Power Consumption

Resistance and Load
Prof. J. B. Jensen

Source: MAN Energy solutions – Marine Engines and Systems, *Basic Principles of Propulsion*

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Learning outcome

- By the end of this session, you should be able to:
  - Explain hull resistance
  - Know what affects resistances and power consumption
  - Explain the propulsion chain efficiency and how it can be improved
  - Discuss the power consumption of auxiliary equipment and hotel load.

- The above criteria must be fulfilled along with criteria in Power consumption and Energy efficiency awareness lessons to:
- *Operate vessels commercially and energy efficiently, in accordance with environmental regulations.*

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Content

- Hull resistance
- Propulsion chain efficiency
- Auxiliary and hotel load

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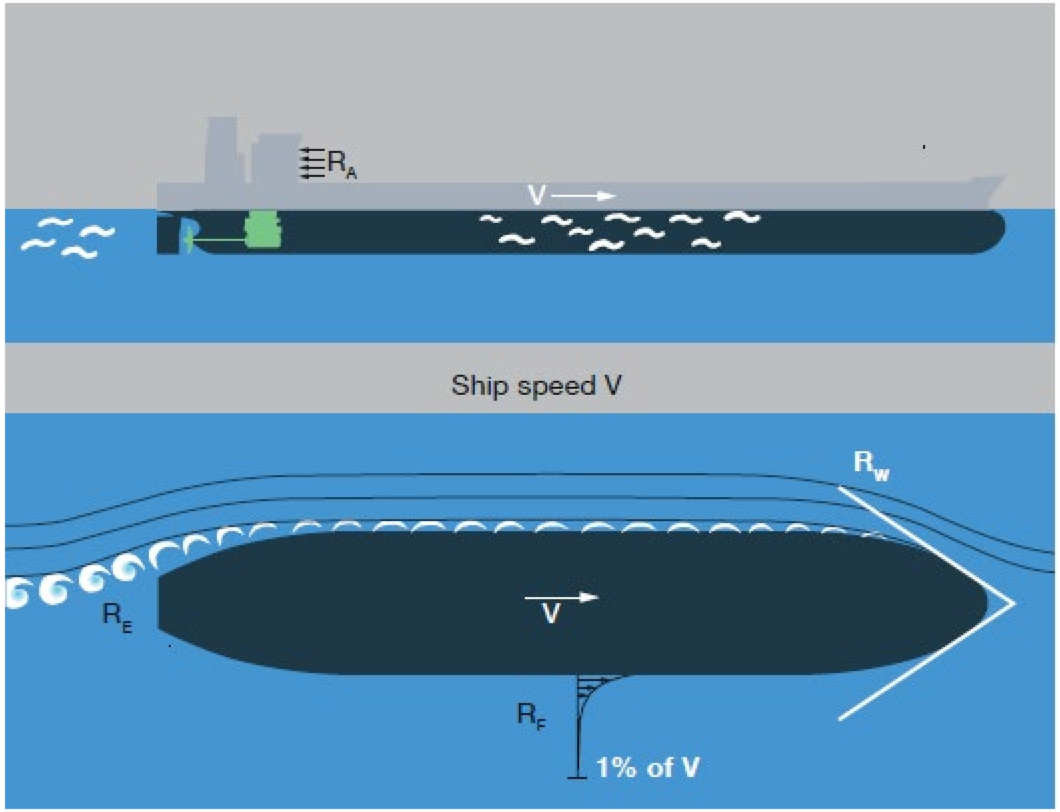
Total Resistance R_T

- Frictional Resistance (R_F)
- Residual Resistance (R_R)
  - Eddy Resistance (R_E)
  - Wave Resistance (R_W)
- Air Resistance (R_A)



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Frictional Resistance (R_F)

- Depends on the wetted surface
- Depends on surface conditions (paint, marine growth etc.)
- For slow moving vessels (Tankers, Bulk Carriers, etc.) frictional resistance can be 70%-90% of the total.
- For faster moving vessels it can be as little as 50% of the total

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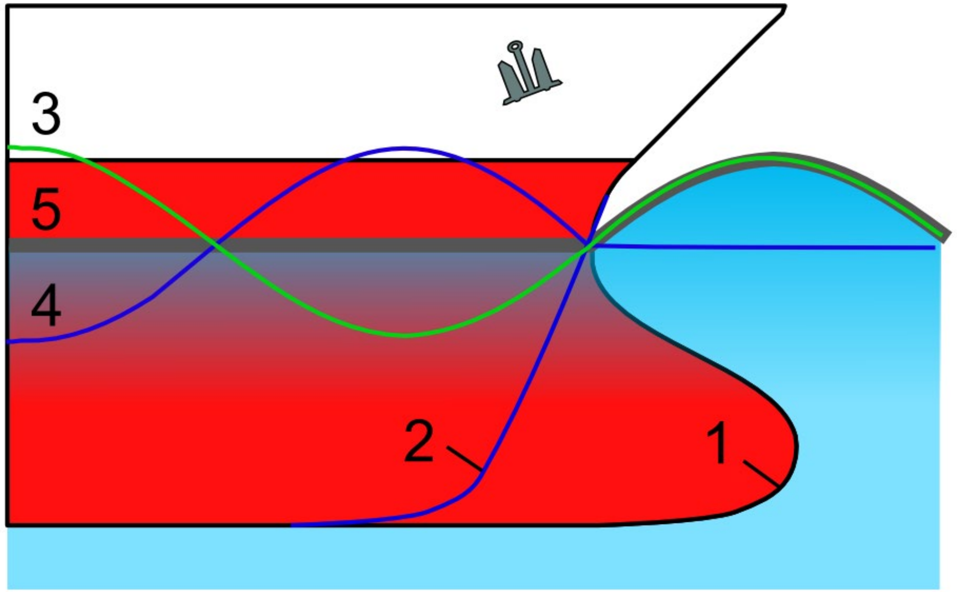
Residual Resistance (R_R)

- Residual resistance is resistance caused by the creation of eddies and waves. Eddies can be reduced by the hull shape, especially at the stern. Waves can be reduced by bulbous bow.



Source: https://en.wikipedia.org/wiki/Bulbous_bow

Source: https://www.britannica.com/science/turbulent-flow

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Air Resistance (R_A)

- Air resistance is usually only around 2% but can be as high as 10% for ships with a large wind area.

Source: https://www.mirror.co.uk/lifestyle/travel/venice-cruise-st-marks-square-2705417

Source: https://www.rivieramm.com/news-content-hub/news-content-hub/msc-guumllsuumln-a-lsquotextbookrsquo-example-of-cargo-handling-system-collaboration-56349

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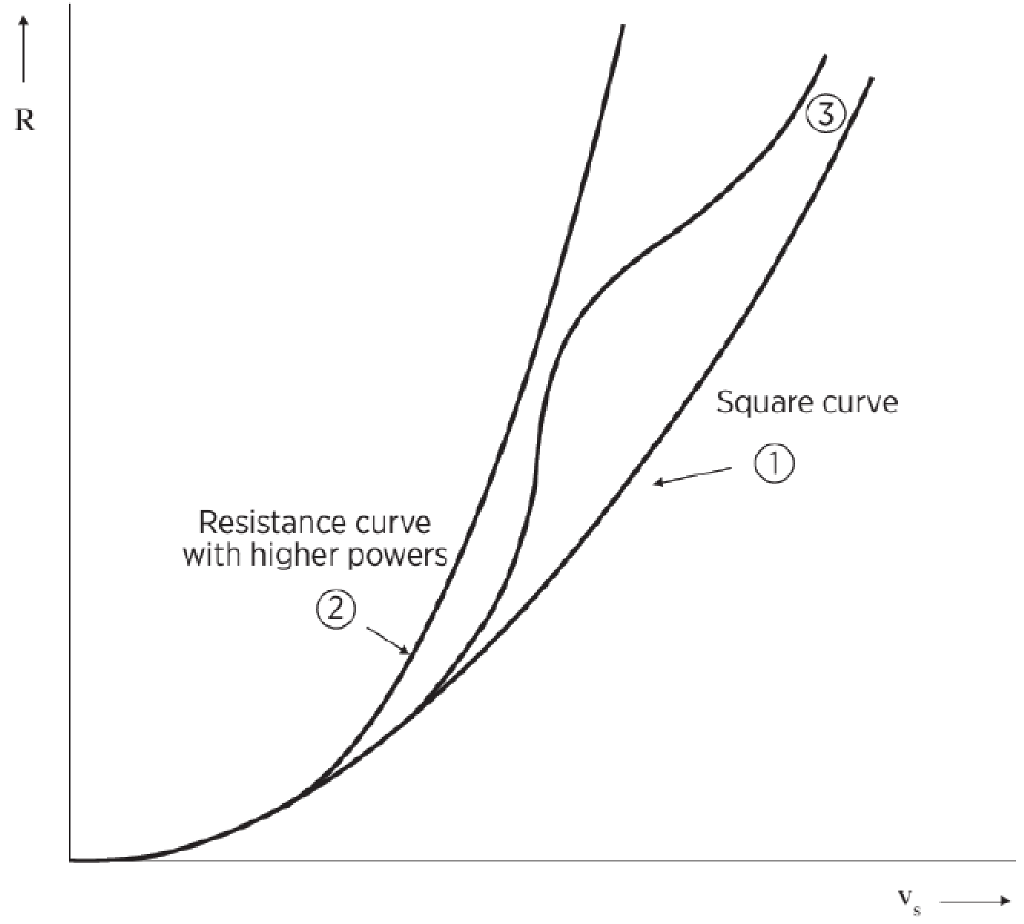
Hull Resistance

- The ship's resistance is roughly square to the ships speed (1)
- For higher speeds the curve may be steeper (2)
- For planing craft, twin hull or other misc. hull shapes the curve be more complex (3)



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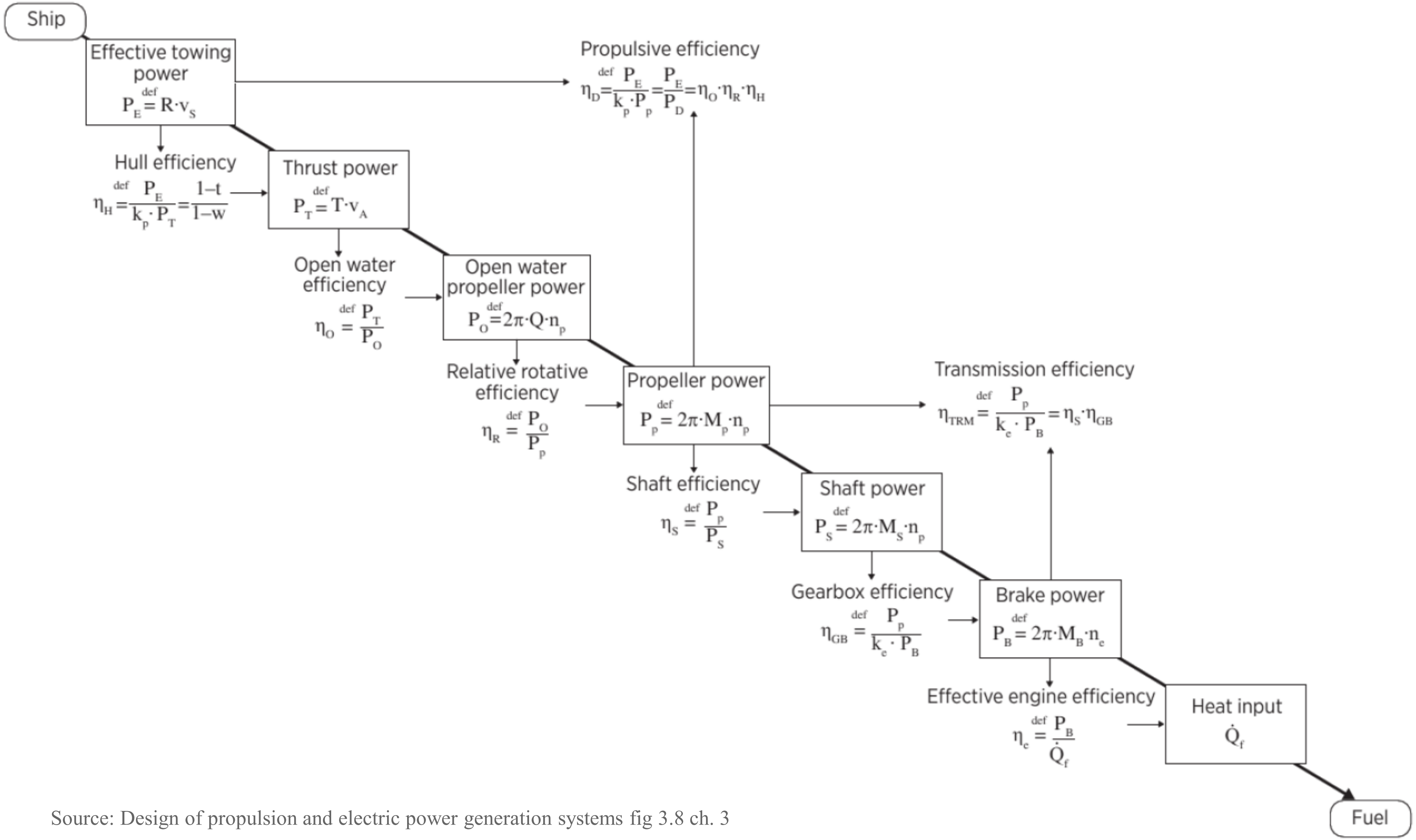
Propulsion chain efficiency



Source: Design of propulsion and electric power generation systems fig 3.8 ch. 3

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Summary for propulsion

- Hull efficiency
- Open water propeller efficiency
- Relative rotative efficiency

Improve these

- Hull Resistance
  - Frictional resistance
  - Wave resistance
  - Form resistance
- Air Resistance

Residual Resistance (Wave resistance, Form resistance)

Lower these

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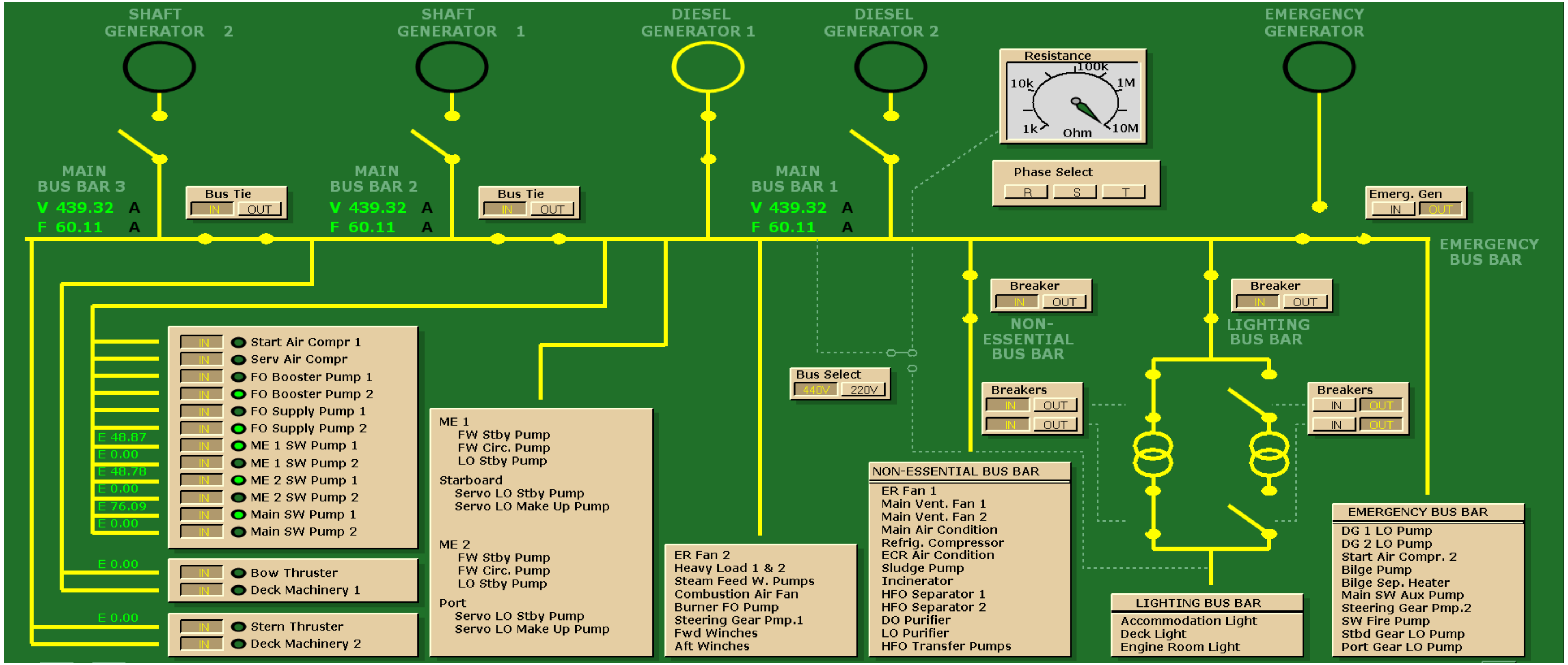
Auxiliary and Hotel loads



Source: Kongsberg MC90 simulator

Reduce load

- Effective pumps/electric motors
- Frequency converters
- Crew behavior and attitude

Source: http://www.iesco.ge/eng/products/?category_id=61

http://waterpumpstech.com/1-2-4-centrifugal-pump/189617/

Hull Resistance Exercise

Bulkcarrier data:

Deadweight: 156,300 metric ton
Displacement Δ: 179,250 metric ton
Design speed: 15.0 knots
Hull resistance at design speed: 1,429.3 kN
Specific delivered power coefficient C_D: 0.0125

Basic data:

Density seawater ρ = 1,025 kg/m^3
1 knot = 1,852 m/h

- Calculate:

a) Effective (towing) power P_E (11,029 kW)

b) Power delivered to propeller P_D (18,411 kW)

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Propulsion Chain Exercise

Following data is given for the propulsion chain:

Ship speed v_S = 20 knot
Engine/propeller speed $n_E = n_p$ = 180 (propeller directly coupled to propulsion engine)
Engine brake power P_B = 15,000 kW
Effective power P_E = 10,000 kW
Shaft efficiency η_S = 0.97
Hull efficiency η_H = 1.10
Relative rotative efficiency η_R = 1.05

Wake factor $w = \frac{v_S - v_A}{v_S} = 0.2 \quad (v_A = \text{advance velocity})$

- Calculate delivered power (P_D), total propulsive efficiency (η_D) and open water efficiency (η_O), thrust force (T), open water torque (Q) and shaft torque delivered to propeller (M_P) (14,550 kW, 0.687, 0.595, 1,104 kN, 810,221 Nm and 771,901 Nm)

Thank you

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