

Basic aspects and contributions to the optimization of energy systems exploitation of a super tanker ship

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Abstract. Today, the concept of energy efficiency or energy optimization in ships has become one of the main problems of engineers in the whole world. To increase the fiability of a crude oil super tanker ship it means, among other things, to improve the energy performance and optimize the fuel consumption of ship through the development of engines and propulsion system or using alternative energies. Also, the importance of having an effective and reliable Power Management System (PMS) in a vessel operating system means to reduce operational costs and maintain power system of machine parts working in minimum stress in all operating conditions. Studying the Energy Efficiency Design Index and Energy Efficiency Operational Indicator for a crude oil super tanker ship, it allows us to study the reconfiguration of ship power system introducing new generation systems.

1. Introduction

Energy and ecological efficiency are today one of the key ability variables for ship operators and in this manner, these perspectives likewise must be one of the centre components in ship configuration design. Ship design and optimization is an unpredictable undertaking where a wide range of parameters should be thought about. Toward the start of the plan procedure certain limits and primary dimensions are chosen for the ship and the concept will be created, for an itemized contract detail in light of which the ship will be at long last fabricated. Energy efficiency development must be a combined some portion of the procedure. Energy efficiency is not just presentation of certain computation, file or innovation. The encounter has demonstrated that keeping in mind the end goal to guarantee best outcomes, improvement of energy efficiency should be a steady procedure inside the new building project, beginning from the meaning of key performance indicators and finishing with appointing of on board performance management system and preparing for installed team at ship conveyance. The most critical thing is that the procedure is steady and reliable in a way that improvement is constantly based on work did before in the design procedure. The initial step in energy efficiency development has to be the definition of key execution markers for ship efficiency. EEDI or EEOI could be appropriate pointers, but typically ship-owners have also their own performance indicators which they like to use for measuring the efficiency of ships.

2. Very large crude carriers design

VLCC (Very Large Crude Carriers) are one of the biggest working freight vessels on the planet. With a capacity, more than 250,000 dwt, these big vessels are equipped for conveying an immense measure of crude oil in a single voyage. Known as supertankers, these vessels are essentially utilized for whole deal rough transportation from the Persian Gulf to Europe, Asia and North America.





Figure 1. VLCC ship.

This paper comprises in ideas studying of a VLCC of 305000 dwt. Main characteristics of VLCC ship are described in table 1.

Table 1. VLCC characteristics.

Characteristics	Value
Lenght overall	333.00 m
Lenght between perpendiculars	324.00 m
Draft	20.83 m
Deadweight	305301 MT
Gross tonnage	160057 MT
Net tonnage	100926 MT
Displacement	347593 MT

VLCC has a size interval from 180,000 to 320,000 dwt. They are able to do going through the Suez Canal in Egypt, and accordingly are utilized broadly around the North Sea, Mediterranean and West Africa. VLCC are expansive transportation vessels with measurements of up to 470 m long, a beam of up to 60 m and draft of up to 20 m. Be that as it may, the standard measurements of these vessels go between 300 to 330 m long, 58 m breath and 31 m in depth. They are known for their adaptability in utilizing terminals and can work in ports with some profundity constraints. The cost of a VLCC goes between 100 million dollars to 120 million dollars relying upon its age. Forefront Limited of Bermuda has the biggest fleet of VLCC comprising of 44 vessels.

Table 2. Ship main systems.

System	Type
Main engine	MITSUBISHI-UE MDE 7UEC85LSII (1 x 27020 kW)
Main diesel generators	YANMAR 6EY26L (2 x 1700 kW)
Turbo generator	MITSUBISHI MULTI STAGE/1 (1 x 1100 kW)

Emergency generator	KTA 19 DM CUMMINS (1 x 620 kW)
Auxiliary boiler	MHI Nagasaki MAC-90B (1 x 90 tonnes / h)

3. Energy saving potentials for ships

This part contains an overview of some Energy Saving Potentials for vessels. A significant number of these possibilities are broadly known, yet not generally exploited, for specific motivations to be broke down later in the paper. It is critical to note that, by utilizing the term „potentials“, we allude to both devices and procedures.

3.1. Appendages to reduce stern waves

The greatest concerns while outlining the aft part of the ship of the vessel is to alleviate the stern waves, maintain a strategic distance from vortexes and enhance the stream into the propeller. By enhancing the stream around the stern of the ship the hull resistance can be diminished. Stream enhancing devices, for example, stern flaps can be connected to do likewise. The other vital thing to be considered while planning the stern is the kind of stern whether a transom or a cruiser or a curved and so on. Each of them has its own arrangement of upsides and downsides along these lines, simply after a legitimate CFD examination or model investigations, the fitting stern must be picked.



Figure 2. Appendages to reduce stern waves.

Frame extremities which lessen the stern wave and, individually, the wave resistance very nearly 2-5%. Thus of the decrease of resistance, it is accomplished:

- either a higher speed for a similar Engine Power Output.
- or a diminished power interest for a similar speed.

3.2. Air bubbles system on the bottom

The air bubble distribution around the body surface is accepted to be an essential parameter for decreasing the resistance taking a shot at the hull, and should in this way be anticipated precisely. In this strategy, a layer of air bubbles is connected to the turbulent limit layer growing downstream on the body in the water stream. The productivity of this strategy was dictated via doing various model tests which demonstrated that the impact of air oil lessened frictional resistance. The rubbing resistance decrease, for specific sorts of dealer boats, is assessed as takes after:

- Tanker: 15% .
- Bulker: 15% .
- LNGC : 7 ~ 9%.
- Containership: 5 ~ 7%.

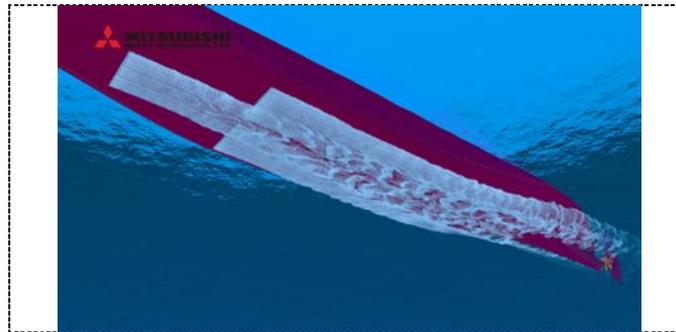


Figure 3. Mitsubishi Air Lubrication System (MALS).

3.3. Fins in front of propeller

- Wake Acceleration (WA) Fin (Oshima). This fin reduces the swirl resistance of the full hull form.
- IHI (Ishikawajima Harima Heavy Industries) Low Viscous Fin This fin reduces the swirl resistance of the full hull form. A reduction of 2% is estimated for tankers and bulk carriers.
- Namura Fin. The Namura Fin, reduces swirl resistance of the full hull form. A reduction of 2% is estimated for tankers and bulk carriers.
- Wake equalizing duct. The Duct prevents the separation of flow in front of semiduct with gathering and accelerating flow. Duct produces thrust with receiving the oblique downward flow due to bilge vortices.
- Fin and Duct Contra fins pre-twist the flow towards propeller and cancel rotational flow behind flow. Semi-duct prevents the separation of flow in front of semiduct with gathering and accelerating flow.



Figure 4. Fins in front of propeller.

3.4. Special propellers

- CLT (Contracted and Loaded Tip) The pitch in the CLT propeller (shown in Picture 5), is increased monotonously towards the tip so that the blade tip bears a substantial load. This is possible thanks to the existence of the tip plate that actuates as a barrier avoiding the communication of water between both sides of the blade. Tip plate is located on the pressure side of the blade with the aim to obtain a higher overpressure downstream. The Claimed gain is 6-12%.
- KAPPEL The KAPPEL (shown in figure 5) is a special propeller with blades curved towards the suction side integrating the fin or winglet into the propeller blade. The claimed gain is 4-6%.



Figure 5. Special propellers.

4. Energy saving practices

In this chapter, certain reduction measures are depicted quickly in the request appeared. A specialized depiction is offered, pertinence to ship sorts or potentially measure classifications and market development is demonstrated. If known decrease potential and cost information are depicted. The decrease potential is given in the rate of CO₂ emanation diminishment on a per ship basis. Two sorts of expenses are separated, non-repeating and yearly repeating costs: Non-repeating expenses are the expenses related to acquiring and introducing a measure. Every year repeating expenses are yearly operational expenses related to the measure.

4.1. Operational speed reduction

By working at lower speeds, ships diminish their energy necessity and henceforth their fuel utilization. As a general guideline, control necessity is identified with ship speed by a third power work. This implies a 10% diminishment in speed brings about a surmised 27% lessening in shaft power requirements. Be that as it may, a ship cruising 10% slower would utilize around 11% more opportunity to cover a specific separation. On the off chance that this is considered, another general guideline can be drafted expressing that per ton mile, there is a quadratic connection amongst speed and fuel utilization, so that a 10% decline in speed would bring about a 19% decrease in fuel utilization. Utilizing this information, we touch base at the connection between ship speed, motor load and fuel utilization, given in table 3.

Table 3. Relation between ship speed, engine load and fuel consumption.

Speed (% of design speed)	Engine power (% of MCR)	Fuel consumption
100%	75%	100%
90%	55%	81%
80%	38%	64%
70%	26%	49%

The possibility to lessen speed is restricted. Engines can't be worked at any load without adjustment in accordance with the engine. The minimum load relies on upon the specialized detail of the maker for every individual engine. From a specialized perspective, a ship working on moderate steaming is most presumably working at supposed off design conditions. Cruising at off-outline conditions may in a few conditions cause engine harm. Electronically controlled engines are more adaptable to work at off design and can for the most part be worked at lower loads than mechanically controlled engines.

- **Applicability:** Subject to the imperatives as to cruising in off-plan conditions, moderate steaming can be connected by all ship type and size classifications. Ships that need to keep up a course/time plan, for instance, voyage vessels and ships, will presumably not make utilization of this measure.

- Technical development: Slow steaming is presently actualized by many delivery organizations confronting high fuel expenses and low transport request. It can in this way be viewed as an, in fact, develop choice.

4.2. Autopilot adjustment

Modifying the autopilot to the course and the operation area anticipates superfluous utilization of the rudder for keeping the ship on course.

- Power utilization diminishment potential: 0.5-3%. In any case, a noteworthy segment of the world's fleet as of now utilizes this innovation. Hence, the genuine decrease potential is much lower.
- Payback time: short.

4.3. Main engine tuning

In main engine turning, the most ordinarily utilized load ranges must be resolved and after that, the main engine is streamlined for operation at that load. This measure requires an alternate engine mapping and involves changes in cam profiles and injection timing. This measure can lessen general fuel consumption, despite the fact that there might be a fuel utilize punishment under occasionally utilized full load operations.

- Applicability: All sorts of ships aside from ship and voyage.
- Technical development: accessible available.
- Reduction potential: 0.1-0.8%.
- Payback time: short.

4.4. Waste Heat Recover

Waste heat is heat, which is created in a procedure by a method for fuel burning or chemical response, and then "dumped" into nature despite the fact that it could, in any case, be reused for some helpful and financial reason. The basic nature of heat is not the sum but instead its "value". The system of how to recuperate this heat depends partially on the temperature of the waste heat fluid and the financial matters included. An extensive amount of hot flue gasses is created from boilers, ovens, stoves and heaters. On the off chance that a specific measure of this waste heat could be recouped, a lot of essential fuel could be spared.

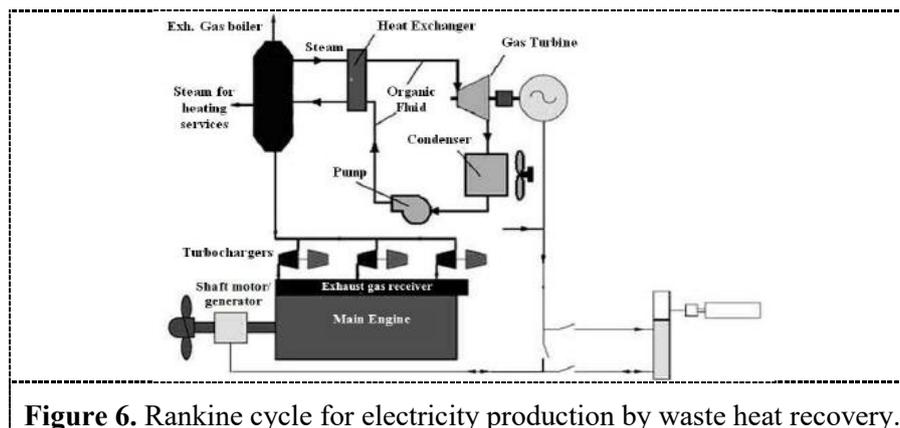


Figure 6. Rankine cycle for electricity production by waste heat recovery.

With a waste heat recovery (WHR) system, the waste heat of the engines can be utilized to cover heat loads, and, if adequate heat is recoverable, to drive turbines for power generation, prompting to less fuel utilization by the diesel generators.

- Applicability: A WHR system is sensibly connected to ships with a high creation of waste heat and a high utilization of power.
- Technical development: accessible available.

- Power utilization diminishment potential: As to the discharge lessening potential, diverse numbers can be found in the writing. For higher yield engines Wärtsilä surveys a high efficiency WHR plant to have the capacity to recoup up to around 12% of the engine shaft control. At the point when the efficiency of an engine is enhanced or speed is decreased, less waste heat is released, prompting to lower reduction potential.

4.5. Wind Power

With a kite that is joined to the bow of a ship, the wind can be utilized to substitute force of the ship engines.

- Applicability: Can be utilized on vessels with a minimum length of 30 m and works best on vessels with a normal speed no higher than 16 knots. Because of this speed limitation, just tankers (crude oil, product, chemical, LPG, LNG, other) and bulk carriers are considered as potential clients. The framework can be retrofitted.
- Technical development: Until now, kites that have a region of up to 640 m² for cargo vessels, fishing trawlers and yachts are accessible. At this point, kite frameworks have been introduced to few business ships (multipurpose cargo vessel and fishing trawler). All vessels are outfitted with a 160 m² kite. Kites up to a zone of 5,000 m² are arranged. For the computation of the cost efficiency and the most extreme reduction capability of a towing kite, we accept that by 2030 kites up to 5,000 m² will be accessible in the market.
- Power utilization decrease potential: It is hard to decide the potential diminishment of the fuel utilization of a towing kite, since the potential does not just rely on upon the range of a kite connected, additionally on the highway a vessel takes and the particular climate conditions. In table 4, the motor comparable forces we utilized for the diverse kite sizes are given. These numbers hold under standard conditions.

Table 4. Engine equivalent powers we used for the different kite sizes.

Kite area (m ²)	Engine equivalent power (kW)
160	600
320	1200
640	2500
1280	4900
2500	9600
5000	19200



Figure 7. Wind Power.

4.6. Solar power

Sun energy can be utilized to convey power for the installed control request. Pertinence: Solar cells must be put on boats that have adequate deck space accessible. In this manner, it is accepted that they can be utilized by tankers, vehicle carriers, and Ro-Ro vessels

- Technical development: Under advancement.
- Power utilization reduction potential: Since speculation expenses are just known from the establishment of sun based cells to a Japanese auto transporter, we accept decreasing potential because of the 40 kW that have been introduced for this situation. This solar-powered controlled car carrier is called M/V Auriga Leader. It highlights 328 sunlight based boards mounted on its top deck. Auriga Leader is a piece of a show project developed by the Port of Long Beach, Toyota and NYK Line, a transportation organization with the central station in Tokyo. Supplanting 40 kW of the auxiliary engines by sun oriented cells, the reduction capability of the sun based cells is inside a scope of 0.2 and 3.75%.
- Costs: For the car carrier Auriga Leader that introduced 40 kW of solar cells the speculation expenses are known to be 1.67 million USD. The cost of sun oriented power may diminish later on when the innovation is developed and connected to vast sizes of boats. A 15% learning rate is connected to catch its impact. This learning rate depends on inland sun oriented power analysis.

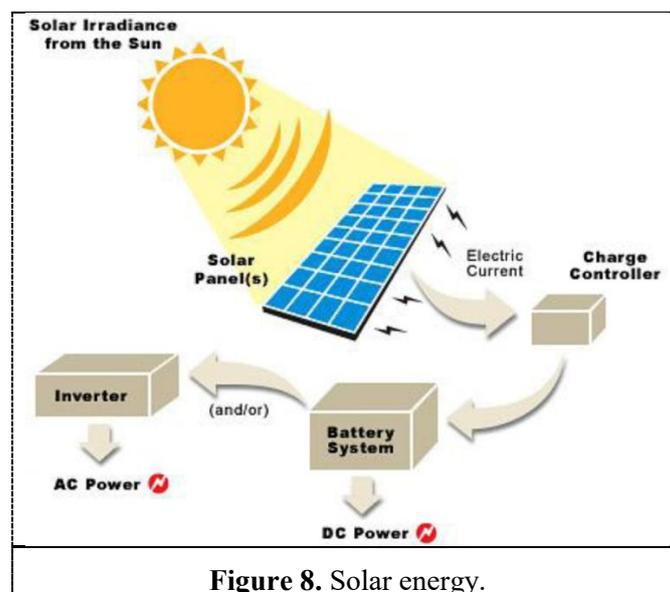


Figure 8. Solar energy.

5. Ship energy efficiency management plan (SEEMP)

A Ship Energy Efficiency Management Plan gives a conceivable way to deal with observing ship and fleet efficiency execution after some time and a few alternatives to be considered when looking to streamline the execution of the ship. The International Maritime Organization (IMO) finished and received Guidance on the Development of a Ship Energy Efficiency Management Plan (SEEMP) under MEPC.1/Circ.683, which gives the system to shipboard energy conservation exercises. The Ship Energy Efficiency Management Plan (SEEMP), being created in agreement with the above system and prerequisites, traces the best practice approach for advancing the vessel's energy efficiency, and gives a particular direction to the execution of energy conservation measures on board the vessel. It advocates estimation and observing procedures for guaranteeing and showing consistence to best practice. The reason for a Ship Energy Efficiency Management Plan (SEEMP) is to build up a component for an organization and additionally a ship to enhance the energy efficiency of a ship's operation.

5.1. MAN Diesel engine management

PMI - Pressure Performance Indicator, means computerized tool that replaces the indicator, used for performance main engine evaluation. The reason for existing is to take after adjustments in the ignition conditions, the general cylinder condition, the general engine condition keeping in mind the end goal to find any operational unsettling influences.

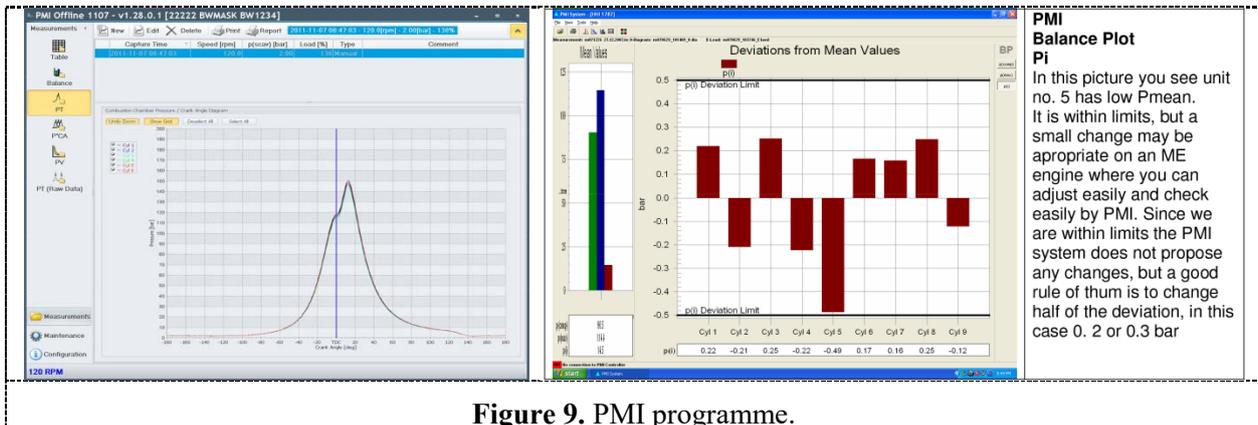


Figure 9. PMI programme.

PMI auto-tuning main characteristics are:

- engine fuel oil consumption (reduction potential +3/kWh, reduction average 1 g/kWh);
- engine emissions (CO2 reduction due to SFOC reduction, carbon particle reduction).

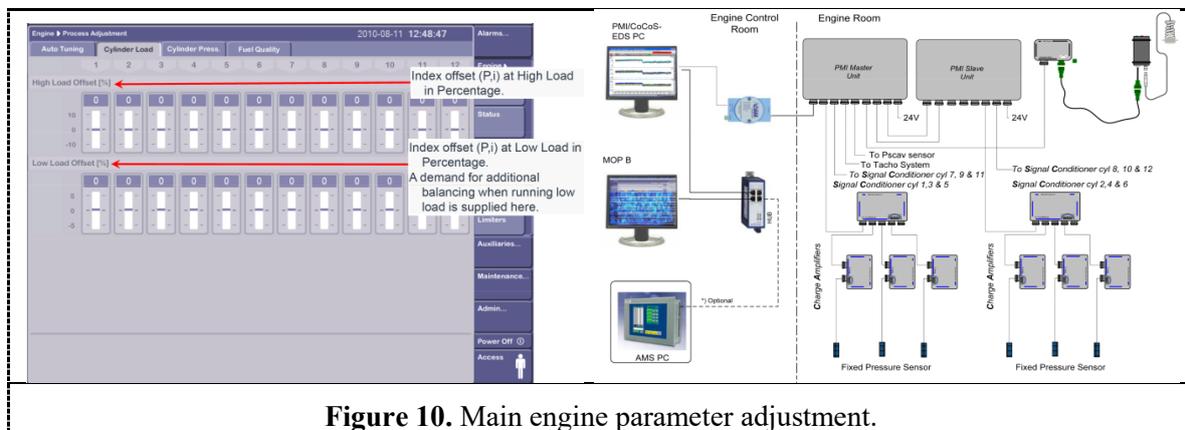
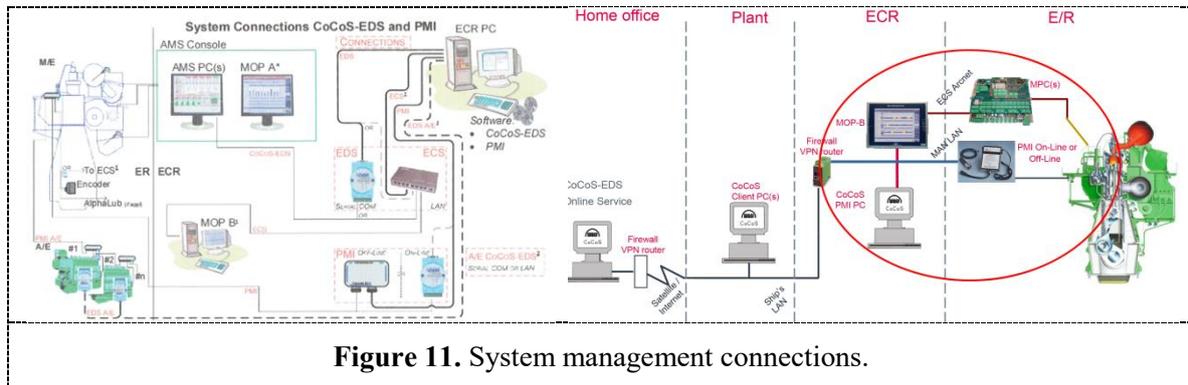


Figure 10. Main engine parameter adjustment.

CoCoS – EDS System (command and control surveillance engine diagnosis system) acts as interpretation and monitoring data available to the operator at all times. The four main features and roles performed by this program are as follows:

- acquisition, display and data entry.
- monitoring.
- diagnosis.
- conducting graphics performance.



In figure 11, we have main components:

- AMS – alarm monitoring system.
- ECS – engine control system.
- MOP – main operating panel.
- ER – engine room.
- ECR – engine control room.
- ME – main engine.
- AE – auxiliary engine.
- PMI – pressure measure instrumentations.
- CoCoS – computer controlled surveillance.

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