Powering predictions from Propulsion tests

- Obtain reliable predictions of speed, power, prop rotation rate

- Obtain an analysis of ship's powering performance, including proper propeller, hull interaction: $\eta_D = \eta_o \eta_h$

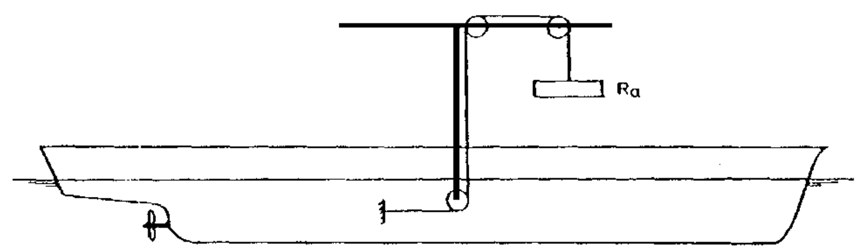
- In conjuction with a resistance test and open water test, interaction parameters are obtained for statistical use: t, w_T, η_R.

Propulsion test procedure

- Froude scaling
- In order to model the propeller working point and the propeller-hull interaction effects correctly, an additional tow force needs to be applied to overcome the excessive viscous drag on model scale

$$\Delta C_D = C_{tm} - C_{ts} = (1+k)\{C_f(R_{nm}) - C_f(R_{ns})\} - C_a$$

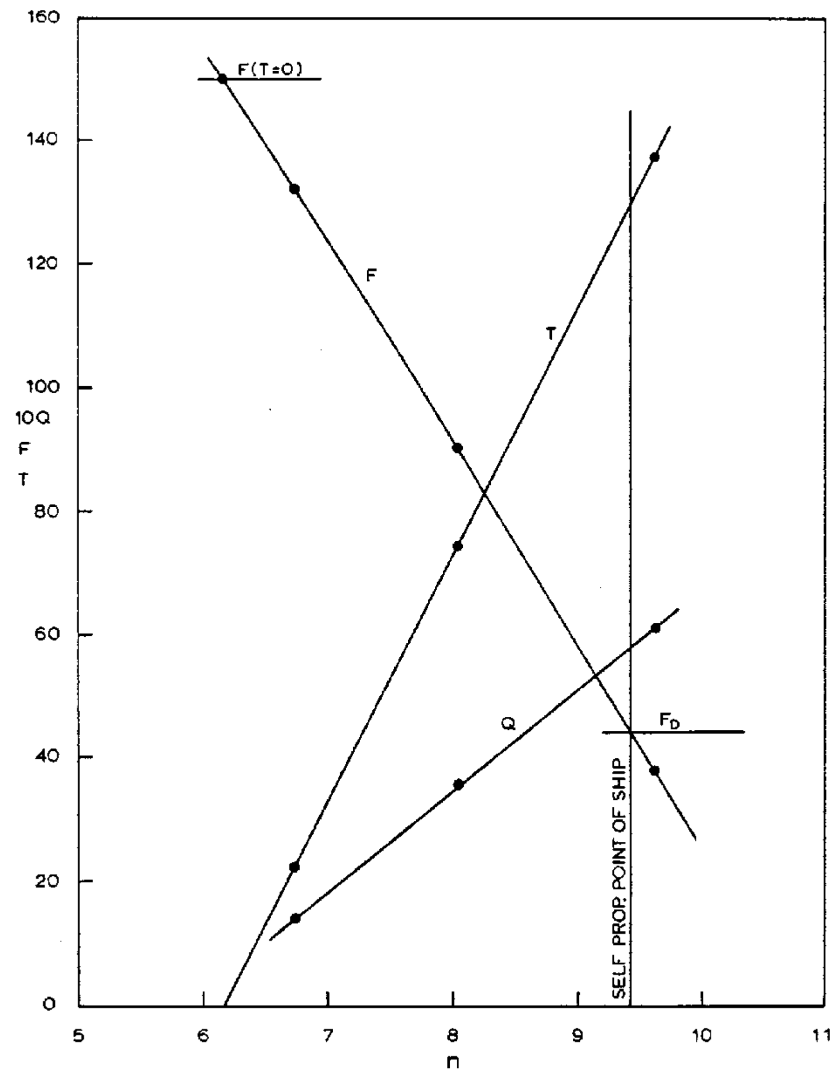
- Free running tests
- Captive tests



Result from Captive test:
over– / underloading for 1 model speed V_m

<u>*Characteristic points*</u>

- Self propulsion point ship ($T_m = T_S$, F_D)
- Self propulsion point model (T_m, $F_D=0$)
- Zero thrust point ($T_m=0$, F_D)

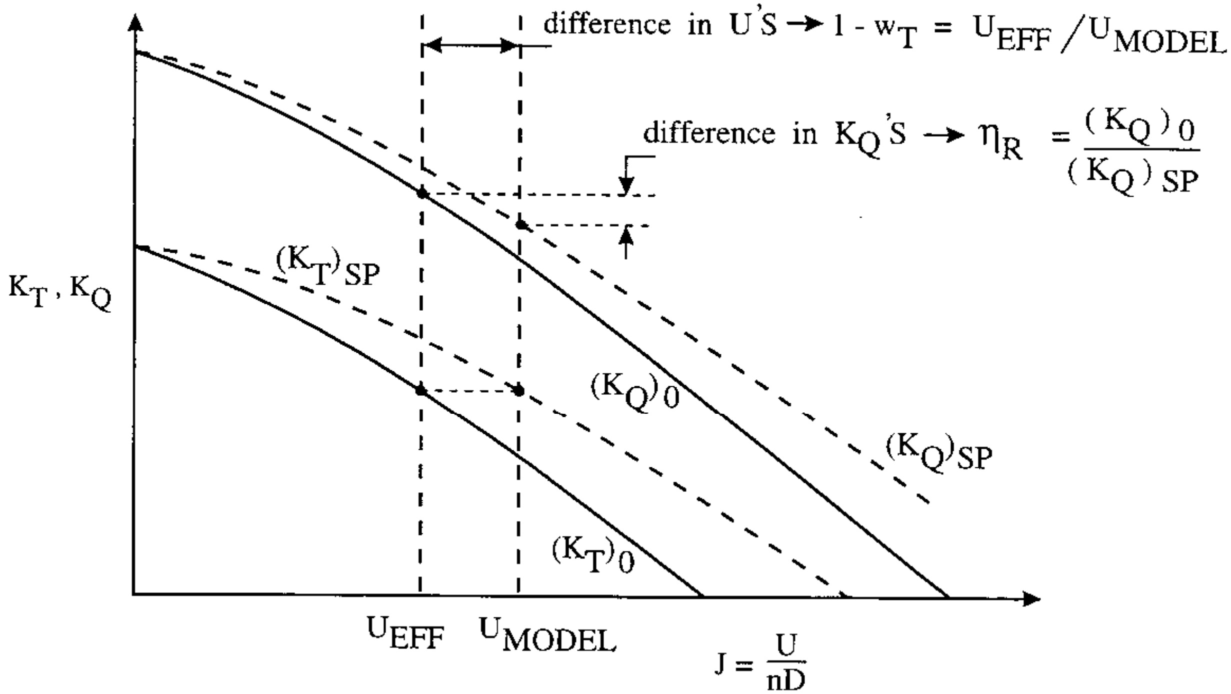


Determination of power-speed-rpm for ship

- Starting point: Propulsion tests are Froude scaled with correctly scaled propeller working point C_T(demand), J
- Propeller rotation rate would follow from J identity: $J_S=J_M$, if no scale effects would be present in wake fraction w_T.
- Interaction factor t follows from $T(1-t)=R$
- Other interaction factors w_{Tm} and η_R follow from combining prop. test results with open water diagram (model scale). Taylor wake fraction needs to be corrected for scale effects.
- Power-speed-rpm relation for ship follows from scaled interaction factors and scaled open water diagram: C_{Ts} and w_{Ts} are known!

Determination propeller–hull interaction

Newman [1989]



K_T = thrust coëfficient

K_Q = torque coëfficient

Subscripts

0 = open water condition

SP = self propelled condition

Extrapolation of Interaction effects

- The thrust deduction t is assumed free of scale effects
- The relative rotative efficiency η_R is assumed free of scale effects
- Taylor wake fraction scales with viscous drag

$$\frac{w_s - t - 0.04}{w_m - t - 0.04} = \frac{(1+k)C_{fs} + C_a}{(1+k)C_{fm}}$$

Extrapolation of open water diagram

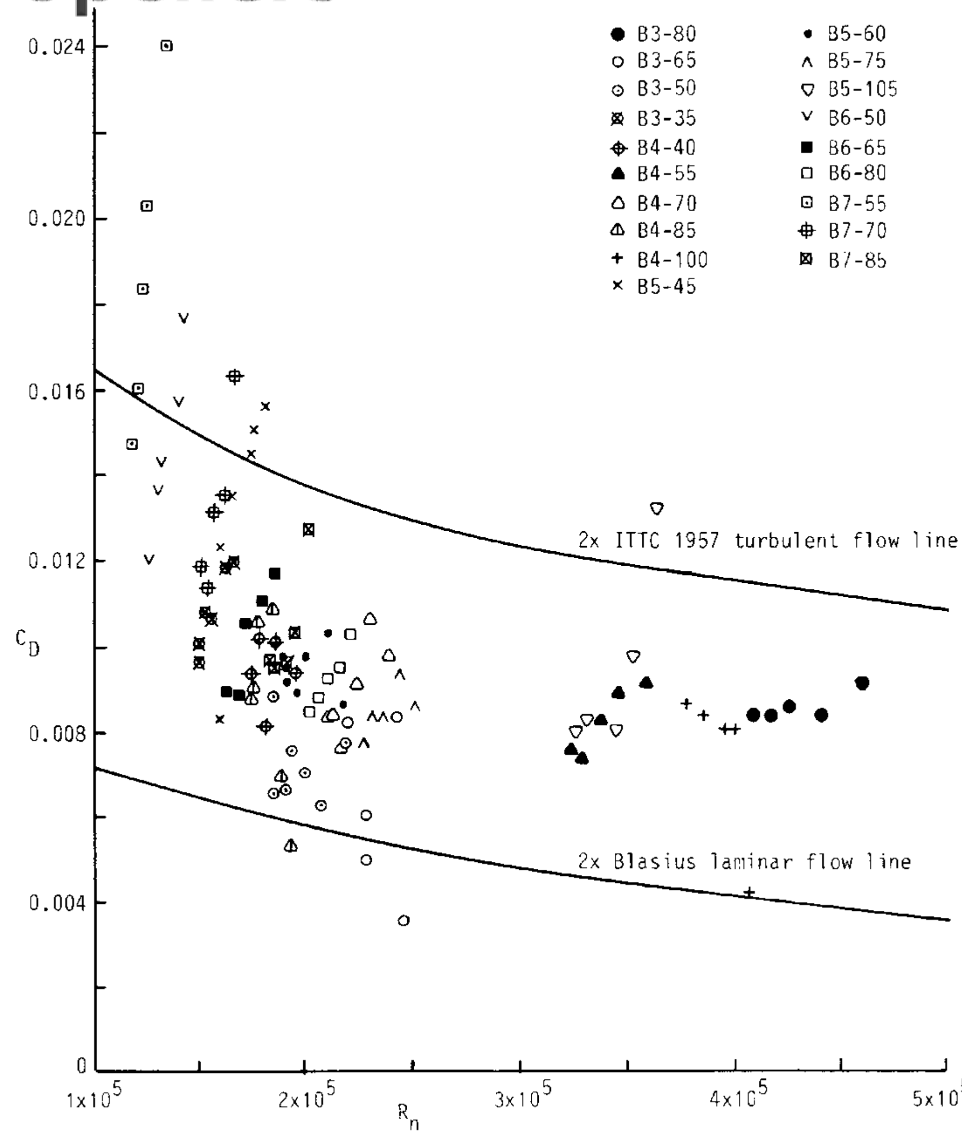
- Consideration of viscous scale effects on equivalent prop blade profile @ 0.75R
- Corrections on viscous drag only (thus not on lift), affect thrust and torque.
- Empirical relation for scaling K_T and K_Q by ITTC 1969

$$\Delta K_T = K_{Ts} - K_{Tm} = 0.28 \Delta C_{Deq} \frac{P}{D} \frac{cZ}{D}$$

$$\Delta K_Q = K_{Qs} - K_{Qm} = -0.248 \Delta C_{Deq} \frac{cZ}{D}$$

- Extrapolation is now reduced to determination of scale effect in C_{Deq}

Eq. Drag coefficients of B-series propellers



Closing remarks

- Service margin
  - A service margin on power also affects the propeller rpm
- Optimisation of propeller-hull design
  - for efficiency and exhaust discharge