Propulsion & Resistance 1 – lecture 3

Mt 527

- 1. Flow around the hull and viscous drag
- 2. Experimental resistance prediction
- 3. Empirical resistance prediction



Example exam question

- What is the rationale behind the 3D extrapolation method
- What are the disadvantages of the 3D extrapolation method.



Decomposition of Resistance

Source: ITTC 1972 Res. Committee





Figure 6.1 Different regions in the flow around the hull.

Development of viscous boundary layer over a body

Development of boundary layer



Non dimensional coefficients

C_f (Re) = Rt / 0.5 ρ U²S is not a constant



Boundary layer characterisation



- BL thickness, δ_{99} is difficult to measure => integral measurements
 - displacement thickness
 - momentum thickness

$$\delta^* = \int_0^\infty \left(1 - \frac{u}{U}\right) dy$$

$$\theta(x) \equiv \int_0^\infty \frac{U(y)}{U_0} \left(1 - \frac{U(y)}{U_0}\right) \, dy$$

Boundary layer development



Flow pattern around a cylinder



Examples



Flow pattern around cylinder





Reduction of the wake > lower momentum loss > lower resistance

Velocity profiles in BL around separation

- ∺ dP/dx > 0: favourable pressure gradient (bow)
 Stabilises BL
- ⊭ dP/dx < 0; adverse pressure gradient (stern)
 </p>

 △destabilises BL



Boundary layer regions

I. The viscous sublayer, $0 \le y^+ \le 5$

$$u^+ = y^+$$
 (6.26)

The profile is thus linear in this region.

II. The buffer layer, $5 < y^+ \le 30$

Here the profile changes smoothly from linear in region I to logarithmic in region III.

III. The logarithmic region, $30 < y^+ < 500-10,000$

$$u^{+} = \frac{1}{\kappa} \log y^{+} + C \tag{6.27}$$



Boundary layer regions



Pressure and velocity distribution along a 2D body





Limited streamlines about the stern



Figure 6.18 Limiting streamlines at the stern, model scale.







Decomposition of Resistance

Study guidelines

- 6.1 read
- 6.2 The boundary layer reproduce but no need to reproduce eq. 6.5 6.6
- 6.3 6.8 Understand! Formulas need not be reproduced in these sections



Exercise

Tentamen W&W mt527 - 17 Jan. 2011 Vraag 1a t/m d

Zie BB: mt527 – course information – exam material

