AE-705: Introduction to Flight AIRFOILS

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OVERVIEW

✓ What is an Airfoil?

- ✓ Airfoil Terminologies and Nomenclature
- ✓ History of Airfoil
- ✓ Types of Airfoils
 - ✓ Flat Plate and Cambered Airfoil
 - ✓ Thick Airfoil
 - ✓ Laminar Airfoil
 - ✓ Low Reynolds Number Airfoil
 - ✓ Supersonic Airfoil
 - ✓ Supercritical Airfoil
- ✓ Modern Developments



Foil paper in air!!

WHAT IS AN AIRFOIL?

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X section of the wing normal to span



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Airfoil Terminology

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Airfoils belong to families too !

AIRFOIL NOMENCLATURE

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NACA 4, 5, 6, 7 & 8 series

RAF series

SERI family

Gottingen series

Eppler family

KFM series NASA family GAW series BAC family

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Bell family Antonov family **Boeing series** Lieback family **Clark family** Wortmann series **TsAGI** family Lissaman series

Beech series



SERI NOMENCLATURE



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Capsule-04

KLINE FOGLEMAN AIRFOIL



Aircraft wing showing the KFm2 Step



Aircraft wing showing the KFm3 Step

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GOTTINGEN AIRFOIL

Created at Gottingen University,Germany~1910s There are one, two and three digit numbers

What's the relation ??

Source: http://www.aerospaceweb.org/question/airfoils/q0197.shtml

Gottingen 622

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EPPLER AIRFOIL





Who was behind all this?? AIRFOIL HISTORY

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A VISIT TO THE PAST

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- > 1849 ; Gliders flown by Sir George Cayley
 > Scientific reasoning on cambered airfoil
 > 1884
- Further studied and developed by Jean Marie Le Bris, John J. Montgomery, Otto Lilienthal, Percy Pilcher, Octave Chanute and Augustus Moore Herring



Sir George Cayley first glider





Lilienthal Ornithopter



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> Wright Brothers developed three gliders > In July 1899 Wilbur tested wing warping



Source: https://en.wikipedia.org/wiki/Wright_brothers#Flights





Thin Airfoils

WTT at low speed

Early WTT **misleading!!**

attached but was separated in reality

At low speeds

most flow

remained

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Let's see what this has to give us?? TYPES OF AIRFOILS



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Seriously!!!!!

FLAT PLATE

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WHY NOT USE FLAT PLATES?

Flat Plates cannot produce Lift?



Air flow speed and static pressure → Lift
Camber → changes V and P → laminar flow
Most wings are designed with this concept
↑ n of the airfoil







Source: https://www.quora.com/Why-are-thick-airfoils-useful-Are-they-for-generating-lift-at-low-airspeeds

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Source: https://www.quora.com/Why-are-thick-airfoils-useful-Are-they-for-generating-lift-at-low-airspeeds

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"Paraglider airfoil" A lot of volume gives much lift and smooth stalling at high angle of attack Also much drag as airspeed increases.

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Source: https://www.quora.com/Why-are-thick-airfoils-useful-Are-they-for-generating-lift-at-low-airspeeds

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Source: https://backcountrypilot.org/forum/horizontalstabilizer-shape-air-foil-vs-flat-pros-cons-18170



Are these stuffed up??

THICK AIRFOILS

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□ Thin airfoils → stall at ↓ α
 □ Separation of the flow over the top surface creates
 ↑ drag → loss of lift

I have a mathematical model

Larger LE radii

Higher α before stall

Ludwig Prandtl (1875-1953)

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□ Thicker airfoils × flow separation till ↑α → ↑L □ German engineers ♀ → planes climbed faster and maneuver more sharply



Gö 410

Source: http://www.aviation-history.com/articles/great-war.htm

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□ Thicker airfoils × flow separation till ↑α → ↑L □ German engineers ♀ → planes climbed faster and maneuver more sharply

- Benefits; more space for:
 - Fuel tanks
 - Space for LG



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□ Thicker airfoils × flow separation till ↑α → ↑L □ German engineers ♀ → planes climbed faster and maneuver more sharply

- Benefits; more space for:
 - Fuel tanks
 - Space for LG
 - Structural spar



Source: http://www.darkgovernment.com/RANCHO/CRASH/TWA/WINGBOX/wingbox.gif





<u>Some Airplanes with</u> <u>their Airfoils</u>

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So they don't have turbulence?

LAMINAR AIRFOIL

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Source: https://blog.rescale.com/leveraging-rescale-for-high-order-cfd-simulation/

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Developed to fly faster Aim: Maintain laminar flow over larger chord





Developed to fly faster Aim: Maintain laminar flow over larger chord



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WHY LAMINAR AIRFOILS?

Turbulent flow on airfoil → more stable?? P-51 Mustang Simple Answer:

Skin friction drag - compared to turbulent flow



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WHY LAMINAR AIRFOILS?



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Fly at low speed....

LOW REYNOLDS NUMBER AIRFOIL

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LRN AIRFOILS

Reynolds number → inertial effects vs viscous (fluid stickiness) effects

Grumman HU-16B Albatross

Drag or stream wise resistance

Limiting and controlling the maximum lift

Chord Reynolds Number = Vc/v

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LRN AIRFOILS



Source: http://www.humanpoweredflying.propdesigner.co.uk/html/the_gossamers.html

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Gossamer Albatross



LRN AIRFOILS

Grumman HU-16B Albatross

U.S. AIR FORCE

Source: https://media.defense.gov/2005/Dec/26/2000574422/670/394/0/050322-F-1234P-028.JPG

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RESCUE

Faster than sound!!!

SUPERSONIC AIRFOIL

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Source: https://www.rt.com/usa/330524-sonic-boom-new-jersey/

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Have you ever wondered that you could be flying on a plane producing shock waves?? Now what does that <u>mean</u>??

Video Courtesy: Russell Croman (https://www.youtube.com/watch?v=HekbC6Pl4_Y)

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Objective: Delay the onset of wave drag
 This aircraft speed is called the critical speed



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Objective: Delay the onset of wave drag This aircraft speed is called the critical speed

Source: https://www.nasa.gov/centers/armstrong/news/FactSheets/FS-044-DFRC.html



Large LE Radius

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The flat upper surface does the ** Reduces aerodynamic drag associated with BL separation





Do these fly at the speed of Maruti 800?

VERY LOW SPEED AIRFOIL

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VLS AIRFOILS

□ Lift with very less speed
 □ Solar powered aircraft → low power engines
 □ The airfoil used on the Solar Challenger





Laminar airfoil was considered <u>Solar Impulse</u>

NACA 63412 profile Lissaman Hibbs 8025, 8230 and Wortmann profiles also



NACA 63-412 AIRFOIL

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Nonrigid (textile) airfoil inflated by the wind Ram-air inflates it to a classic wing cross-section Material-Ripstop nylon











REFLEX AIRFOIL

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Non-symmetrical airfoils on flying wings

A flying wing is a tailless fixed-wing aircraft that has no definite fuselage

Source: Google images (B2 Bomber)

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Non-symmetrical airfoils on flying wings



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Nature loves symmetry!!

SYMMETRICAL AIRFOIL

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Line of symmetry (chord)

HR-FPG

Pilatus PC-12

Air	foi	ITod	ols.	com

NACA 0012 AIRFOILS

Source: http://www.wbko.com/content/news/The-Latest-Missing-pilots-company-calls-it-a-difficult-day-408890925.html

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Line of symmetry (chord)
 Best L/D ratio
 Lower C₁ than the asymmetrical airfoil
 Tilting changes the flow of air ----- Lift
 Used on control surfaces



Source: http://www.wbko.com/content/news/The-Latest-Missingpilots-company-calls-it-a-difficult-day-408890925.html

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So we can fly upside down?
INVERTED AIRFOIL

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The second second



□ Usually for horizontal stabilizer □ Provide –ve lift → downforce

AB aur

Dornier 228

Source: https://planefinder.net/data/aircraft/G-SAYE

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Time for some self-study now THAT'S ALL !

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