if a ship has sustained damage to the underwater structure due to grounding, collision or any other damage which will affect the water integrity of ship's hull



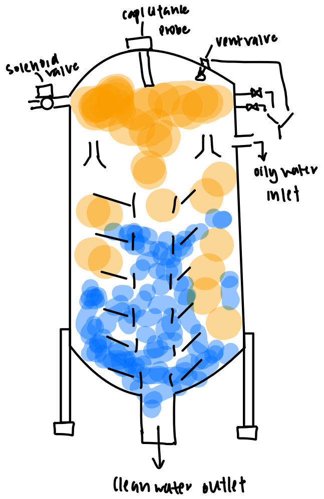
3c)

- purifier



- purifier contains a shaft and discs and a bowl
- rotates at a very high speed and works on 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
- So, when fuel with unwanted water and dirt in the fuel is fed into 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 in awhile, the bowl is brought down and flushed with wash water to desludge the accumulated dirts around the bowl

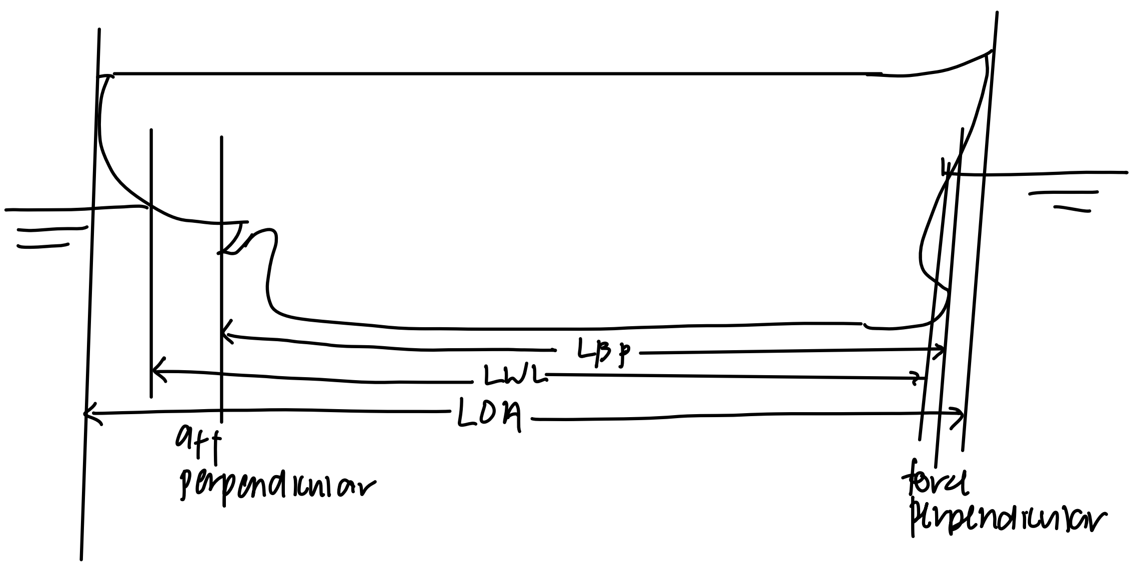
• Oily water separator



- ows is used to separate the oil from water through heating over the surface area of the baffles
- oil eventually floats on top of oil and when the top chamber has acertain amount of oil is accumulated, a solenoid valve is activated to discharge the oil to separator bilge tank
- The water from the bottom is then discharged overboard through a oil content meter

4a)

• Length between perpendiculars (LBP): distance between the forward and aft perpendiculars measured summer load line
• Length overall (LOA): length of vessel as measured over all extremeties
• Length on waterline (LWL): length of the vessel measured along the waterline from forward to aft



4b)

Global maritime distress and safety system (GMDSS)

- internationally agreed-upon set of safety procedures, types of equipment, and communication protocols used in ships and boats
- ensure maximum availability of safety-related communication for all passenger ships as well as for vessels of 300 GT and above engaged in international voyage

Functional requirements

- transmission of ship-to shore distress alerts by at least two separate and independent means, using different radio communication service

- reception of shore-to-ship distress alerts
- transmission / reception of ship-to-ship distress alerts
- transmission / reception of search and rescue coordinating communications
- transmission / reception of on-scene communications
- transmission / reception of search and rescue transponder (SART) signals for locating
- transmission / reception of maritime safety information
- transmission / reception of general radiocommunication to and from shore-based radio systems or networks
- transmission / reception of bridge-to-bridge communications

Five elements of GMDSS

1. International maritime statellite (INMARSAT)
- satellite operated system that includes ship earth station terminals — INMARSAT B, C and F77
- provides telex, telephone and data transfer services between ship-to-ship, ship-to-shore, and shore-to-ship
- priority telex and telephone service connected to shore rescue centres

2. Navigational Telex (NAVTEX)
- an internationally adopted automated system
- Distribute maritime safety information (MSI):
  - ↳ weather forecasts and warnings,
  - ↳ navigational warnings,
  - ↳ search and rescue (SAR) notices,
  - ↳ other similar safety information

3. Emergency positioning indicating radio beacon (EPIRB)
- installed on marine vessels
- Registrated through the flag state
- operated automatically after an incident by fitting them to an auto-housing which releases the EPIRB once submerged allowing the units water contacts to activate the signals
- manually carried and activated in an emergency
- help to determine the position of survivors during SAR operation
- a secondary means of distress alerting

4. Search and Rescue (SAR) locating equipment
- primarily the search and rescue radar transponder
- used to home search and rescue units to the position of distress which transmits upon interrogation

5. Digital selective calling (DSC)
- a calling service between ship-to-ship, ship-to-shore or vice versa for safety and distress information
- mainly on medium frequency (MF) or high frequency (HF), and very high frequency (VHF) maritime radio

4c)

• Surveillance tools
- shore authorities establish automated AIS stations to monitor the movement of vessels through their shores
- coast stations can also use the AIS channels for shore to ship transmissions, critical information on tides, non-tariff measures (NTMs) and located weather condition
- may also use AIS to monitor movement of HAZMAT (hazardous cargoes)
- control of commercial fishing operations in territorial waters
- useful in supplementing SAR operations whereby maritime rescue and coordination centre (MRCC) to use AIS information to assess the availability of other vessels in the vicinity of the incident.

5a) ✓ minimise or eliminate human error
✓ reducing crewing costs which is the biggest vessel operating cost (VOC)
✓ increase safety of life
✓ efficient use of space in ship design
✓ efficient use of fuel

✓ solution to prevailing shortage of seafarers
X incompatibilities between the current marine infrastructure and an unmanned vessel
X challenge in remote maintenance of moving parts
X breakdown during ocean voyage can lead to substantial disruption and loss of money
X disruptive to seafarers employment that needs to be mitigated

5b)

Examples of Drone Technology in maritime

- "agency by air" : supply ships with small spare parts, documents, supplies or even consumables for 3D printer
- traffic control and monitoring in port
- supervise operations and risk detention in terminal operations
- environmental control: routine flight surveillance with video recording / orthophotos

5C) smart port

- Deploying automation and innovative technologies to improve its performance
  ↳ e.g. artificial intelligence (AI), big Data, internet-of-things (IoT) and blockchain etc

Augmented Reality (AR)
: an interactive experience of a real-world environment

- Objects enhanced by computer-generated perceptual information
- Display all kind of operational and productivity data, such as the movement of cargo and vessels
- visual support provided to staff during their operation watch
- port day-to-day operations through real-time video imagery and related information
- remote support in maintenance