Aerodynamics of Revolving Bristled Wings at Low Reynolds Number

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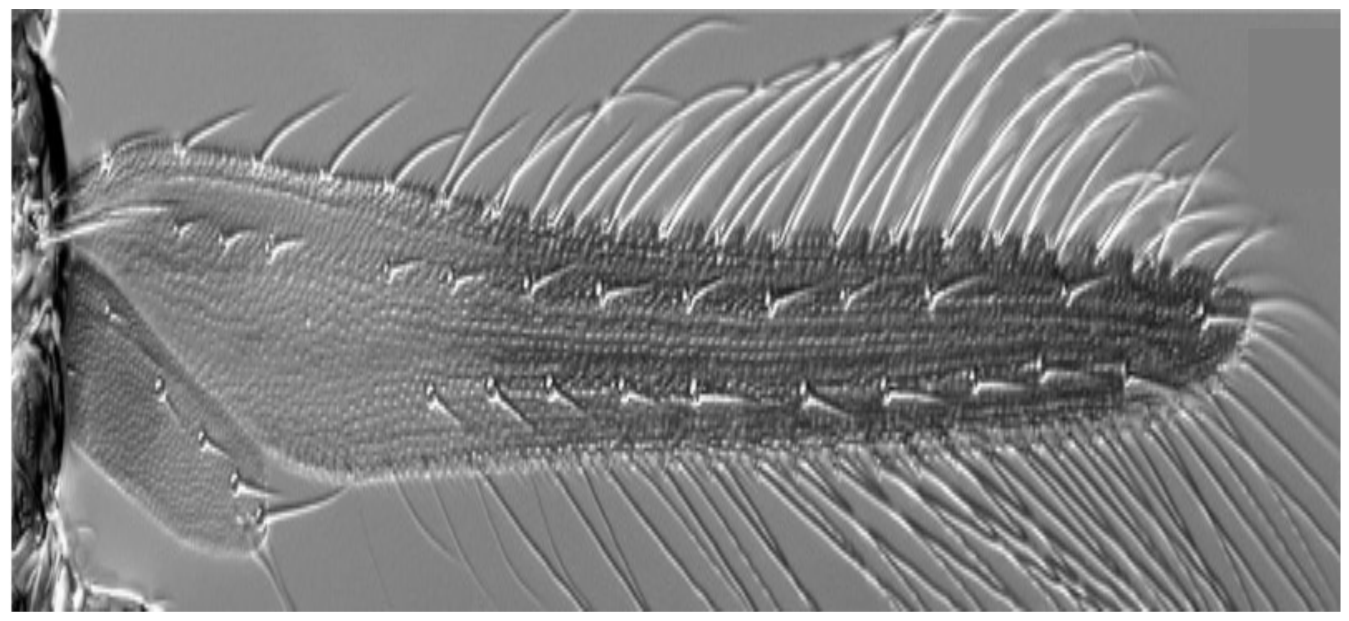
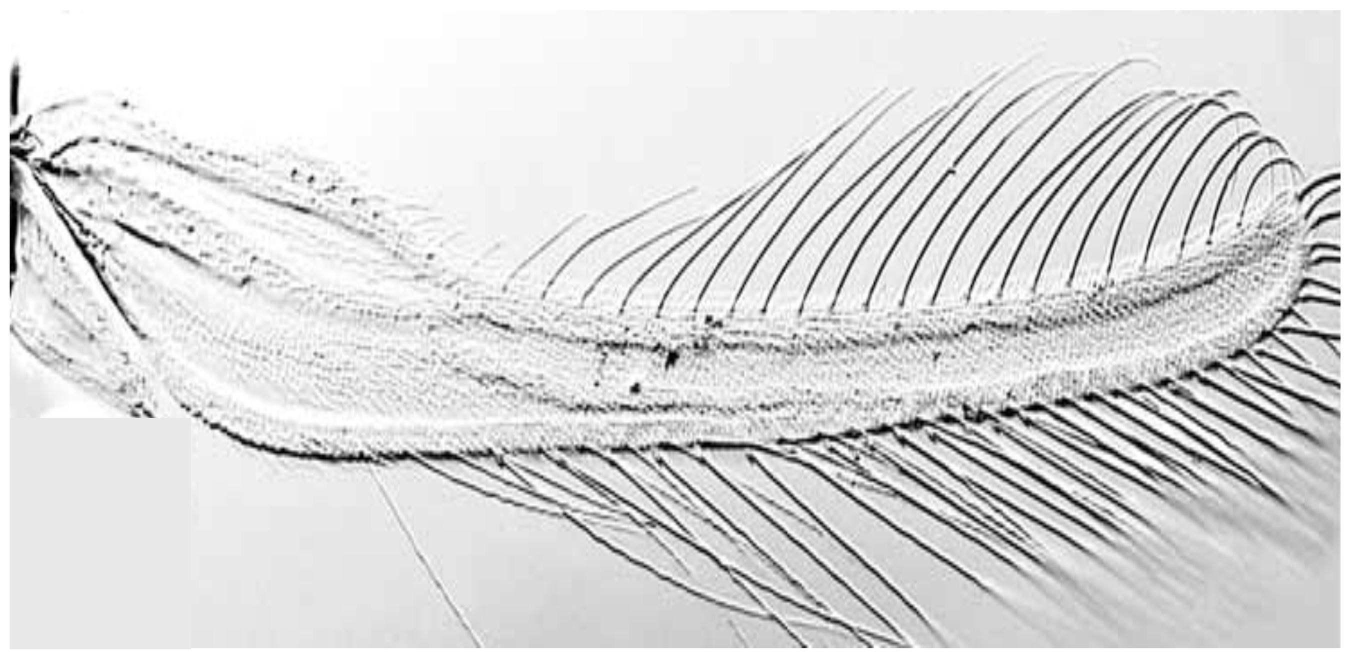
Background

- Thrips are one among the wide variety of tiny insects (body length under 2 mm) that are capable of flight at Reynolds Number (Re) = 10.
- Flapping flight is highly inefficient at such low Re due to significant increase in drag with insufficient lift generation.
- Their wing structure is composed of a thin membrane with long bristles at the fringes.



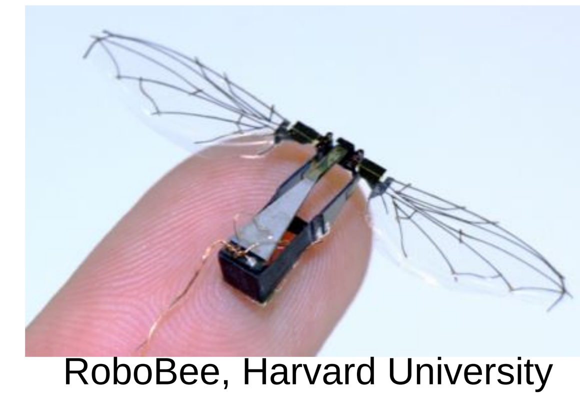
Forewing image of *Pandanothrips ryukyuensis* (Masumoto et al. 2013)



Forewing image of *Bhattithrips borealis* (Laurence A. Mound et al., 2009)

Significance

- Wing design for Micro Aerial Vehicles (MAVs)
- Vectors of plant viruses
- Biological control of invasive pests



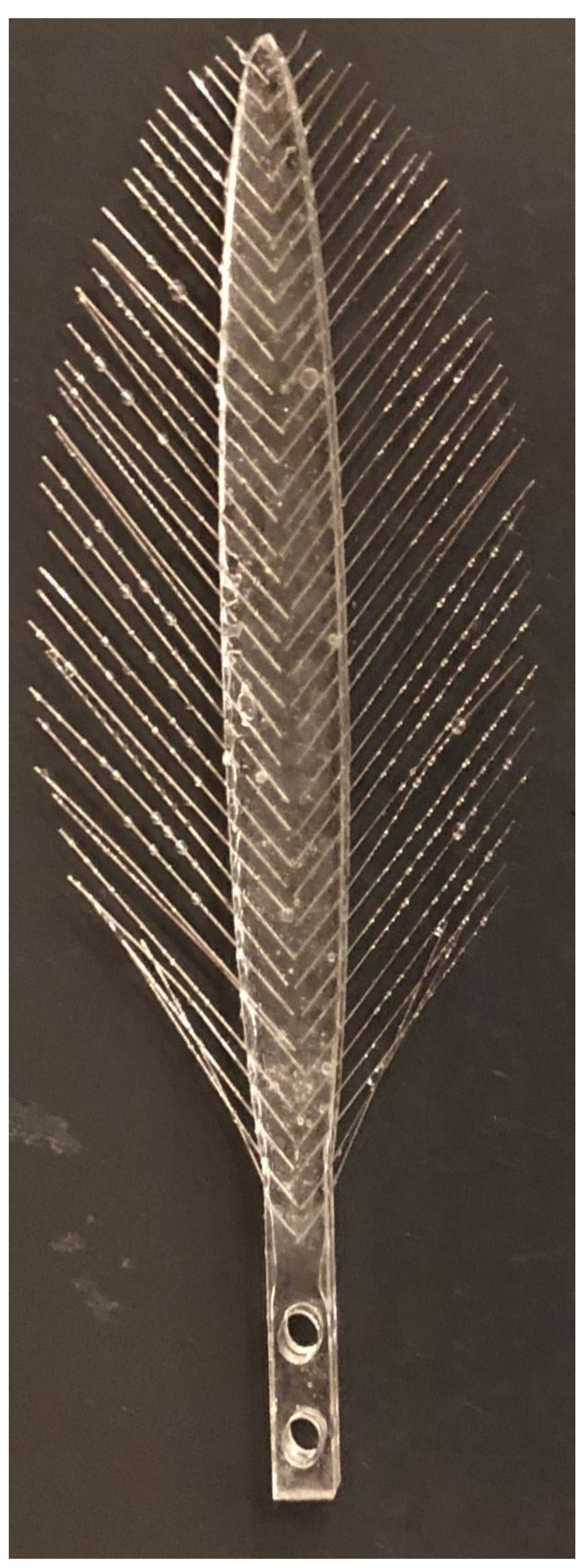
RoboBee, Harvard University

T.A. Zitter, Cornell University

Question: **Do bristled wings in comparison to solid wings provide aerodynamic benefits during wing revolution at Re =10?**

Wing Models

Solid

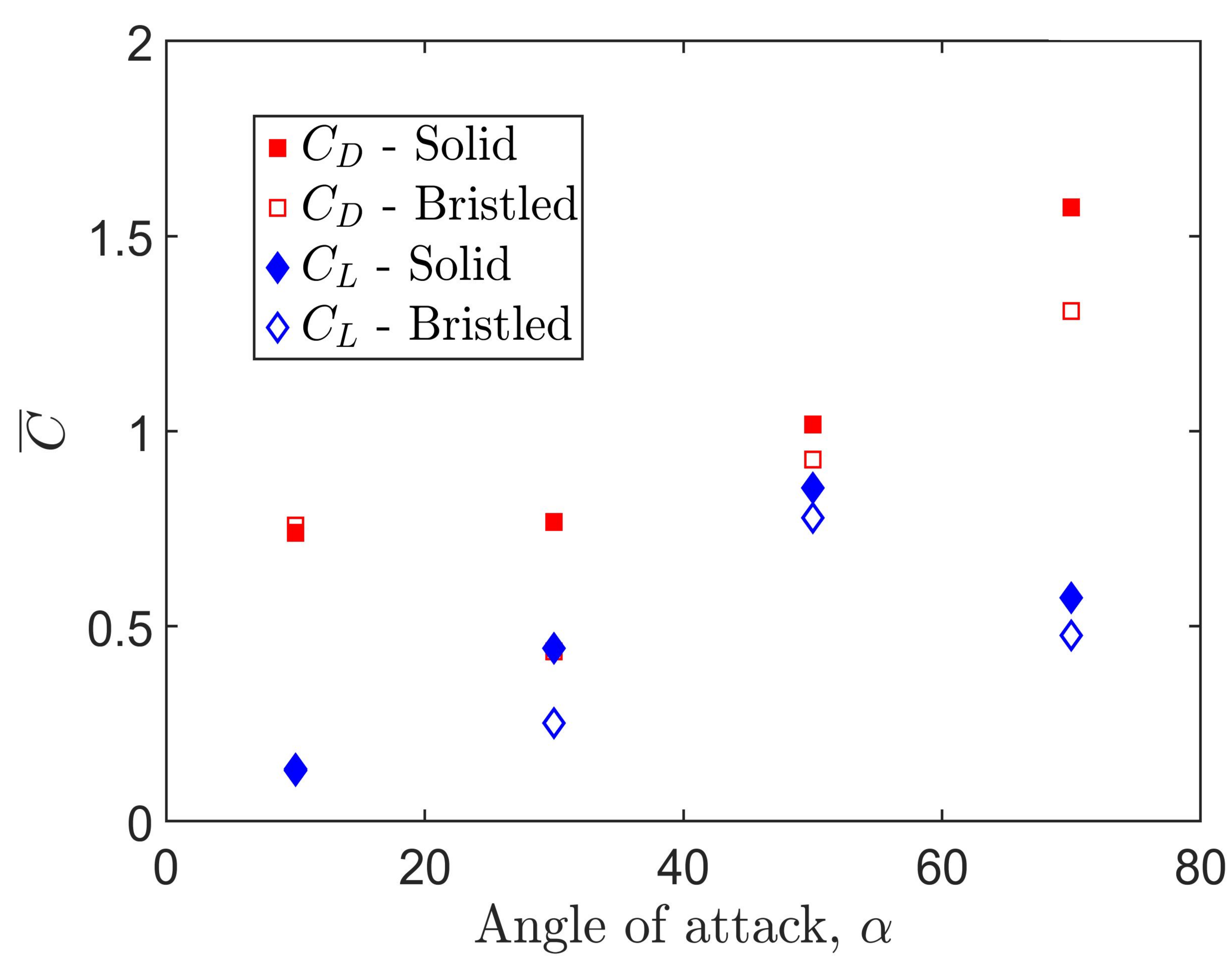


Bristled

Span = 90 mm
Chord length = 12 mm
Bristle spacing =2.29 mm
Number of bristles = 76

Results

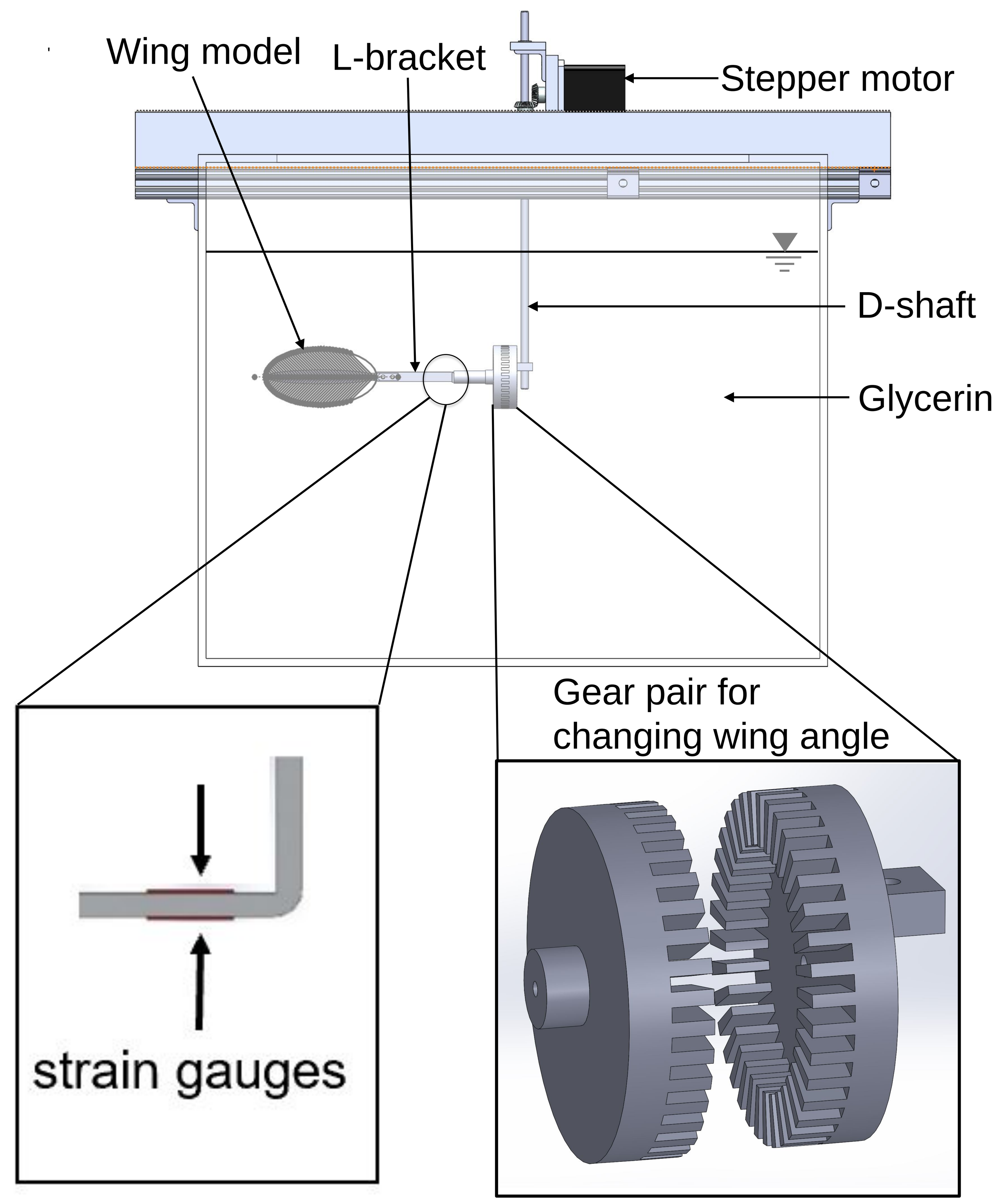
Average force coefficients of solid and bristled wing at Re = 10

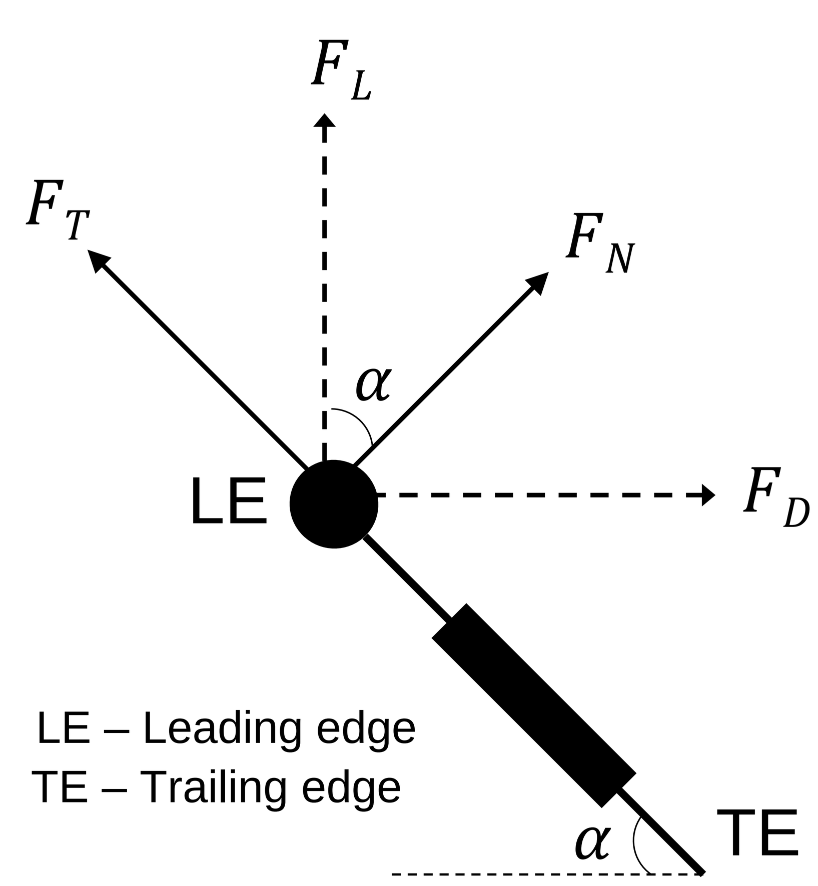


Conclusions

- The solid wing produced substantially larger drag than bristled wing at higher α.
- Lift increases with α until 50° and then decreases for both solid and bristled wings.

Robotic Platform





F_N : Normal force
F_T : Tangential force
F_D : Drag force
F_L : Lift force
α : angle of attack

$$C_D = \frac{F_D}{0.5\rho U^2 A}$$

$$C_L = \frac{F_L}{0.5\rho U^2 A}$$

ρ =glycerin density, U = wing tip velocity, A = wing area

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