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2D ANALYSIS OF NACA 4412 SERIES WIND BLADE AT DIFFERENT ANGLE OF ATTACK

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Abstract - *The wind turbine blade is very important part of the rotor. Wind turbines provides an alternative way of generating energy from the power of wind. Extraction of energy depends on the design of blade. At windy places where the wind speeds are so high, sufficient amount of energy can be harnessed by making use of wind turbines. The blades of such turbines are designed that they generate lift from wind and thus rotate. In this work, the wind turbine blade is modelled 2d in ansys design modeler using airfoil coordinates and then apply velocity at different angle of attack. The lift and drag forces are calculated at different angle of attack varying from 0◦ to 20◦.*

Key Words: **Airfoil, Ansys, Angle of attack, Lift force , Drag force, Wind turbine**

1. INTRODUCTION

Wind turbine is a device that converts kinetic energy from the wind into electrical power. A turbine converts the kinetic energy of the wind to useful mechanical energy. This energy could be used in mechanical form or turn generator turbines and provide electricity. Just like in the hydropower systems, wind energy is harnessed through conversion of the wind kinetic energy to mechanical energy. It is a mechanical machine that converts kinetic energy of the fast moving winds into electrical energy.

On the basis of axis of rotation of the blades, it is divided into two parts

1. Horizontal axis wind turbine (HAWT)
2. Vertical axis wind turbine (VAWT)

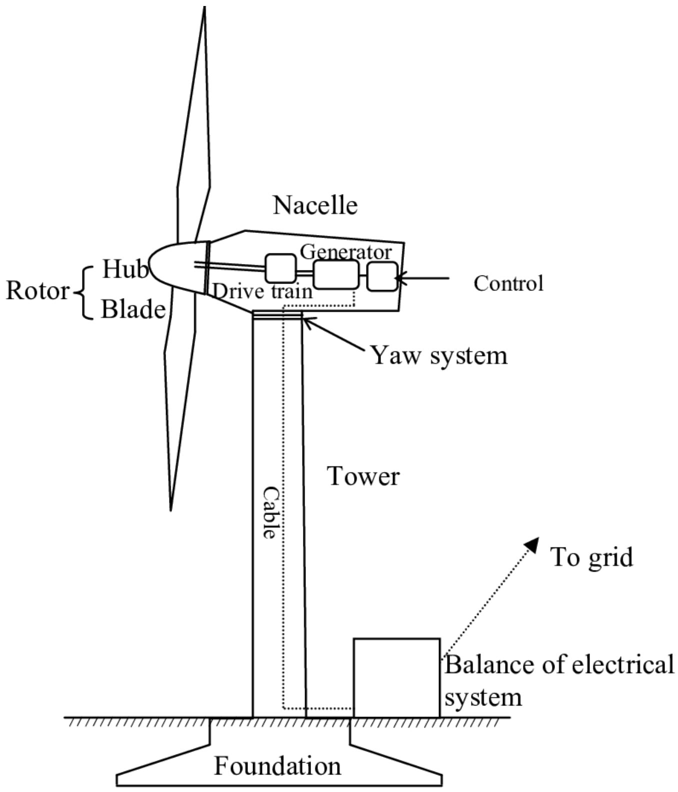

Fig 1: Components of horizontal axis wind turbine

2. LITERATURE REVIEW

Airfoil :-

An airfoil is defined as the cross section of the body that is placed in an airstream in order to produce a useful aerodynamic force in the most efficient manner possible. The cross section of wings, propeller blades, windmill blades, compressor and turbine blades in a jet engine, and hydrofoils are example of airfoils. The basic geometry of an airfoil is shown in Figure 2 [1]

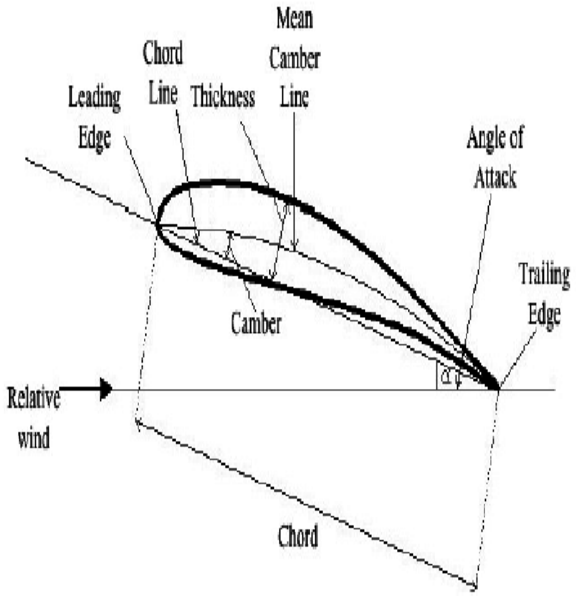

Fig 2: Diagram of airfoil geometry

Lift on a body is defined as force on the body in a direction normal to the flow direction. Lift will only be present in the fluid incorporates a circulatory flow about the body such as that which exist about a spinning cylinder. The velocity above the body is increased and so the static pressure is reduced. The velocity beneath is slowed down, giving an increase in static pressure. So, there is normal force upwards called the lift force.

The drag force on a body in an oncoming flow is defined as the force on the body in a direction parallel flow direction. For a windmill to operate efficiently the lift force should be high and drag force should be low. For small angle of attack, lift force is high and drag force is low. If the angle of attack (α) increases beyond a certain value, the lift force decreases and drag force increases. So, the angle of attack plays a vital role, lift and drag is presented in Fig (3)

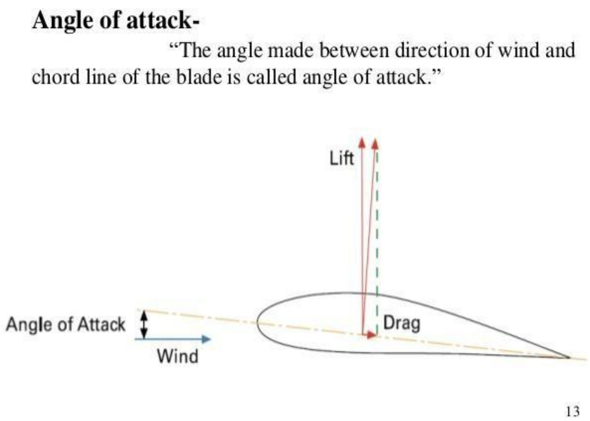

Fig 3: Forces on stationary rotor blade in airflow

An airfoil means a two dimensional cross section shape at a wing whose purpose is to either generate lift or minimize drag when exposed to a moving fluid. The word is an Americanization of the British term aerofoil which itself is derived from two greek work Aeros("of the air") and Phyllon ("leaf"), or air leaf.

The NACA (National Advisory Committee for Aeronautics) four digit wing sections define the profile by:

1. One digit describing the maximum camber as percentage of the chord.
2. One digit describing the distance of maximum camber from the leading edge in tens of percentage of the chord.
3. Two digit describing maximum thickness of the airfoil as percent of the chord.

3. RESEARCH GAP IDENTIFICATION

Horizontal Axis wind turbines have a better efficiency as compare to the Vertical Axis wind turbine. HAWT produce more electricity at wide range farm in any type of field at both low and high speed of the wind. Maximum industries is working on this sector and doing optimized of wind turbine in every parameter. Mainly the focuses of optimization in wind turbine are the blade and rotor size, Blade parameter are tip speed ratio, twisting angle, chord length, pitch angle and lift & drag coefficient, that are the point to optimized the blade for maximize the blade efficiency at every condition of wind.

Wind turbine blade profile is the key to transfer wind kinetic energy to rotational mechanical energy. Standalone small wind turbine applications are mostly interested in electrical generation for remote areas. Due to small size and face to low wind velocity, Special design dedicated to low Reynolds number airfoils are needed. While the design and analysis of airfoils for Reynolds numbers above 50000 can be accomplished with a high level of confidence that the resulting aerodynamics will be predicted. Due to the dependency of airfoil performance at low Reynolds number on the location of the laminar separation bubble, the design philosophies of such airfoils are considerably different than those employed at higher Reynold number.

4. METHODOLOGY

Aerfoil used for analysis is NACA 4412 series wind blade. Anaysis type is 2d analysis.

Fluent will set little parameter which are

Table 1: Fluent parameter

Solver	Pressure based steady state
Viscous model	K-epsilon (2 Eqn)

Viscous model type	Realizable
Density (Kg/m3)	1.225
Inlet velocity	25,50,100,120 m/s
Chord length	1 m
Reynolds number	50000
Momentum	Second order upwind
Angle of attack	0◦,2◦,5◦,7◦,10◦,12◦,15◦,17◦,20◦
Velocity Specification Method	Magnitude and Direction

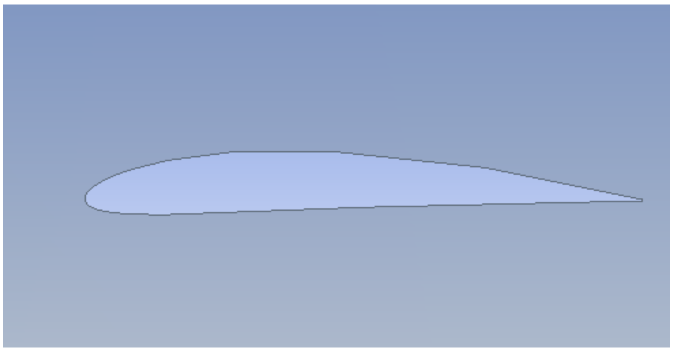

Fig 4: Naca 4412 series wind blade geometry at 0◦ angle of attack

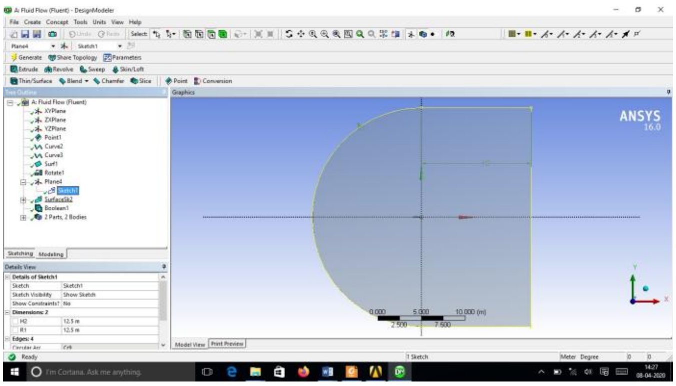

Fig 5: C-mesh region geometry detail at 0◦ angle of attack

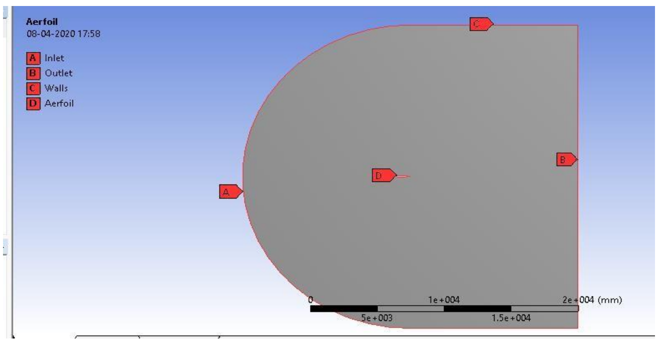

Fig 6: Named selection of geometry

Table 2 : Mesh input detail

METHOD	TRIANGLES
EDGE SIZING ON AIRFOIL EDGES	
TYPE	NUMBER OF DIVISIONS -300
BEHAVIOUR	SOFT
REFINEMENT ON C-MESH FACE	
REFINEMENT NO.	2

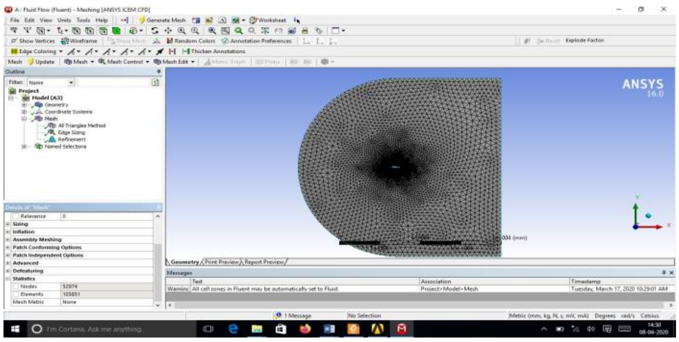

Fig 7: Mesh geometry detail at 0◦ angle of attack

Table 3 : Node and element after meshing blade at 0◦ angle of attack

NODES	52954
ELEMENTS	103851

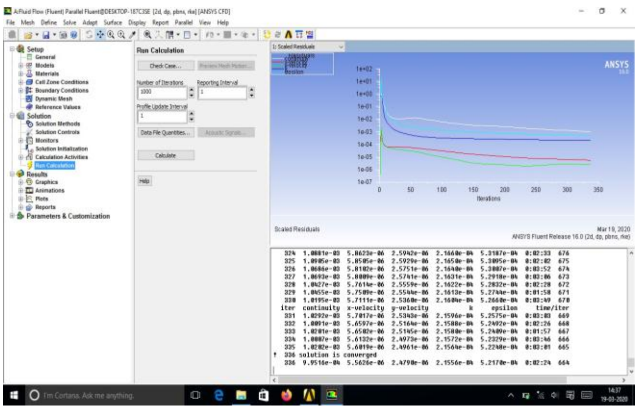

Fig 8: Scaled residual of blade at 0◦ 25 mps velocity

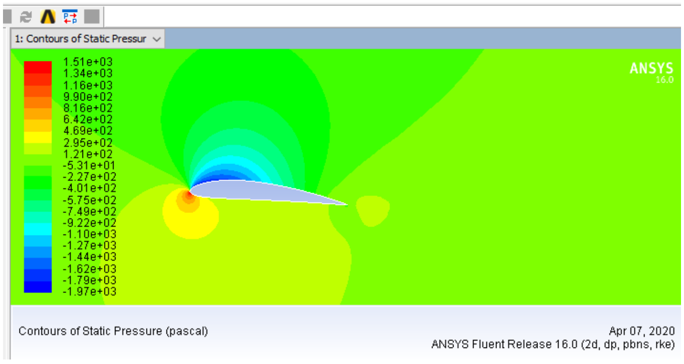

Fig 9 : Static pressure contour at 15◦ 50 mps velocity

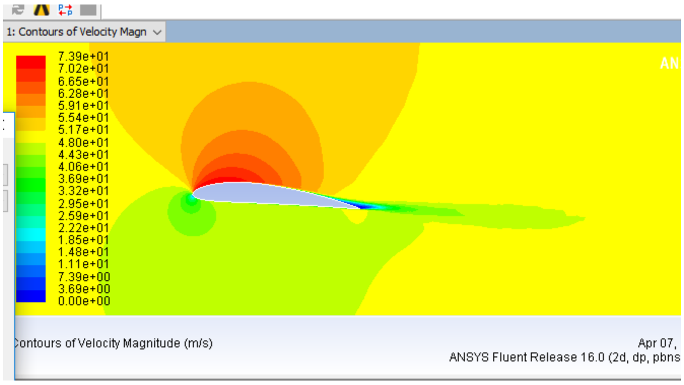

Fig 10 : Velocity magnitude contour at 15◦ 50 mps velocity

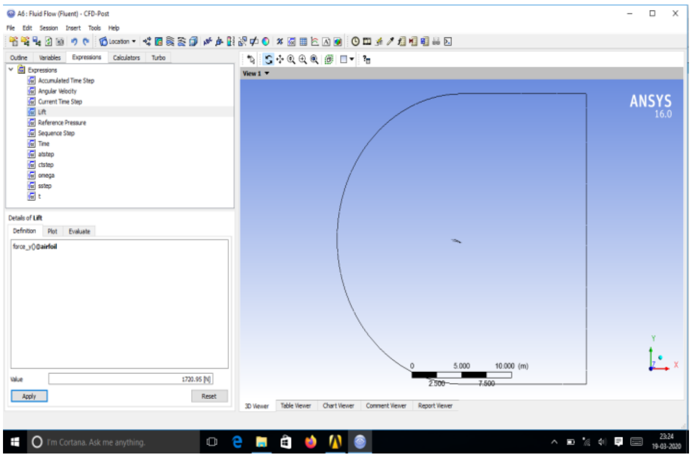

Fig 11 : Value of lift force by cfd-post for 15◦ 50 mps velocity

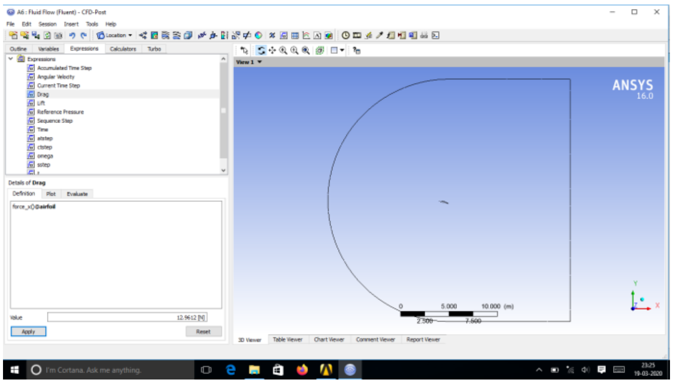

Fig 12 : Value of drag force by cfd-post for 15◦ 50 mps velocity

4.1 MATHEMATICAL EQUATIONS

Lift coefficient

$$C_L = \frac{F_L}{\frac{1}{2}\rho V^2 A}$$

Drag coefficient

$$C_D = \frac{F_D}{\frac{1}{2}\rho V^2 A}$$

Where
FL =Lift force in newton
ρ =Density (kg/*m*3)
V 2 = Velocity in *m*3
A=Swept area of blade = π * (chord lengh) 2
FD =Drag force in newton

4. RESULT AND DISCUSSION

Lift and drag force for 0◦,2◦,5◦,7◦,10◦,12◦,15◦,17◦,20◦ at 25m/s,50 m/s,100 m/s and 120 m/s are shown in table below :

Table 4 : Lift force (N)

Sr. no.	Angle of attack	25 mps	50 mps	100 mps	120 mps
1	0◦	151.628	598.889	2331.47	3349.37
2.	2◦	208.358	832.991	3358.13	4843.62
3.	5◦	329.238	1188.76	5184.83	7774.98
4.	7◦	401.876	1586.34	6537.16	9399.07
5.	10◦	478.85	1912.29	7987.95	11196.3

6.	12◦	498.045	1867.04	7744.03	11070.7
7.	15◦	490.917	1720.95	7953.21	10673
8.	17◦	428.527	1746.84	7040.68	10148.5
9.	20◦	469.113	2278.09	7656.93	65407.8

Table 5 : Drag force (N)

Sr. no.	Angle of attack	25 mps	50 mps	100 mps	120 mps
1	0◦	5.33147	18.3529	63.6684	88.634
2.	2◦	4.76793	16.0889	59.0171	83.2133
3.	5◦	8.03393	14.838	80.2116	113.61
4.	7◦	11.1871	41.7639	100.185	139.177
5.	10◦	17.7298	39.0015	143.026	227.804
6.	12◦	10.4241	24.4177	61.1622	13.5534
7.	15◦	21.0669	12.9612	180.821	276.283
8.	17◦	38.6044	160.015	423.081	644.056
9.	20◦	57.2648	329.589	903.071	10614.4

Table 6 : Ratio of lift coefficient to drag coefficient

Sr. no.	Angle of attack	25 mps	50 mps	100 mps	120 mps
1	0◦	28.42	102.92	36.69	38.96
2.	2◦	43.69	52.45	58.60	58.26
3.	5◦	40.97	80.23	65.70	68.41
4.	7◦	35.91	38.33	65.33	67.84
5.	10◦	27.08	49.07	55.87	49.26
6.	12◦	45.96	76.55	126.95	13.5534
7.	15◦	23.32	132.98	44.017	3.86
8.	17◦	11.15	10.93	16.64	15.78
9.	20◦	8.19	6.91	8.47	6.16

5. CONCLUSIONS

For a windmill to operate efficiently the lift force should be high and drag force should be

The coefficient of lift and drag force is calculated for this NACA 4412 series for the angle of attack of 0◦ to 20◦ at different velocity.

1.For 25 m/s velocity 12◦ angle of attack is efficient to operate windmill.

2. For 50 m/s velocity 15◦ angle of attack is efficient to operate windmill.

3.For 100 m/s velocity 12◦ angle of attack is efficient to operate windmill.

4.For 120 m/s velocity 12◦ angle of attack is efficient to operate windmill.

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