

# ADVANCED PROPULSION SYSTEM – MID-TERM EXAM

25/11/2005 - 14:00-15:00

1. Asses the quality of the wake given below according to the BMT's wake non-uniformity criteria ( $w_\Delta$ ,  $\sigma_{nl}$ ) given in figure 1. (20 Points)

**Given:**

$D = 4.8$  m (propeller diameter)

$N = 125$  (number of propeller revolution per minute - RPM)

$Z = 4$  (number of blades)

$Z_p = 2.6$  m. (shaft height from the base line)

$T_a = 7.98$  m (Draft at the aft perpendicular)

$P_a = 100000$  Pa (Atmospheric Pressure)

$P_v = 1700$  Pa (Vapour Pressure)

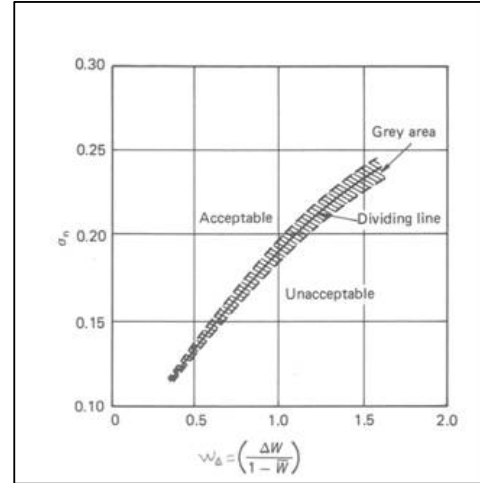
$\rho = 1025$  kg/m<sup>3</sup>. (Density of sea water)

$g = 9.80665$  m/sn<sup>2</sup>. (Acceleration of gravity)

$$\sigma_{nl} = \frac{P_a - P_v + P_H}{\frac{1}{2} \rho (\pi n D)^2}$$

$P_H$  = Hydrostatic pressure at the propeller tip

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



The wake is given in the following table.

| ANGLE | Wake Fraction - w |       |       |       |       |       |       |       |
|-------|-------------------|-------|-------|-------|-------|-------|-------|-------|
| 0     | 0.986             | 0.908 | 0.863 | 0.860 | 0.880 | 0.920 | 0.964 | 0.990 |
| 10    | 0.978             | 0.860 | 0.851 | 0.860 | 0.946 | 0.933 | 0.949 | 0.950 |
| 20    | 0.976             | 0.860 | 0.860 | 0.871 | 0.958 | 0.920 | 0.923 | 0.913 |
| 30    | 0.986             | 0.934 | 0.876 | 0.876 | 0.888 | 0.893 | 0.855 | 0.802 |
| 40    | 0.990             | 0.944 | 0.794 | 0.753 | 0.770 | 0.795 | 0.737 | 0.660 |
| 50    | 0.988             | 0.907 | 0.764 | 0.691 | 0.650 | 0.636 | 0.585 | 0.523 |
| 60    | 0.962             | 0.815 | 0.689 | 0.596 | 0.530 | 0.468 | 0.431 | 0.404 |
| 70    | 0.954             | 0.746 | 0.617 | 0.513 | 0.422 | 0.333 | 0.305 | 0.308 |
| 80    | 0.950             | 0.689 | 0.556 | 0.445 | 0.336 | 0.243 | 0.219 | 0.238 |
| 90    | 0.951             | 0.626 | 0.495 | 0.380 | 0.271 | 0.189 | 0.168 | 0.191 |
| 100   | 0.954             | 0.576 | 0.426 | 0.310 | 0.218 | 0.154 | 0.140 | 0.160 |
| 110   | 0.963             | 0.542 | 0.360 | 0.244 | 0.172 | 0.132 | 0.123 | 0.140 |
| 120   | 0.980             | 0.531 | 0.321 | 0.205 | 0.138 | 0.120 | 0.111 | 0.123 |
| 130   | 0.986             | 0.535 | 0.326 | 0.204 | 0.127 | 0.118 | 0.103 | 0.110 |
| 140   | 0.988             | 0.546 | 0.352 | 0.222 | 0.139 | 0.116 | 0.097 | 0.101 |
| 150   | 0.985             | 0.570 | 0.354 | 0.224 | 0.158 | 0.112 | 0.093 | 0.096 |
| 160   | 0.985             | 0.615 | 0.344 | 0.221 | 0.174 | 0.120 | 0.097 | 0.092 |
| 170   | 0.984             | 0.648 | 0.438 | 0.316 | 0.239 | 0.188 | 0.137 | 0.091 |
| 180   | 0.990             | 0.733 | 0.567 | 0.471 | 0.409 | 0.364 | 0.232 | 0.076 |
| r/R   | 0.305             | 0.407 | 0.508 | 0.610 | 0.712 | 0.813 | 0.915 | 1.017 |

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

Good Luck!

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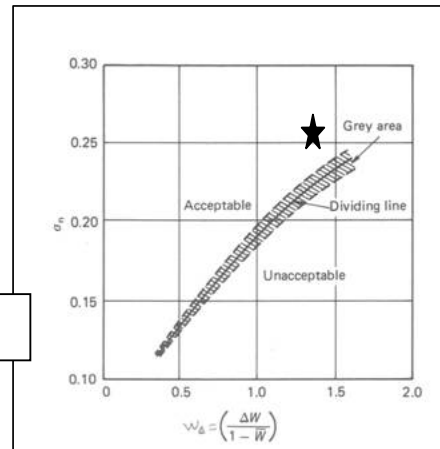
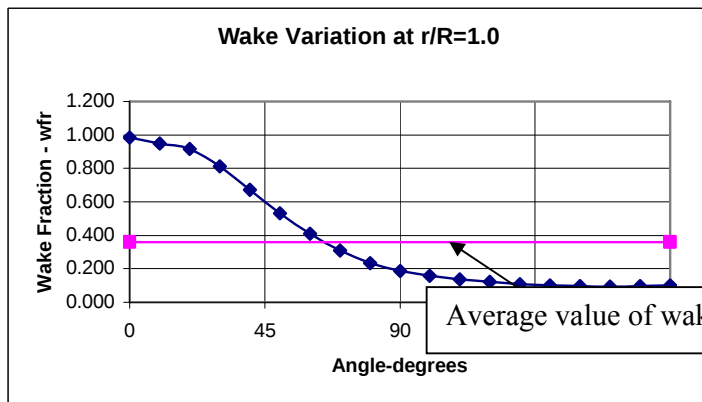
## SOLUTION

1. a) First calculate the parameter  $\sigma_{NI}$ ,

$$\sigma_{nl} = \frac{100000 - 1700 + 9.80665 \times 1025 \times \left(7.98 - \frac{4.8}{2} - 2.6\right)}{\frac{1}{2} \times 1025 \times \left(\pi \times \frac{125}{60} \times 4.8\right)^2} = \frac{128254.4124}{505817.2256} = 0.2535$$

Second calculate the wake parameter

$$w_{\Delta} = \left( \frac{\Delta w}{1 - \bar{w}} \right)_{1.0R} = \left( \frac{0.986 - 0.093}{1 - 0.359} \right)_{1.0R} = \frac{0.893}{0.641} = 1.393$$



| w     | SM | Mult  |
|-------|----|-------|
| 0.986 | 1  | 0.986 |
| 0.950 | 4  | 3.799 |
| 0.915 | 2  | 1.829 |
| 0.811 | 4  | 3.243 |
| 0.673 | 2  | 1.346 |
| 0.533 | 4  | 2.133 |
| 0.409 | 2  | 0.817 |
| 0.308 | 4  | 1.230 |
| 0.235 | 2  | 0.470 |
| 0.187 | 4  | 0.749 |
| 0.157 | 2  | 0.313 |
| 0.137 | 4  | 0.549 |
| 0.121 | 2  | 0.242 |
| 0.109 | 4  | 0.435 |
| 0.100 | 2  | 0.201 |
| 0.096 | 4  | 0.382 |
| 0.093 | 2  | 0.186 |
| 0.099 | 4  | 0.395 |
| 0.102 | 1  | 0.102 |

Sum= 19.406

Area= 1.129

Mean = 0.359