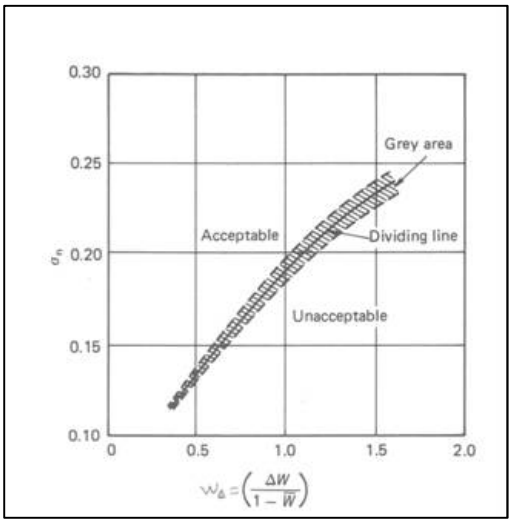
ADVANCED PROPULSION SYSTEM – MID-TERM EXAM
16/12/2011 - 13:30-14:30

1. Asses the quality of the wake given below according to the BMT's wake non-uniformity criteria (w_Δ, σ_{nI}) given in figure 1. (**25 points**)

Given:

D =5.6 m (propeller diameter)
N =104 (number of propeller revolution per minute - RPM)
Z = 4 (number of blades)
Zp = 2.9 m. (shaft height from the base line)
Ta = 6.30 m (Draft at the aft perpendicular)
P_a = 100000 Pa (Atmospheric Pressure)
P_v = 1700 Pa (Vapour Pressure)
ρ = 1025 kg/m^2. (Density of sea water)
g = 9.80665 m/sn^2. (Acceleration of gravity)



$$\sigma_{nI} = \frac{P_a - P_v + P_H}{\frac{1}{2}\rho(\pi nD)^2}$$

P_H = *Hydrostatic pressure at the propeller tip*

$$w_\Delta = \left(\frac{\Delta w}{1 - \overline{w}}\right)_{1.0R}$$

The wake is given in the following table as velocity ratios.

r/R	0.214	0.357	0.500	0.643	0.786	0.929	1.071
Angle							
0	0.194	0.191	0.313	0.390	0.393	0.322	0.311
10	0.218	0.236	0.283	0.345	0.363	0.384	0.406
20	0.239	0.273	0.267	0.312	0.359	0.418	0.475
30	0.254	0.303	0.269	0.309	0.366	0.447	0.526
40	0.260	0.326	0.281	0.323	0.380	0.480	0.565
50	0.260	0.346	0.301	0.355	0.417	0.521	0.596
60	0.260	0.366	0.329	0.402	0.475	0.567	0.620
70	0.265	0.392	0.365	0.453	0.534	0.613	0.652
80	0.273	0.418	0.406	0.501	0.583	0.655	0.680
90	0.280	0.429	0.445	0.548	0.627	0.691	0.720
100	0.287	0.412	0.471	0.596	0.676	0.719	0.755
110	0.294	0.376	0.478	0.635	0.724	0.751	0.770
120	0.297	0.339	0.472	0.655	0.746	0.761	0.801
130	0.290	0.308	0.457	0.653	0.766	0.783	0.815
140	0.271	0.281	0.429	0.634	0.761	0.810	0.830
150	0.242	0.252	0.390	0.606	0.760	0.831	0.860
160	0.212	0.223	0.350	0.570	0.800	0.840	0.880
170	0.187	0.194	0.310	0.511	0.820	0.830	0.902
180	0.140	0.170	0.240	0.418	0.720	0.820	0.920

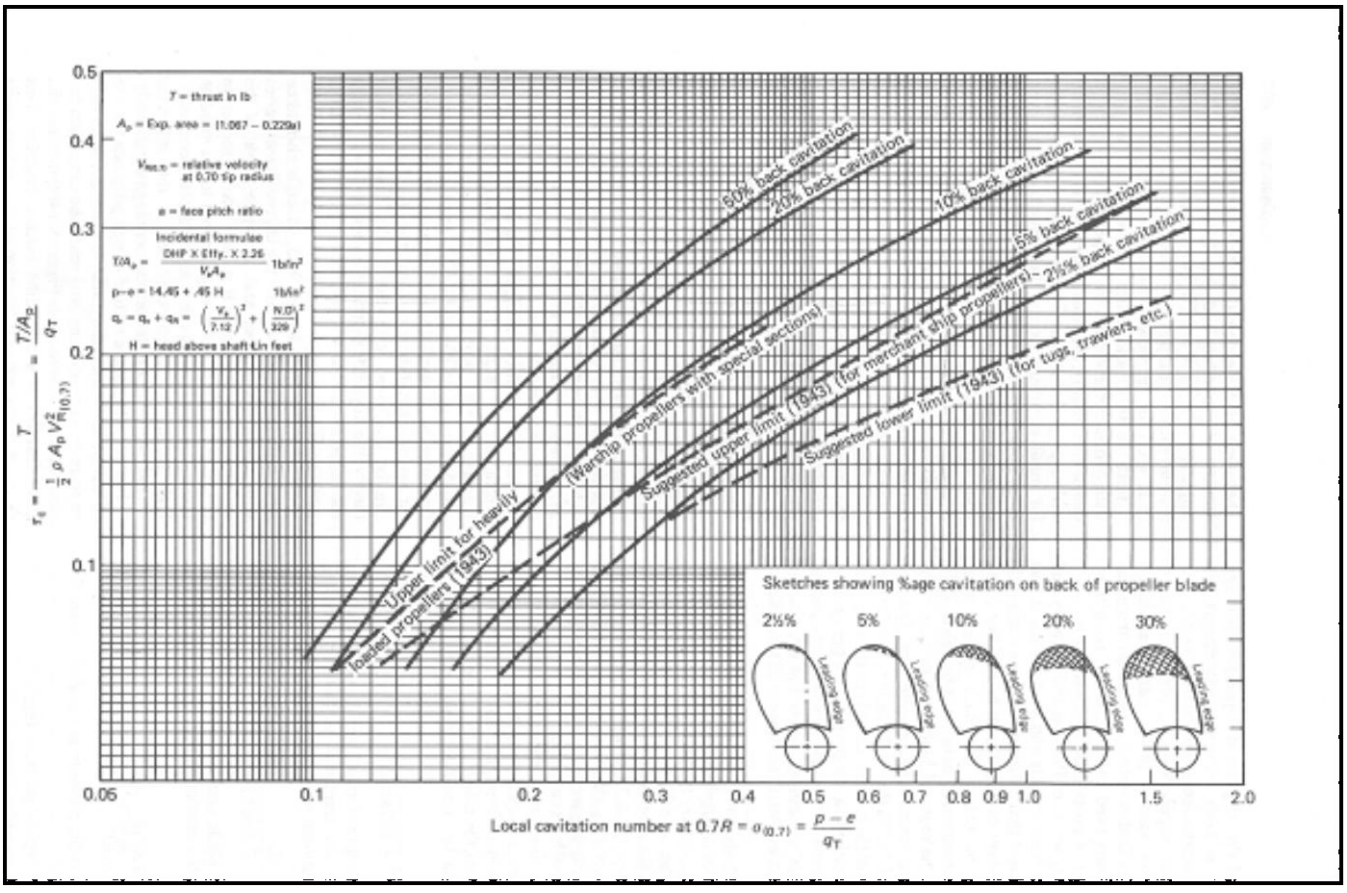
Here 0 – Top dead center – 180 – bottom death center

2. Determine the minimum permissible blade surface area –EAR of the propeller given in question 1, according to the suggested upper limit of merchant propeller at the Burrill's chart. (1**5 Points**)

Additional Data:

V_s = 14.0 knots (ship's speed)
w_t = 0.350 (effective wake fraction)
P/D = 0.825 (mean pitch ratio of the propeller)
P_d = 5000 kW (delivered power)
η_0 = 0.553 (open water efficiency)
$q_T = (11.66\ V_a)^2 + (0.828ND)^2$
$p_0 - e = 99629 + 10179H$ (H is the shaft immersion)
$\sigma_R = (p - e) / q_T$ (Cavitation number at 0.7R of propeller)
$T/A_P = \tau_c * q_T$

$$A_P = \frac{P_D \eta_0 1941.3}{V_a \dfrac{T}{A_P}} \left(m^2\right) \qquad A_D = \frac{A_P}{\left(1.067 - 0.229 P/D\right)} \left(m^2\right)$$



Good Luck! Dr. Ali Can Takinacı

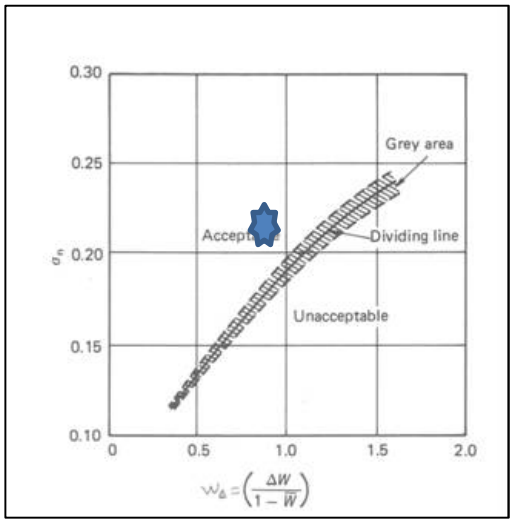
SOLUTION

1. **a)** First calculate the parameter σ_{NI},

$$\sigma_{nI} = \frac{100000 - 1700 + 9.80665 \times 1025 \times \left(6.30 - \frac{5.6}{2} - 2.9\right)}{\frac{1}{2} \times 1025 \times \left(\pi \times \frac{104}{60} \times 5.6\right)^2} = \frac{104331}{476577} = 0.219$$

Second calculate the wake parameter

$$w_\Delta = \left(\frac{\Delta w}{1 - \bar{w}}\right)_{1.0R} = \left(\frac{0.701 - 0.152}{1 - 0.331}\right)_{1.0R} = \frac{0.549}{0.669} = 0.82$$



2.

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.............. GIVEN.....................
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DELVERED POWER ..............Pd =  5000.00 kW
PROPELLER RPM ..............N =  104.000 R.P.M.
INFLOW VELOCITY ..............Va =    9.100 Knots
          "                    (   4.681 m/sn)
PROPELLER DIAMETER .. ....D =    5.600 m.
PITCH TO DIAMETER RATIO.P/D =     .825
OPEN WATER EFFICIENCY  Eta0 =     .553
SHAFT IMMERSION ..............Hs =    3.400 m.
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.............. OUTPUT ....................
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.................qT =  243801.5 N/m2
................p0-e =  134237.6 N/m2
.............Sigma_R =  .551
..............Tau_C =  .193
................Vtip =  30.5 m/sn (< 30 m/sn)
...PROJECTION AREA ….Ap = 12.528 m2
......DEVELOPED AREA Ad = 14.268 m2
..........DISC AREA A0 = 24.630 m2
.AREA RATIO - ……..Ae/A0 = 0.579 (Upper limit)
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