Final Project's Description

Background

Airfoils are specially designed shapes that are used in a variety of applications to generate lift and reduce drag. They are typically used in aircraft wings, wind turbines, and other lifting surfaces. The shape of an airfoil is designed to create a difference in air pressure between the top and bottom surfaces, which generates lift. Airfoils are essential components in aviation and wind energy systems. In aircraft, airfoils are crucial for generating lift, allowing planes to take off and stay aloft. In wind turbines, airfoils are used to capture the energy of the wind and convert it into rotational energy to generate electricity [1].
(Watch the video for a better grasp: https://youtu.be/E3i_XHlVCeU)

Simulation plays a critical role in airfoil design. Before an airfoil is manufactured and tested, it must be thoroughly simulated and analyzed to ensure that it will perform as expected. Simulation allows engineers to model the behavior of airfoils under different conditions, such as varying wind speeds and angles of attack. By simulating the performance of airfoils, engineers can optimize their designs, reducing the need for expensive and time-consuming physical testing. Moreover, simulation also enables engineers to study the impact of different parameters on airfoil performance, such as the thickness, curvature, and angle of attack. This helps in identifying the optimal design parameters for a particular application. In summary, airfoils are essential components in various industries, and simulation is a crucial tool in airfoil design, helping to optimize their performance and reduce the cost and time associated with physical testing.

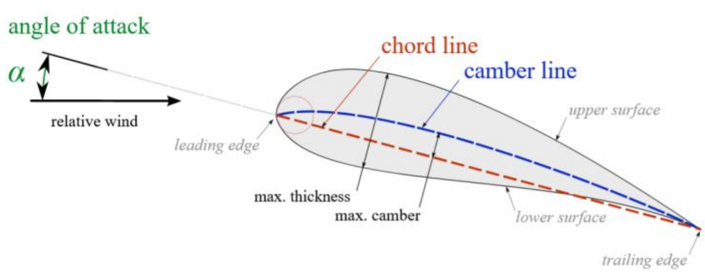

Figure 1- Airfoil terminology

Based on the thin airfoil theory, for incompressible and inviscid flows, the lift coefficient only depends on the angle of attack, and the slope of the lift coefficient versus the angle of attack line is equal to $2\pi/180$. For airfoils with low thickness, this theory has good accuracy in calculating lift coefficient at the low angles of attack. However, the more the angle of attack is, the more the deviation becomes. This theory cannot predict the drag force. In fact, for incompressible viscous flow around an airfoil, the lift and drag forces depend on the Reynolds number and the angle of attack. For large angles of attack, the fluid flow is detached from the surface of the airfoil, and the lift force does not increase linearly by increasing angle of attack. Finally, at a critical angle of attack, the flow separates entirely from the airfoil surface, and the lift coefficient decreases suddenly, which is called the Stall phenomenon.

Procedure

In this project you are supposed to simulate an airfoil numerically to study its aerodynamic characteristics using ANSYS Fluent software. For this purpose, you will need to take these steps:

- Consider a proper domain for your numerical study.
- Generate a suitable grid for your fluid domain based on the turbulence model you are implementing.

In your numerical solver:

- You can choose $k-\epsilon$ or $k-\omega$ turbulent models.
- Use second order upwind scheme for the convective term's discretization.

Tasks

1. Draw the pressure distribution curve in different angles of attack in one plot and analyze the results. (At least 6 different angles)
2. By calculating the lift and drag coefficients in different angles of attack up to the onset of the stall phenomenon, validate your results with the experimental data represented in appendix IV of the source book [2].
3. Compare the zero-lift angle of attack and slop of the lift coefficient curve versus the angle of attack with the relation of the thin airfoil theory and experimental data.
4. Investigate the use of other numerical methods, their application and their differences.
5. Research the different methods used to manufacture airfoils, such as computer numerical control (CNC) machining, 3D printing, and composite layup and explore the use of airfoil simulation software, such as ANSYS Fluent or XFOIL, and how it is used in industry and academia to design and optimize airfoils.
6. Research the purpose of prism layer meshing and the meaning of y^+.

*Please note that there are unique airfoils assigned to individual students, you can find yours in the Appendix section.

References

[1] Fox, R. W., Pritchard, P. J., and McDonald, A. T., Introduction to Fluid Mechanics, 8th edition, Wiley, 2011.
[2] I. H. Abbott and A. E. Von Doenhoff, Theory of wing sections, including a summary of airfoil data. Courier Corporation, 1959.
[3] Klaus A. Hoffmann (Author), Steve T. Chiang, Computational Fluid Dynamics for engineers, 4th edition, Engineering Education System, 2000.
[4] https://www.cfd-online.com/Tools/yplus.php

Appendix

Student name	Student Number	Airfoil Code
Ahmadreza Kashefi	**810699249**	NACA 2408
Hamid Motallebi	**810699266**	NACA 23016
Armin Arman	**810699173**	NACA 4424
Elina Firoozi	**810699243**	NACA 23018
Makan Baghban	**810699182**	NACA 2215
Amirhossein Ghazanfarian	**810699238**	NACA 65-410
Alireza HajiMohammadi	**810698234**	NACA 2412
Amirhossein Fallahi	**810699242**	NACA 63-212
Ali Saeedi	**810699215**	NACA 1408
Amirhossein Nasiri	**810699278**	NACA 2212
Arshia Samadikhah	**810699230**	NACA 63-412
Pejman Mehrshahi	**810699272**	NACA 2415
Helia Ghasemzadeh	**810699245**	NACA 4421
Taravat Yazdani	**810699286**	NACA 4412
Mohaddese Aslani	**810699176**	NACA 64-108
Yasmin Seifi	**810699218**	NACA 23112
Mohammad Zarei Dehseraji	**810699212**	NACA 4424
Sepehr Ghodrati	**810699299**	NACA 23021
Ali Ghiasi Tari	**810699239**	NACA 0006
Mohammad Montazeri	**810699269**	NACA 23017
Mahdieh Talkhab	**810699194**	NACA 0008
Bahareh Davtalab	**810699206**	NACA 0018
Hoora Badihi	**810699184**	NACA 6409
Zahra Ghayouri	**810699301**	NACA 2410
Mohamadhossein Habibi	**810696229**	NACA 4418
Alireza Harirforoush	**810699197**	NACA 64-110
Vandad Safaeian	**810699227**	NACA 63-210
Mohsen Davari moghadam	**810699205**	NACA 24112
MohammadAmin Radman Mehr	**810699188**	NACA 6412
Shahryar Ahmadi	**810698209**	NACA 4424
Alireza Akhundi	**810698211**	NACA 2421
MohammaadReza Ghasemian	**810697328**	NACA 0015
Melika Mansouri	**810699270**	NACA 4415
Mohammadmehdi Karami	**810600030**	NACA 1408