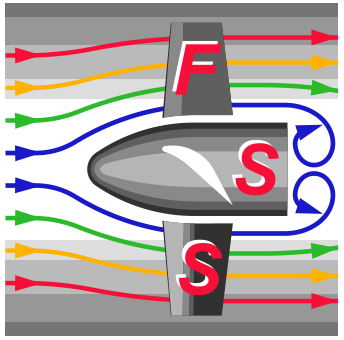


Uwe Borchert

HOST
Hochschule Stralsund
University of
Applied Sciences

Power Generation by Flettner rotors?

Numerical Investigation of a Wind Turbine with Flettner Rotor Rotating on and Transversely to the Main Axis

Introduction

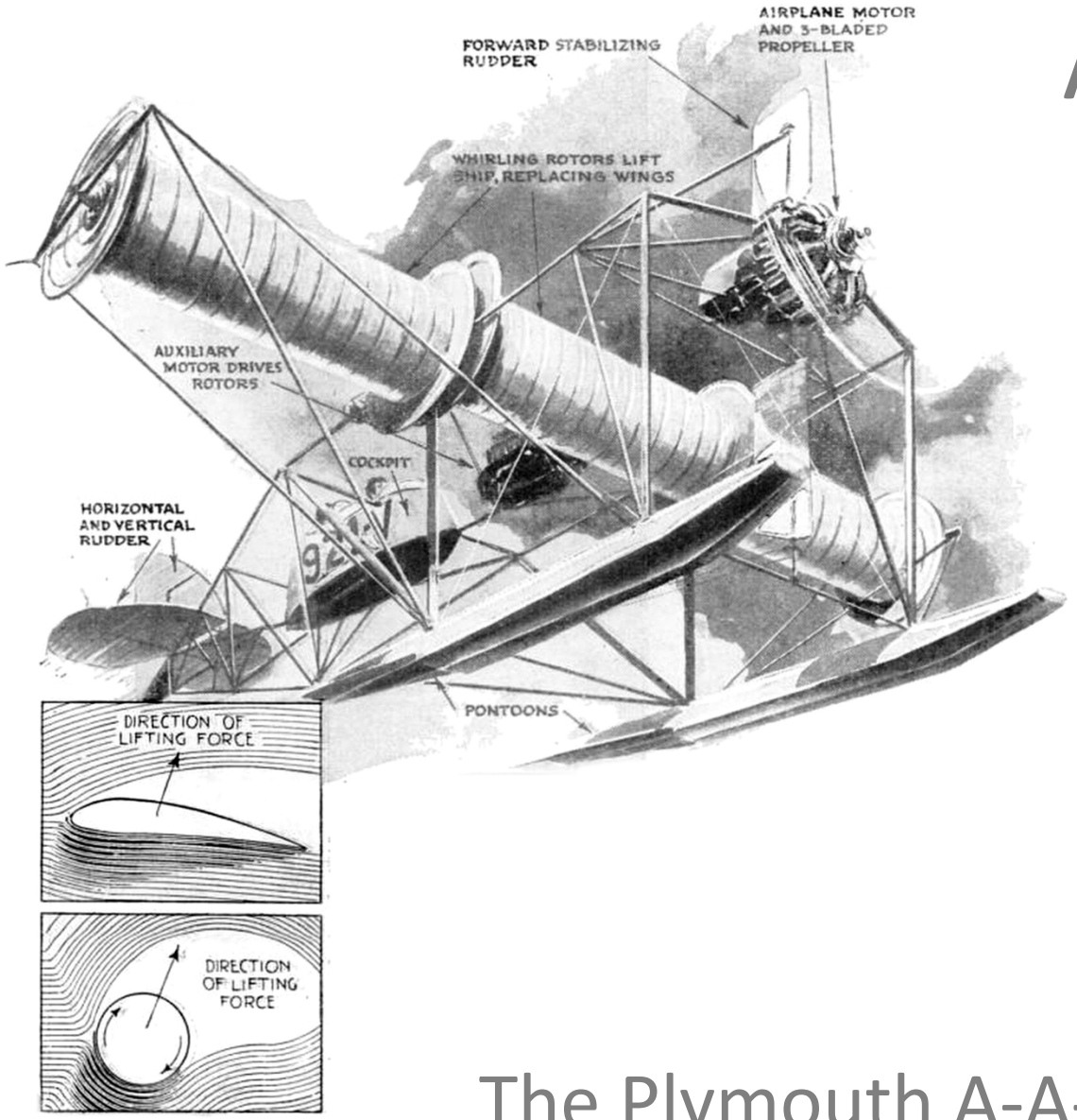
Propelling watercrafts

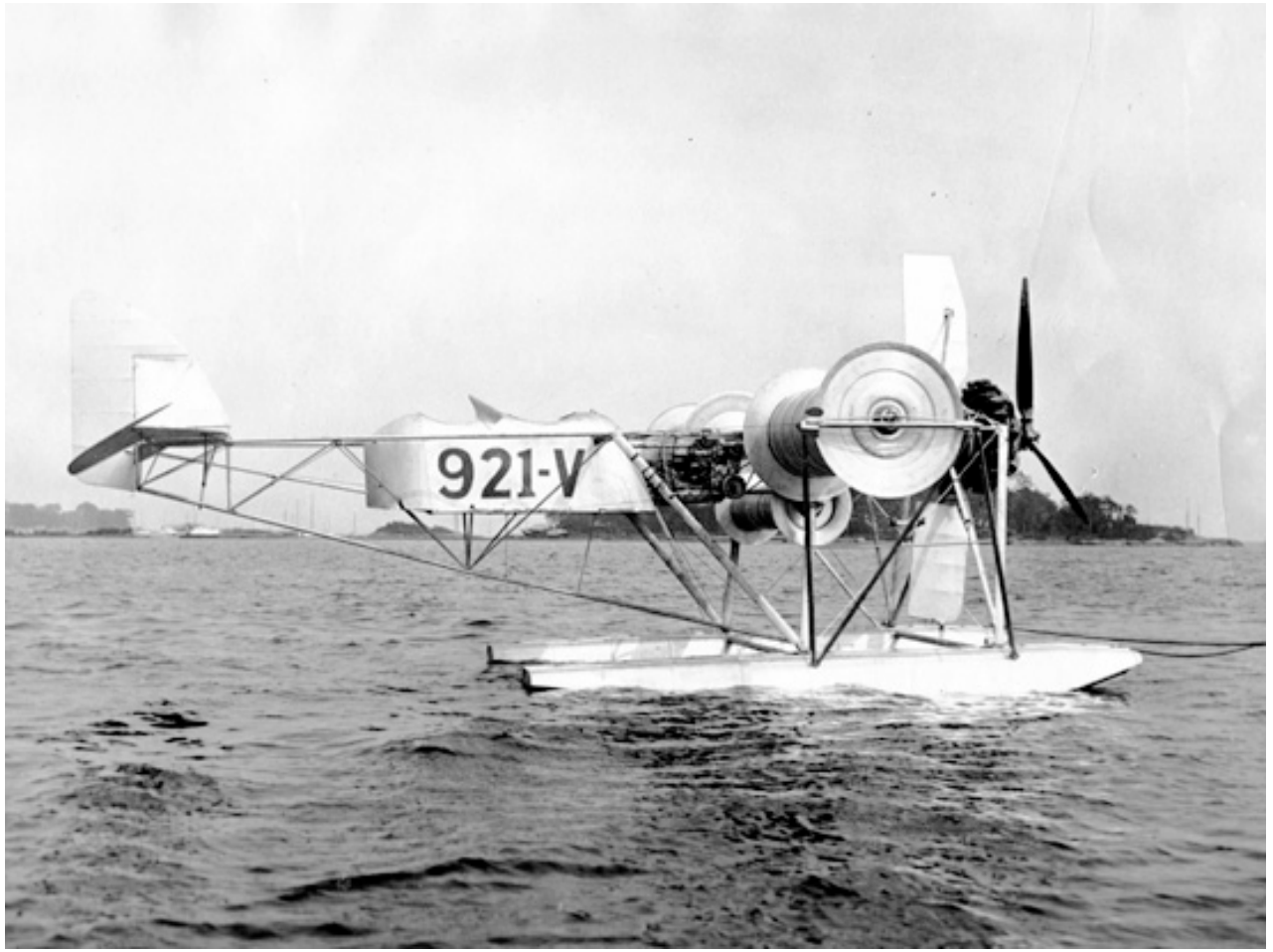
← E-Ship 1

Uni-Kat Flensburg →

Introduction

Aviation





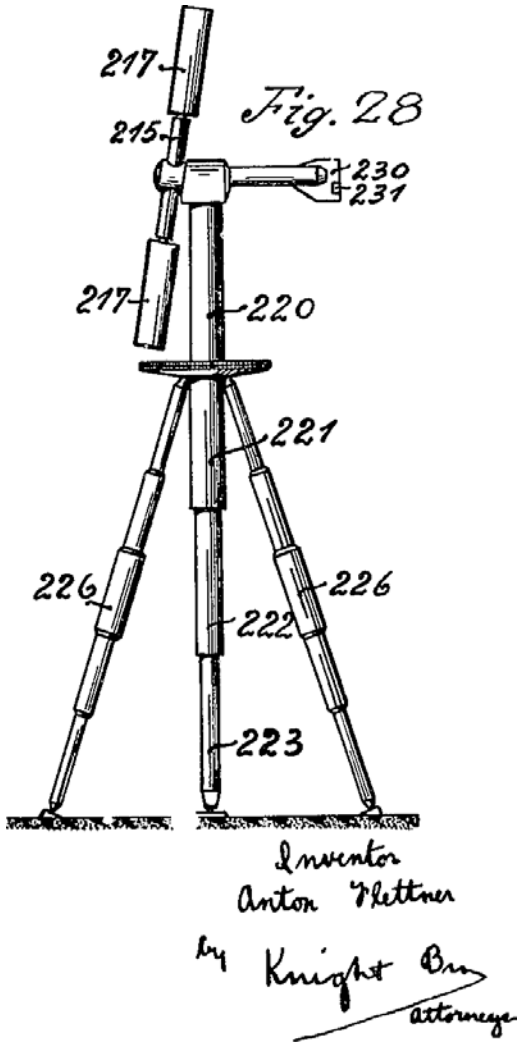
The Plymouth A-A-2004 rotor aircraft (1930)

Power generation by wind turbines with **Flettner** rotors?

Introduction

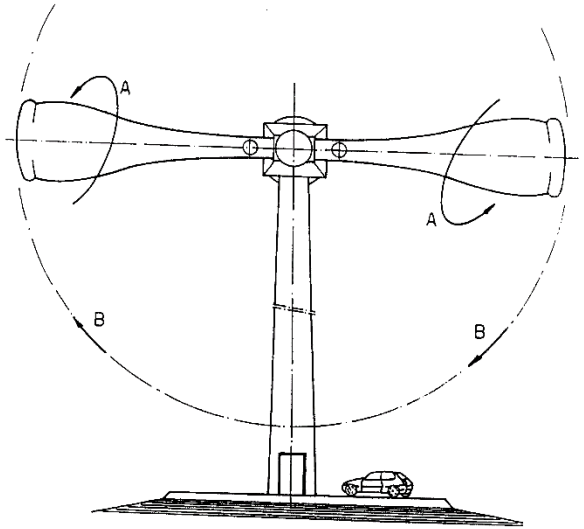
Since 1924

- "Arrengement for Exchanging Energy between a Current and Body Therein"
  Anton Flettner, Pat. US 1,674,169 (1924)



Recent developments

- "Magnus effect horizontal axis wind turbine"
  Pat. US 06,375,424 B1 (1996)
- "Spiral Magnus Wind Power Turbine"
  Mecaro Akita (1998)
- AES-Technology
- …



"Magnus effect horizontal axis wind turbine"

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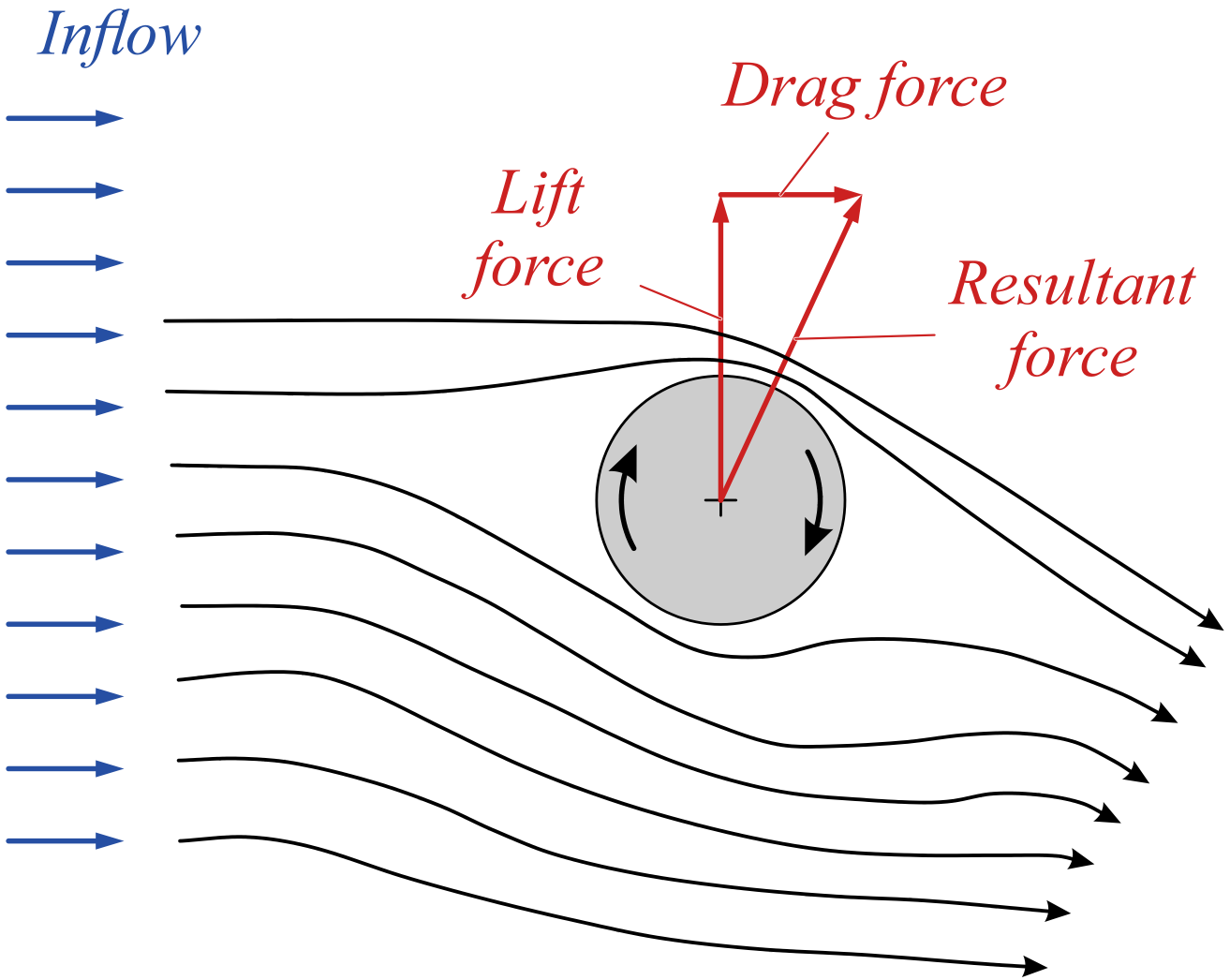
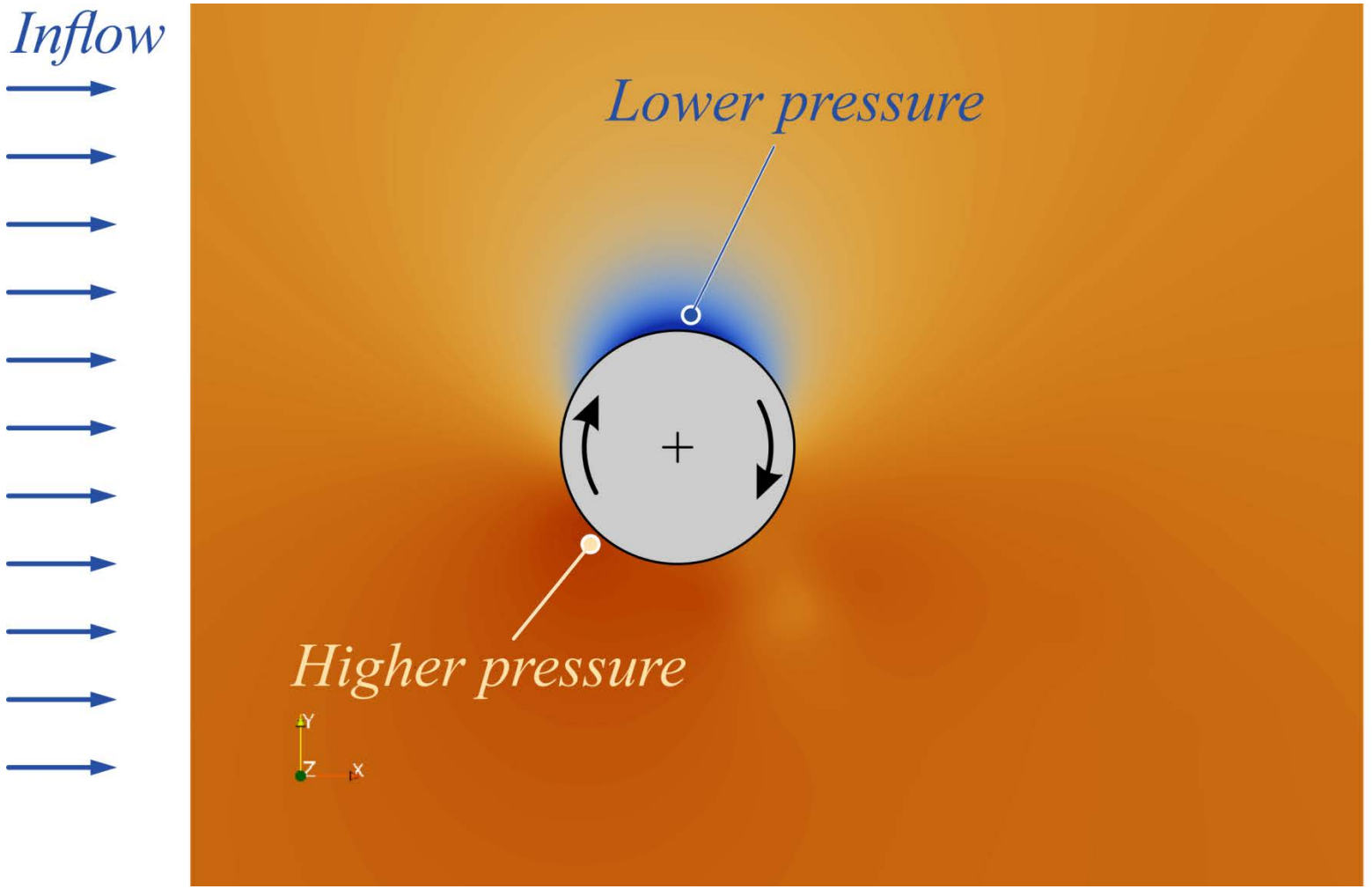
1. Theoretical Considerations

Lift force generation on rotating surfaces



Lift force generation on rotating surfaces



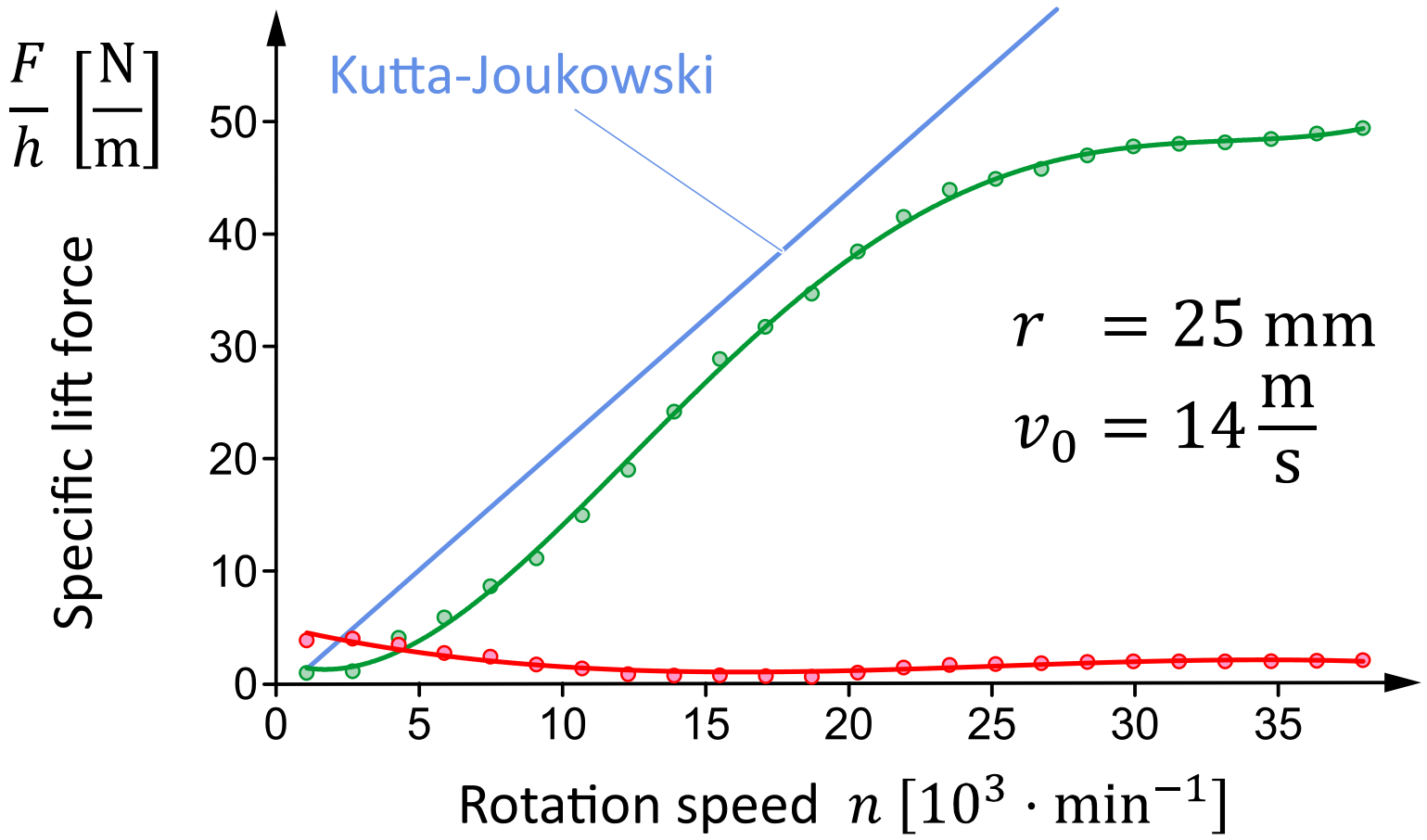
Lift force generation on a **rotating cylinder**

According to Kutta-Joukowski

$$F_a = 4 \cdot \pi \cdot \rho \cdot v_0 \cdot n \cdot r^2 \cdot h$$

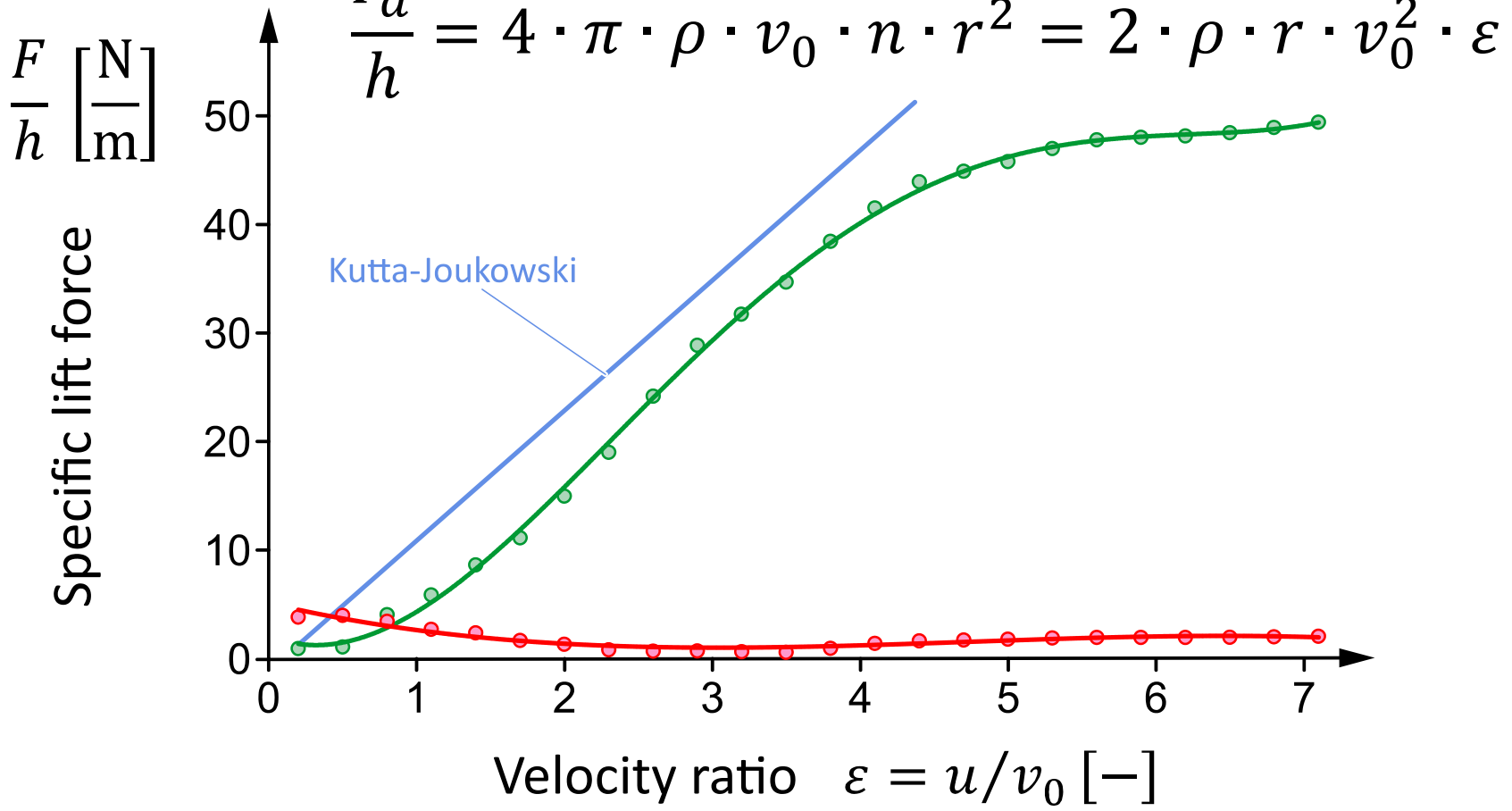
F_a – lift force
ρ – fluid density
v_0 – inflow velocity
n – rotation speed of the rotating surface
r – radius of the rotating surface
h – cylinder length or height

Specific lift force on a rotating cylinder



Specific lift force on a rotating cylinder

$$\frac{F_a}{h} = 4 \cdot \pi \cdot \rho \cdot v_0 \cdot n \cdot r^2 = 2 \cdot \rho \cdot r \cdot v_0^2 \cdot \varepsilon$$



2. Magnus Effect Depending of the Velocity Ratio

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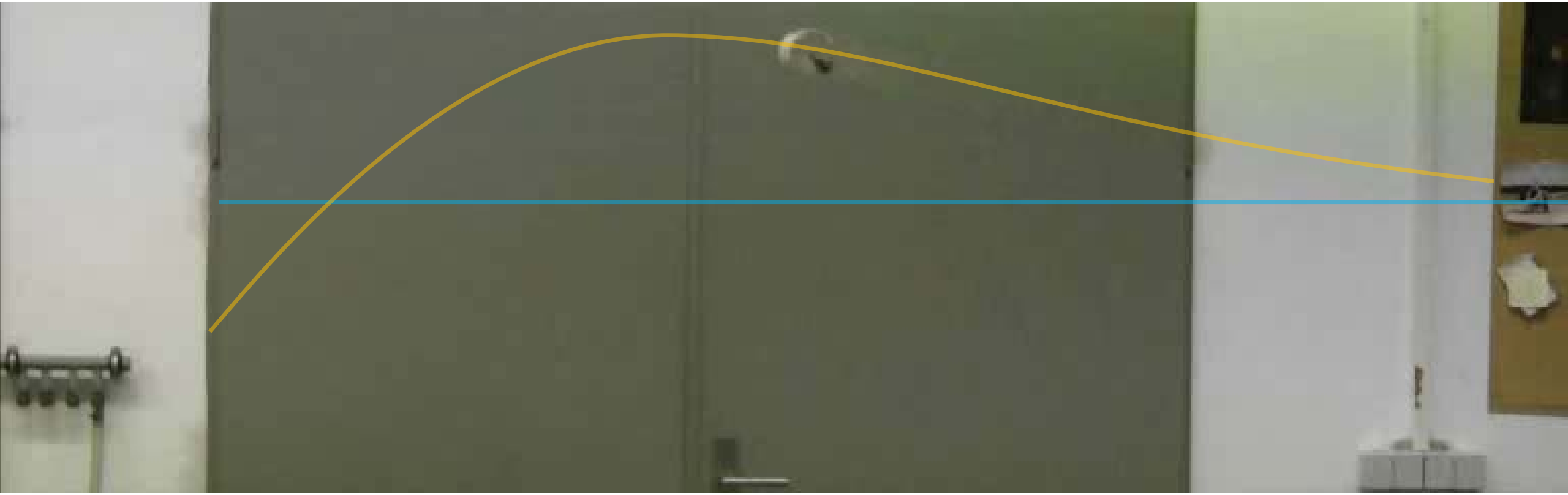

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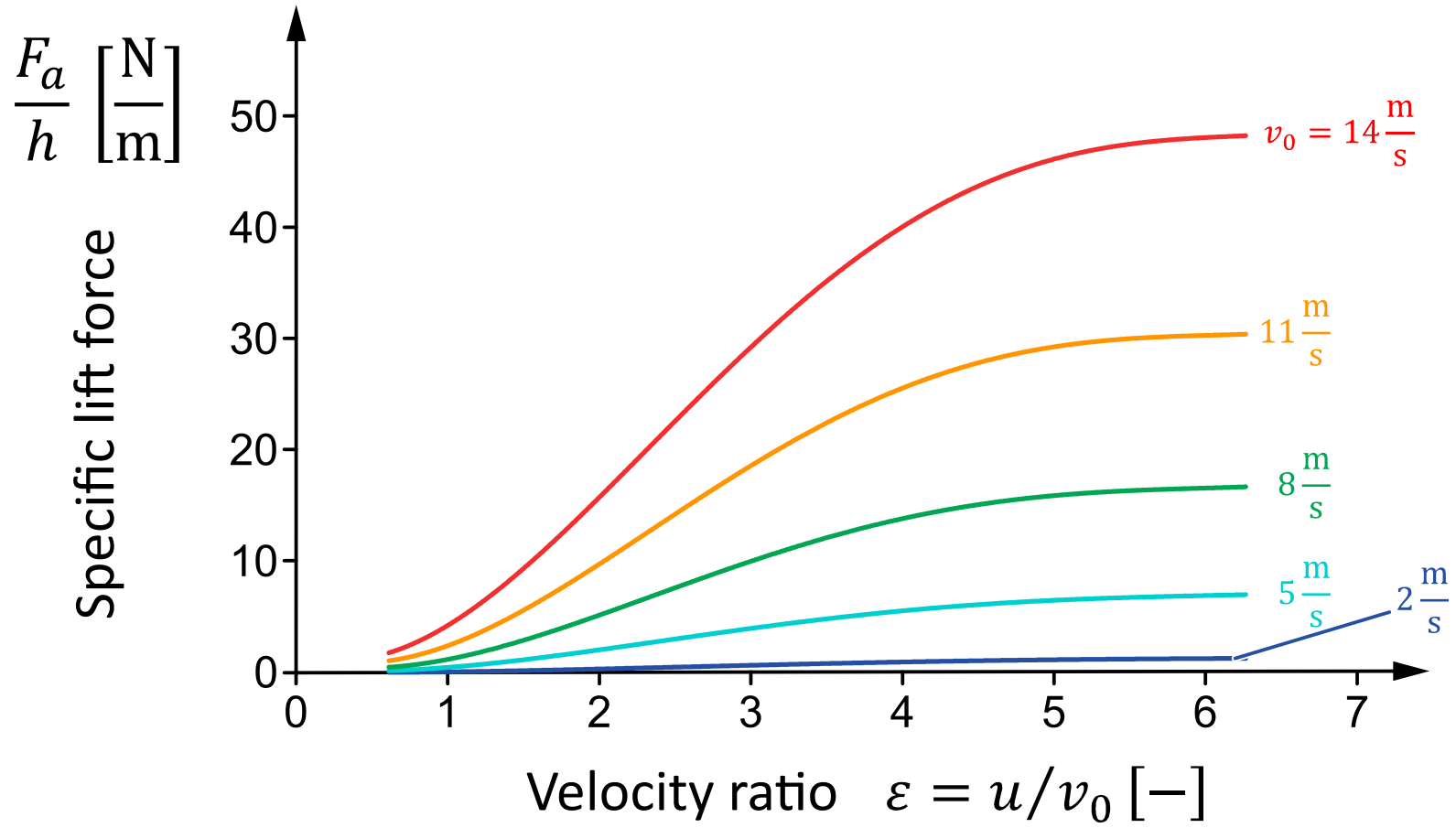
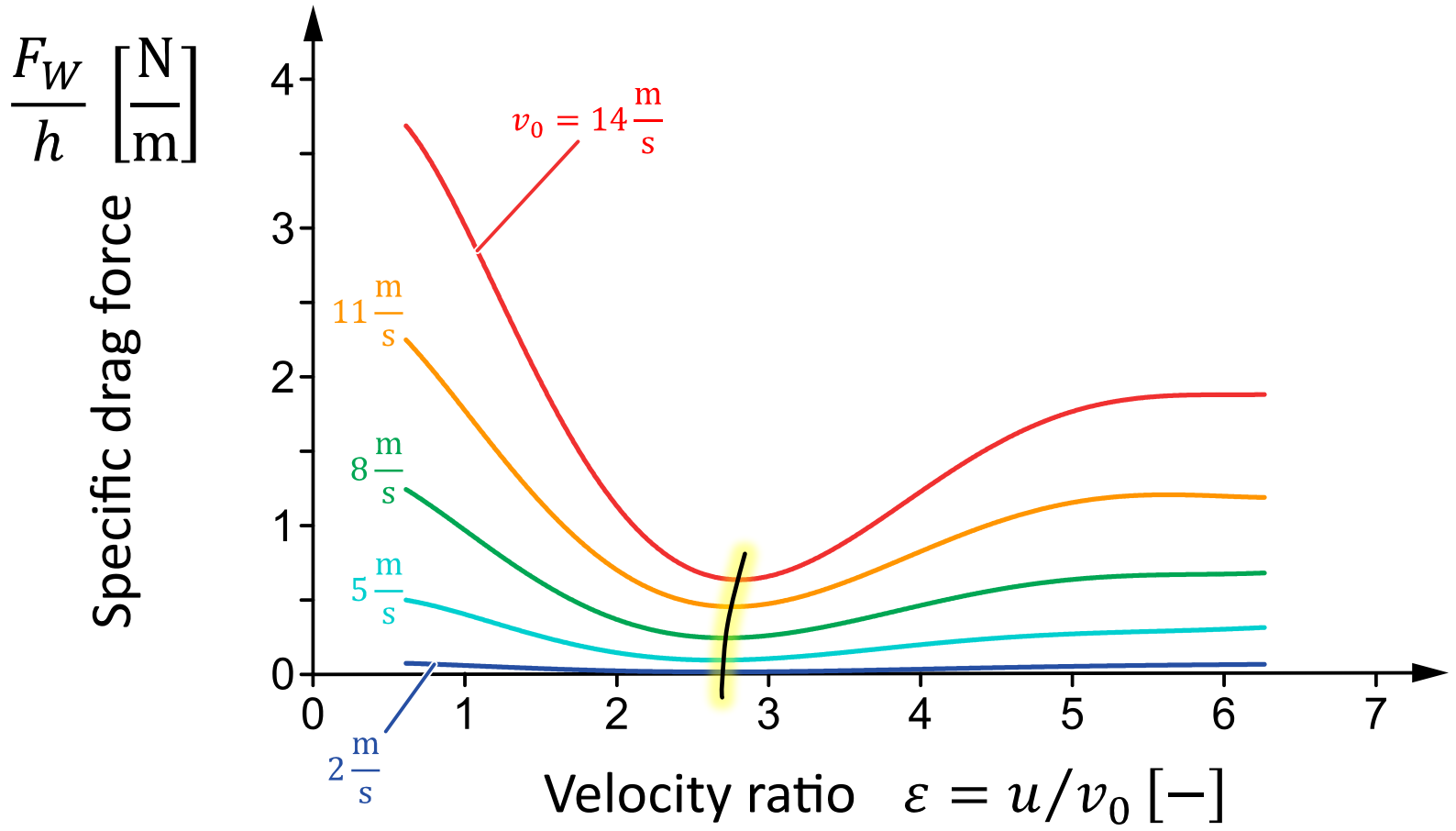
Specific lift force on a rotating cylinder



2. Magnus Effect Depending of the Velocity Ratio

Specific **drag** force on a rotating cylinder



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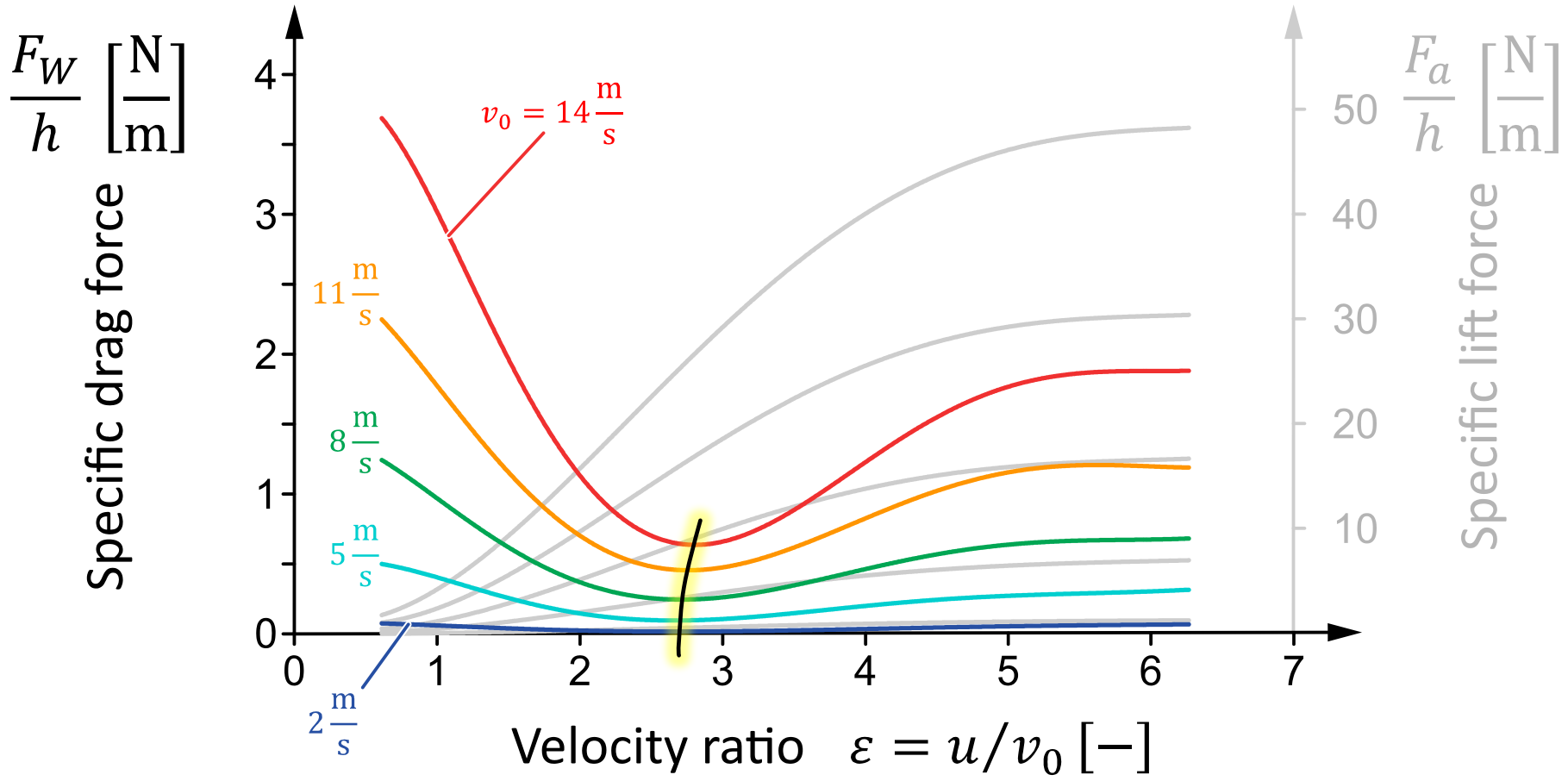
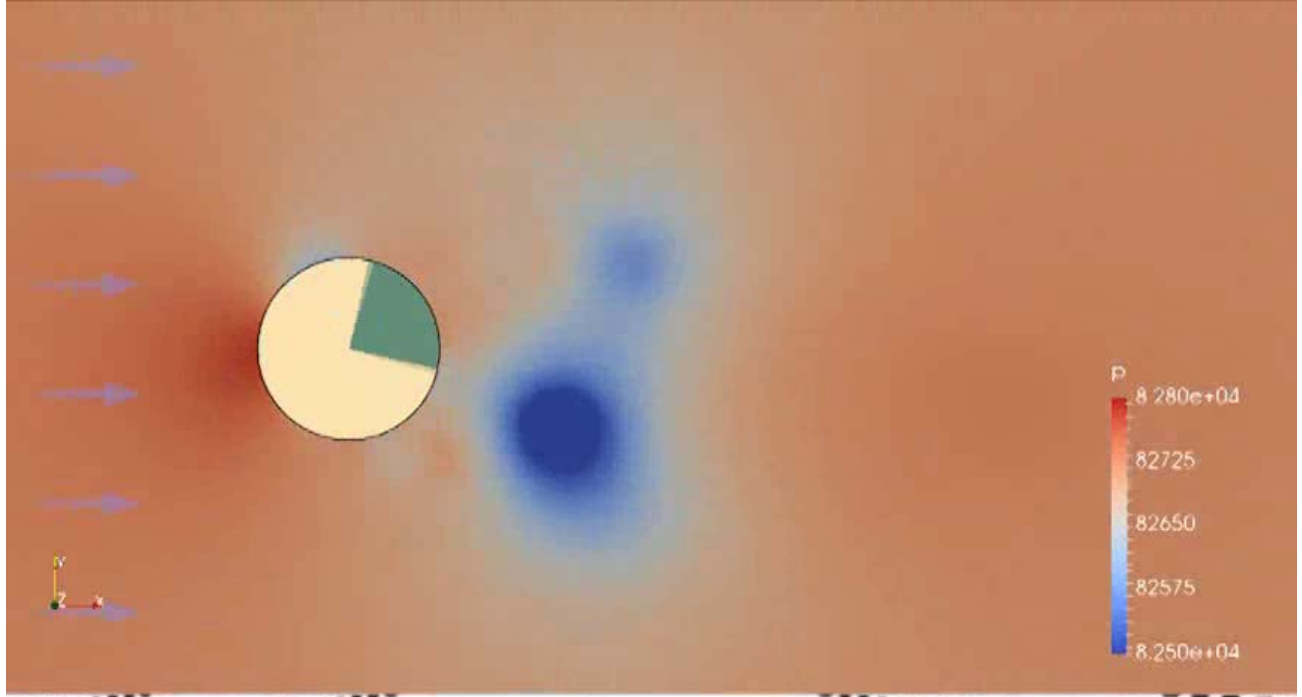
Specific **drag** force on a rotating cylinder





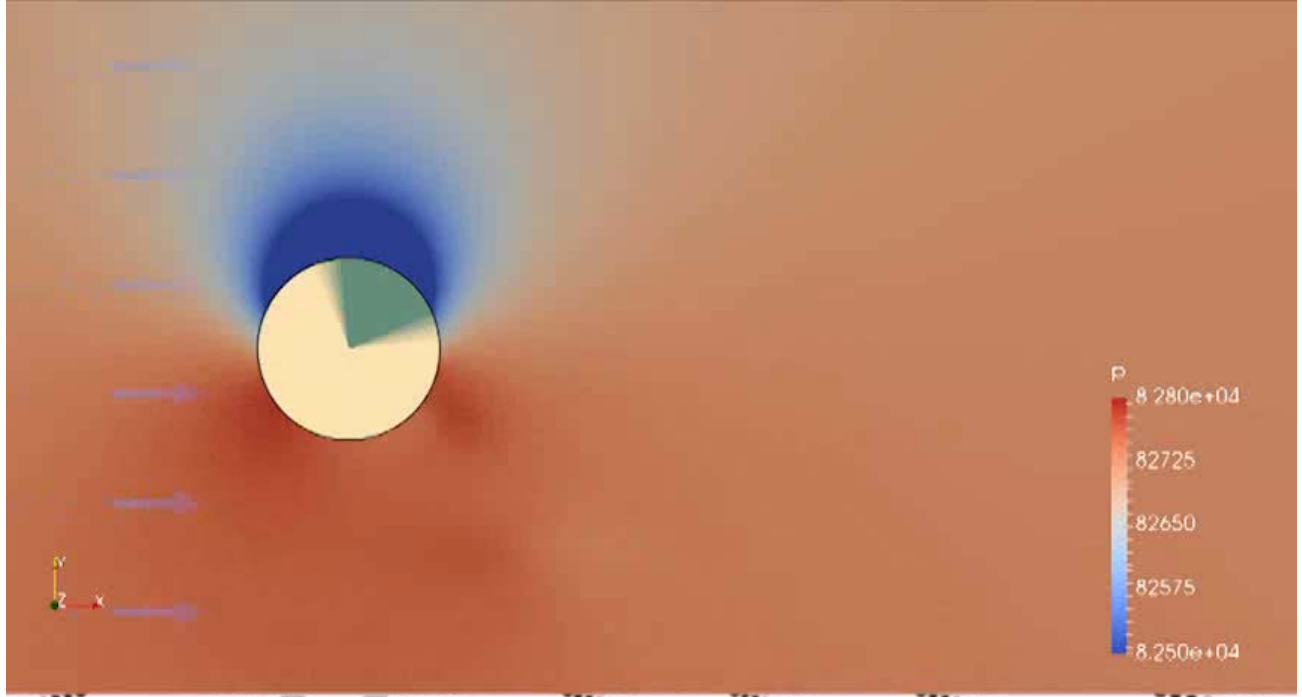
$\varepsilon = 0{,}5$

$$\frac{p}{\rho}\left[\frac{\mathrm{m}^2}{\mathrm{s}^2}\right]$$

82 800
82 725
82 650
82 575
82 500

$$v_0 = 11\,\frac{\mathrm{m}}{\mathrm{s}}$$

$$\varepsilon = \frac{u}{v_0}$$



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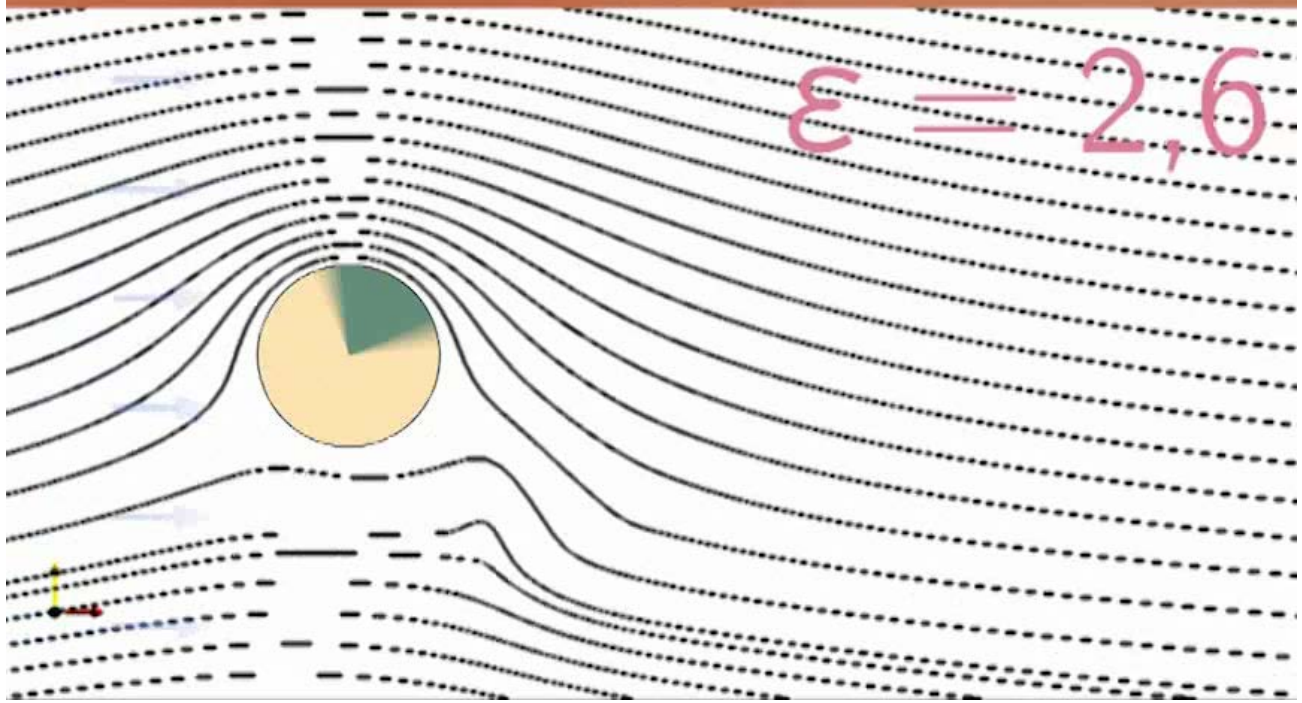

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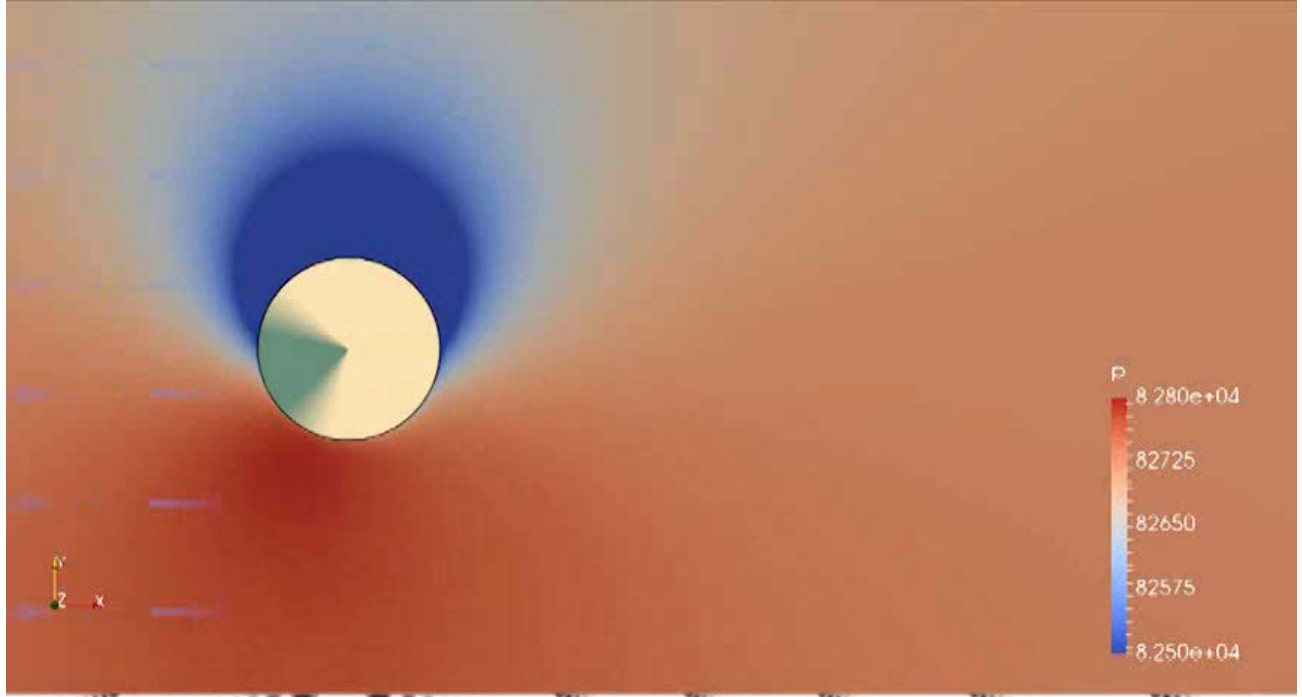

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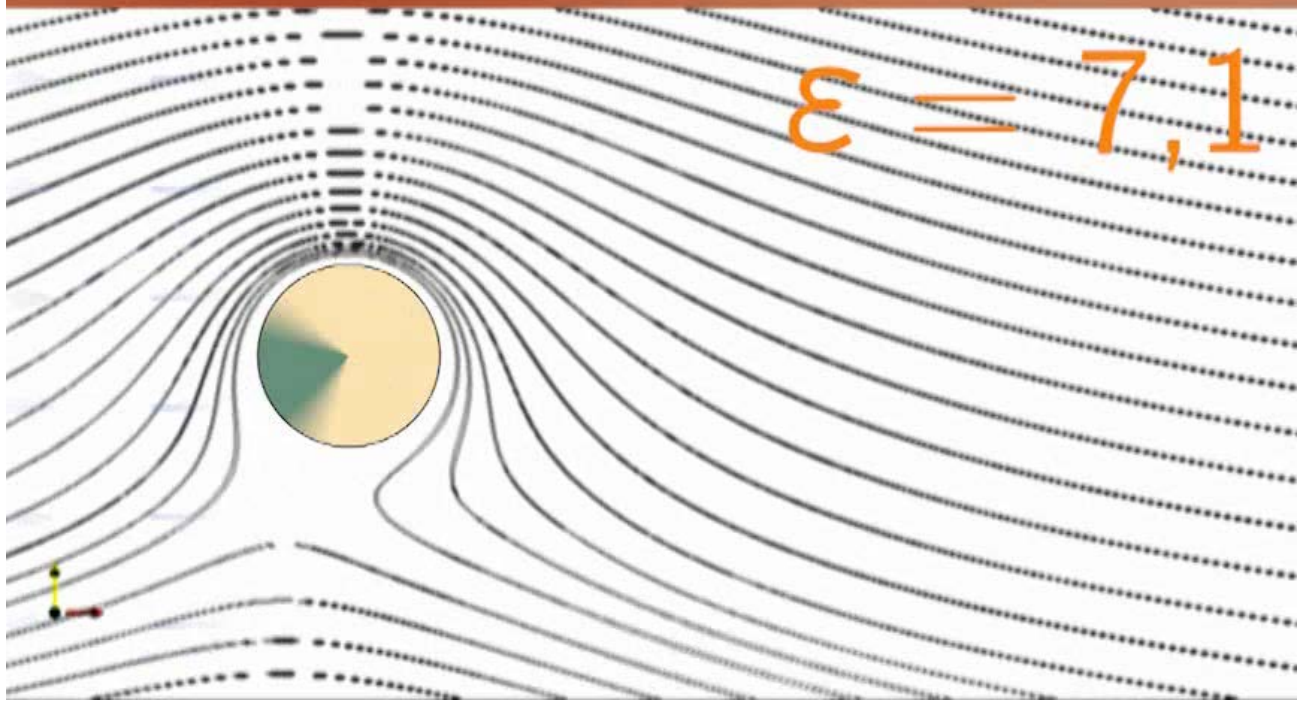

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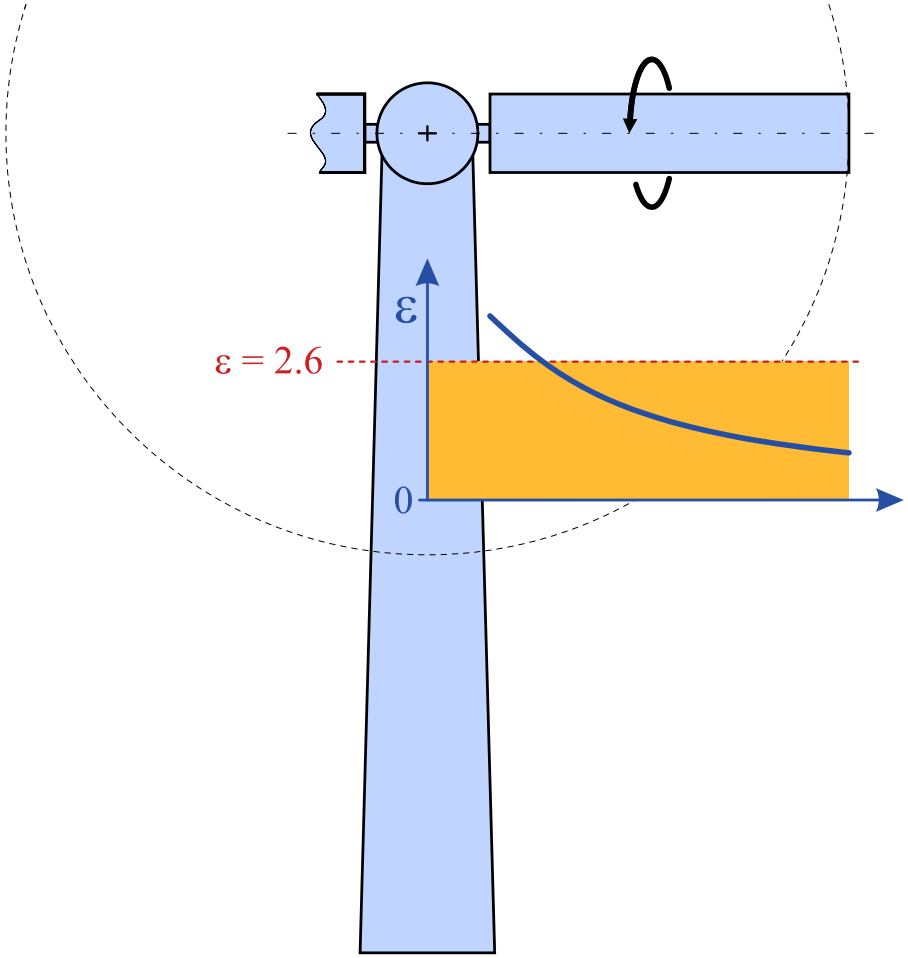
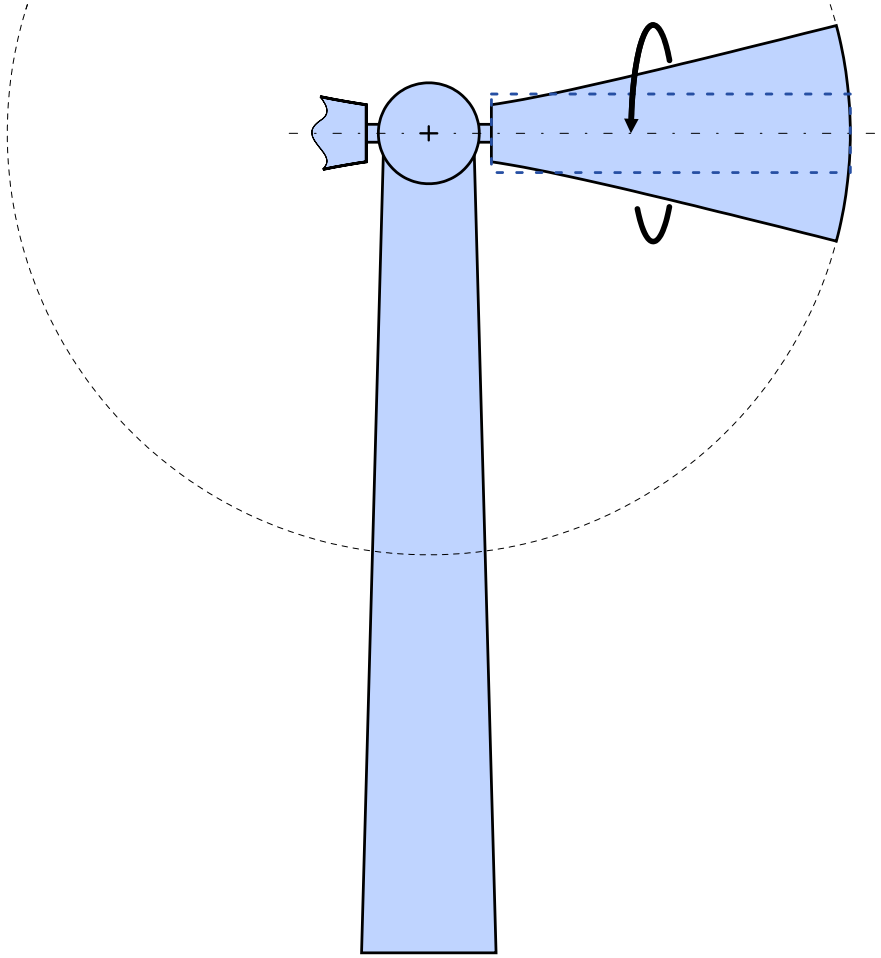
2. Magnus Effect Depending of the Velocity Ratio

Deduction for Flettner rotors in wind turbines





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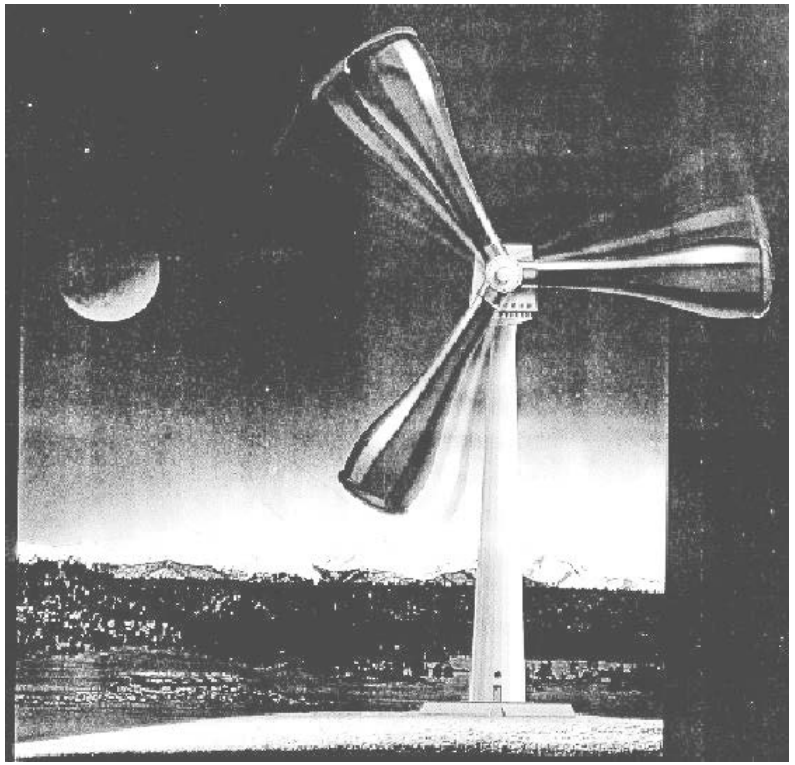

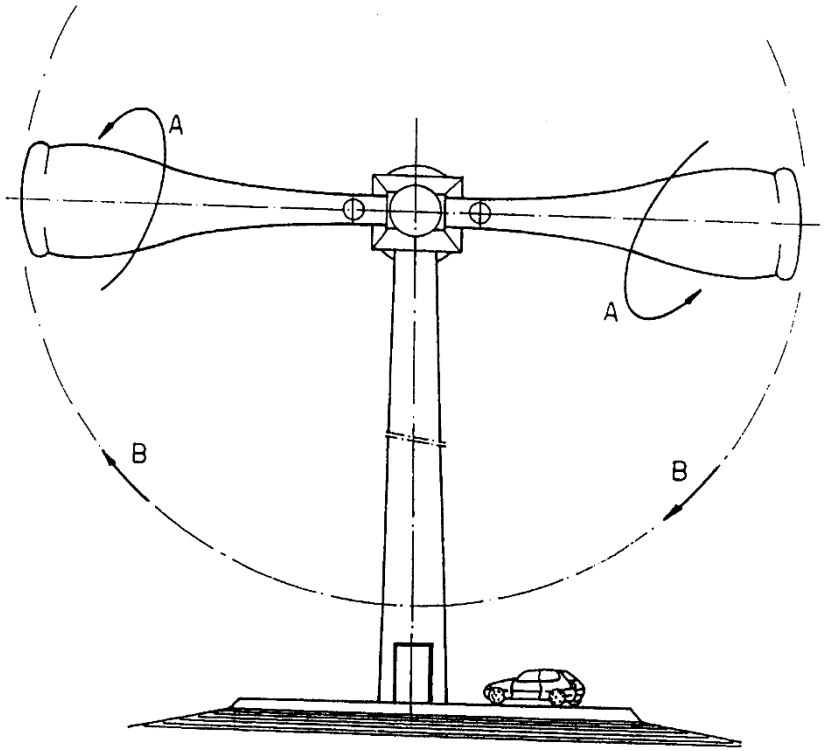

Paolo Scarpa: "Magnus effect horizontal axis wind turbine“, Pat. US 06,375,424 B1 (1996)

3. Conclusions

- Using the Magnus effect requires optimized boundary conditions.
- “Blades” with cylindrical surfaces produces a braking torque at the tip (reduces the efficiency).
- The ratio between lift and drag force is favorable only at higher velocity ratio.
- Problems to achieve the optimal tip-speed ratio.
- No fundamental advantage can arise.