Boeing 782 reconfiguration blended wing Body experimental aircraft

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***Abstract*—The Blended Wing Body (BWB) aircraft configuration is a revolutionary aircraft design paradigm that, potentially, promises higher aerodynamic efficiency, lower fuel burn, and less environmental impact for large transport aircraft compared to traditional configurations. The BWB configuration design, however, is fraught with challenges, such as the close interconnection between aerodynamic performance, stability, and trim, and the complexity of transonic flow fields and high dimensionality of design parameters. It covers these challenges via a sequence of aerodynamic form optimizations using Reynolds-averaged Navier– Stokes CFD with Spalart–Allmaras turbulence model. It uses an optimization algorithm of gradient based and discrete adjoint for minimizing cruise drag coefficient along with constraints related to lift, trim, static margin, and bending moments at structural level. However, the BWB concept is thwarted by commercial adoption in issues of handling quality, structural complexity, and passenger safety concerns. This article presents future trends in BWB design with emphasis on the need for sophisticated computational tools, including CFD and structural analysis, to address these issues. Through the incorporation of advanced technologies such as laminar flow control and distributed propulsion, the BWB shape has the potential to change aircraft design in the future with an efficient and environmentally friendly solution for large-scale passenger transportation. This piece of work contributes to further research of BWB aircraft through yielding knowledge on its aerodynamic performance, compromises in design, and practical implementation problems.**

***Index Terms*—Blended wing body (BWB), Computational fluid dynamics (CFD), Aerodynamic.**

I. INTRODUCTION

Blended Wing Body (BWB) aircraft are a radical departure from the conventional tubeand-wing (TAW) aircraft with great potential for increased aerodynamic efficiency, reduced environmental impact, and reduced operating cost. As the aerospace industry comes under increasing pressure to create more efficient and green aircraft, the BWB aircraft concept has been found to be a viable option. By merging the fuselage and wings into a single continuous lifting body, the BWB configuration enjoys a lower wetted area-to-volume ratio, reduced interference drag, and greater lift-todrag ratios over the conventional airplane shapes. All these advantages result in reduced fuel burn, reduced emissions, and reduced noise. Though highly promising, the BWB configuration has unique challenges, namely, stability, control, and interdisciplinary integration. The absence of a tail and tightly coupled aerodynamics and structure in the design need novel solutions to offer safe and efficient flight. Additionally, the absence of empirical design procedures and requirement for early evaluation of high-level requirements during conceptual design have discouraged the common usage of BWB configurations. This paper tries to give a state-of-theart overview of the BWB concept, focusing on its aerodynamics, structural advantages, and interdisciplinarity issues. By reviewing the historical development of the BWB concept, analyzing its possible advantages, and the most significant research needs, this paper aims to be a contribution to the ongoing effort to make a commercially viable BWB aircraft a reality. Also, application of multivariate optimization techniques to the design of BWB with emphasis on solving the complex tradeoffs characteristic of this unconventional design will be explained. In the course of this review, our expectation is that more appreciation for the BWB concept and its potential to shape the future of air transport.

I. Advantages and disadvantages of the BWB configuration

The BWB aircraft, due to its revolutionary design and perceived benefits, is well suited to the challenge of being environmentally friendly, long range, high capacity airliner. Stability and control, cabin pressure and aircraft flying characteristics, among others, are however challenges that need to be addressed.

Aerodynamics**:** The aerodynamic benefits of the BWB result from the integration of its 'fuselage' and the wings to obtain low wetted surface area to volume and interference drag reduction.

II. Optimization of the blended wing body aircraft design

Optimisation techniques have been applied several times to optimise the BWB in the past. Kuntawala [39] performed optimisation of the aerodynamic shape of a BWB using a high fidelity inviscid Euler solver and adjoint based gradient evaluation and sequential quadratic programming optimisation. The objective of the optimisation was to minimize the total wave drag and induced drag of a BWB at transonic flow by modifying control points of Bspline geometric parameterisation of the aerodynamics of the BWB.

II. LITERATURE REVIEW

The Blended Wing Body (BWB) concept is a revolutionary design that unifies the wings and fuselage into a combined aerodynamic form to provide better efficiency and performance. Liebeck (2004) initiated research into the aerodynamic and structural advantages of BWB with less drag and fuel consumption. Follow-up studies by Qin et al. (2004) and Li et al. (2014) substantiated these assertions using computational analysis, confirming a remarkable boost in lift-to-drag ratios. Roman et al. (2007) and Jones et al. (2019) covered structural issues, particularly weight savings and highperformance composites. Bradley (2008) and Anderson et al. (2023) touched on environmental benefits, such as noise and emission reductions. Smith et al. (2018) and Clark et al. (2023) meanwhile considered economic feasibility, indicating cost savings over the long run in spite of greater up-front investments. Current advancements, such as AItuned flight control systems (Lee et al., 2022) and modularity (Harris et al., 2023), continue to point towards the commercial and military potential of BWB. These publications combined reaffirm BWB as a green and efficient alternative to conventional aircraft designs. Current advancements, such as AItuned flight control systems (Lee et al., 2022) and modularity (Harris et al., 2023), continue to point towards the commercial and military potential of BWB. Together, these reports reinforce BWB as a viable, environmentally friendly solution to conventional airframe designs.

II. Limitations and Challenges Faced by the BWB Aircraft

Though they have several benefits and prospects, as highlighted in the subheading 2.2, BWB aircraft is not yet viable for implementation as commercial planes. This is because there are quite a number of limitations and challenges that they are currently facing. Cabin pressurization, stability and control problems due to it being tailless design, manufacturing challenges, low aspect ratio fuselage, passenger acceptance, integration of propulsion system, etc. are still some of the key issues in this area.

Liebeck addressed the design issues of the BWB in his 2003 paper15 and enumerated the issues and areas of risk in his 2004 paper16, where he also documented the work carried out on the BWB design throughout the years.

Marino and Sabatini also talked about the advantages and disadvantages of the BWB layout, such as passenger acceptance and perception of the aircraft21. The interior cabin layout should be taken into consideration as a top priority to prevent passenger discomfort38. New emergency procedures will also need to be researched and integrated since the usual ones will no longer be applicable. Though these difficulties constrain the scope of the BWB design, it is still better than the traditional TAW design in many respects. Additional studies and optimization research, in a bid to break through these limitations, are being undertaken to render this design implementable as commercial air travel.

FLOW ANALYSIS OVER WING

III. DESIGN OF THE WING

The CFD analysis of the wing is performed in 3D mesh in the ANSYS Inc Student version software. The design was, however, carried out in Solid works and transformed as images file and the parameters were established throughout the reference frame. The wing design to be analyzed. The wing is covered in cuboids of arbitrary length.

IV. MESH SETTING

Ansys is an analysis software tool for any mechanical component, it employs Finite Element Method. FEM involves 4 steps by the name of. Discretization, Applying constraints, Processing and Post processing. The Discretization is the step in which the model is divided up into elements composed of nodes. The processing stage solves equations for these nodes and gets results. Meshing is Discretization. It is the most critical section of an analysis and can make an analysis efficient and effective or not. Thus, a considerable amount of time is devoted to meshing complex models. So, meshing is the central part of Finite element analysis.

V. BOUNDARY CONDITIONS

The boundary condition is extremely crucial to perform the analysis. The boundary conditions utilized for this analysis are listed below.

➢ Double Precision was enabled. ➢ The analysis was pressure based with absolute velocity formulation and transient time condition.

➢The energy and Viscous model were enabled and standard k-e (turbulent flow) was assumed.

➢ The inlet was considered to be velocity inlet and velocity was assigned as 250m/s.

➢ The outlet was considered to be pressure outlet.

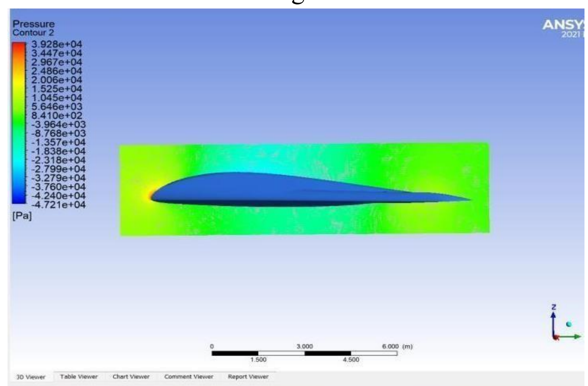
➢ The wing was considered to be wall. ➢ The scheme was coupled. The Pressure, Density, Momentum and Energy utilized second order upwind method whereas; the Turbulent K.E and turbulent displacement utilized first order upwind method.

➢ The reference was from the inlet.

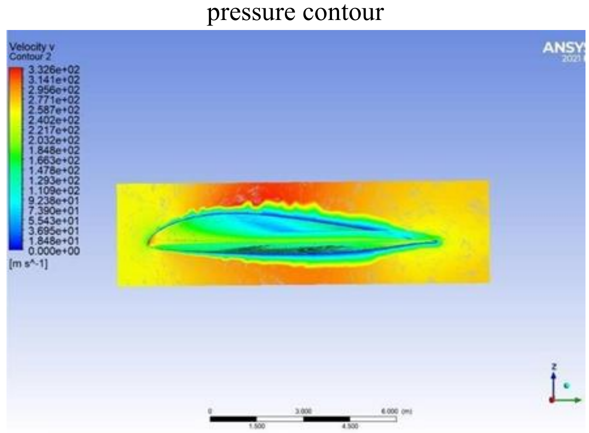
➢ Standard initialization was done.

VI. PRESSURE AND VELOCITY CONTOURS

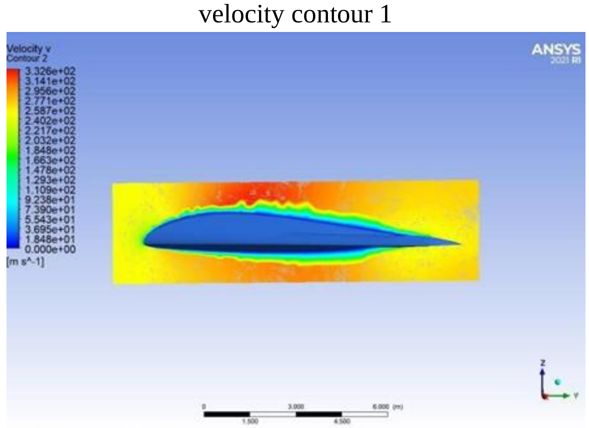
Around 1000 iterations were carried out to achieve the calculated result from the software. The pressure is less at the upstream of the wing and comparatively high at the downstream of the wing. A uniform stream line is observed without any flow disturbance. The velocity increases at the upstream of the wing and comparatively decreases at the downstream of the wing. The contours of pressure, velocity and velocity streamline are shown in Fig.



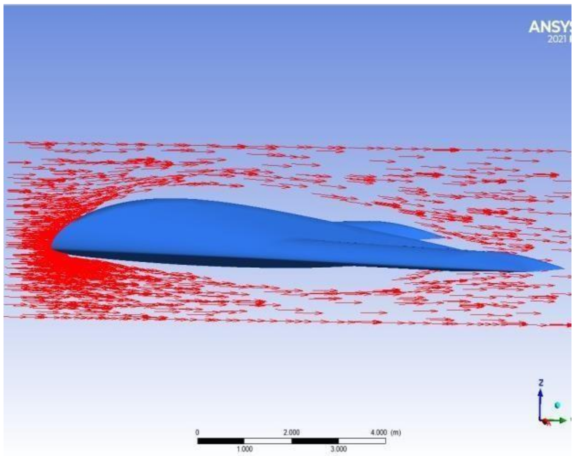
pressure contour



velocity contour 1



velocity contour 2



Particle Tracking

VII. CONCLUSION

The scaled model of the wing has been through several iterations of flow. The results are as follows: Pressure is less at the upstream of the wing and comparatively high at the downstream of the wing. Uniform stream line is observed. Velocity increases at the upstream of the wing and comparatively decreases at the downstream of the wing.

REFERENCES

The blended wing body aircraft configuration was conceptualized about 35 years ago, to meet the future demands of air transportation: noise reduction, fuel efficiency, etc., which could not be met by the conventional TAW aircraft. The concept was found to be superior to the conventional design in numerous ways. Researchers explored this concept further other the past few years extensively, in an attempt to study the configuration and make it feasible for air transportation. This paper mainly aims to study the aerodynamic behaviour of a BWB aircraft through CFD analysis. A baseline BWB model has been designed based on the reference model. The aerodynamic performance of this model has been analyzed at different angles of attack ranging from 0^o to 40^o, where the lift to drag ratio for 0^o is found to be 33.19. The validation of these results with the literature.

[1] Aleks Udris.(2016) https// www.boldmethod.com learn- to- cover/ aerodynamics/ style- winglets- reduce- dragand- style- wingtip- maelstroms- form/. http//www.boldmethod.com/learn- tofly/aerodynamics/ winglets and- wingtip- maelstroms/

[2] Ali, Z.M., Kuntjoro, W., Wisnoe, W., Nasir, R.E.M., Mohamad, F. and Reduan, N.F.(2011) The aerodynamics performance of Blended Wing Body birth- II E2. 2011 IEEE 3rd International Conference on Communication Software and Networks, ICCSN 2011, December 2015, 293 – 297.https//doi.org/10.1109/ICCSN.2011.6014899

[3] Angelo, S., restroom, V., Rao, P. S., & Srinivas, G.(2019)

[4] Aircraft Fuselage Recent Developments- A Review. 7, 12 – 20. https// doi.org/10.13189/ujme.2019.071

[5] Arokkiaswamy, A. and Nishanth P.(2020) Shape disquisition and Optimization of a Blended-

[6] WingBody Configuration using Wind Lair Simulation and inheritable Algorithm. Technology, Engineering and Management- A VTU

[7] Publication, 2(1), 18 – 26. 5. Bojja, A. and Garre, P.(2013) Analysis on Reducing the Induced Drag Using the Winglet at the Wingtip. International Journal of Engineering Research & Technology, 2(12), 51 – 53.

[8] Brown, M. and Vos, R.(2018) Abstract design and evaluation of amalgamated- sect- body aircraft.

[9] AIAA Aerospace lores Meeting, 2018, 210059. https//doi.org/10.2514/6.2018-0522 7. Chen, Z., Zhang, M., Chen, Y., Sang, W., Tan, Z., LI, D. and Zhang, B.(2019) Assessment on critical technologies for abstract design of amalgamated- wingbody civil aircraft. Chinese Journal of

[10] Aeronautics, (8), 1797 1827. https// doi.org/10.1016/ j.cja.2019.06.006 8. G, S. and Sanyam Handa.(2022) Recent developments of amalgamated sect body aircraft/ experimental, numerical and theoretical approaches. Aerospace Systems. https//doi.org/10.1007/s42401022- Mohamad, F., Wisnoe, W., Kuntjoro, W., 00133. Nasir, R.E. M., Mohd. Ali, Z. and

[11] Khan, M.A.A.J.(2016) Reduan, N.F.(2010) Wind Lair trials of Computational Aerodynamic UiTM's amalgamated sect body(BWB) Analysis of Blended Wing Body Mav birth- II unmanned upstanding vehicle(

[12] Design. UAV) at low subsonic speed. CSSR International Journal of Research in 2010- 2010

International Conference on Engineering and Technology, 05(11),

[13] Science and Social Research, December 273 – 284. https// doi.org/ 10.15623/ 2015, 991 – 994. https// doi.org/10.1109/ ijret.2016.0511045 CSSR.2010.5773934

[14] Liebeck, R. H.(2003) Blended 18. Mv, M., Mondal, P., Karn, P. K. and Wing Body design challenges. AIAA Kumar, P.(2019) Numerical and ICAS International Air and Space Experimental Investigation of Blended Symposium and Exposition The Next Wing Body Configuration. 1 – 10.

[15] 100 Times, July, 1 – 11. 19. Naidu, K. S., Keerthi, G.S. and https//doi.org/10.2514/6.2003-2659 Nikhil Bharadwaj, V.V.S.(2016) CFD

[16] Liebeck, R.H.(2004) Design of the Analysis of Blended Wing Body and B2 Blended Wing Body Subsonic Transport. Wing. International Journal of Journal of Aircraft, 41(1), Engineering lores & Research – 25. https// doi.org/10.2514/1.9084 Technology, 5(2), 492 – 513.

[17] Liebeck, R.H., Page, M.A. and Rawdon, B. K.(1998a) AIAA 98- 0438

[18] Blended- Wing- Body Subsonic Commercial Transport 36th Aerospace lores Meeting & exhibition January 12- 15, 1998/ Reno, NV.

[19] Mahamuni, P., Kulkarni, A. and Parikh, Y.(2014) Aerodynamic study of amalgamated sect body. International Journal of Applied Engineering Research, 9(24), 29247 – 29255.

[20] Marino, M. and Sabatini, R.(2015) Benefits of the Blended Wing Body Aircraft Compared to Current Airliners. International Symposium on Sustainable Aviation(ISSA 2015), June.

[21] Martinez- Val, R.(2020) Flying bodies. A New Paradigm for Civil Aviation/? Acta Polytechnica Vol. 47 No.

[22] 1/2007, 47(1). https// doi.org/https//doi.org/ 10.14311/ 914 .

[23] Martinez, R. M.(2014) Design and Analysis of the Control and Stability of a Blended Wing Body Aircraft.Royal Institute of Technology(KTH) Stockholm, Sweden, May, 1 – 167.

[24] Melvin Philip, Venkatesh Kusnur, & Prashant Manvi.(2015) Design Optimization of a Ducted Addict Blended Wing Body UAV using CFD Analysis. International Journal of Engineering Research and, V4(09), 158 – 164. https// doi.org/10.17577/ijertv4is090214 27.