**Numerical Simulation Approaches for Vertical-Axis Wind Turbines: Investigating Airfoil Design and Predictive Techniques**

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SUPPLEMENTARY MATERIALS

A. MATLAB Code

Below is the MATLAB code for the computational analysis of the obtained values from the solver exported to a CSV file.

% First do the housekeeping

clear % Clears all variables from the current workspace

clc % Clears all texts from the command window

close all % Closes any open windows

c = 100 % Assumed Length of chord of the airfoil in m

rho = 1.225 % Density of air in kg/m^3

% Importing NACA 4412 data %

Airfoil\_data = xlsread ('Airfoil\_data.csv'); %Reads the CSV file

AOA = Airfoil\_data (:,1); % Angle of attack in degrees

L\_V5 = Airfoil\_data (:,5); % Lift force for velocity = 10 m/s

L\_V10 = Airfoil\_data (:,8); % Lift force for velocity = 15 m/s

L\_V16 = Airfoil\_data (:,11); % Lift force for velocity = 20 m/s

D\_V5 = Airfoil\_data (:,4); % Drag force for velocity = 10 m/s

D\_V10 = Airfoil\_data (:,7); % Drag force for velocity = 15 m/s

D\_V16 = Airfoil\_data (:,10); % Drag force for velocity = 20 m/s

LD\_V5 = Airfoil\_data (:,6); % Lift-Drag coeffi for velocity = 10 m/s

LD\_V10 = Airfoil\_data (:,9); % Lift-Drag coeffi for velocity = 15 m/s

LD\_V16 = Airfoil\_data (:,12); % Lift-Drag coeffi for velocity = 20 m/s

%% Plotting the various components of the Imported data

figure()

hold on

grid on

plot(AOA,L\_V5, AOA,L\_V10, AOA,L\_V16);

xlabel('Angle of attack, degrees')

ylabel('Lift, N')

legend('Velocity = 5 m/s', 'Velocity = 10 m/s', 'Velocity = 16 m/s')

title('A graph of Lift force against angle of attack')

figure()

hold on

grid on

plot(AOA,D\_V5, AOA,D\_V10, AOA,D\_V16);

xlabel('Angle of attack, degrees')

ylabel('Drag, N')

legend('Velocity = 5 m/s', 'Velocity = 10 m/s', 'Velocity = 16 m/s')

title('A graph of Drag force against angle of attack')

xlim ([-6 14])

ylim ([0 0.5])

figure()

hold on

grid on

plot(AOA,LD\_V5, AOA,LD\_V10, AOA,LD\_V16);

xlabel('Angle of attack, degrees')

ylabel('Lift-Drag coefficient')

legend('Velocity = 5 m/s', 'Velocity = 10 m/s', 'Velocity = 16 m/s')

title('A graph of Lift-Drag coefficient against angle of attack')

%% Obtaining optimum AOA value based on L/D ratio

[pksA,index] = findpeaks(LD\_V5); %Obtains the peak value of lift-drag at velocity 5m/s

 AOA\_Optimum\_V5 = AOA(index); %Returns the index value as the AOA optimum

[pksB,index] = findpeaks(LD\_V10); %Obtains the peak value of lift-drag at velocity 10m/s

AOA\_Optimum\_V10 = AOA(index); %Returns the index value as the AOA optimum

[pksC,index] = findpeaks(LD\_V16); %Obtains the peak value of lift-drag at velocity 16m/s

AOA\_Optimum\_V16 = AOA(index); %Returns the index value as the AOA optimum.

1. **Supplementary data**

Table S1. Showing forces acting on the Airfoil.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **S/N** | **Lift (N)** | **Lift (N)** | **Lift (N)** | **Drag (N)** | **Drag (N)** | **Drag (N)** | **LD ratio** | **LD ratio** | **LD ratio** |
| **AOA** | **5 (m/s)** | **10 (m/s)** | **16 (m/s)** | **5 (m/s)** | **10 (m/s)** | **16 (m/s)** | **5 (m/s)** | **10 (m/s)** | **16 (m/s)** |
| 0 | 0.0542 | 0.2270 | 0.5949 | 0.0028 | 0.0101 | 0.0245 | 19.5901 | 22.5355 | 24.2600 |
| -5 | -0.0146 | -0.0527 | -0.1271 | 0.0012 | 0.0039 | 0.0090 | -12.5082 | -13.6819 | -14.2003 |
| -3 | 0.0128 | 0.0587 | 0.1607 | 0.0030 | 0.0111 | 0.0276 | 4.3016 | 5.2684 | 5.8200 |
| -1 | 0.0404 | 0.1709 | 0.4504 | 0.0032 | 0.0120 | 0.0297 | 12.5041 | 14.1877 | 15.1481 |
| 1 | 0.0680 | 0.2829 | 0.7389 | 0.0019 | 0.0065 | 0.0151 | 35.6857 | 43.6879 | 48.8993 |
| 3 | 0.0951 | 0.3932 | 1.0238 | 0.0010 | 0.0056 | 0.0162 | 93.6362 | 70.4933 | 63.0636 |
| 7 | 0.1465 | 0.6030 | 1.5672 | 0.0114 | 0.0482 | 0.1269 | 12.8875 | 12.5154 | 12.3497 |
| 10 | 0.1806 | 0.7440 | 1.9346 | 0.0225 | 0.0942 | 0.2470 | 8.0373 | 7.8950 | 7.8327 |
| 12 | 0.1990 | 0.8234 | 2.1452 | 0.0307 | 0.1294 | 0.3394 | 6.4761 | 6.3643 | 6.3201 |