International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Experimental and Numerical Analysis of Rectangular, Tapered and Tapered Swept Back wings

Mukesh M[1], Arun MD[2], Divyasharada NS[3], Koushik Prakash[4], Ram Rakshith V[5]

[1]Asst Professor, Aerospace Engineering, R.V College of Engineering, Karnataka, India
[2,3,4,5]Student, Aerospace Engineering, R.V College of Engineering, Karnataka, India

---

Abstract - *Wings form an essential component of an Aircraft. They help in producing the essential lift to an Aircraft while moving through air. They are subjected to various aerodynamic parameters like Lift, Drag and Moments. The values of these parameters determine the Aerodynamic efficiency of an Aircraft. The main objective of our project would be to compare different Aerodynamic Parameters like Lift, Drag on the three wing configurations namely Rectangular, Tapered and Tapered Sweptback Wings of NACA 4418 Airfoil series, and validate the numerical results obtained with the experimental results.*

Key Words: Lift, Drag, CFD, Rectangular Wing, Tapered Wing, Tapered Swept Wing, Sweep Angle, Force Balance, Wind Tunnel

1. INTRODUCTION

A Rectangular wing is one of the wing configurations that generates more lift in Subsonic regime with a lesser induced drag with a constant Taper ratio (1:1).

A Swept Back Wing usually sweeps backward or occasionally forward from its root. These are mostly tapered in configuration. A swept wing is a wing that angles either backward or occasionally forward from its root rather than in a straight sideways direction. Wing sweep has the effect of delaying the shock waves and accompanying aerodynamic drag rise caused by fluid compressibility near the speed of sound, improving performance. Swept wings are therefore often used on jet aircraft designed to fly at high speeds

1.1 Rectangular Wing

The Rectangular wing (refer Fig 1.1) span of the wing were chosen to be 540mm so that the wing can be accommodated the test section (0.6m*0.6m*2m) with sufficient spacing from the wall of the test section so that the wall effects and hence the drag due to such effects are negligible during the experimental testing.

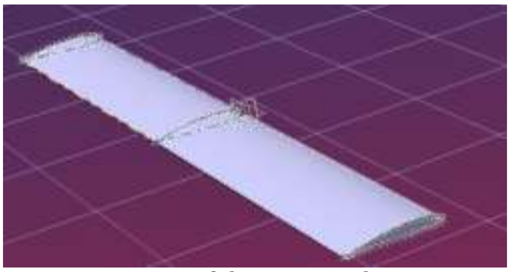


FIG 1.1 3D Geometry of the rectangular wing in CATIA Workspace

1.2 Tapered Wing

The Tapered wing (refer fig 1.2) span of the wing were chosen to be 540mm so that the wing can be accommodated the test section (0.6m*0.6m*2m) with sufficient spacing from the wall of the test section so that the wall effects and hence the drag due to such effects are negligible during the experimental testing.

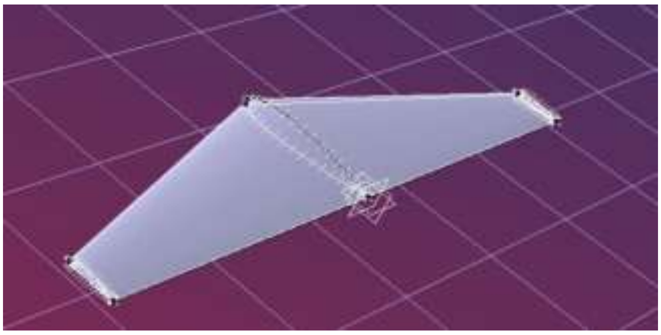


FIG 1.2 3D Geometry of the Tapered wing in CATIA Workspace

1.3 Tapered Swept Back Wing

The Tapered Swept back Wing (refer fig 1.3) span of the wing were chosen to be 568.16mm so that the wing can be accommodated the test section (0.6m*0.6m*2m) with sufficient spacing from the wall of the test section so that the wall effects and hence the drag due to such effects are negligible during the experimental testing.

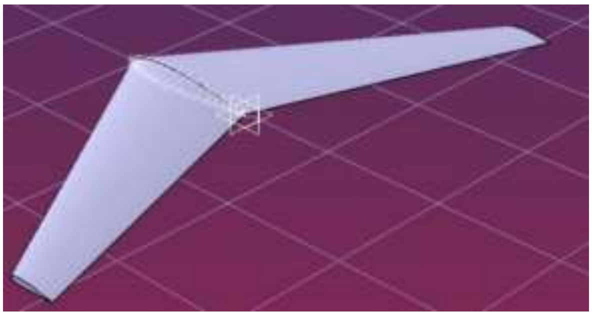


Fig 1.3 3D Geometry of the Tapered Swept Back wing in CATIA Workspace

GEOMETERIC PARAMETERS OF 3 WINGS		
Rectangular wing	Taper wing	Tapered swept back wing
Aspect Ratio = 6	Aspect Ratio = 6	Aspect Ratio = 6.3
Span b = 540mm	Span b = 540mm	Span b = 568.16mm
Chord = 90mm	Root Chord = 135mm Tip chord = 45mm Mean Chord = 90mm	Root Chord = 135mm Tip chord = 45mm Mean Chord = 90mm
Taper ratio = 1	Taper ratio = 0.33	Taper ratio = 0.33

.

TABLE – 1 Geometric Parameters of three Wings

2. NUMERICAL ANALYSIS

After Catia modelling the model was imported to Ansys workbench where preprocessing and design conditions were set and it was then imported to ICEM Meshing tool where structured meshing was done. Finally Analysis was done using Ansys Fluent. Then Grid Independence study was done and Lift and Drag were calculated.

2.1 Rectangular Wing Results of Grid Independence Study

Grid Elements (millions)	Lift (N)	Lift Coefficient	Drag (N)	Drag Coefficient
0.2	38.32	0.0561	8.53	6.88e-03
0.4	38.32	0.0563	8.68	6.91e-03
0.6	38.34	0.0566	8.75	6.92e-03
0.8	38.36	0.0569	8.86	6.92e-03
1	38.36	0.057	8.96	6.94e-03
1.2	38.36	0.057	8.96	6.94e-03
3	38.36	0.057	8.96	6.94e-03

TABLE – 2.1 RESULTS OF RECTANGULAR WING

2.2 Tapered Wing Results Grid Independence Study

Grid Elements (millions)	Lift (N)	Lift Coefficient	Drag (N)	Drag Coefficient
0.2	38.32	0.0561	8.53	6.88e-03
0.4	38.32	0.0563	8.68	6.91e-03
0.6	38.34	0.0566	8.75	6.92e-03
0.8	38.36	0.0569	8.86	6.92e-03
1	38.36	0.057	8.96	6.94e-03
1.2	38.36	0.057	8.96	6.94e-03
3	38.36	0.057	8.96	6.94e-03

TABLE – 2.2 RESULTS OF TAPERED WING

2.3 Tapered Swept Back Wing Grid Independence Study

Grid Elements (millions)	Lift (N)	Lift Coefficient	Drag (N)	Drag Coefficient
0.2	29.04	5.01e-02	9.06	7.32e-03
0.4	29.08	5.06e-02	9.07	7.36e-03
0.6	29.16	5.09e-02	9.07	7.45e-03
0.8	29.21	5.14e-02	9.23	7.45e-03
1	29.23	5.18e-02	9.23	7.52e-03
1.2	29.23	5.18e-02	9.23	7.52e-03
3	29.23	5.18e-02	9.23	7.52e-03

TABLE – 2.3 RESULTS OF TAPERED SWEPT WING

2.4 Plots And Graphs

1. **Rectangular Wing**

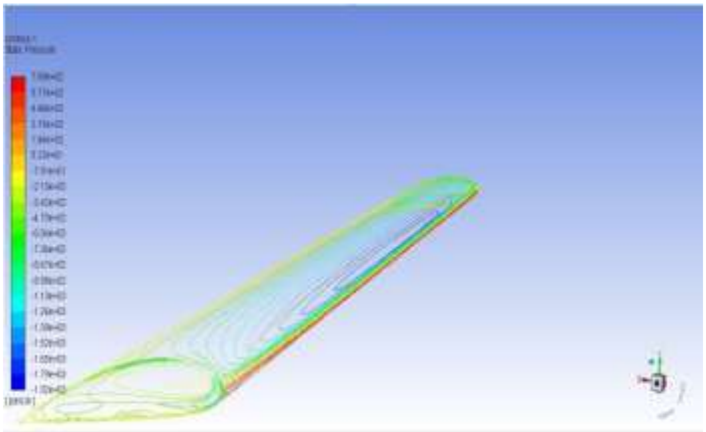


Fig 2.4a- Total pressure contour plot for Rectangular wing

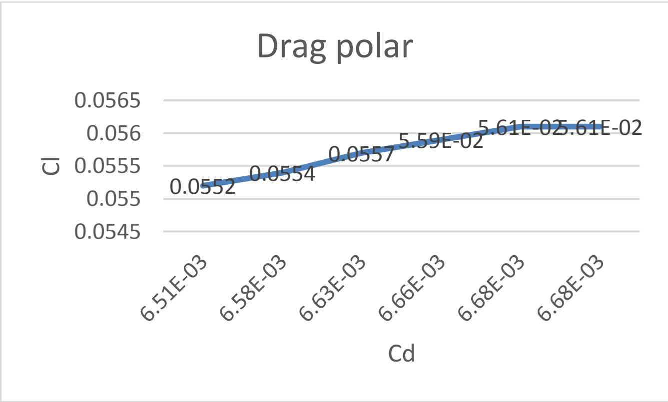


Fig 2.4b – Coefficient of Lift vs Coefficient of Drag Plot (Velocity – 33.3m/s and AOA- 15Deg)

2. Tapered Wing

Fig 2.4cTotal pressure contour plot for Tapered Wing

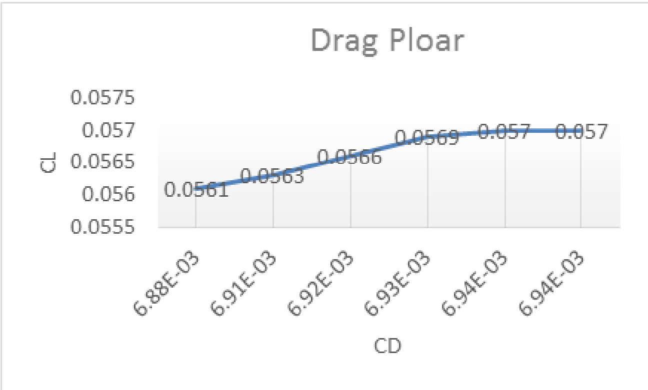


Fig 2.4d – Coefficient of Lift vs Coefficient of Drag Plot (Velocity– 33.3m/s and AOA- 15Deg)

3. Tapered Swept Wing

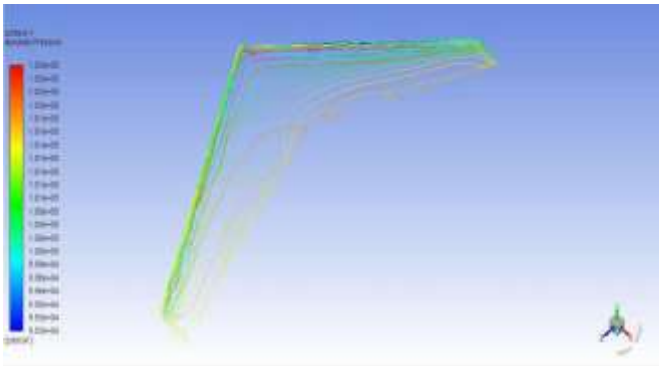


Fig 2.4e– Absolute pressure contour plot for Tapered Swept Wing

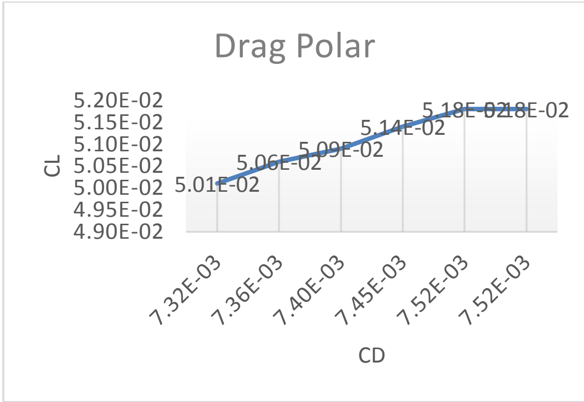
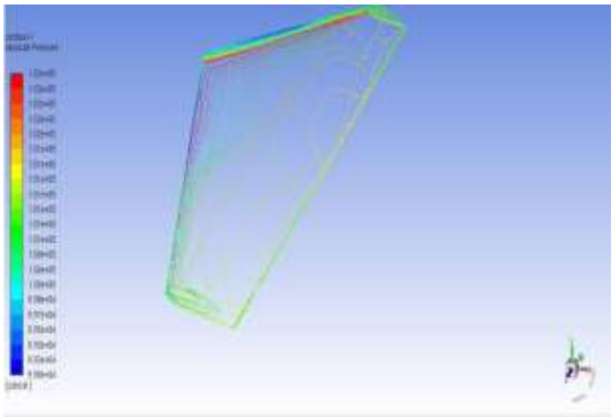


Fig 2.4f– Coefficient of Lift vs Coefficient of Drag plot (Velocity – 33.3m/s and AOA- 15Deg)

3. EXPERIMENTATION



All the three wing Configuration of NACA 4418 Airfoil series were tested in the subsonic wind tunnel with rpm of 500 corresponding to 33.3 m/s air velocity (refer table **3**.1). A six degree Force Balance system was used to calculate Lift and Drag values for all the three wings configuration.

Finally PLA 3d printing material was chosen because of cost effectiveness and easy availability the material.

Wing	Lift		Drag	
	Kg	N	kg	N
Rectangular wing	3.760	36.85	0.891	8.74
Tapered wing	3.766	36.91	0.895	8.78
Tapered Swept wing	3.830	37.63	0.93	9.13

Table 3.1 Experimental Results of all the three wings

4. COMPARISON OF RESULTS OF NUMERICAL AND EXPERIMENTAL RESULTS

Wing Type	Numerical Results	Experimental Results
Rectangular Wing	Lift – 42.88N Drag – 8.81N	Lift – 36.85N Drag – 8.74N
Tapered Wing	Lift – 38.36N Drag – 8.96N	Lift – 36.91 Drag – 8.78N
Tapered Swept back Wing	Lift – 29.23N Drag – 9.23N	Lift – 36.63N Drag – 9.13N

Table 4.1 Comparison of results

5. CONCLUSIONS

- All the three wing configurations were successfully designed keeping same mean chord of 90mm and nearly constant Aspect ratio of 6.
- Aerodynamic Performance parameters were successfully analyzed for all the three wing configurations. Aerodynamic efficiency L/D ratio of 4.21 was obtained for all the three wing configurations.
- The numerical results were consistent with the experimental results for rectangular and tapered wing. But for tapered swept wing, error percentage was found to be 22% with respect to experimental and numerical results.
- The lift performance for rectangular and tapered wing was found to be higher than that of tapered swept wing and drag was found to be greater for tapered swept wing. Therefore, the main conclusions would be to highlight the advantage of Rectangular Wing over Sweptback wings in subsonic regime.

Rectangular Wing	14%	0.8%
Tapered Wing	2.7%	2%
Tapered Swept Back Wing	2.2%	1.1%

Table 5.1 Error Percentage

REFERENCES

[1] Narayan U Rathod , Aerodynamic Analysis of a Symmetric Aerofoil ,Department of Mechanical Engineering, BMS college of Engineering, Bangalore, India 2014 IJEDR | Volume 2, Issue 4 | ISSN: 2321-9939

[2] John D. Anderson, Fundamentals Of Aerodynamics, Tata mcgraw Hill publications.2nd edition

[3] Ankit Ahuja, “CFD Analysis of an Aerofoil, International journal of engineering research, Vol. No.3,Issue No.3(2014)154-158.

[4] S.Kandwal“ Computational Fluid Dynamics study of Fluid Flow and Aerodynamic Forces on an Airfoil”, International journal of engineering research & Technology Vol No.1, Issue 7, (2012)1-8.