Advanced Propulsion System
GEM 423E

Week 8: Prediction of Power at Preliminary Design Stage

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Prediction of Power at Preliminary Design Stage

Objective

The method is appropriate to large ocean-going vessels with modern slow speed direct drive diesel engines.

Ship owner will require that ship will achieve and average speed in service, $V_{SERVICE}$, at a certain engine power.

Initial acceptance will be basis of demonstration of a higher speed on trial, V_{TRIAL} ,at same power.

- i.e.

$$V_{TRIAL} = V_{SERVICE} + \delta V$$
$$\text{where } \delta V \cong 1 \text{knot}$$

- The contract will state that ship should achieve V_{TRIAL} with engine developing, say, 85% of its <u>M</u>aximum <u>C</u>ontinous Power or <u>R</u>ating (MCR).
- Under the above circumstances:

1. Resistance & Power Estimation

- Estimate resistance and P_E for range of speed (covering $V_{SERVICE}$ and V_{TRIAL}) using appropriate “Methodical Series” data or “Statistical Analysis” data

$$P_E \ : \text{Methodical series or else}$$
$$P_{E_{TRIAL}} = (1+x)P_E$$
$$P_{E_{SERVICE}} = 1.2P_{E_{TRIAL}} \ :(\text{Based upon 20\% "sea margin"})$$

- Where for trial

$$(1+x)_{FROUDE} = \left(0.44 + 2.229L^{-1/4} + 10.058L^{-1}\right) / 1.20$$
$$(1+x): \text{The correlation or power prediction factor}$$

- The curves $P_{E_{TRIAL}}$ and $P_{E_{SERVICE}}$ versus speed is plotted

2. Design of Suitable Propeller and Engine Selection

- Assuming that the maximum permissible propeller diameter, D=0.6T and using the charts [B_p-δ] , [K_T-K_Q-J] or computer programme determine the optimum propeller and engine speed corresponding to the trial conditions, the required maximum continuous power and the mean face pitch of the propeller.

- Select an appropriate engine from the machinery leaflets provided.

- For propeller-hull interaction coefficients it might be used the following semi-empirical relationships given by Andersen&Guldhammer.
- Wake Fraction — Thrust Deduction — Rel. Eff.

Wake Fraction

$$w = w_1 + w_2$$
$$w_1 = a + \frac{b}{\left[c\left(0.98 - C_B\right)^3 + 1\right]}$$
$$w_2 = -0.18 + \frac{0.00756}{\left[D/L + 0.002\right]}$$
$$a = 0.1\frac{B}{L} + 0.149$$
$$b = 0.05\frac{B}{L} + 0.449$$
$$c = 585 - 5027\frac{B}{L} + 11700\left(\frac{B}{L}\right)^2$$

Thrust Deduction

$$t = t_1 + t_2$$
$$t_1 = d + \frac{e}{\left[f\left(0.98 - C_B\right)^3 + 1\right]}$$
$$t_2 = 2\left(\frac{D}{L} + 0.004\right)$$
$$d = 0.625\frac{B}{L} + 0.08$$
$$e = 0.165 - 0.25\frac{B}{L}$$
$$f = 825 - 8060\frac{B}{L} + 20300\left(\frac{B}{L}\right)^2$$

Rel. Eff.

$$\eta_R = 1.0$$

3. Prediction of Performance in Service

- Predict the ship speed and propeller rate of rotation in service with the engine developing 85% of the maximum continuous power

4. Determination of the Blade Surface Area and B.A.R.

Assuming that the height of the shaft centreline above the base is given by

$$\left(\frac{D}{2}+0.2\right) or \%60*T \ \ meters$$

use the Burrill cavitation diagram provided to determine the blade surface area and B.A.R.

$$\tau_c = 0.2761\sigma_{0.7R}^{0.625}$$

(approximation equation for "*suggested upper limits of merchant propellers*" of Burrill 's chart)