Kutta condition

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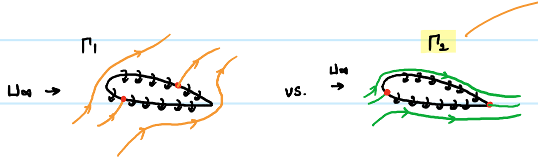
For the glory of God

Introduction

- When we studied about the lifting flow over a circular cylinder, we observed that an infinite number of potential flow solutions were possible, corresponding to the infinite choice of Γ
- The same situation applies to the potential flow over an airfoil.
  - For a given airfoil at a given angle of attack,

It seems like nature adopts this particular value Γ_2

• : stagnation point



  - This illustrates two different flows over the same airfoil with same condition.
- Hence, there are an infinite number of valid theoretical solutions, corresponding to an infinite choice of Γ.
- Then, which one is meaningful ?

  ∴ The answer will be given from the Kutta condition. → made by M. Wilhelm Kutta (German) in 1902

Experimental results (Prandtl and Tietjens)

i.e. the development of steady flow over an airfoil

- Although there is an infinite number of possible potential flow solutions, nature (or Experiment) demonstrated that ;
  - The (steady) flow is smoothly leaving the top and the bottom surfaces of the airfoil at the trailing edge.

Kutta Condition (Inviscid and Incompressible)

- In order to apply the condition in a theoretical analysis, we need to be more precise about the flow at the T.E.

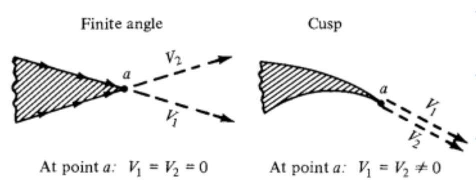


Figure 4.19 Different possible shapes of the trailing edge and their relation to the Kutta condition.

When we think about the vortex sheet,

the statement of the Kutta condition in terms of the vortex sheet

is as follows ;

$\gamma(T.E.) = V_1 - V_2 = 0 \quad \therefore \gamma(T.E.) = 0$

$\begin{cases} \text{Finite}, & V_1 = V_2 = 0 \quad \therefore V_1 - V_2 = 0 \\ \text{Cusped}, & V_1 = V_2 \quad \therefore V_1 - V_2 = 0 \end{cases}$

- So, the statement of the Kutta condition is as following ;
  - For a given airfoil at a given angle of attack, the value of Γ around the airfoil is such that the flow leaves T.E. smoothly.
  - If the T.E. angle is finite, then T.E. is a stagnation point.

    ↳ For smooth, V_1 and V_2 should be disappeared at point a and then start the journey from the a point.
  - If the T.E. is cusped, then the velocities leaving the top and bottom surfaces at the T.E. are finite and equal in magnitude and direction.

    ↳ If not such that $V_1 \neq V_2$, $\begin{cases} V_1 > V_2 \\ V_1 < V_2 \end{cases}$

cf. Joukowski hypothesis says that any steady flow cannot turn around a sharp corner with a non-zero velocity.