Workshop 5:
Op weg met de minste weerstand

Next Generation Rowing Boats?

Ir. A.J. Greidanus

International rower and researcher

13 oktober, 2009

Contents

Introduction

Drag Reduction Technologies

Drag Reduction Design

Conclusion

Introduction

International rowers train very intensively.

Boat speed is determined by:

Propulsive power and Power loss

- Aerobic and anaerobic condition
- Maximum strength
- Training methods

- Inefficient rowing technique
- Low propulsive efficiency of blade
- Drag forces

Introduction – Research objective

Boat design optimal and seems to stagnate.

All innovations are focused on reduction of power losses

Resistance: skin + air + wave

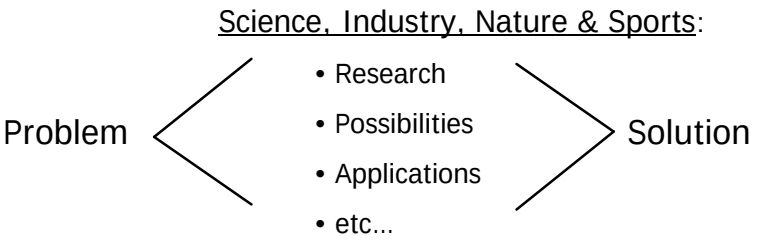
85% 15%

$$R_f = \frac{1}{2} C_f \rho v^2 A = F_{rower}$$

"Which kind of material and/or technology can be used to reduce the skin drag of competitive rowing boats?"

Drag Reduction

Think broad! Be inspired by other fields!



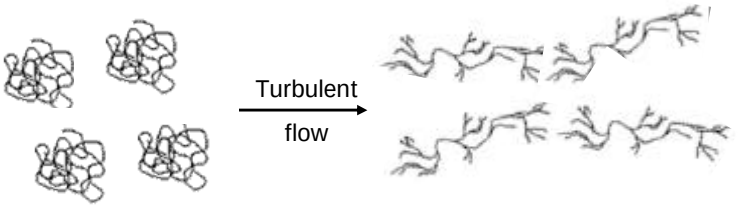
Look for technologies, designs, research and hypothesis

Drag Reduction Technologies

Polymers (Industry)

Polymer in solutions (15ppm) results in large DR in pipe flow transportation ("Toms effect")

Complex theory



Coil configuration

Stretched configuration

50% - 80% DR for pipe flows

Result

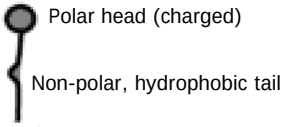
Viscous effect: Viscosity ↑, Re ↓

Elastic effect: Elastic energy stored, dissipation turbulent kinetic energy

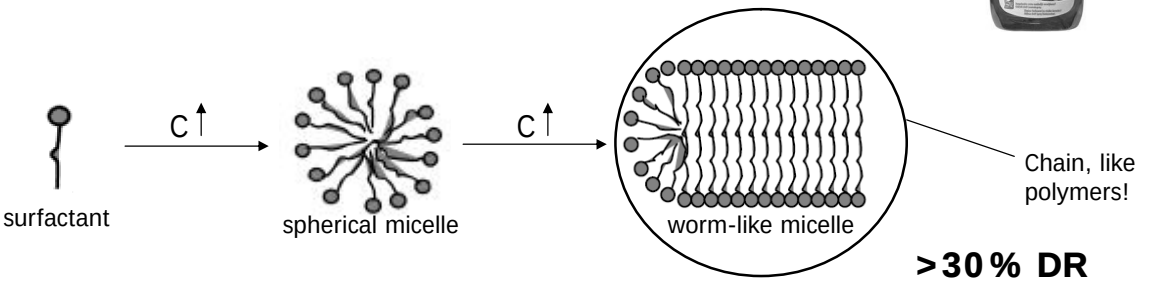
Drag Reduction Technologies

Ionic surfactants (Industry)

Addition of soaps in flow



Anionic (-), cationic (+), non-ionic (0)



>30% DR

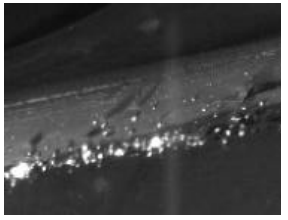
for pipe flows

Reversible network formation with shear stress, polymers are irreversible

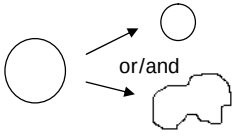
Drag Reduction Technologies

Microbubbles (Commercial shipping)

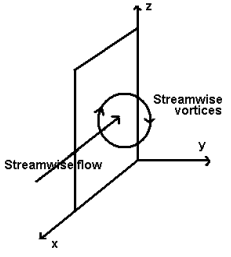
Ejection of microbubbles

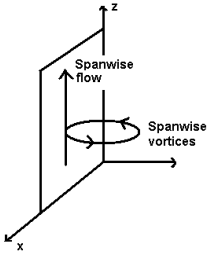


Bubbles dissipate turbulent energy by deformation



10% - 15% DR





Bubble diameter critical

Too small, no result

Too large, increase turbulence

} Dependent on boundary layer and sublayer

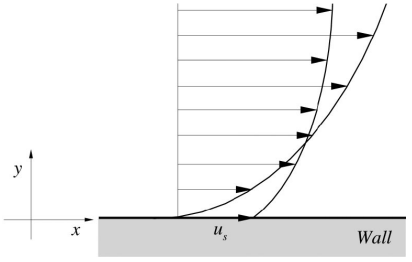
Ejection method very important!

Drag Reduction Technologies

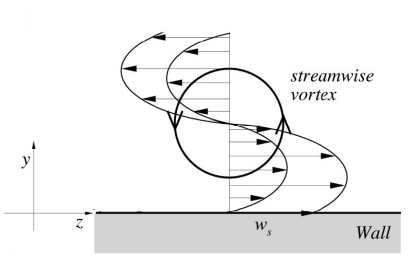
Hydrophobic / hydrophilic (Nature)

Hydrophobic surface: water repelling
Hydrophilic surface: water attracting

Based on non-zero slip boundary conditions



Streamwise slip



Spanwise slip

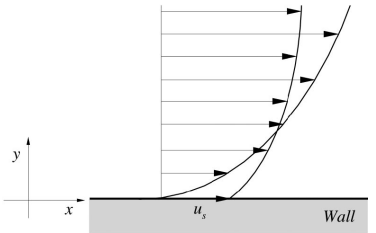
Overall net
drag reduction!

Drag Reduction Technologies

Hydrophobic / hydrophilic (Nature)

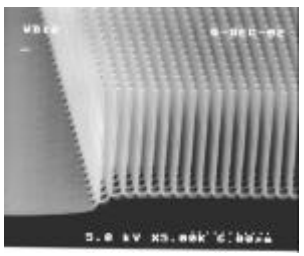
Slip length determines drag reducing effect

Normal hydrophobic surface <1µm ⟶ no effect!

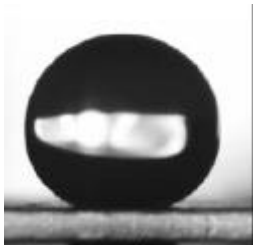


Superhydrophobic surface: Micro/nanostructures coated with hydrophobic substance, lip length 10-100µm (~180° contact angle)

(Lotus effect)



Nanograss



Water droplet contact angle

Water wants to avoid surface!

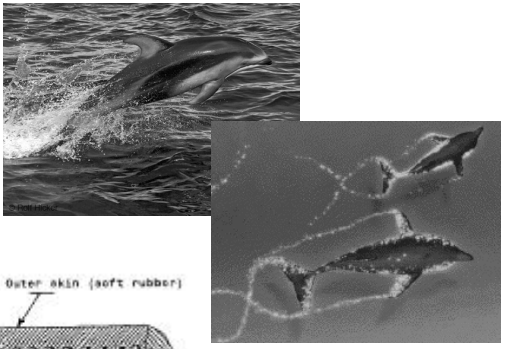
↓

Slip

10 % DR

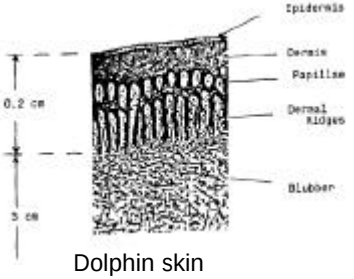
Drag Reduction Technologies

Compliant coatings (Nature)

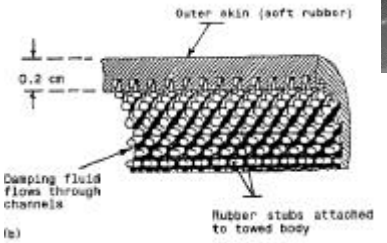


Dolphins swim very fast with little effort

Muscles ⟷ Speed



Dolphin skin

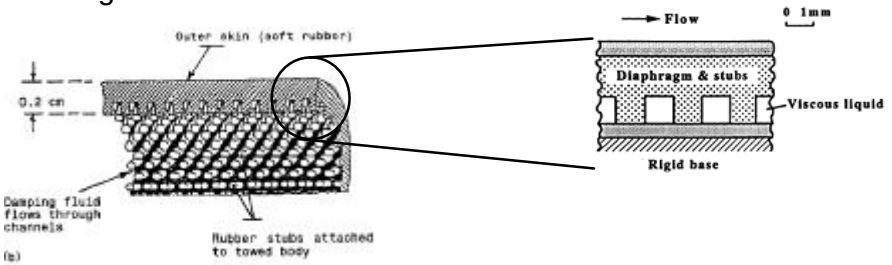


Compliant coating

Weaken vortices, dissipate Turbulent Energy ⟶ Skin drag reduction

Drag Reduction Technologies
Compliant coatings (Nature)

The right combination of material properties in compliant coating determines drag reduction



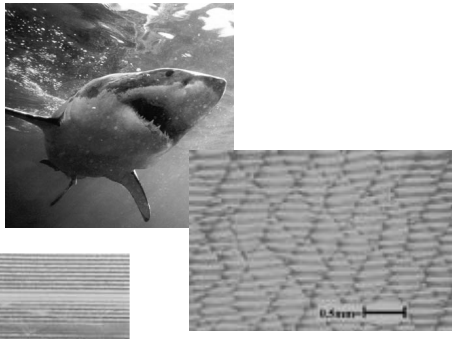
Natural frequency must give right response to the fluctuating pressure forces at the wall (**x < Re < y**)

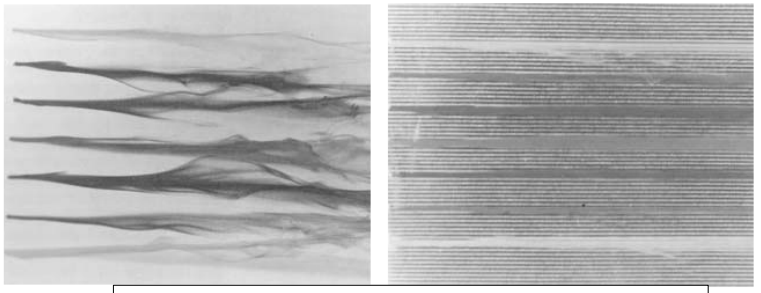
This is very difficult!! But interesting…

Drag Reduction Design

Riblets (Nature)

Riblet surfaces are better known as shark skin (swimming suits)





Flat plate Riblet surface

5-10% DR

Streamwise vortices induce spanwise flow ⟶ Riblets constrains flow

Drag Reduction Design

Dimples (Sports)

Golf ball

Increase lift and reduce drag of a spinning, spherical objects

Works for non-spinning objects?

Ferrari F1

NO!

Cycle wheels

YES!

Conclusion

The drag reduction technologies segmented in three groups:

1. Addition of substances (polymers, surfactants, microbubbles)
   Ejection method and influence natural property of water

2. Control of boat surface property (hydrophobic/-philic, compliant)
   Within FISA rules
   Superhydrophobic surfaces shows large potential
   Compliant coatings looks attractive, but complex to engineer

3. New design of boat or surface (riblets, dimples, etc.)
   Riblets works, only might be allowed by in-situ production
   Dimples and others are not fully understood
   Shorter boat is simple to apply, but…….
   Boat lifting in grey area of FISA rules

Thank You!!

Let’s get started !!