DESIGN AIRCRAFT WING (NACA SERIES) BY USING ANSYS

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ABSTRACT
The aim of this study is to analyze the modal and theoretical analysis of Aircraft Wing. Aeroelastic phenomena arise when structural deformations induce changes on aerodynamic forces. The additional aerodynamic forces from some sort of perturbation cause increase in the structural deformations, which lead to greater aerodynamic forces. Aeroelasticity is the science which studies the interaction among aerodynamics, inertia and elastic forces.

1. INTRODUCTION
Aircraft wing is the main component of an aircraft. Which produces lift due to Pressure difference created on the upper and lower surface. Pressure on the upper surface is low because of high velocity and the pressure on the lower surface is high due to low velocity on the lower surface. Hence pressure having tendency to move from high pressure to low pressure which generates the lift. The NACA airfoils are airfoil shapes for aircraft wings developed by the National Advisory Committee for Aeronautics(NACA). The shape of the NACA airfoils is described using a series of digits following the word "NACA"

Aeroelasticity is the science which deals the study interaction among aerodynamics, inertia and elastic forces. Now a days Modern airplane structures which are not completely rigid, and Aeroelastic phenomena happen when structural deformations make changes on aerodynamic forces. The extra additional aerodynamic forces from some sort of perturbation cause increase in the structural deformations, which guide to greater aerodynamic forces. Aeroelasticity explain the reserved elastically deformable under the action of heating and pressure. With the help of these forces to explore the dynamics elasticity and thermodynamics

NACA SERIES AEROFOIL
The NACA airfoils are airfoil shapes for aircraft wings developed by the National Advisory Committee for Aeronautics (NACA). The shape of the NACA airfoils is described using a series of digits following the word "NACA”. The parameters in the numerical code can be entered into equations to precisely generate the cross-section of the airfoil and calculate its properties.

Types of NACA aerofoil
1. Four Digit Aerofoil-NACA 2412 airfoil has a maximum camber of 2% located 40% (0.4 chords) from the leading edge with a maximum thickness of 12% of the chord.
2. Five Digit Aerofoil-NACA 23112 profile describes an airfoil with design lift coefficient of 0.3 (0.15*2), the point of maximum camber located at 15% chord (5*3), reflex camber (1), and maximum thickness of 12% of chord length (12).
   - L: a single digit representing the theoretical optimum lift coefficient at ideal angle-of-attack C_{L1} = 0.15*L
   - P: a single digit for the x-coordinate of the point of maximum camber (max camber at x = 0.05*P)
   - S: a single digit indicating whether the camber is simple (S=0) or reflex (S=1)
   - TT: the thickness in percent of chord, as in a four-digit NACA airfoil code
3. Six Digit Aerofoil-NACA 612-315 a=0.5 has the area of minimum pressure 10% of the chord back, maintains low drag 0.2 above and below the lift coefficient of 0.3, has a maximum thickness of 15% of the chord, and maintains laminar flow over 50% of the chord.
   - The number "1" indicating the series
• One digit describing the distance of the minimum pressure area in tens of percent of chord.
• A hyphen.
• One digit describing the lift coefficient in tenths.
• Two digits describing the maximum thickness in percent of chord.

4. Seven Digit Aerofoil-NACA 712A315 has the area of minimum pressure 10% of the chord back on the upper surface and 20% of the chord back on the lower surface, uses the standard "A" profile, has a lift coefficient of 0.3, and has a maximum thickness of 15% of the chord.
• The number “7” indicating the series.
• One digit describing the distance of the minimum pressure area on the upper surface in tens of percent of chord.
• One digit describing the distance of the minimum pressure area on the lower surface in tens of percent of chord.
• One letter referring to a standard profile from the earlier NACA series.
• One digit describing the lift coefficient in tenths.
• Two digits describing the maximum thickness as percent of chord.
• "a=“ followed by a decimal number describing the fraction of chord over which laminar flow is maintained. a=1 is the default if no value is given.

Aeroelasticity

Aeroelasticity is the science which deals the study interaction among aerodynamics, inertia and elastic forces. Now a day’s Modern airplane structures which are not completely rigid, and Aero elastic phenomena happen when structural deformations make changes on aerodynamic forces. The extra additional aerodynamic forces from some sort of perturbation cause increase in the structural deformations, which guide to greater aerodynamic forces. Aero elasticity explain the reserved elastically deformable under the action of heating and pressure. With the help of these forces to explore the dynamics elasticity and thermo dynamics. We can also define the aero thermo elastic problem which is related with the elastic under the forces of aerodynamic pressure and aerodynamic heating. Aero thermo elastic problem can be resolved out in two ways i.e. first way to explain the aerothermal and the next one define to explain aero elastic.

2 SOME RESEARCH STUDY RELATED TO AEROELASTICITY AND WING

T Y Yang (1978): Flutter analyses are performed for an NACA 64A006 and an NACA 64A010 airfoil by simultaneously using two transonic aerodynamic computational codes: (1) STRANS2 and UTRANS2 based on the relaxation method and (2) LTRAN2 based on the indicial and time-integration methods. Flutter results are obtained as plots of flutter speeds and the corresponding reduced frequencies versus one of the four parameters; airfoil-air mass ratio; position of the mass center; position of the elastic axis; and free stream Mach number. On each figure, several sets of curves for different values of plunge-to-pitch frequency ratios are shown simultaneously. The flutter results obtained by using relaxation and the indicial methods are, in general, in good agreement.

Raffia Zara (2008): Flutter is a critical instability phenomenon for aircrafts. In previous investigations, the authors have proposed several online statistical subspace-based algorithms for flutter monitoring. Each algorithm monitors some stability criterion (damping, flutter margin) with respect to a fixed reference flight point using the online CESUM test. The drawback of this technique is that the flutter detection corresponds to a light trend of the criterion toward instability and thus the estimated flutter airspeed is conservative.

Chinmaya Panda (2009): Aero elasticity phenomena involve the study of the interaction between aerodynamic forces and elastic forces (static aero elasticity), aerodynamic forces, inertia forces and elastic forces (dynamic aero elasticity), and aerodynamic forces, inertia forces, elastic forces and control laws (aero-servo-elasticity). Modern aircraft structures may be very flexible and this flexibility of the airframe makes aero elastic study an important aspect of aircraft design and verification procedures. Wing tensional divergence and flutter are the two major aero elastic phenomena considered in aircraft design. Divergence is a static instability which occurs when the static aerodynamic effects counteract the tensional stiffness of the structure. Flutter is a dynamic aero elastic instability characterized by sustained oscillation of structure arising from interaction between the elastic, inertial and aerodynamic forces acting on the body.

Zhao Ling & Liu Ziqiang (2014): It is difficult to achieve completely dynamic similarity because of some material or technological constrains, and only lower order modes including mode shape and frequency are
accurately simulated to construct a compromised model. Theoretical support would be necessary to answer the question which modes must be simulated to guarantee data validity of wind tunnel flutter test. An analytical study of a sweep back wing has been undertaken to estimate the flutter influence mode needed for accurate flutter prediction by analyzing generalized aerodynamic stiffness coefficient, unsteady aerodynamic force and flutter results.

Nikhil A. Khadse (2015): The modal analysis deals with the dynamics behavior of mechanical structures under the dynamics excitation. The modal analysis is used to determine the dynamic characteristics of a system such as natural frequency, mode shapes etc. The modal analysis helps to reduce the noise emitted from the system to the environment. It helps to point out the reasons of vibrations that cause damage of the integrity of system components. Using it, we can improve the overall performance of the system in certain operating conditions.

3. Equations

\[
\begin{align*}
\left[ -M_{hh} \omega^2 + i \omega B_{hh} + (1 + i \gamma) K_{hh} - \left( \frac{1}{2} \rho U^2 \right) Q_{rh} (m, k) \right] \{u_h\} &= 0 \\
\left[ M_{hh} B_{hh} \left( B_{hh} - \frac{1}{4} \rho c V Q_{rh}^2 / k \right) \right] + \left( K_{hh} - \frac{1}{2} \rho U^2 Q_{rh}^2 \right) \{u_h\} &= 0 
\end{align*}
\]

4. Results

![Figure 1 Wing Modal](image)

Table 1 Tubular Frequency Data

<table>
<thead>
<tr>
<th>Mode</th>
<th>Frequency [Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>4.2905</td>
</tr>
<tr>
<td>2.</td>
<td>13.211</td>
</tr>
<tr>
<td>3.</td>
<td>22.029</td>
</tr>
<tr>
<td>4.</td>
<td>28.909</td>
</tr>
<tr>
<td>5.</td>
<td>38.996</td>
</tr>
<tr>
<td>6.</td>
<td>51.249</td>
</tr>
</tbody>
</table>

Table 2 Frequency with Mode Shape

<table>
<thead>
<tr>
<th>MODES NO</th>
<th>Numerical frequency in Hz</th>
<th>Mode Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
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<tr>
<td>---</td>
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<td>---</td>
</tr>
<tr>
<td>1</td>
<td>4.2905</td>
<td><img src="image1.png" alt="Image" /></td>
</tr>
<tr>
<td>2</td>
<td>13.211</td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>3</td>
<td>22.029</td>
<td><img src="image3.png" alt="Image" /></td>
</tr>
<tr>
<td>4</td>
<td>28.909</td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>5</td>
<td>38.996</td>
<td><img src="image5.png" alt="Image" /></td>
</tr>
</tbody>
</table>
5. Discussion & Conclusion

The discussion and conclusion on the basis of results which is obtained through Workbench under ansys 13.0. under modal analysis in which proper boundary and meshing is applied. Theoretical analysis is not good enough to produce easier results due to rigorous mathematical solution. Hence the results obtained through numerical analysis which gives the better results with the references (14).

References


[14.] Nikhil A kha, “Modal analysis of wing:"

AUTHOR

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