Aerodynamic Design Optimization of Blended Wing Body Aircraft

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Abstract -The blended wing body aircraft configuration has the potential to be more efficient thanconventionallargeaircraft with higher capabilities. However, the design of the blended wing ischallenging due to the tight coupling between aerodynamicperformance and stability. This study introduces new concept development of BWB aircraft. Airfoil shape, chord, sweep and span and many more design variables are considered for designing of aircraft. The investigation of aerodynamic propertiesarecarried out. For thatcomputa-tionalfluid dynamics with a K-epsilon turbulence model is used.The lowest drag coefficient is obtained for the aircraft concept.

***Key Words*:**aircraft, wings, aerodynamic, model, concept, contours

1.INTRODUCTION

Blended wing body aircraft (BWB) is a hybrid of flying wing aircraft and the conventional aircraft where the body is designed to have a shape of an airfoil and carefully stream-lined with the wing to have a desired planform. The BWB concept aims at combining the advantages of a flying wing with the loading capabilities of a conventional airliner by creating a wide body in the centre of the wing to allow space for passengers and cargo. BWB has low wetted surface area to volume ratio and reduced interference drag. This lowers total drag and provides higher L/D ratio compared to conventional configuration.

2. METHODOLOGY

2.1. Airfoil Selection

For 2D airfoil selection in the conceptual design, a basicand simple approach was adopted by analyzing chosen airfoilusing Airfoil Investigation Database and online Airfoil Toolssoftware, which are interactive database and programs.Eppler, Martin Happerle and NACA airfoil series wereanalyzed for the BWB conceptual design. The airfoil selectionprocess was focused on the airfoil components to achievefavourable pressure distribution, maximum lift and minimumdrag coefficients. The Eppler 343 airfoil (Fig.1) was best suited forselected geometry which is a cambered airfoil and thesame airfoil is used for center body, wing root and wing tip.

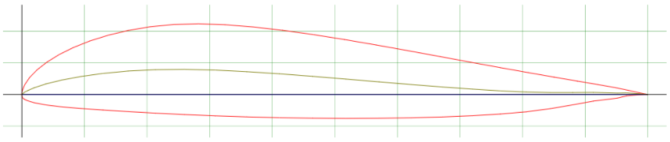

Fig -1. Eppler 343 airfoil profile

2.2. Development of model

For the designing of the model, the mentioned airfoil Eppler 343 of different chord lengths is used for various cross section of model. These chord lengths are precisely taken to optimize the wetted surface.Also the winglets are developed at wing tip in order to reduce the induced drag. Swept wing angle is taken 50° to delay the flow separation over the wings. The small scaled model is developed by using CATIA V5 designing tool. Figure -2 shows the isometric view of the designed conceptual model.

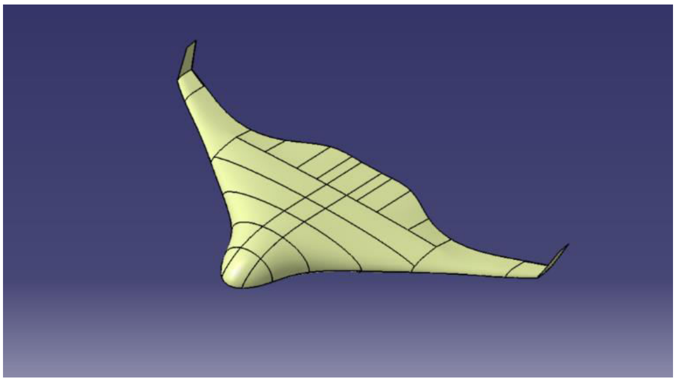

Fig -2. Design of the model

2.3. Aerodynamic Analysis

An Initial aerodynamic analysis was conducted usingANSYS Fluent. The focus was onthe main basic geometry, which excludes the effects of enginenacelles. The turbulence model k-epsilon is taken for flow model setup. The analysiswas run for several angles of attack(AoA) at 40 m/s for subsonic and 0.8 Mach for transonic region. A smooth pressure gradient on the upperand lower body surface was obtained. The pressuredistribution information permits to estimate thelocation of aerodynamic centre, which constitute the neutral point of theaircraft.Ascan be seen in Fig. 3, Higher positive pressure acting on the lower surface and negative pressure acting on the upper surface. Hence the lift was generated at cruise condition.

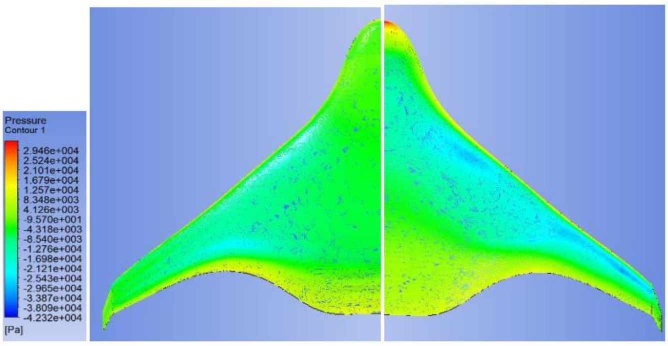

Fig -3. Pressure distribution over the bottom(left) and upper(right) surface of model at 0° AOA

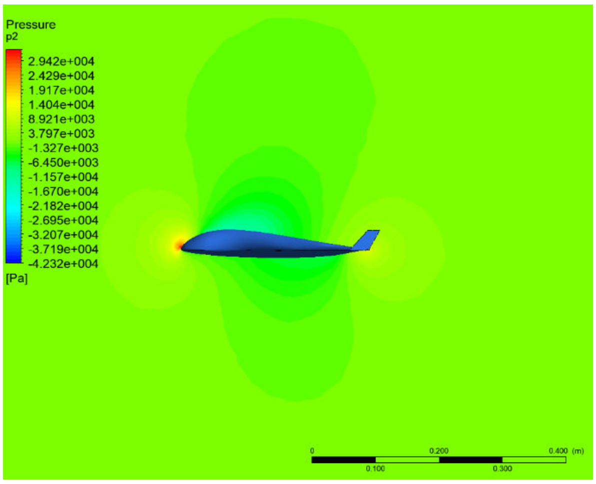

Fig -4. Pressure contour at the middle section at 0.8 M

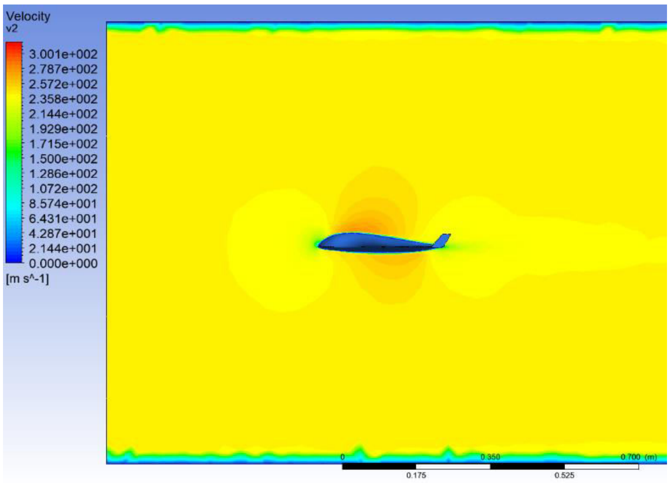

Fig -5. Velocity contour at the middle section at 0.8 M

The pressure contour around the mid-section is presented in Fig. 4. The maximum pressure acting on the nose tip of the aircraft. And the fig. 5 represents the velocity contour about the mid-section. These contours suggest ideal aerodynamic conditions around any other aircrafts. Hence this concept works fine in ideal conditions also the zero lift drag co-efficient $C_D$is 0.0007 which is very less for these types of aircrafts.

3. RESULTS

The analysis is carried out for different AoA at 40 m/s speed in order to simulate subsonic flow condition. The lift force generated at 0° is 4.52 N which is presented in the first plot of Fig. 6 also the stalling angle is obtained at 40° AoA for this model.

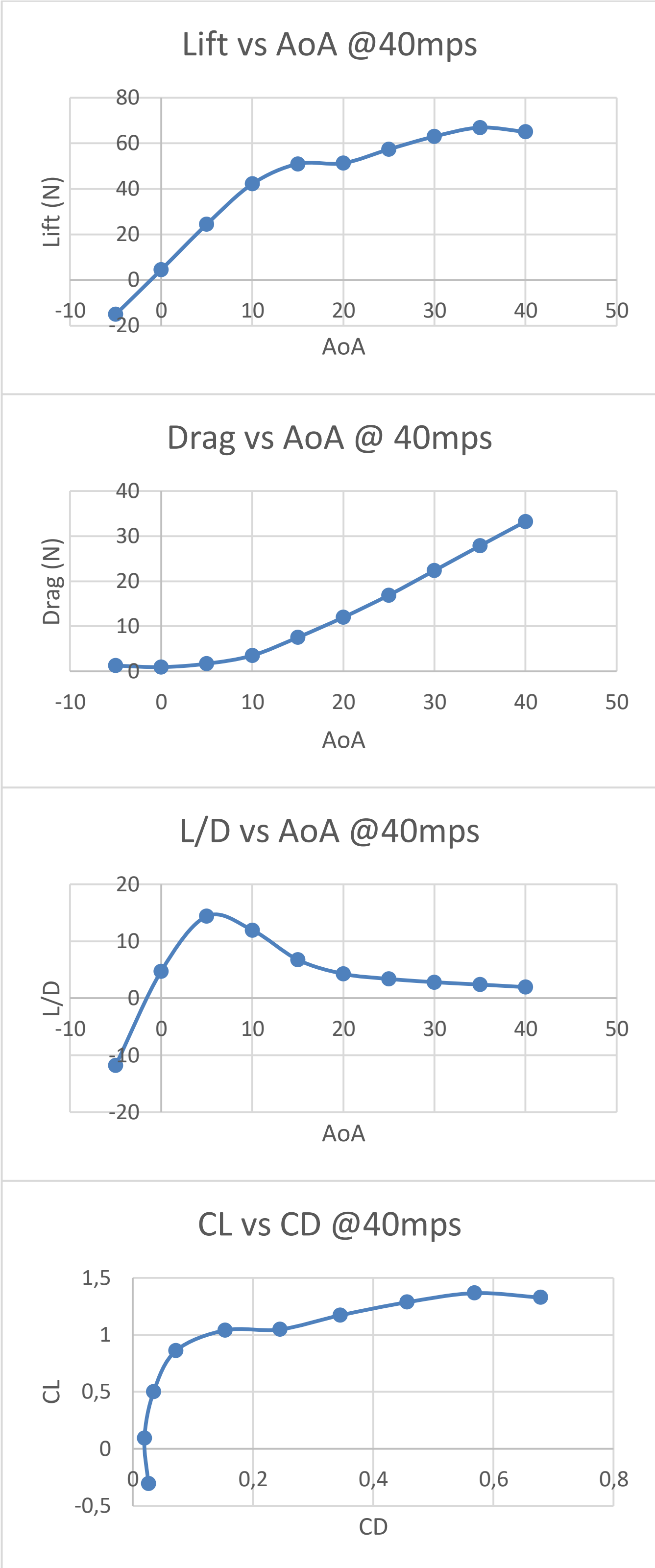

Fig -6. Aerodynamic characteristic Plots

These plots represent aerodynamic characteristics of the model. The drag is increasing linearly with the AoA in the second plot of Fig. 6. The other plots L/D vs AoA and C_L vs C_D are used to determine performance characteristics. Higher L/D ratio is obtained which is one of the advantages of the blended wing body aircraft. In this model airfoil chord lengths and distance between cross sections are taken such a way that optimization of aerodynamic characteristic is achieved.

4. CONCLUSIONS

In this paper, an initial design of commercial aircraft withBlended Wing Body configurationwas obtained based on a typical requirement for a long-range large commercial aircraft. The designresulted in a small scaled comparable aircraft size with that of conventional configuration, but BWB configurationoffermuch more cabin volume and reduction in fuel consumption about 20%.A preliminary CFD analysis on thebasic design has shown that a smooth pressure distributionwas obtained to avoid shockwave formation in cruisecondition. More iteration has to be made toimprove spanwise lift distribution. Further, analysis of nacelle effectwould benecessary to understand better their impact on the basic design geometry.

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