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Testing of ONERA Model

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Abstract- the aim of the project is to estimate of the aerodynamic coefficients of the ONERA M4 using section positioning mounting mechanism, six component balance and integrated data acquisition system. A wing-body-tail with and without winglets model of ONERA M4 model of suitable scale to fit in the test section of our subsonic wind tunnel is designed and fabricated with pressure ports at suitable points. The model is to be tested at various pitch angles from -10° to 30°, in steps of 10 degrees and yaw angle is varied from -30 degree to +30 degree in steps of 10 degrees. For each pitch and yaw angle the rpm is varied from 300 to 600 in steps of 60 and the variation of coefficient of pressure on the surface of the model is determined using a suitable data acquisition system. The experiment is done for all yaw angle and readings are taken for the model. The aerodynamic coefficients are calculated for the model. Aerodynamic coefficient plots are made for different rpm and pitch angle. Comparison charts are made by keeping rpm as constant in one case and pitch angle as constant in the other. Variations are observed and are validated using theoretical results. Similar experimental procedure should be followed for all the yaw angles in case model with winglets and finally a comparative study is made on the experimental studies. The experimental observations should be compared with computational results for validation.

Keywords: Aerodynamic testing, subsonic flow, wind tunnel, force measurements, ONERA M4 model

I. Introduction

The wind tunnel in which testing was carried out is the boundary layer tunnel in which test section velocity attained is 20 m/sec at 720 rpm. The test section area of the wind tunnel is 915*1220 cm^2. The model is made hollow so that the internal balance can be placed inside at a particular location. The fixing of the model is made rigid to the balance using an adaptor placed in the metallic sheet placed inside in the hollow section of the model. It also has provision to hold the internal balance rigidly to prevent movement of the balance during testing. The metallic sheet is provided to avoid any damages to the model as it is made in wood. The model is tested at various pitch angles ranges from -10° to 30° and yaw angles from -30° to 30° in steps of 10° at different velocities in steps of 1 m/sec using a suitable setup mounted in the test section of wind tunnel. The model is tested at different velocities at different angles of attack and the readings are obtained using Spider 8-30 data acquisition system and Catman professional software package.

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The data obtained from the system are tabulated and compared with the reference values obtained from the report by Goran Ocokoljic (2004).

II. Experimental Procedure

The following resources are required for the experiment is:

1. Six component strain gage balance
2. ONERA models with and without winglets
3. Adapter
4. Section positioning mounting mechanism
5. Spider8- data acquisition system
6. Catman professional software
7. Subsonic wind tunnel

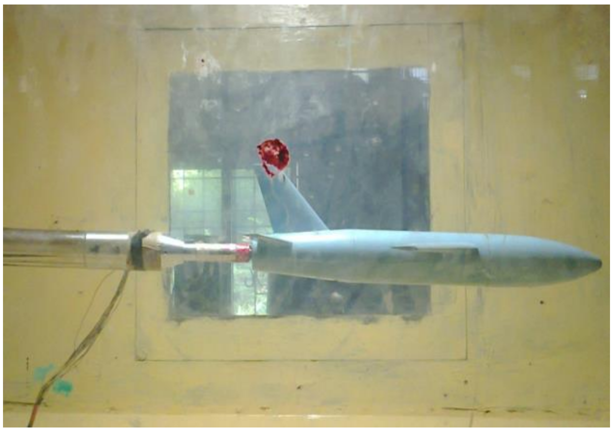
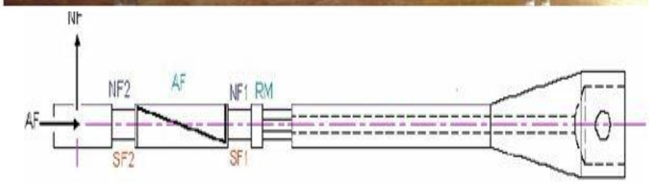


Fig1 model with balance placed in tunnel



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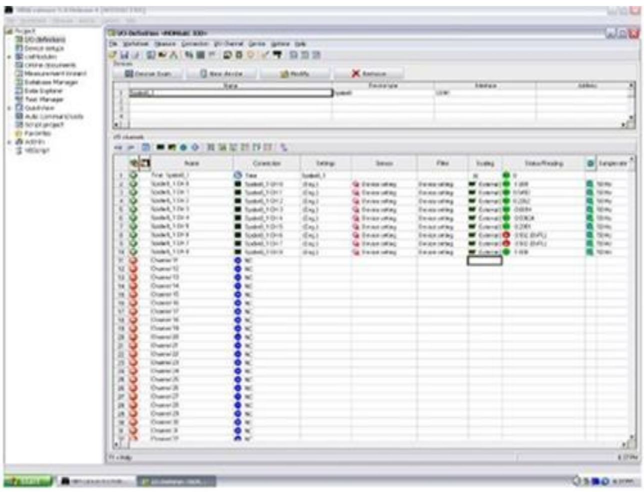


The various sketches of the equipments used for analysis of the experiment.

First of all, the velocity measurement of the tunnel is carried out using u-tube manometer and DSA-pressure scanner system. Velocity is estimated for different rpms and plot is studied. Then, ONERA M4 is mounted to the section positioning mechanism without winglets and experiment is done for different pitch angles ranges from(-10° to 30°) and various yaw angles (-30° to 30°) at different velocities calibrated above for the tunnel using spider8. Then, ONERA M4 is mounted to the section positioning mechanism with winglets and experiment is done for different pitch angles ranges from (-10° to 30°) and various yaw angles (-30° to 30°) at different velocities calibrated above for the tunnel using spider8.From the experiment values tabulated various aerodynamic coefficients are evaluated such as C_L , C_D , C_M, C_Y, C_N, C_A .Various plots between aerodynamic coefficients and pitch angles for different yaw angles is drawn. A performance characteristic of the model with and without winglets is studied and compared. These results are finally compared with CFD results for validation.

III. Results and Conclusion

1. **Coefficient of Axial Force:**

$$C_{A}=\frac{AF}{q_{\infty}\times S_{ref}}$$

2. **Coefficient of Normal Force**:

$$C_{N}=\frac{(N1+N2)}{q_{\infty}\times S_{ref}}$$

3. **Coefficient of Pitching Moment:**

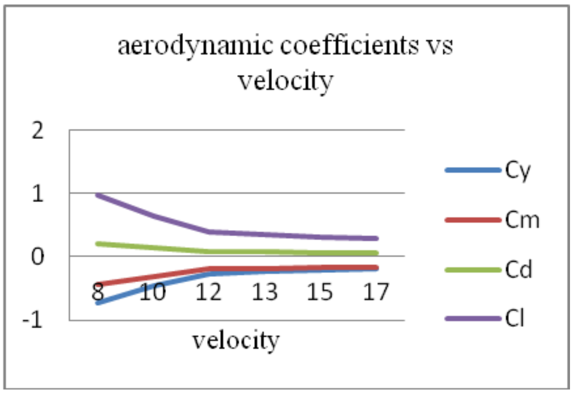
$$C_{M}=\frac{(N1-N2)\times BC}{q_{\infty}\times S_{ref}\times C}$$

4. **Coefficient of Yawing Moment:**

$$C_Y=\frac{(S1-S2)\times BC}{q_{\infty}\times S_{ref}\times b}$$

- **N1 & N2 = normal forces**
- **S1 & S2 = side forces**
- **q_{∞} = $(1/2\times\rho\times V^2)$**
- **C = chord length**
- **S_{ref} = Plan form area**

For a given pitch angle at different yaw angle (-30° to 30°) at different velocities the aerodynamic coefficients varies as shown in the plot .As the velocity increases, aerodynamic coefficients decreases.



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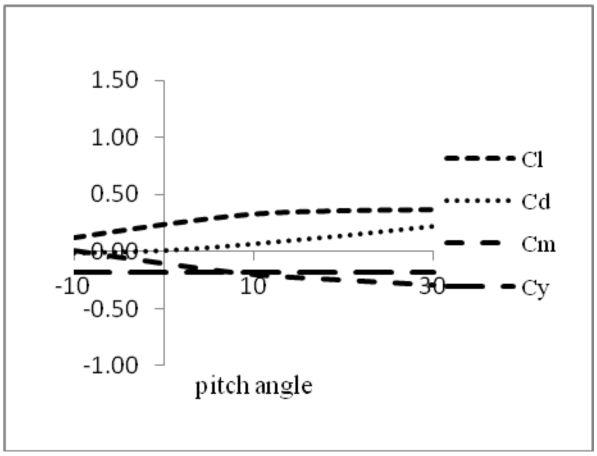
Without winglets

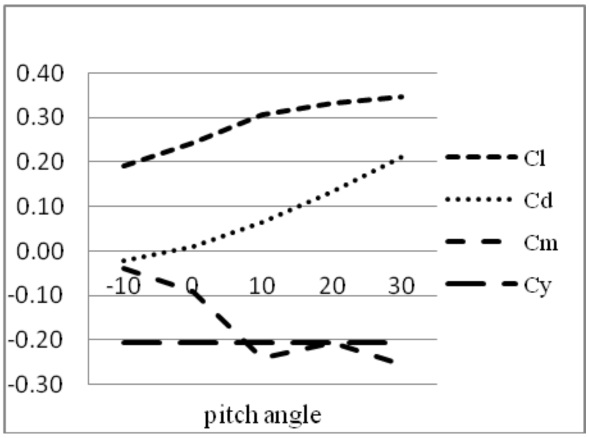
C_L	C_D	C_M	C_Y
0.13	0.01	0.01	-0.18
0.24	0.03	-0.10	-0.18
0.33	0.07	-0.20	-0.18
0.36	0.14	-0.25	-0.18
0.37	0.22	-0.29	-0.18

With winglets

C_L	C_D	C_M	C_Y
0.15	0.02	-0.02	-0.18
0.21	0.01	-0.08	-0.18
0.28	0.06	-0.22	-0.18
0.31	0.12	-0.20	-0.18
0.32	0.20	-0.24	-0.18

Aerodynamic coefficients vs pitch angles





For 10° yaw at speed 17 m/sec for pitch angle of (-10° to 30°) the various plot is drawn between aerodynamic coefficients such as (CL , CD, CM, CY) and pitch angles. There is comparison chart for wing-tail body model with and without winglets is studied and their performances characteristics is determined. From the plot we get following inferences as follows: for constant speed at various pitch angles the CL increases linearly with pitch angles due to increase in the normal force component. CD increases with pitch angles have higher values due to very low contribution of axial force component. CM varies linearly from negative to positive plot as shown in figure since the variation of centre of pressure with respect of pitch angle. CY varies due to the side force variation with respect to pitch angle it show deviation from the original path. Presence of winglets increases the aerodynamic coefficients but it shows deviation from the compare values due to disturbances encountered in the experiment during survey. Thus, the various aerodynamic coefficients such as (CL. CD, CM & CY) are estimated for the fabricated model with and without winglets and their performance characteristics is studied and compared. As, the values show some deviations from theoretical results due to following problems encountered during experiment. The values of yawing moments do not change due to some problem encountered in strain gauge during testing.

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