An investigation of Oval Wing model of an Aircraft

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Abstract: The main focus of this research article is to minimize the vortices which form in the air at the tip of the wing. It is better to reduce noise pollution by developing the design of the aerodynamic systems for the commercial use of transport aircraft successfully. An analysis of longitudinal steadiness concerns including slender and less period oscillation compared with further cantilever wing which is the cause of design and developing the oval wing. For this, the software used is Catia and Computational Fluid Dynamics for analysis of the aerodynamic design. It begins with the preliminary estimation of components followed by limitations analysis to select the design criteria. From the literature review it has been seen that there are scanty information regarding conceptual design process for the oval wing aircraft compared with conventional aircraft. An aircraft structure of concern is the oval/ joined wing aircraft arrangement, which in current days has given more focus of research scholars because of its merits of less structural weight and low induced drag. Oval/ joined wing aircraft has the potential of better-quality fuel performance and reduced direct operating costs.

Key words: Air Craft, Fluid Dynamics, Joined wing, Drag, Cost

I. Introduction

According to future designs of aircrafts, the external body parts of aircrafts are designed with the aerodynamic calculations of the best wing system by Prandtl. This is introduced to reduce the formation of vortices at the tip of wing to certain extends more than other wing tip vortices reduction methods. The oval wing is the concept based on joined wing system in which the wing and the stabilizer are connected in such a manner it looks like an oval structure of wing, from the front view. It is a closed wing concept based on non-planar wing plan form that uses a continuous surface, eliminating the wing tip. Closed wing designs include the annular wing (commonly known as the cylindrical or ring wing), the joined wing, and the oval wing.

A closed wing can be thought of as the maximum expression of a wingtip device, which has the aim of eliminating the influence of the wingtip vortices which occur at the tips of conventional wings. These vortices form a major component of wake turbulence and are associated with induced drag, which negatively affects aerodynamic performance in most regimes. A closed wing surface has no wingtips whatsoever, and thus is capable of greatly reducing or eliminating wingtip drag, which has great implications for the improvement of fuel efficiency in the airline industry. The oval wing aircraft should be trimmed in order to counteract the negative pitching moment produced mainly by the wings. In conventional tail aft configurations, such moment is counteracted by the horizontal stabilizer. The main advantages it offers are the low induced drag and alleged structural superiority. The first feature allows this type of aircraft to achieve lower fuel consumption. In order to save costs and time, it is important to determine, with certain level of accuracy, the flying and handling qualities of an aircraft in the early stages of the design. These qualities will allow the aircraft designer to correct and improve different parameters, in order to fulfill the final design requirements. In order to save costs and time, it is important to determine, with certain level of accuracy, the flying and handling qualities of an aircraft in the early stages of the design.

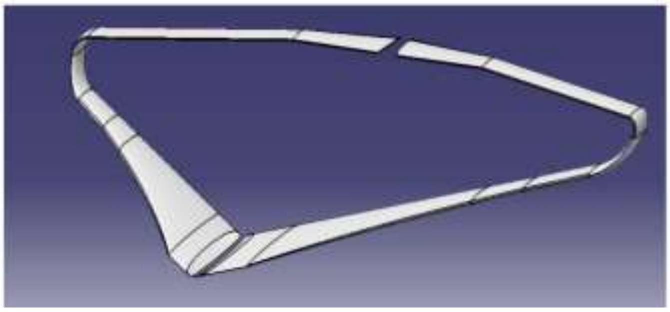

FIGURE 1. Shows the design of Joined Oval Wing.

II. AIRFOIL USED

The airfoil is defined as the cross sectional area of the wing of an aircraft. There are many different types of airfoils. They are classified based on digits used according to the norms of NACA (National Advisory Committee of Aeronautics). The airfoil used in the oval wing concept is NACA 6-digit. Based on the norms of the NACA 6-digit airfoil, the wing is being designed

FIGURE 2 Shows the NACA 6-series airfoil with boundary layer formation on top.

The NACA 6 series airfoil, given in fig 5.1, is developed based on work in late 30's and 40's was to provide laminar flow over a large portion of airfoil surface. Thickness distributions were calculated to obtain pressure distribution that would allow laminar flow and delay the transition to turbulent. This resulted in significantly lower section drag coefficients for 6 series when compared to earlier airfoils.

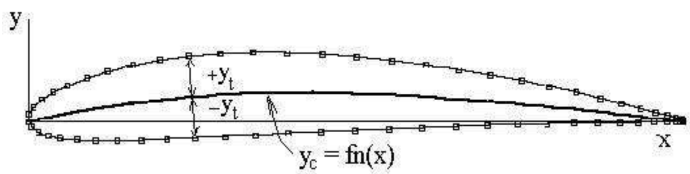

FIGURE 3 Shows the co-ordinate markings of a NACA airfoil.

The thickness distributions were generally given in tabular form for thickness values of 0.06c, 0.08c, 0.09, 0.10c, 0.12c, 0.15c, 0.18c and 0.21c, where 'c' is the airfoil chord. The schematic diagram is given in fig 5.2. Thickness distributions based on other maximum thickness use linear interpolation to scale the profile. The 67 and 747 are later developments of this work and are only available for a 15 percent thickness

Mean lines are based on the theory of thin wing sections, developed in 20's. In this theory, a wing section thickness was assumed to be replaced by, and equivalent to, its mean line. The mean line was in-turn composed of a chord-wise distribution of vortices and a related chord-wise distribution of load. Solving for the vortex strength resulted in several simple relationships between lift, drag and pitch coefficient.

NACA mean lines are calculated based on the design lift coefficient and desired chord-wise load distribution. The mean line equations can be combined to alter the mean line's shape and corresponding behaviour. For example, the NACA 747A315 airfoil is the 747- thickness distribution, cambered with two mean lines, a = 0.4Cl = 0.763 and a = 0.7Cl = -0.463. The two equations combine algebraically and result in the mean line that has a slight trailing edge reflex.

The calculated values shown on the form for ideal angle of attack, ideal Pitch coefficient and of zero lift provide an estimate of the wing section properties, based only on the shape of the mean line. The mathematical model developed by Theodorsen is used to estimate the angle of zero lift, pitch coefficient and design lift coefficient that will result from the mean line.

III. MODELLLING OF JOINED OVAL WING

The wing construction required for this concept is the Dihedral wing as the concept is meant to carry passengers. The dihedral wing gives more stability to the aircraft. The dihedral wing development is being mentioned in fig 5.3. This leads to improve controllability and maneuverability. The dihedral effect is performed by the wing when the aircraft loses its control. When the aircraft is attacked by the gust wind, the aircraft normally loses its level flight. The dihedral configuration brings the aircraft to its original position in which it can maintain the level flight. The maximum dihedral angle should be 8^0.

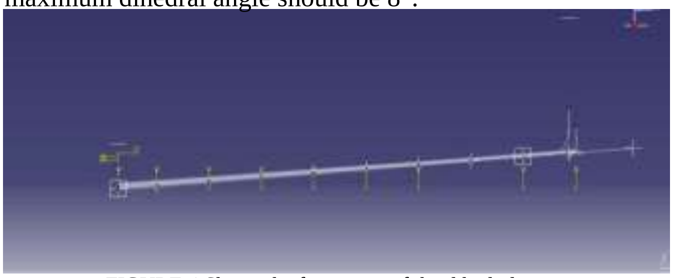

FIGURE 4 Shows the front view of the dihedral wing

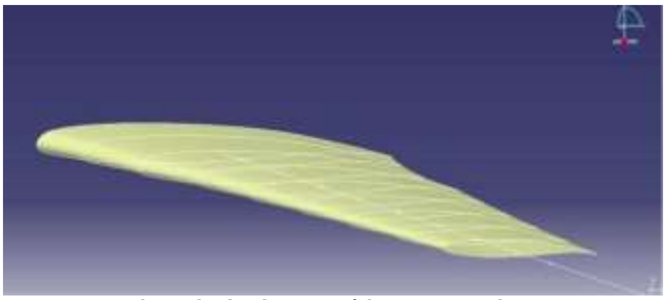

FIGURE 5 Shows the development of the wing using the NACA 6 series airfoil.

The dihedral angle can be given by clicking on constraint and the angle should be notified. Therefore, an airfoil is being created at the dihedral reference line as shown in figure 6. Select the line and give the direction as reverse direction and the length should be given and select the option 'repeat after object'.

The co-ordinates of the NACA 6-digit airfoil have been given at the plane, which is placed at the bottom of the fuselage and the airfoil section is being created, which leads to the development of the joined wing on fuselage as shown in figure 6. The reference line is being made according to the dihedral angle and the airfoil sections are made along with the axis of planes placed on the reference line.

Then by using the 'translate' and 'multisections' the wing is being designed from the bottom of the fuselage. Designing of the stabilizer section is being given in the Following steps.

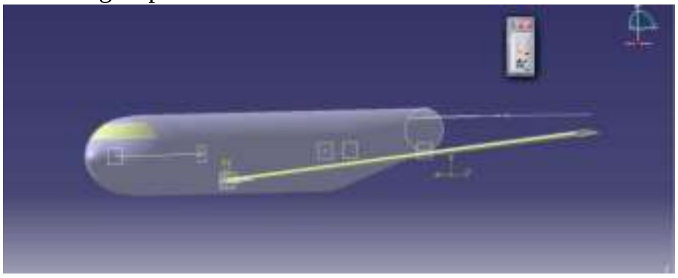

FIGURE 6 Shows the dihedral wing and the development of stabilizer.

The actual Oval wing configuration has been designed and the front view of the configuration is being given in the figure 7. The joint of the wing and stabilizer is of smooth surface and there are no sharp edges. Therefore, this gives more stability to the aircraft.

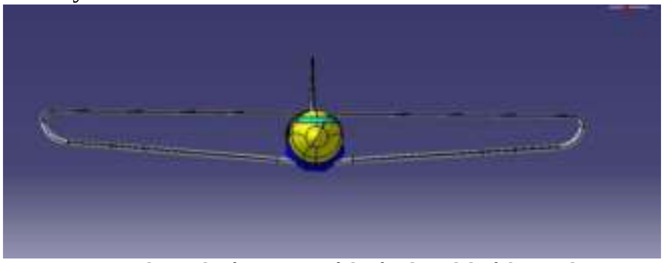

FIGURE 7 Shows the front view of the final model of the Oval wing configuration.

The figure 8 shows a complete three dimensional view of the Oval Wing Configuration. The placement of the wing root at the front portion of the fuselage is to give the advantages of the Canard. Like the Canard, this wing improves the lift coefficient and reduces the drag to more extend, compared to other wing designs.

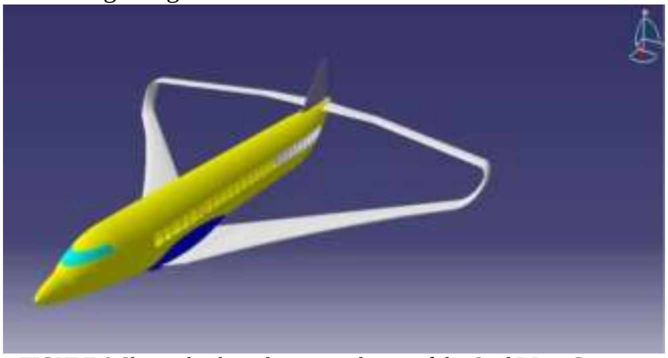

FIGURE 8 Shows the three dimensional view of the Oval Wing Concept.

IV. MESHING

A mesh is a discretization of a geometric domain into small simple shapes, such as triangles or quadrilaterals in two dimensions and tetrahedral or hexahedra in 3D. Meshes find use in many application areas. In geography and cartography, meshes gives compact representations of terrain data.

FIGURE 9 Shows the process of meshing in ANSYS WORKBENCH

In computer graphics, most objects are ultimately reduced to meshes before rendering as shown in fig 6.1. Finally, meshes are almost essential in the numerical solution of partial differential equations arising in physical simulation.

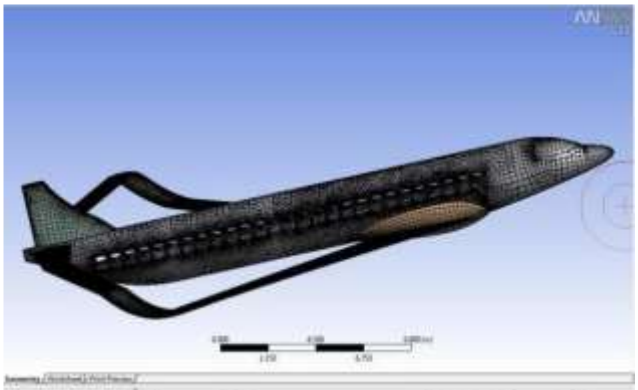

FIGURE 10 Shows the meshing at all the sections of aircraft.

Meshing of a model is to apply the loads and the material properties to that structure as it occurs. Only a meshed model can make the conditions to the analysis. The figures for mentioned types of meshes are given above.

V. RESULTS AND DISCUSSION

After all the design and analysis, the results are being obtained from the ANSYS Workbench software. The graphical representation of the results of the Oval Wing Configuration is being given as follows.

This shows the fluid flow over the section at the x, y and z directions. The process of analysis of the Joined Oval Wing configuration under different pressures and different densities at different altitudes has been done but these results are not suitable to find out the coefficients of lift and drag.

Therefore, the configuration is being analyzed again to find the values of coefficients of lift and drag acts on the wing of the aircraft. This helps us to find the lift efficiency and the reduction in drag.

FIGURE 11 Shows the result of flow analysis based on pressure at 2000m altitude, 9.8m/s^2

The given graphs and theoretical results show that the Coefficient of lift is more and the coefficient of drag is very less when compared to other wing designs.

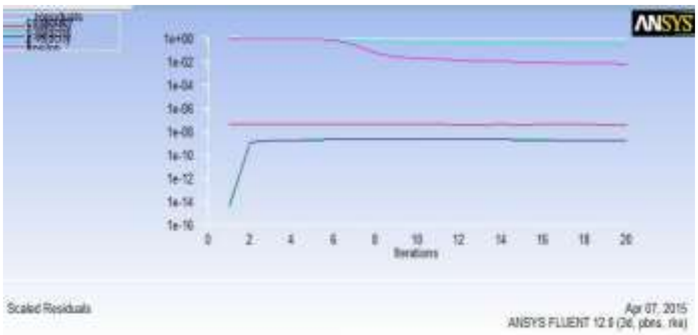

FIGURE 12 Shows the final results in the form of graphical representation

The value of the Coefficient of lift (C_L) is 0.3238 and the value of Coefficient of drag (C_D) is 0.0068, which is less than the predicted induced drag.

VI. Conclusion

Design of the Joined Oval Wing Configuration is being carried out to show the aerodynamic efficiency of this conceptual design. The analysis of this configuration is being done and the results have been obtained. The analysis has been done by creating the conditions of various altitudes with different pressures, and densities. The results extracted from the analysis show the aerodynamic efficiency of the Joined Oval Wing Configuration.

According to the future designs, these types of Joined Wing Configurations will be used to improve the fuel efficiency, to reduce the noise pollution, etc. These types of designs have its advantages than all other configuration. The most important requirement of this concept is, the structural strength of the wing should be high, compared to other design.

VII. FUTURE WORK

At present, only the design and analysis of the Joined Oval Wing Configuration are done. In future, the further analysis of this design will be done and implementing these kinds of designs will be carried out. As these types of configurations provide more efficiency, the hope still remains that this design will be applied practically to come on reality. In future furthermore types of joined wing configurations will be designed, analyzed and implemented, that will result to give more aerodynamic efficiency.

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