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Conceptual design of Blended Wing Body for Future Air Transportation

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Abstract

Blended wing body is a fixed wing aircraft which are smoothly blended together with no clear dividing line and no distinct wings also be given a wide Aerofoil shaped body. The future transportation is of aircrafts will incline towards the aerodynamically efficient and capable of carrying large number of passengers over long range and environmental benefits is the main paradigm in the design of aircraft BWB has a high lift to drag ratio which increases the C_L max and velocity of the airplane with high load factor and high economy compared with traditional aircraft. Evacuation pressure or the cabin pressurization is the major issues in most of the designs with the minimum aerodynamic lift coefficient and drag coefficient. On the other side of the trend is towards the increasing cruise speed. High speed flow is connected with overcoming of intensive drag rise accruing due to existence of intensive shock, closing local area of supersonic flow. Increase of flight Mach number is possible only by using flow control methods and through affecting the shock increases of aspect ratio leads to increase of lift coefficient corresponding to maximal lift to drag. High bypass ratio engines have smaller fuel consumption and lower noise level but have negative effect on flow around airframe including take-off and landing phases. The necessity of solving problem of intensive aerodynamic heating of surface element of flight vehicles and by ensuring of their stability and controllability and also by need of implementing of high-volume tanks for hydrogen fuel and super high bypass ratio engines.

Introduction

The blended wing body design faces the most common challenges like design and Optimization of wing. On the other side weight is related to fuel efficiency have been focused by using lightweight structural composites such as carbon fibre, reinforced plastic frames as used in the A380 aircraft designers trying to improve aerodynamic efficiency through increasing wingspan or reducing weight but there are some limitations based on the material strength, conceptually the advantage of the BWB design to help reduce noise fuels as because of engine mounted on top of the main body lower wetted area to volume ratio and lower interference drag as compared to conventional aircraft. BWB allows for potential higher cruise speeds and reduce the wave drag. Boundary layer investigation or distributed propulsion are the well-integrated propulsion system can lead to propulsive efficiency. The absence of an empennage makes stability and control more challenging. Drag reduction potential obtained through high fidelity aerodynamic shape. The Tractor propeller nosed is one of the solutions for weight and balance advantage [15,3,6,8]. Propulsion system of BWB configuration for minimizing zero fuel weight of the aircraft total weight, lift distribution, value of static margin, speed, distance, ROC, thrust and C_d can be calculated using CFD analysis bays are used to design the family of BWB weight can be found by assuming 3 aft mounted engines [11]. The size of BWB increase the length of fuselage and wingspan, but this would not be feasible in most design approaches. By improving the aerodynamic shape to reduce the noise and structural loading CFD methodology are used to simulate the BWB analyse at higher speeds. The subsonic wind tunnel can be used for simulations and investigation at low subsonic speeds of BWB aircraft. BWB have high L/D ratio in comparison with conventional aircraft BWB would be beneficial for commercial application and perform 9.4% better than conventional aircraft at higher speeds (BWB) and more efficient [6,8,13,14]. In plane compression and tension loads can be carried out by internal box structure, new concept are in good acceptance by the customer due to flexibility. Uniqueness of BWB is that the fuselage is also act as a wing which

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burned 27% lower fuel 15% take-off weight 12% lower empty operating weight, 27% lower thrust and 20% high L/D ratio[6,10,11,12,13]. In case of BWB Male UAV loiter, speed is 140km/h and service ceiling exceed to 8h,200km/h and gross take-off weight can be calculated pitching moment coefficient is negative and nose down pitching moment gives positive camber airfoil. Integration of advance system and laminar flow technology gives aerodynamic and environmental benefits Profile drag increased the L/D ratio 10-15 % compared to conventional configuration [3,4]. BWB can create good handling and riding quality that enhance operating efficiency and cruising speed with prohibitive fuel burn. The design under CFD and XFLR5 analysis must be easy to deal with stall speed and wing loading also possible to improve design by performing optimization twist, dihedral and sweep effect of lift, drag and moment.[2,3,16]

Methodology

Throughout this, the emphasis will be on design. The governing equations and analysis methods will be discussed in terms of their place in the design process. The analysis will be specific to aeronautics, but the design thinking and methods you will learn through design problems and examples are applicable to any type of creative problem-solving situation. Most challenges faced by the BWB is how to reconcile the low-speed aerodynamics requirement for various mission profile like take-off and Landing with maximum cruise efficiency. Next challenge is with structures and stability aspects in accordance with design challenges faced by industry dictates that unconventional BWB is a solution for increased efficiency aircraft to meet future challenges of aviation transport.[1,17]

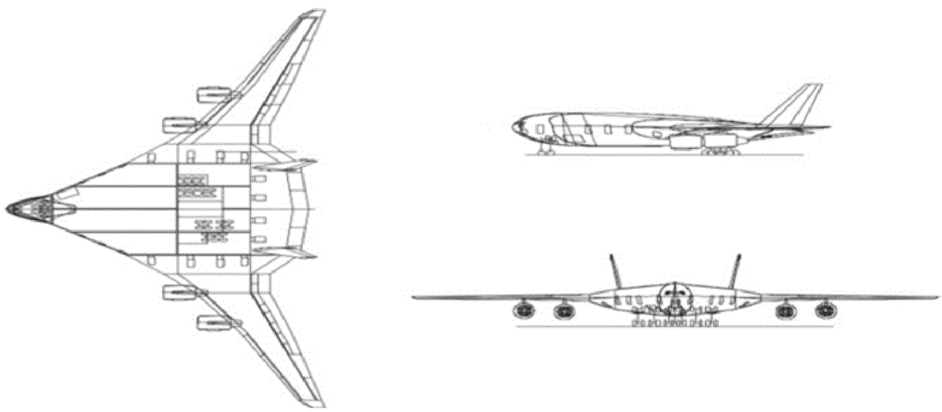

Figure .1 Blended Wing Body [1]

1. 1 Design Methodology

Many Engineers work solely with the actual building or production of a product but most are involved in planning so that when it is built the construction process Is efficient and makes the best use of resources and the product meets the requirement set forth for it. The process of planning the physical characteristics and construction method of a product is called design. In the process of creating a new product, design is the most important phase. The engineer who will build is the important step in the design flow process.[17]

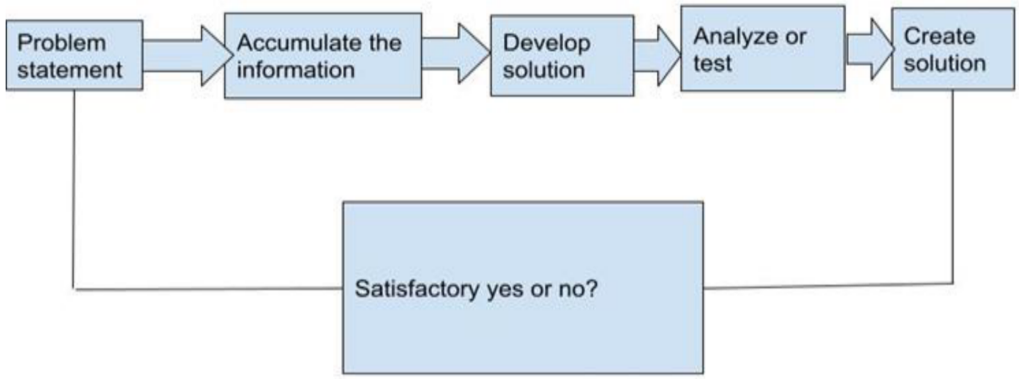

Fig .2 design flow process [2]

1.2 Design process

Define the Problem, collect Data, Create Hypothesis, Test the hypothesis. If the hypothesis fails the test return, In defining a design problem, one must specify what function the product is to have, what constraint limit possible design choices, and what performance the product must be achieve. In place of the hypothesis, the designer creates a design or a design concept this creative process is also called synthesis. The criteria for design success are called measures of merit.[17]

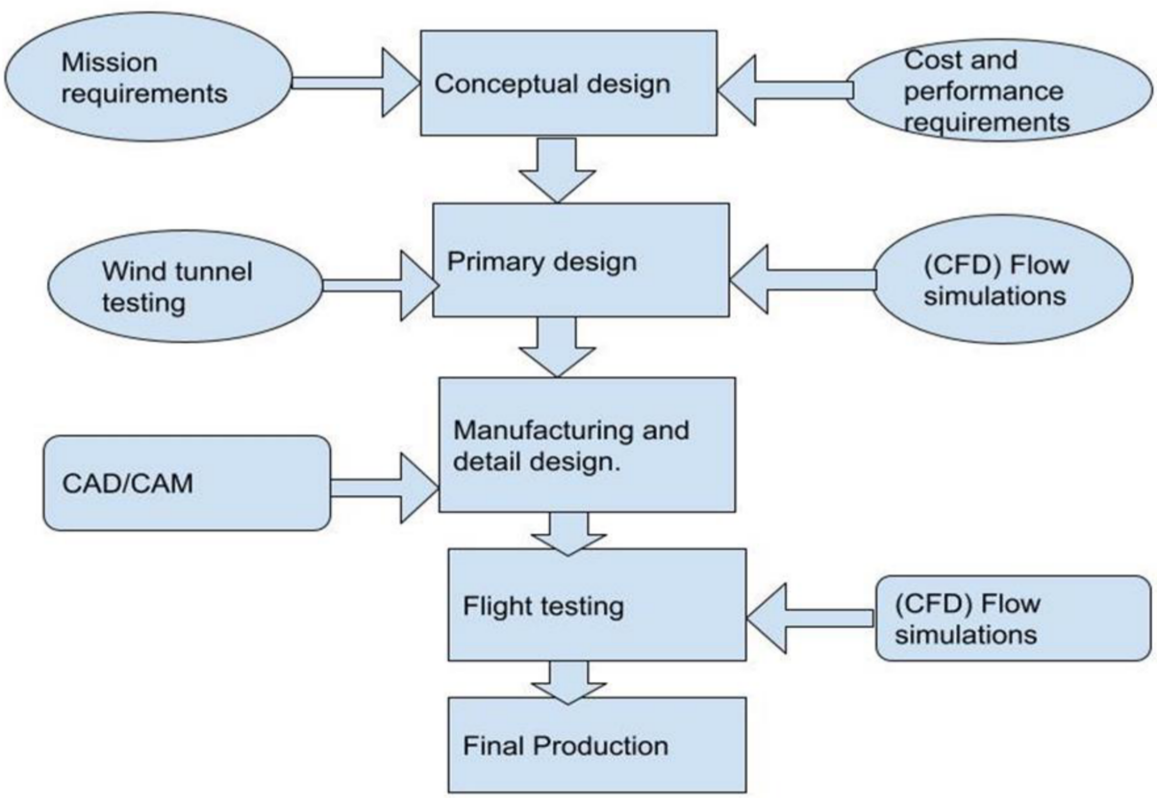

Figure .3 Design cycle

This design cycle has been described by Leland Nicolai of the Lockheed advanced aeronautics company, Nicolai group
The steps of the design process into three actions, synthesis, analysis and decision making.[17]

Conceptual design of an BWB involves mostly paper and conceptual study with heavy emphasis on optimization and finding the best possible aircraft concept.[3,10] The result BWB conceptual design is describe by drawings and models with analysis results that predict what the aircraft will be able to do. The conceptual design phase also includes layout of an initial concept. In the primary design phase, selected aircraft concept is developed and refined. Wind tunnel testing computer flow simulation and in many cases subscale free flight model are built and tested to ensure the aircraft will be efficient and controllable in the air, flight and avionics simulators are used to prove and refining the aircrafts handling qualities, instrument displays and pilot comfort and visibility. Detail physical and CAD/CAM drawings and Three dimensional databases are created. These databases are used to construct maintenance simulators, many of which now used for virtual reality to ensure all required maintenance functions can be performed safely and efficiently. Once manufacturing and detail design its completed the aircraft is prepared for final production.[4,5,7,11,14,16,]

1.3 Design phases

The design process is usually describe as having three phases. The initial phase is called conceptual design the goal of conceptual design is to select a workable concept and optimize it as much as possible.[3] Once a concept is selected, further iterations through the design cycle are needed to select, the material and work out the dimensions, structure and functions of the design. Computer simulations are performed, and physical model of the design are built ad tested. This phase is usually called preliminary design. Once the preliminary design phase is complete detail design begins.[9] In the detail design phase, the product is prepared for production the design is described in complete detail and the process by which it will be manufactured is also designed. A detail design set of drawings, a material list and a detailed cost estimate are prepared in later iterations through the cycle, a prototype is often built and tested. Often the design need to implemented in many cases as much as possible but the best or optimal design is possible by optimizing the design of aircraft in which a set of variables can be added to obtain the best output which is discussed in next section.
The result of aircraft conceptual design is an aircraft configuration described by drawings and models, with analysis result that predict what the aircraft will be able to do.[3,9,17]

Optimization

The goal of refining a design is not just to meet the requirements, but to make the best possible or optimum design the concept of optimizing a design to its full potential is crucial to creating a superior product.[13] The measures of merit must be adjusted to be reasonable but with performance that still satisfies the customer. The measures of the merit may also change because the customers requirement change. This is a particularly common for design that continues to evolve for many years after initial production. The creative step of creative problem. It is at this point in the process where new ideas are emerged and new products are created once you have immersed yourself in the facts and constraints of the problem, give yourself some time to come up with creative solutions. For instance, military aviator working on a spacecraft project come up with the idea that aerial refuelling of horizontal take-off and landing spacecraft, would greatly reduce the weight needed for the vehicles landing gear. Because the vehicle could take off and land at very light weight and then take on the majority of its propellants once airborne the landing gear could be built to take much lower loads this saved weight.[13,17]

By minimizing drag w.r.t spanwise lift distribution subjected to a lift constraint, performs a optimization for BWB. In case of baseline BWB baseline optimization air foil profiles are same as for the original geometry. To improve base line optimization of BWB changes in the sectional air foil shape can be taken into consideration. At the beginning of the optimization due to shock reduction local shape changes and it causes a reduction in drag coefficient. The camber air foil of BWB aircraft and the centre body increases lift coefficient. The benefit of the optimization can be improved by multi point optimization at the nominal cruise condition and these improves design performance of

BWB under off design condition compare to base line exhibits significantly lower drag over the entire transonic regime compare to the optimize designed. The optimized design increases the span and reduces the sweep angle, While enforcing a centre plane bending moment constraint and by adding wing planform design variables space design can be explored.[6,8,17]

It requires you to determine, first how you will evaluate your design to see how well it meets the measures of merit. Use the list of analysis method you made into plan a sequence of tests you will perform be sure to involve the customer in this planning and make sure you are testing every characteristic that the customer thinks is important next, perform the test and/or analysis record the result in the selection matrix and communicate them as appropriate. For and aircraft conceptual design involved mostly paper and computer studies, with heavy emphasis on optimization and finding the beat possible aircraft concept.[3,17]

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Blended Wing Body Boundary Influence

Boundary layer in case of an airplane, the thin layer of a liquid or gas flowing over the surface of the wing. Boundary layer fluid is always subjected to shearing forces. Toward trailing edge boundary layer is thicker and toward leading-edge boundary layer is thinner. The situation of condition when dp/dx=0 is called critical condition or transition condition. Transition condition it is the condition when the flow changes from laminar to turbulent and turbulent to laminar. In the inner flow region, the velocity gradient develops up to certain distance in the vertical direction from solid surface is called laminar. If the dynamic viscosity is low then the flow is at high velocity and low viscosity such flow is called turbulent flow. Because flow separation and stall are caused by depletion of flow velocity in the boundary layer, several methods can be used to remove or reenergize low energy air and delay separation. One method is to drill thousands of tiny holes in the wing surface and use suction to pull the low energy air. Inside the wing. Another method is to use blowing of high velocity air tangent to the wing surface to reenergize the boundary layer and delay separation.[15,18]

The RAM drag reduction from boundary layer ingestion directly on a BWB is difficult to calculate, because the separation between the stream tube entering the inlet and the flow passing through the outlet can be taken into account at high-speed flights, the flow around the BWB upper surface because supersonic and then shockwaves are generated due to compressibility losses. The viscous drag reduction is higher than the reduction in weighted area because the lower local Reynolds number result in higher nacelle surface skin friction coefficient then the airplane average. BWB airplane with highly efficient engines gives exceeded operability limits for inlet flow distortion with benefit in lower noise characteristics in drag reduction where the maximum boundary layer thickness is present. The nacelle design reduces the boundary layer ingestion in order to reduce the total pressure distortion and decrease the divergence in the external channel flow between the nacelle in boundary layer ingestion inviscid flow can be countered by diffusion back to free stream or ambient condition. The RAM drag to net thrust ratio can be used to determine the change in net thrust from the reduction in ram drag. Net thrust loss was calculated by the total pressure losses in the fan bypass flow. BWB boundary layer ingestion results in a large reduction (RAM drag). But these is largely influence by the reduced total pressure recovery. In case of boundary layer ingestion configuration optimization, the degree of BLI is not as beneficial as reducing wetted area. Reducing pressure drag using inverse CFD methods can be use full in boundary layer optimization of BWB [16,17,18].

Conclusion

Blended wing concept has evolved past many years ago. The desire was to build new type of aircraft which can accommodate passengers in it. The main intention behind this was to bring new life for civil transportation. Many researchers and organisations have contributed to the Blended wing concepts. In retrospect, it is believed to be a key reason for the success of the BWB flight tests. Parallelly the technical evolution has brough new perspectives in the design methodology as detailed in earlier section. To address these design challenges a multivariable optimization method is preferred to obtain potential benefits in commercial aviation. The BWB concept is still at rudimentary level only, there is huge requirement to integrate physics-based mass estimation and more reliable models in the optimization of design. At the same time, technology evolution brings new perspectives to the design process.

Therefore, it imperative to develop tools that will allow us to fully understand the extent to which technology evolution is likely to change system/subsystems design as we pursue the development flexible and adaptable systems that exploit new and emerging technologies.

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