

AERODYNAMIC ENHANCEMENT OF THE BLENDED WING BODY AIRCRAFT

Submitted in partial fulfilment of the requirements for the award of

Bachelor of Engineering degree in
Aeronautical Engineering

By

GURSHARAN KAUR PABLA (Reg. No. 38260014)

DIPESH RANJAN (Reg. No. 38260009)



DEPARTMENT OF AERONAUTICAL ENGINEERING

SCHOOL OF MECHANICAL ENGINEERING

SATHYABAMA

INSTITUTE OF SCIENCE AND TECHNOLOGY

(DEEMED TO BE UNIVERSITY)

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JEPPIAAR NAGAR, RAJIV GANDHI SALAI, CHENNAI – 600119

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SATHYABAMA
INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)
Accredited with "A" grade by NAAC
Jeppiaar Nagar, Rajiv Gandhi Salai, Chennai - 600 119
www.sathyabama.ac.in



DEPARTMENT OF AERONAUTICAL ENGINEERING

BONAFIDE CERTIFICATE

This is to certify that this Project Report is the bonafide work of DIPESH RANJAN (Reg. No. 38260009) and GURSHARAN KAUR PABLA (Reg. No. 38260014) who carried out the project entitled "**Aerodynamic Enhancement of the Blended Wing Body Aircraft**" under my supervision from September 2021 to April 2022.

Internal Guide & Head of the Department
Dr. P. BOOMADEVI, ME., PhD.,

Submitted for Viva voce Examination held on _____

Internal Examiner

External Examiner

DECLARATION

We Dipesh Ranjan (Reg. No. 38260009) and Gursharan Kaur Pabla (Reg. No. 38260014) hereby declare that the Project Report entitled “**AERODYNAMIC ENHANCEMENT OF THE BLENDED WING BODY**” done by us under the guidance of **Dr. P. BOOMADEVI, M.E., Ph.D.**, is submitted in partial fulfilment of the requirements for the award of Bachelor of Engineering degree in Aeronautical Engineering.

DATE:

SIGNATURE OF THE CANDIDATE

PLACE: CHENNAI

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ABSTRACT

This project presents results from a subsonic investigation on the effects of reduction in the wing surface area on the aerodynamic efficiency as well as on the introduction of wing fences. The purpose of this project is to develop the conceptual design synthesis of the design space of the blended wing body commercial passenger aircraft. The benefit of this aircraft mainly arises because of distributed structural and aerodynamic load which lead to better aerodynamic performance and provide lighter structural weight as well. Find the opportunity to reduce the overall weight/wing area without affecting aerodynamic performance. Increase the Lift to Drag ratio on modified design. Owing to its huge wing area plus greater lift to drag ratio it was seen that high lift devices could be effectively used in BWB aircraft, with reference to longitudinal stability. It is such that the take-off and landing needs for a field length comparable to that of conventional aircrafts. The necessity to design a budget and a conservative aircraft which is aerodynamic efficient have directed the designers to produce the notion of the Blended Wing Body (BWB) aircraft. When compared to with the conventional wing and fuselage design, Blended Wing Body design has been proved to have significant enhancements in terms of aerodynamic efficiency. This project presents results from a subsonic investigation on the effects of reduction in the wing surface area on the aerodynamic efficiency and on the introduction of wing fences. Forces are determined by the fluid flow over the reduced surface area. The wing fences in the reduced surface area elevated lift coefficient and reduced induced drag without significantly affecting the aerodynamic efficiency. Measurement of force was carried out to observe the effect of decreased wing surface area and the introduction of wing fences. 3-D numerical analysis were performed using the commercial software Ansys. Reasonably good results were obtained from computations. With the reduction of 25% in the wing surface area and introducing the wing fences resulted in a slight improvement in lift to drag ratio. With the reduced wing surface area the aerodynamic efficiency decreased. But with the application of wing fences, the aerodynamic efficiency was seen to be increased as compared to the base model.

TABLE OF CONTENTS

Chapter No.	TITLE	PAGE No.
	ABSTRACT	v
	LIST OF FIGURES	ix
	LIST OF TABLES	xii
	LIST OF SYMBOLS AND ABBREVIATIONS	xiii
1	INTRODUCTION	15
	1.1 HISTORY	15
	1.2 BLENDED WING BODY	17
	1.2.1 Droning Parameters of Blended Wing Body Configuration Design	21
	1.2.2 Potential advantages	34
	1.2.3 Potential disadvantages	34
	1.3 BLENDED WING BODY VS CONVENTIONAL AIRCRAFT	35
	1.4 CHALLENGES	36
2	LITERATURE SURVEY	39
3	AIM AND SCOPE	52
	3.1 AIM	52
	3.2 SCOPE	52
4	RESEARCH METHODOLOGY	53
	4.1 INTRODUCTION TO COMPUTATIONAL TECHNIQUE	53
	4.2 COMPUTATIONAL FLUID DYNAMICS BACKGROUND	53
	4.3 CREATION OF GEOMETRY	54
	4.4 SOLUTION METHODOLOGY	54

Chapter No.	TITLE	PAGE No.
	4.4.1 Governing Equations	55
	4.4.2 Turbulence Modelling	56
	4.4.2.1 SST <i>k-Omega</i> model	56
	4.5 BOUNDARY CONDITIONS & SOLVER SETTINGS	56
5	RESULTS AND DISCUSSIONS	61
	5.1 COMPUTATIONAL RESULTS	61
	5.2 BASELINE MODEL RESULT	62
	5.2.1 Pressure Contours	62
	5.2.2 Velocity Contours	63
	5.2.3 Streamline Plot	63
	5.2.4 Aerodynamic Forces	64
	5.3 PROPOSED MODEL 1 (25% REDUCED WING AREA)	64
	5.3.1 Pressure Contours	65
	5.3.2 Velocity Contours	65
	5.3.3 Streamline Plot	66
	5.3.4 Aerodynamic Forces	66
	5.4 PROPOSED MODEL WITH FENCES	67
	5.4.1 Pressure Contours	67
	5.4.2 Velocity Contours	68
	5.4.3 Streamline Plot	68
	5.4.4 Aerodynamic Forces	69
	5.5 RESULT COMPARISON	69
	5.5.1 Pressure Contours	70

Chapter No.	TITLE	PAGE No.
	5.5.2 Velocity Contours	70
	5.5.3 Streamline Plot	71
	5.5.4 Aerodynamic Forces	71
6	FABRICATION	73
	6.1 SELECTION OF MATERIAL	73
	6.2 CASTING	73
	6.3 PAINTING	77
7	EXPERIMENTAL ANALYSIS	79
	7.1 PROCEDURE	79
	7.2 EXPERIMENTAL SETUP	80
	7.2.1 Inlet Duct	80
	7.2.2 Test Section	81
	7.2.3 Diffuser	82
	7.2.4 Axial Flow Unit	82
	7.2.5 Propellers	82
	7.2.6 Bell Mounted Entry	83
	7.2.7 Smoke Generator	83
	7.2.8 Multi Tube Manometer	84
8	CONCLUSION	85
9	FUTURE SCOPE OF WORK	86
	REFERENCE	

LIST OF FIGURES

FIGURE No	TITLE	PAGE No.
1.1	Blended Wing Body	18
4.1	Computational domain	53
4.2	Grid view of Basic BWB model	54
4.3	Cd- α	55
4.4	Aerodynamic Forces	56
4.5	Boundary Conditions	57
4.6	Computational Domain Mesh	58
4.7	Basic BWB Model	58
4.8	Basic BWB Model Side View	59
4.9	Base BWB Model with measurements	59
4.10	Proposed Design	60
4.11	Proposed Design Overlapping Basic Design	60
5.1	Convergence Check (Momentum and mass)	61
5.2	Convergence Check (Normal Forces)	62
5.3	Pressure distribution on aircraft surface	62
5.4	Velocity Distribution over the wing section	63
5.5	Velocity Streamlines over the aircraft	63
5.6	Proposed Design Model with reduced wing surface	64

FIGURE No	TITLE	PAGE No.
5.7	Pressure distribution on aircraft surface (Model with reduced wing surface)	65
5.8	Velocity Distribution over the wing section (Model with reduced wing surface)	65
5.9	Velocity Streamlines over the aircraft (Model with reduced wing surface)	66
5.10	Proposed Model with Fences	67
5.11	Pressure distribution on aircraft surface (With Fences)	67
5.12	Velocity Distribution over the wing section (With Fences)	68
5.13	Velocity Streamlines over the aircraft (With Fences)	68
5.14	Result Comparison	69
5.15	Comparison of Pressure distribution on aircraft surface	70
5.16	Comparison of Velocity Distribution over the wing section	70
5.17	Comparison of Velocity Streamlines over the aircraft	71
6.1	Material Selection	73
6.2	Wing and fuselage attachment (Top view)	74
6.3	Smooth body after Sanding	74
6.4	Tissue mould fence (Left Wing)	75
6.5	Tissue mould fence (Right Wing)	75
6.6	Tissue mould fence (Left Wing, bottom view)	76
6.7	Tissue mould fence (Right Wing, bottom view)	76

FIGURE No	TITLE	PAGE No.
6.8	Full body	77
6.9	Final Model with fences (Side view)	77
6.10	Final Model with fences (Fuselage)	78
6.11	Final Model with fences (Top view)	78
7.1	Subsonic Wind Tunnel	79
7.2	Inlet Duct	80
7.3	Test Section	81
7.4	Attachments	82
7.5	Propeller	83
7.6	Smoke Generator Apparatus	84
7.6	Multi Tube Manometer	84

LIST OF TABLES

TABLE No	TITLE	PAGE No.
4.1	Boundary Conditions	57
4.2	Wing Design Difference	60
5.1	Aerodynamic Forces on Baseline design	64
5.2	Aerodynamic Forces on Proposed Design (Model with reduced wing surface)	66
5.3	Aerodynamic Forces on Proposed Design with Fences	69
5.4	Comparison tables among designs	72

LIST OF SYMBOLS AND ABBREVIATIONS

α	Angle of attack
δ	Apex deflection
ρ	Density of air
Λ	Sweep angle
μ	Coefficient of viscosity
q^∞	Free stream Dynamic pressure
b	Span of the double delta wing
c	Root chord of the double delta wing
x/c	Pressure port location with respect to chord from tip
z/s	Pressure port location with respect to local span
CP	Coefficient of pressure
P^∞	Free stream pressure
CN	Normal force co-efficient
CL	Lift co-efficient
CA	Axial force co-efficient
CD	Drag co-efficient
CS	Side force co-efficient
N1, N2	Normal Force values for corresponding strain gage location
A1, A2	Axial Force values for corresponding strain gage location
Cg	Centre of gravity
CMX	Coefficient of moment about pitch plane
CMY	Coefficient of moment about yaw plane

X, Y, Z	Axis in three dimensions
MY	Moment about yaw plane
MX	Moment about roll plane
MZ	Moment about pitch plane
R	Resistance
AoA	Angle of Attack
FDM	Fused Deposition Modeling
FV	Finite Volume
RAM	Random Access Memory
CATIA	Computer Aided Three Dimensional Interactive Application
LEX	Leading Edge Extension
ABS	Acrylonitrile butadiene styrene
CFD	Computational Fluid Dynamics
DC	Direct Current
CAM	Computer Aided Manufacturing
LabVIEW	Laboratory Virtual Instrumentation Engineering Workbench
DAS	Data Acquisition System
EPICS	Experimental Physics and Industrial Control System
FORTTRAN	Formula Translating
BASIC	Beginner's All-purpose Symbolic Instruction Code
CAD	Computer Aided Design
SA	Spalart–Allmaras

CHAPTER 1

INTRODUCTION

1.1 HISTORY

Aircraft wing produces lift while the aircraft moves through the air which is its major purpose. The notion of using a wing assembly for flying was integrated in the utmost basic ideas of gliders and flying machines. For example, in 16th Century, Leonardo da Vinci's designs were built on mechanical replica of prolonged bird wings. The preliminary power-driven aircraft to fly by the Wright Brothers in 1903, was built on a binary fixed-wing design. This advanced over numerous additional concepts. Some of the various noteworthy developments comprises of the introduction of stick controls for roll and pitch in the Bleriot VII and airframes made of metal at the time of World War I. All of the prior aircrafts have set the standard for all the designs that has further trailed. Certainly, boundless deal has been altered in different designs over the many years. These design improvements are various and included the aircraft becoming larger, usage of modern age lighter composite materials, as well as retaining significant aerodynamic improvements. Even then the essential form as well as the operation of the fixed-wing in the conventional tube configuration are an equivalent. Obviously, maximum number of aircrafts have advanced to a single wing design from a long back. Even then, based on the aircraft design and other purposes the location of the wing below, above, or within the middle of the fuselage are altered. There is a spread of fixed-wing designs that are currently being used for various purposes. Simple rectangular fixed-wing is being used by some of the smaller sized airplanes, for example, Piper PA 38. Most larger jets used swept-back wings. Few of the aircrafts which are used in military have exercised swept-forward wings. High-speed jets which are used in military make use of delta wing which is most usually used for this purpose as they provide even more competent supersonic performance. Concorde also makes use of a type of delta wing configuration. The blended wing body configuration is although distinct from all of the mentioned and used fixed wing designs in the aviation sector. A blended wing body aircraft does not contain any fixed fuselage but, instead it 'blends' that is attaches the wing and

fuselage into one single structure. The lift essential for flight is then provided by this complete aircraft. Therefore, it is also known as the 'flying wing.' The increase in the space in the fuselage due to this configuration can be utilized for transportation of payload which can include avionics, fuels, cargo, or passengers. The blended wing body is not at all a completely new thought. Even earlier than the Second World War a number of experimentations were done with the blended wing body configuration in Germany, Britain, and US. The blended wing body brought forth various advantages in military use in the field of efficacy and in radar detection. Moreover, there were various interest coming up to evolve the configuration for passenger use. Armstrong Whitworth, a British manufacturer, developed the AW 52 which consisted of two flying prototypes. But failure in research resulted in non-production of any of the aircraft. A US manufacturer was also interested in the same. It advanced the investigational to bomber aircrafts namely YB-35 and YB-49. It released plans in the 1950s, for a flying wing passenger aircraft but the progress was never continued by them. In the early parts of 1920s, Nicolas Woyevodsky progressed a theory of the Blended Wing Body, followed by wind tunnel testing, resulting in the Westland Dreadnought construction. Which in 1924 stalled on its initial flight. In the process there were severe injuries to the pilot and negation of the project took place. Some sort of similar idea was projected once more in the early 1940s for a Miles M.26 airliner project and the Miles M.30 "X Minor" study. The construction of the prototype took place to explore it. In 1944, the McDonnell XP-67 prototype interceptor was also flown but it did not meet the expectations. NASA reverted back to the idea in the 1990s with an artificially stabilized 17-foot (5.2 m) prototypical (6% scale) called BWB-17 which was built by Stanford University. It was flown in 1997 and presented good handling potentials. From 2000, NASA carried on to progress a remotely controlled study model with a 21-foot (6.4 m) wingspan. NASA has also simultaneously explored Blended Wing Body designs for the Boeing X-48 which is an unmanned aerial vehicle. Studies have advised that a Blended Wing Body airliner which can carry 450 to 800 passengers can attain fuel savings of over 20 percent. Airbus is also studying a Blended Wing Body design which can possibly replace the A320 neo family. A sub-scale model was flown for the initial time in June 2019 which was the part of the MAVERIC (Model Aircraft for Validation and Experimentation of Robust Innovative Controls) programme. Airbus is in the hopes that it will help in

the reduction of the CO₂ emissions by up to 50% comparative to 2005 levels. The N3-X NASA thought uses different types of superconducting electric motors to power the distributed fans to reduce the burning of fuel, emission, and also noise. The required power to drive all of these electric fans is produced by the two wing-tip mounted gas turbine which is driven by superconducting electrical generators. This notion for a possible futuristic aircraft is known as "hybrid wing body" or also as blended wing body. In this strategy, the wing blends effortlessly into the body of the aircraft making it tremendously aerodynamic. It holds bombastic promises for dramatic drops in fuel consumption, noise and also emissions. NASA also developed concepts like these to examine in computer simulations and also as models in wind tunnels. It is done to prove if the possible profits would truly happen. The wide internal spaces shaped by the blending stance originate new structural challenges. NASA has been reviewing foam-clad stitched-fabric carbon fibre composite skinning to create and enhance incessant cabin space.

1.2 Blended Wing Body

The needs as well as requirements of aircrafts for the transmission of load and passengers from one place to the other has elevated since the last few decades to larger heights. Conventional aircrafts having the chief contributor of the lift by their external wings as are the only accessible intermediate for gratifying such intention. Numerous expansions in technologies have taken off in various areas of aircraft design such as avionics, propulsion, aerodynamics, etc. Blended Wing Body aircraft shows higher efficiency in the aerodynamic parameters being one of the hopeful aircraft that exists. Even though the name i.e., Blended Wing Body was actually renowned in the aviation trade only before one or two decades, even then the perspective since 1933 and has been flying in the sky. It is the first glider which was perceived then by the Horten brothers. In the present times, Boeing and NASA are endlessly producing models of Blended Wing Body, with various advancements one after another with X48C being the current one in the design. The Blended Wing Body aircraft in the aviation industry is able to catch as many eyes on account of its numerous advantages. With these advantages it overpowers over the well-known and established conventional aircraft. There is an advantage in the interference drag as it has no clear boundaries in between the wing and fuselage. The centre body

being one of the sections of the aerofoil, it acts as a lift producing surface and gives a greater lift to drag ratio. A noteworthy decrease in noise is provided by the back-end placement of the engines. A number of challenges in the design have been experienced in the designing of Blended Wing Body aircraft configuration. Some of it being less favourable for cabin pressurization of the interior. As for such pressurization, a tubular body is best suitable as a resolution.



Fig: 1.1 Blended Wing Body

The Blended Wing Body shape enables the ideas of exceptional interior designs. Cargo or passengers can encumber the aircraft from the rear as well as from the front of the aircraft. Extensive fuselage which provides a large working volume. For passengers who are inside the aircraft can experience real time video which can be provided at every seat. This can take the place of the window seats in the conventional aircrafts. NASA and other industry studies propose that a large commercial Blended Wing Body aircraft can be constructed. Due to its such an effective configuration when compared to the conventional tube aircraft which flies at the similar subsonic cruise speeds of over a 7,000 nautical-mile range, the Blended Wing Body will devour over 20 percentage of reduction in fuel. A Blended Wing Body aircraft of the above mentioned type will have a wingspan a tad greater than the already existing Boeing 747 aircraft. It could also function from existing airport terminals. The Blended Wing Body aircraft would also have reduced weight, will generate a lesser amount of noise and emissions. In addition to that it would have reduced cost to run than an equally

advanced conventional transport aircraft. In the former few decades, fuel efficiency and noise reduction have demonstrated to be one of the major tasks for all the aircraft builders. Conventional tube aircrafts are not able to satisfy the various needs required according to their manner. The seeds for the future of the air transportation and air travel were planted by Dennis Bushnell, (who is also now the chief scientist of the NASA Langley Research Centre in 1988. To meet the upcoming difficulties in air transportation and air travel, the notion of Blended Wing Body aircraft was put forward by McDonnell Douglas (who is now the part of the Boeing Company) in 1988. The awareness of Blended Wing Body aircraft is to deliver a sole lifting surface by extending the complete wing span of the aircraft. The Blended Wing Body has a copious aerofoil like shaped fuselage section which then combines with the engines, the wings and the body. The crucial gain of the Blended Wing Body is its way of minimally distinguishing among the wing and the fuselage, and the fuselage and the tail. It has an added "centred" volume as compared to a conventional aircraft. The Blended Wing Body does not consist of tail and a conventional fuselage. The Blended Wing Body aircraft design approach is to make the most of the wide-ranging efficiency provided by it by making an improvement in the propulsion system, the wings, and the body and concluding it into a unified surface producing lift which bids boundless potential to significantly diminish the operating costs simultaneously improving the performance. The concept of Blended Wing body aircraft was put forth nearly 25 years ago. The initial idea was to construct an innovative type of aircraft which would permit the aircraft to transport more passengers. The Blended Wing Body aircraft is not a fully fresh idea as it was considered by others philosophers like Horten, Northrop, between the 1930s to the 1950s, nonetheless as it was discarded due to the stability and control issues. Summing it up, the Blended Wing Body aircraft was also formerly called the "Tailless Airplane" and, "Flying Wing Aircraft". An archetypal study discloses that a twin deck of A380 aircraft can house 550 passengers very comfortably. But if the Blended Wing Body is executed, the passenger volume will increase to be 800 in addition to the increase in passenger capacity as well as reduction in fuel consumption of the aircraft. In spite of the extensive list of all the inadequacies; the Blended Wing Body passenger aircraft conformations hold three very sombre advantages which include high Lift to Drag ratio which is achieved due to the reduced relative wetted area, favourable load dispersal along the span of the aircraft and the conceivable

engine noise shielding. Ikeda et al. calculated that Blended Wing Body aircraft configurations produce enhanced performance which includes a huge improvement in the high Lift to Drag ratio of wing. Also, there is an evolutionary development in the composite structures and the engines. The Blended Wing Body bids a drop in the operating costs simultaneously improving the aerodynamic performance and elasticity for both passenger and cargo missions. R. H. Liebeck studied that owing to the shape of the Blended Wing Body aircraft configuration, it uses 27% lesser fuel, had 15% deductions in the take-off weight. In addition to it there was 27% lower total thrust, and 20% increase in the Lift to Drag ratio as compared to the conventional tube aircraft. The wing in the conventional tube aircraft is the chief donor to the generation of lift whereas the fuselage of the Blended Wing Body produces lift in addition to the wing therefore giving the rise in the effective surface area. This can be done by expanding the propulsive systems, the body, and the wing and construct it into a single surface which produces lift. The mentioned Blended Wing Body aircraft is a novel design still in concept which looking ahead can offer boundless potential which can further significantly diminish operating costs. It will also improve the performance in the aerodynamic and suppleness for both cargo and passenger task. A Blended Wing Body aircraft is an arrangement where the wing and fuselage are unified resulting in a larger flying wing. The Blended Wing Body configuration in future makes us expect everything in terms of aerodynamic efficiency. In particular when talking about huge aircrafts used for transportation, since the Blended Wing Body has an only lifting surface, this results in the configuration being aerodynamically clean all around. With addition to that, a Blended Wing Body aircraft were formerly also known as 'tailless airplanes' and 'Flying-Wing aircraft'. Blended Wing Body aircrafts have been on the drawing board and in the thoughts for more than a half time by aircraft academics such as the Northrop Corporation and the Horten Brothers. A Blended Wing Body is a configuration which has been projected as a commercial airliner. The idea and the design both are under progress and examination of its flight capabilities. The Blended Wing Body aircraft for the upcoming generations was considered with the conceptual design process. Specifically, the aerodynamic performance of Blended Wing Body configuration is to examine and boost using the Computational Fluid Dynamics solver which is based on the Raymer's design process. Numerous software were serious tools used to design and envision the structures such as CATIA V5 and FLUENT 6.2.

Quite a few key mathematical parameters were applied to design and optimise the configurations. Some of the other measurements to approximate the Lift to Drag ratio is to analyse the relationship between the wetted area of the Blended Wing Body configuration and wingspan. Since the Lift to Drag ratio is extremely dependent on the configuration arrangement, it straightaway affects the wingspan and wetted area particularly at subsonic speeds. In level flight at subsonic cruise, the parasite drag is linked to the skin friction drag, which is directly resultant to the total surface area of the Blended Wing Body configuration subjected to the air. The contrast between wetted area and wingspan can also be called as the wetted aspect ratio. It can be defined as the square of the wing span which is divided by the wetted area of body configuration which is almost similar to the normal Aspect Ratio. For preliminary design purposes, the wetted aspect ratio is used to assume Lift to Drag ratio based on the initial stages of the sketch.

1.2.1 Droning Parameters of Blended Wing Body Configuration Design

The significance contemplations of a Blended Wing Body aircraft design were that five hundred and fifty-five passengers can be accommodated simultaneously attaining flight comfort and also meeting safety standards with sixty-seven tonnes of payload, eight thousand nautical miles (which is approximately 15,000 km) range and the cruising speed of Mach 0.85, as compared to the conventional tube aircraft. To cover even farther distance and faster and also to have greater fuel efficiency is the chief target of the design for civil transport and military cargo plane along with few war crafts. The flying wing and the Blended Wing Body are taken into account so that all the mentioned goals can be achieved. The Blended Wing Body can increase the efficiency in the cruise lift to drag ratio without the presence of horizontal tail, cylindrical fuselage, and the vertical fin etc, which are the parts that generate drag and don't have any contribution in lift. The alike aerodynamic arrangements have countless advantages in the terms of aerodynamic efficiency when compared with all the traditional layouts. One of the control method which is new and effective for Blended Wing Body is the examination of drag on all the typical types of civil transport exhibits that the parasitic drag, the induced drag, the pressure drags and the friction drag respectively take up to three, nineteen, twenty-seven and fifty-one percentages of the

total drag of the complete Blended Wing Body aircraft. The major part of all the drags is taken up by the friction drag as it can be visualised. It is well known that the friction drag is directly proportional to the size of the wetted area. The transport capacity for the number of passengers that can be carried by the civil transport is regulated by its volume. Therefore, the concept used in the design of the Blended Wing Body configurations is to simultaneously recollect all the essential volume by decreasing the wetted area. The wetted area size of a Blended Wing Body aircraft configuration is nearly two-third of a traditional conventional tube airliner with the similar volume. In the current years, the hotspot for the new generation of airliners and cargo crafts is Blended Wing Body configurations because of the above-mentioned causes. small radar cross section acts as an additional advantage of the Blended Wing Body configuration and the flying wing design. This advantage makes them perfect to be a military scout, and bomber etc as they're less expected to be detected. If we take for an example, with its flying wing layout, the stealth bomber B2 has very minor radar reflection area. In addition to the cruising efficiency advantages, the Blended Wing Body and flying wing configuration also has a few disadvantages. Deprived directional-lateral and longitudinal controllability are some of the disadvantages that the configuration has. In general, the traditional horizontal tail and vertical fin is absent in the flying wing aircraft configuration. Its elevator, aileron, and rudder blades etc. are positioned at the wing's trailing edge. Yet, the production of yawing and rolling stability (especially yawing stability) is the traditional vertical fin's elementary purpose. The rudder blade of vertical fin of the conventional aircraft provides the yawing controllability. Forfeiture of the yawing controllability and the directional lateral static stability of the aircraft is directly due to the absence of the vertical fin. When Blended Wing Body is compared with the traditional horizontal tail, the trailing edge consisting of the control surface is nearer to the gravity centre. The lateral and longitudinal stability and controllability is also decreased by the horizontal tail. Smaller longitudinal static stability and pitching controllability along with the failure to encounter the requirements of the artificial stability takes place in aircrafts which are deprived of vertical fin. Hence, to overcome the difficulties of controllability and stability for Blended Wing Body configuration, a great deal of work is being done by the scholars. In order to innovate new control methods lot of thoughts were presented. So that the yaw control can be attained all moving wingtips were practised by Zuo and Wang.

Experiments were initiated. It was found that yawing moment could be delivered by the unilateral movement of the all moving wingtips only if the lift is same continuously. But huge amounts of pitching and rolling was associated with it. The side force was slightly joined with the unilateral moving of the moving wingtips. Also, they investigated that the synchronic moving had comparable longitudinal characteristics, but then again with higher amplitude. Articulated split wingtips usage was an idea which was put forth by Bourdin. Experimental and numerical results were also provided by him. By alteration of the dihedral angles of split wingtips the yawing, longitudinal, and lateral control was achieved. Morphing of wing tails was proposed by Wildschek. In order to control the flying wing configuration aircraft, this technique stated various advantages. The shape of the aft wing section can be controlled by the mechanism fabricated by him. Wing deformation was one of the other ideas which was put forth in order to control the flying wing configuration aircrafts. Yawing, pitching, and rolling moments production was proposed by giving different wing deformations respectively. Each deformation was produced by giving the control torque. In researches, for Blended Wing Body configuration aircrafts, wing deformation is a decent control method in the field of aerodynamics. In addition, by the given method, the surface won't have juncture and pits over it (which for radar reflection and flow separation is considered to be one of the main issues), therefore, efficiency and stealth cruise performance is improved. Requirement of a greater wing span to balance out the centre wing box which has to be tall so that it is available to be used as passenger cabin. A Blended Wing Body has more vacant weight for a provided payload. This can prove to be uneconomical for quick missions of around four or rarer hours. A greater wing span may be unsuited with some of the airport infrastructures, resulting in the requirement of folding wings. Further to be added it is extra expensive to adapt the design to generate variants of different sizes as compared to a conventional tube fuselage and wing which can be overextended or contracted effortlessly. The need to expand the performance and reduction of fuel consumption in the recent years has led to UAV shapes optimization. The spirited aerospace market majorly focusing on it. The advancement in the Blended Wing Body design configuration is such a struggle. To sum it up there has to be the eradication of the tail for this specific kind of UAV. There has to be substantial decrease in corresponding weight. The reduction of obtainable space for installation and the active range should also take place. In spite of all the

above stated advantages, instability of the aircraft is the undesirable outcome of eradicating the tail. Amending of this flaw necessitates designing of an amalgamation of reflexed wing sections and control surfaces and usage of complex computer control systems. Thus, the aerodynamic shape project optimization of Blended Wing Body aircrafts, laterally with the necessity to meet the design necessities, has stimulated numerous researchers to prevail over its challenges. Nevertheless, Blended Wing Body configurations have a few changes in definition, and in some of the ideologies of aerodynamic design which are practical for each of them. The Blended Wing Body design configuration holds various tasks laterally with the necessity of the development of the aircraft. This efficiency levy more computational effort on the initial design process. A number of purposes and diverse constraints in the design of Blended Wing Body configurations turn them into a proper candidate. The features of their shape compel their geometry parameterization to be much easier. A study was done to refine the Concurrent Subspace Optimization (CSSO) structure on the basis of response surface. Single objective optimization of Monte Carlo analysis of the flying wing was directed in the same field. For battery-powered composite Blended Wing Body configuration with Delta wing advancement of aerodynamic shape optimization by Multidisciplinary Design Optimization (MDO) was done. Pan presented an orderly method in aerodynamic and furtive MDO issue for dual sweep flying wing configuration. They functioned the hybrid assemblage of universal optimization and gradient algorithm and also using it in optimization plan which is done in conceptual design. Morris devoted all of his consideration to the multidisciplinary and the multilevel optimization presented for the instantaneously optimizing the aerodynamic shape. The pure strategy of the aerodynamic shape was to be sustained so that it can be the topmost detached of optimization in some of the studies. Although in some of the other studies the main focus was the airfoil cross-section. It was revealed so that there can be advancement in the fineness of the mesh which was altered at the time of optimization. The sturdy proposal of airfoil shape optimization is exposed to decline the sensitivity of negligible random geometry perturbations and also the undefined operational environments. Based on Kriging and gradient enhanced Kriging, the formation of meta models is beached on a moderately lesser number of CFD evaluations. Henceforward, the static geometry aircraft optimization strains to content conflicted constraints in all the diverse given flight circumstances. Hunsaker did the

study on the optimization of aerodynamic shape of morphing wing is the key emphasis of the same. This method increases permissible wingspan while also reducing the induced drag for a stated weight of the structure. There also some theories which were put forward like the optimal Lifting Fuselage Configuration shape for BWB in the study done by Reistand Zingg. The 12th aerodynamic shape was amplified for the premium cruise altitude which was provided with decrease in fuel consumption. The fusion design of the aerodynamic shape and structure of the blended wing body configuration was enhanced by the blending of the multi bump method which had involuntary optimization and flow control in the other study. This upsurges the lift-drag ratio and also upgrades longitudinal static stability. The methods which already exists are largely different in the organization of the geometry of the problem. In the present time, the given complex engineering design glitches such as Blended Wing Body are studied and established to provide an enhancement in the accuracy as well as providing steadiness of the present-day optimization process. Above all, because of the elevated computational charges of solving the Computational Fluid Dynamics models has led to the researchers using the meta model in aerodynamic optimizations. Yet, building precise meta-model would still result to be time consuming and is every so often related with inadequate accuracy in to safeguard a countless degree of change in variables, the occurrence of local extrema and constraint functions. The introduction of the idea of sequential approximation method was acknowledged to incapacitated the above stated boundaries of the meta-models obligated by large-scale and complex design space. The simulation outcomes demonstrate that constructing suitable low fidelity model decreases the computational price as well as improves the model accuracy. Koziela introduced the response correction techniques which are used for aerodynamic shape optimization. The accuracy of the other such models which are derived from low accuracy models is enhanced. An automatic selection of low fidelity model for aerodynamic shape optimization is also projected in one of the other studies. Misalignment of high as well as low fidelity models is utilized by this method. The tiered kriging technique is exploited for the modification of low fidelity kriging model in the variable fidelity shape optimization. As the low fidelity model is erected on the basis of a single design point, as a result some subjective aerodynamic data accurate the meta model as the high-fidelity. Added studies ponder the outcomes of boundary layer transition which is done to optimize the shape of a

lifting body with alteration of the meta models. The sample selection method which is used for correcting the model acts as a crucial role in these architectures. Making the most of the Expected Improvement function, Probability of Improvement function are few of the examples of these methods. K-means algorithm categorizes the keys for all the selecting points and altering the database of the meta model, however genetic algorithm is undertaken with optimization of the aerodynamic form. The submission of the parallel processing abilities as compared to the optimization of aerodynamic glitches is simplified by uniting these techniques so that it can ease the defects of each of them. Some of the other methods for retrieving local adaptive meta model structure includes the move limit strategy. The chief worth of all of these methods is the clampdown of design space in the existing optimum point neighbourhood and filtering of the model in the mentioned space. The dynamic significance of choosing the move limit strategy is governing optimization performance. Among all of these, the global convergence could be attained by applying the trust region technique. Alternatively, the choice of design variables in shape optimization affects very largely on the suitable covering design space as well as reducing the computational charge. Even though the gradient-based algorithms are prevalent as a result of their greater computational speed in resolving aerodynamic problems and the evolutionary algorithms. In addition to that its ability of also solving the particle swarm optimization have been used in several of the studies. It should be taken into account that the practice of some of these algorithms would result to be more cost effective on account of the countless number of evaluations in multi objective problems. They also bid improved guarantee of evading the local minima. Then again, a number of studies have been directed to decline the computational time of algorithms based on gradient. There has been minimal conversation of earning up to a blended wing body design configuration since the invention of the jet aircraft. Efficiency enhancements have been done by focusing on the upgradation of engines, wing design, and by the usage of lighter weight components. The blended wing body configuration promises a higher step in efficient design by making the design work. In current years, a few transformed interests can be seen. Considerations were done on model prototypes even though; it is still at very early stages. The conventional aircraft design consisting of fuselage and wing is the utmost convincing idea in the aviation industry. This design concept has been in existence since the first powered flight in 1903 by wright brothers' flyer. Even though,

a number of design variations have been done throughout the very first century of powered flight in order to enhance performance, nonetheless most of the present aircraft has conventional design configuration consisting of tube and wing as a core. Separate roles are played by the fuselage and wing in conventional design configuration. The function of the fuselage is to carry payload and wings produce lift. The conventional design configuration is proven and as a result its aerodynamic efficiency has been enhanced over the period of time. Since there has been continuous development for more than a century, which has resulted in the conventional design reaching the stagnation point, leaving little room for added improvement in efficiency. The hike in the fuel prices and various environmental fears are compelling the industry to peek into new concepts for high fuel efficiency. The Blended Wing Body configuration is seen to be the future of aviation that not only offers very high fuel economy but also offers huge payload and quieter & cleaner action. Being a hybrid shape, it consists of single lifting surface which is produced by the fuselage and wings smoothly blended together. The Blended Wing Body bear a resemblance to a flying wing, but then again it also includes features from conventional aircraft. Numerous advantages are produced by this combination as compared to the conventional tube and wing airframe structures. As airframe incorporates airfoil shape body which is blended with the high lift producing wings, therefore, it permits the whole airframe to produce lift that improves the fuel efficiency. It is studied that Blended Wing Body aircraft configuration would advance lift to drag ratio by 50 % and fuel efficiency by 20-25 % when compared to conventional tube configuration. In the first half century of powered aircraft the main concern was to fly longer, faster as well as higher. The latter half of century was seen shifting their focus slowly in the direction of the need of transport with high fuel efficiency, and decreased noise. In the present modern world, priorities shifted to having high efficiency, low noise and cleaner operation owing to continuous increase in the fuel prices and numerous environmental concerns. The Blended Wing Body is considered to be the only one promising replacement which can not only meet the demands of the present but also of the future of aviation. Numerous advantages are proposed by the Blended Wing Body aircraft configuration over the already existing conventional tube and wing configuration. The chief motivation for this project originated from the success of the flight test program which ended in April 2013 of X-48C by NASA and Boeing. The aerodynamic characteristics

of the Blended Wing Body design configuration was discovered and authenticated by the mentioned 8-month lengthy flight test program. Test results have proved better fuel efficiency and compact noise as a wonderful promise proposed by the Blended Wing Body aircraft. The Blended Wing Body configuration can be controlled as effectively as a conventional tube and wing aircraft during take-offs, landings and other low speed sections of the flight regime. In current years, the increase in requirement of air travel has resulted in various issues such as hefty air traffic, terminal overcrowding and parking amenities. Huge airliner is the requirement of time which can transport 18 more passengers at the same time confining the number of operations from airports. The pursuit for a greater number of people on a smaller number of aircrafts has been defined by NASA as "The Lure of Large Aircraft". The complete motivation to design large Blended Wing Body passenger aircraft configuration is the necessity of quieter and cleaner aircraft with higher performance. To decrease fuel burn up and upsurge the efficiency globally by 2%, ICAO has set a target to achieve it by 2050 for the aviation industry. Conventional tube aircraft efficiency has been enhanced continuously with new flow control systems namely vortex generators and wing let. These flow control systems improve the aircraft efficiency by a reduction in drag. Fresh Notions are now analysed by huge companies like Boeing, NASA, Airbus etc, to decrease drag produced by the aircraft as well as tend to reach the sustainable status that has been set and required by the ICAO and other airlines. The combination of a flying wing aircraft and a conventional tube-wing aircraft is the idea on which the Blended wing body aircraft configuration is formed. The wings and fuselage of a Blended Wing Body configuration are combined to produce one lifting body from where it gets its name. The Blended Wing Body configuration have been studied and concluded that the wings which are integrated to the bigger and broader aerofoil centre body which allows to decrease parasite drag, in specific interference drag and produce lift by the whole aircraft. Lift induced drag is enhanced as a greater surface area of the aircraft is subjected to produce lift. Though, the developments upsurge the total lift to drag ratio which provides a greater performance aircraft that results in the conservation of twenty-seven percentage of fuel burn per passenger per mile when compared to the conventional configuration in the modern times. Keeping the aerodynamic improvements aside, countless other advantages can also be seen. These other advantages include noise decrease,

effortlessness in manufacturing, structural loading, surface area reduction of thirty three percent and benefits related with in flight emergencies. The aircraft desired by the ICAO which is cost saving and sustainable in operation can be seen by adding all the above advantages. With all these efficiencies which are generated, the aircrafts will be able take lengthier flight paths or upsurge in the aviation industry in a positive manner because of more affordable flights for passengers. Long range airlines were mandated after studying the potential market by long draw aircraft design programs in 1998 by NASA Langley Research centre for Research and Background Theory Blended Wing Body Programme. Focusing on the examination and design of a novel aircraft configurations started shortly after that time, where McDonnell Douglas started an initial design project. Decrease in flight fuel burn, notable increase in lift to drag ratio and reduction in weight were some of the original advantages which McDonnell Douglas received. It was this idea and instant which gave NASA the motivation to further fund such studies to disparagingly compare conventional tube aircraft to this novel blended wing body configuration. NASA, sideways with McDonnell Douglas began a determined design program where the necessities were to propose a subsonic aircraft for eight hundred passengers and also be able to travel to a larger range of 7000nm. The project proceeded as strategically as it was planned and was compared against a conventional tube wing aircraft configuration. The blended wing body configuration aircraft was concluded with a reduction in maximum take-off weight of fifteen percent as well as reduction in surface area by thirty three percent. Also, a decrease in fuel burn of twenty seven percent per passenger per mile was studied. Noise and emissions emitted by the blended wing body configuration was seen to be knowingly decreased as compared to the conventional tube aircraft additionally plummeting the operational cost of the blended wing body configuration. Structural loading claimed to be the single disadvantage within the centre body which was noticed at this point. The blended wing body design configuration was evaluated continuously and the design necessities changed slightly accordingly by dipping the passenger count to four hundred and sixty-eight passengers. This resulted in the increase of the range to 7750nm. This developed aircraft was called the Blended Wing Body 450. This design persisted to be very alike but the aerodynamics was reformed by Boeing's software where the structural investigation was taken out by methods of finite element analysis. The propulsion was also analysed using many different

Computational Fluid Dynamic techniques. A number of additional advantages were expanded from this research. The capability to perform well in emergencies, high performance at higher Mach speeds, and ease of manufacture were some of the additional advantages. In recent times, Boeing and NASA's Blended wing body program designed the BWB-X4 to judgmentally study the stability and on-board flight control systems. This study was carried out by evaluating flight tests with the use of manufactured scaled model and an indoor wind tunnel. In June (2007), the initial flight test took place. A total number of eighty flights were performed till the program ended in 2010. This happened before the new-fangled BWB X-48C program began. Numerous lessons were cultured from this BWB X-48B program. One of these lessons was what happens to the Blended Wing Body at α stall. When the Blended Wing Body undergoes a stall owing to the aircraft flying at a high angle of attack resulted the Blended Wing Body to come in a rotational tumble motion. For a Blended Wing Body, a rotational tumble is studied to be tremendously difficult or intolerable to exit as a result of the design of the Blended Wing Body. Because of this condition the Blended Wing Body falls till it crashes. This can result to be a catastrophic event in flight which means further analysis has to be done before preparing to execute this configuration for either commercial or military usage. Averting the Blended Wing Body from stalling, a new program called the BWB X-48C was published by Boeing and NASA in which flight controls were supplemented. Going further, various flight as well as wind tunnel tests were done till the point when the program stopped in 2013. Nevertheless, the Blended Wing Body was taken back to the wind tunnel for added testing in 2016, by NASA. They still have confidence that for the blended wing body configuration there is real scope and hence be applied to use as novel ultra-sustainable aircraft. NASA is still acute to advance an ultra-sustainable aircraft which is the reason that they considered alternative blended wing body designs on their NASA X-plane program. This program is intended to support the advancement of numerous diverse novel concept in aircraft which all display scope to upsurge efficiency. Concepts ranging from blended wing configurations, quiet supersonic technology to electrically powered aircraft, are under the NASA X-plane program. Blended wing body configuration plans on the NASA X-plane program are of several different types and many diverse designs. After studying different project NASA and Boeing have advanced the most. Blended wing body configurations also seem to precedent in research and growth.

Yet, all the other companies have witnessed the advantages of blended wing body configurations which they have to offer and also initiated their own ideas for design. In spite of the delays stated in the early programs, NASA and Boeing are still self-confident that their Blended Wing Body-48 series will be in the market commercially by 2030. Aurora flight sciences D8 double bubble notion is one of the other candidates for the 2030-2035 timescale. It has a fuel burn decrease of seventy one percent which can result to this aircraft being the novel market leader for blended wing body designs if it completes the project in the predicted timespan. By 2025, entry of the Dzyne Technologies regional jets can happen in the same. Lockheed Martin has not yet published an in-service time scale which suggests that they are still stuck at the initial design phases. The Lift to Drag ratio can be defined as the ratio of the Lift and the Drag forces which are related to a specific aircraft. An aerodynamically efficient aircraft configuration is considered to have a greater Lift to Drag ratio which would in turn suggest that the aircraft produces a large quantity of lift and small amount of drag. A number of diverse aspects could affect the Lift to Drag ratio of a specific aircraft. These aspects can be the geometry design, area, airfoil selection, position of the wing, wing sweep and so on. In one of the other studies which was done focused on the Lift to Drag ratio variance between Blended Wing Body and conventional tube aircraft configurations. At cruise speed of 0.8 Mach, the experimentation of the replicas took place and also at an approach speed of 0.16 Mach. The outcomes of the study and experimentation confirm that the Blended Wing Body beats the present time conventional aircraft at both of the speeds. At cruise speed it was studied that there is an improvement in the Lift to Drag ratio by twenty four percent and at approach speed by 23.79 percent. Additionally, the Blended Wing Body does not steadily have greater lift and smaller drag as associated to the conventional aircraft so that it can have a larger Lift to Drag ratio. This attests that the Lift and drag ratio is of more importance rather than targeting for only one higher constraint such as lift. Aerodynamic Design and Exploration of a Blended Wing Body Aircraft which studies the optimum operational angle for the Blended Wing Body design was published by Scholarly Commons in 2019 and was done at an appropriate cruise angle of approximately $\alpha 5^\circ$ as well as at an apt approach angle of 1.5degrees to 2.5degrees. In this specific experimentation the maximum Lift to drag ratio was found to be 8.5, which takes place at $\alpha=0^\circ$. Nevertheless, the maximum Lift to Drag ratio is not required always for a

specified airframe. Lift coefficient and drag coefficient connection can be represented by the drag polar. The drag polar is exercised to govern the drag coefficient of the aircraft which is encountered at a firm lift coefficient. A tangent line from the origin to the curve is drawn to find the maximum C_L by C_D ratio. In this specific case, a C_L of roughly 0.175 experiences the slightest quantity of drag which provides the maximum efficient cruising condition. This happens due to the cause that from this particular point the gradient of the drag curve is tremendously flat, which means that the lift upsurges a little, the drag would upsurge meaningfully which in turn reduces the overall Lift to Drag ratio. The maximum efficiency in Lift to Drag ratio can be experienced at C_L equal to 0.175. This examination can deliver some of the other wing parameters namely the type of aerofoil which can be used and whether the wing contains of an incidence angle. This specific case displays that the wing comprises of cambered aerofoils and an incidence angle to produce such a high lift at angle of attack equal to zero degrees. The deductions which are grounded on studying the three diverse sources, such that there is a mutual ground for the desire of maximum Lift to Drag ratio which is probable to deliver a foundation for the sustainable Blended Wing Body. The Blended Wing Body executes finest at low angles of attack as suggested by the study which was done at $\alpha=5$ degrees which is the greatest optimum angle. It can also be suggested from the study showing $\alpha=0$ degree and proves that $\alpha=2$ degrees is the maximum optimal for these types of configurations. The perfect cruise angle has been studied to be in between $\alpha=0$ degree to $\alpha=5$ degree as with low angle of attack cruise angles, results in the reduction of induced drag of the Blended Wing Body while even producing high lift. These are the effects that provide the Blended Wing Body its essential larger Lift to Drag ratio. Nevertheless, there are numerous different constraints that can cause the Blended Wing Body to execute greatest at somewhat different angles of attack. These constraints can be the position of the wing, Wing area, span of the Wing, Aspect ratio, airfoil selection, wing sweep and the incidence angle. The width to chord ratio continues to be uniform transversely the span of Blended Wing Body configuration. The lift coefficient across the span of the Blended Wing Body can be defined as the Centre body acknowledges the maximum C_L because of the airfoil length and width at this specific point. As the geometry lessens across the wing span to the wing tip the lift also progressively decreases. A complete elliptical distribution is not replicated by the lift distribution which suggests signs of

induced drag presence associated with the Blended Wing Body. Nevertheless, to increase the odds of attainment of an elliptical distribution is by reduction of the connective gradient from centre body to the outboard wing. The results of the lift allocation across first half of the Blended Wing Body were observed. Two dissimilar runs were associated counter to the ideal elliptical distribution. Both of the experiments experience spikes at roughly 30%-40% of the span. The connection between the centre body and outboard wing is represented by this point. By making the connection as smooth as possible between the centre body and the outer wing is the lone way to upsurge lift at this specific area and also to produce an elliptical distribution. A clarification of span-wise lift distribution, the chord ratio thickness, and the CL distribution is desirable. The breadth for subsonic flight is obligatory to be between 15% - 17%. As the centre body encompasses cabins and systems, therefore, greater geometries are carefully chosen. As lesser lift is produced the more external you go. Advanced lifting airfoils are essential for this area of work. Therefore, picking airfoils with lower lift for the inboard will hence stable the lift distribution. The disadvantage with this method is that the wing loading will be significantly be on the outboard wing which in turn will require higher supports. Negative camber is additional to the trailing edge centre-body airfoils as they stabilize the trim. The design displays that the lift is distributed in an elliptical distribution. The contrast in between the conventional tube and Blended Wing Body having inertial load and their aerodynamic lift is revealed. The fuselage of the conventional tube aircraft contributes to the greater part of inertial load. Since, the fuselage delivers almost negligible lift, therefore, higher stress on the linking between the fuselage and wing is visible. The Blended Wing Body fluctuates as we can see that the lift is produced across the whole Blended Wing Body which in turn reduces the wing loading. Reduction of structural necessities is resulted. This increases the structural efficiencies of the Blended Wing Body. The reduction in the structural requirements of the aircraft causes the reduction in the aircraft weight. As there is an increase in lift is centrally, the balance and stability of the Blended Wing Body configuration changes. All these mentioned in turn changes the force dynamics as compared to that of conventional configuration. This is the reason why stability is avoiding the Blended Wing Body being commercially installed. At various span locations across the chord the pressure coefficient of the Blended Wing Body was assessed. In the Blended Wing Body aircraft at the leading edge a great positive

pressure is knowledgeable. The point where it occurs is known as the stagnation point and this is where the flow first comes in contact with the Blended Wing Body. The velocity is moving quicker over the top surface than compared to the bottom surface which therefore results in great negative pressure on the upper surface. This results in the occurrence of high suction which is caused due to the pressure differences. Therefore, showing that lift is produced. C_p graph and the width of the airfoil are directly associated with each other. This is where the flow over the Centre body begins to separate beforehand as compared to the outboard sections. The flow stays attached for longer period than usual which proposes that the outboard airfoil thicknesses is decreased. The pressure remnants at comparatively low negative value at the top surface of the centre body. This is where just before the trailing edge it progressively increases. This is where the flow begins to separate. In the merging point direction, witnessing of the negative pressure. The centre body and outboard wing are connected at this point. The unexpected change in geometry is the reason for the increase in the velocity. The outer wing's thickness to chord ratio is negligible hence, the flow remnants attached for longer period as compared to when it does at the centre body.

1.2.2 Potential advantages

- Noteworthy payload improvements in strategic airlift, air freight as well as aerial refuelling roles.
- Upsurge in fuel efficiency – 10.9% more than a conventional widebody to over 20% than a similar conventional aircraft.
- Reduction in noise.

1.2.3 Potential disadvantages

- Abandoning a Blending Wing Body during an emergency could be a task. On account of the aircraft's structure, the seating design could be theatre sort of style in the place of tubular. This levies characteristic restrictions on the number of exit doors.
- It is suggested that a Blended Wing Body configuration may have interiors which is windowless. Recent information displays that window could be placed in a different manner but it may include the same weight penalties as a conventional tube aircraft.

- At the time of wing roll, it is suggested that the passengers at the cabin ends could feel uncomfortable. Although, passengers in large conventional aircraft are also equally vulnerable to dutch roll.

1.3 Blended Wing Body vs Conventional Aircraft

Blended Wing Body configuration is an innovative type of aircraft conformation that has a structure which appears to be between the flying wing and the already known conventional 'tube and wing' aircraft. The exceedingly blended wing and fuselage provides larger amount of lift. This helps the Blended Wing Body aircraft to have a greater lift to drag ratio than the commonly conventional tube aircraft. When compared with flat shaped flying wing aircraft, the Blended Wing Body configuration aircraft have an additional noticeable fuselage and higher accessible internal storage space. This makes it convenient for transportation of passenger or cargo. Hence, Blended Wing Body aircraft have clear advantages when compared to conventional aircraft. The advantages can be seen in terms of economy, comfort, and also environmental protection. Given that the Blended Wing Body configuration aircraft eradicates the horizontal tail and makes use of a smaller area V tail in the place of a vertical tail. This subsequently results in significant reduction of longitudinal and directional static stability of the aircraft. The damping of pitch and yaw of Blended Wing Body aircraft is small and the aerodynamic and stability characteristics are sturdily united. The V tail, and the control effectiveness of the pitch control effectors is reduced due to shorter fuselage length. On the other hand, to have reduction in noise emissions and to improve the interference of engine jet flow on the rear flow field, the engines are generally mounted on top of the rear end of the fuselage. Therefore, the difference in thrust will give a substantial impact on the aircraft longitudinal motion. Several studies on the Blended Wing Body aircraft configuration were done. This includes the studies done on the budget and ecological safety, conceptual design, and the various aerodynamic configuration design. Though, insufficient works have scrutinised the numerous aircraft flying characteristics. The trimming features were investigated by Castro of a conceptual Blended Wing Body configuration. Suaces assessed the number of control and power necessities for a Blended Wing Body aircraft which is based on a distinctive flight assignment of civil aircraft. The directional and lateral closed loop stability were studied by Roysdon and Mahmood. They also studied the

handling characteristics of a business jet class Blended Wing Body aircraft at take-off and landing phase. Six degree of freedom flight simulation was used for doing this by them. Jung and Lowenberg investigated the trim traits of an enduring Blended Wing Body aircraft during cruise flight. They came to the evaluation that the flying excellence level of longitudinal and lateral directional modals using flying eminence specifications for military aircrafts. The impact of belly-flaps through take-off and landing on the handling features of a Blended Wing Body aircraft was studied by Stalens and Blackwelder. It is understandable that former researches largely paid attention towards the calculation and study of the airframe stability and handling characteristics of the Blended Wing Body aircraft. The alterations in the flight characteristics of Blended Wing Body aircraft and conventional tube aircraft have not been studied and concise. There is no discussion anywhere whether the prevailing airworthiness regulations for conventional tube civil aircraft are even now valid for the assessment of the flight safety of Blended Wing Body aircraft as these alterations are considered. The Blended Wing Body aircraft configuration reduces the total wetted area. Wetted area can be defined as the surface area of the aircraft skin. Therefore, this leads to the reduction in the skin drag to the least. Never the less, it also forms a thickening of the wing root area which as a result leads to a more effective structure and reduced weight compared to a conventional tube aircraft. The Ultra-High Bypass ratio jet engines along with the hybrid wing body is planned to be incorporated by NASA. A conventional tubular fuselage carries 12-13% of the total lift compared to 31-43% which is carried by the centre body in a Blended Wing Body aircraft. As an transitional lifting fuselage configuration is well suitable to narrow-body sized aircrafts which would carry 25-32% with a 6.1% - 8.2% surge in the fuel efficiency.

1.4 CHALLENGES

Since the few decades there has been an incessant development in the fields of avionics and control technology. In addition, there has also been growing requirements for aircraft fuel efficiency, carbon and nitrogen oxide emissions. The Blended Wing Body aircraft has turn out to be one of the feasible possibilities to substitute the traditional aircrafts as result of its high aerodynamic performance. Nonetheless, it also airs several challenges. Multidisciplinary design optimization, manoeuvrability, and stability is needed for some of these. The stability and dynamic

features of the Blended Wing Body aircrafts are diverse from those of conventional tube aircraft. In precise, the lateral and directional stability and manoeuvrability asks for more challenging necessities on confirming safety near the boundaries of the flight envelope of the Blended Wing Body. The learning of the intricate flight state of the aircraft is of boundless significance in guaranteeing flight safety and stoppage of flight accidents. Full-scale flight tests and wind tunnel tests are features which are included in Lessons on aircraft departure. The conventional wind tunnel test method founds a model over static and dynamic force test data to foresee the manoeuvring features and flight eminence of the aircraft. This technique is active at small motion rates and small angles of attack. Nonetheless, the outcomes become progressively indeterminate at progressive angles of attack and angular rates. Prediction of the behaviour under intense flight situations with this approach can be imprecise. Even though, the real flight tests can imitate real full-scale flight conditions just fine, but all these tests are really very expensive and time consuming. In few of the conditions, as considering safety and all the various other factors, the test flight envelope is also restricted. Virtual Flight Test expertise in a wind tunnel appears as a possibly powerful prediction/verification method. This type of technology is capable of filling the gap in between conventional wind tunnel test and Flight Test. This enables a decrease in the hazard which is involved in flight testing as well as it tends to shorten the development cycle by dropping the number of trials. Using the virtual flight test technology, extensive research on aircraft control and flight dynamics has been done. Pattinson constructed a 5-Degree Of Freedom rig at University of Bristol (which can be functioned in their 2.1 m 1.5 m closed wind tunnel or the 1.1 m open jet tunnel), and performed multibody dynamics modelling and simulation. Due to all these studies, there have been realisation of several key technologies which were discovered, including similarity criteria, support mechanisms, test models, and flight control systems. It also demonstrates study of aircraft departure characteristics can be utilised for the virtual flight tests. There were numerous problems that prohibited blended wing body aircraft configuration from proceeding further. Maximum efficiency dealing aircraft design and with reduced drag is obtainable in theory in blended wing body. Some of the features also include it being lighter than a traditional fixed-wing aircraft which in turn improves the efficiency. There are also numerous practical tasks that have an effect on the commercial design. One of these problems is that the

blended wing body aircraft would have a large internal fuselage area therefore it would only aim for the high-capacity aircraft market. So, development of this would not be worth the of its higher cost. Various problematic challenges can be there for operating at the smaller airports as result of its wingspan. Potential safety matters and access can take place if the engines are placed inside the airframe structure instead of the external pods. Similar safety necessities for evacuation and disasters would be places as it being an aircraft.

CHAPTER 2

LITERATURE SURVEY

Al-Garni (2002), performed a numerical study and experimentation in order to attain drag, lift, as well as moment of pitching data on the types 65degree delta and 65/40 degree DD wings. KFUPM low-speed wind tunnel facility is where the experimental data was obtained whereas CFD software FLUENT was used to perform the numerical tests. The numerical and experimental results were compared to each other as well with the other experimental results found in Polhamus literature. The distribution of coefficient of surface pressure and location of vortex bursting results comparison displayed good pact with experiments. The result comparison demonstrated decent equity in between a number of experimental studies and along with the Computational Fluid Dynamics predictions as well as theoretical calculations.

Ashwin (2010) conducted experiments and numerical simulation on leading edge shapes of double delta wings which were carried out with three double delta wing models of varying leading edge radius of 1.75 mm, 3 mm semi rounded of 45° bevel angle and 6.25 mm fully rounded in a low subsonic wind tunnel facility. The Reynolds number has been equated to 2.54×10^5 . Qualitative and quantitative techniques such as oil flow and force and static pressure measurements respectively have been applied to analyze the effect of aoa and shape of leading edge on strake/wing vortex breakdown location. Observations lead to the conclusion that the increase in radius of the leading edge will cause the location of the vortex breakdown to move downstream and normal force coefficient to increase.

Barberis (2009), focused on numerical and experimental research on the vortices at leading edge and on vortex breakdown characteristics. The initial aim was to study the vortical structures around a delta wing in separating of the shear layers taking place in the vortices at the leading edge. All experimentations were done in close type wind tunnel at subsonic speed at ONERA. Experimentation offers a thorough explanation of the vortical field of flow over a delta wing model with rounded leading edge with a 60degree sweep angle. To investigate the vertical flow structure acting over a 76°/40°double delta wing Nettelbeck focused his project on experiments in the wind

tunnel. A series of experiments using the subsonic wind tunnel has been deployed to broaden the understanding of the complex flow field structure interacting with these planforms. The design of the wind tunnel model was created to accommodate pressure ports over the top wing surface. As the model transitions through specified α , the unsteady surface pressure measurements were collected particularly when the wing exhibits wing rock motion. For developing a detailed understanding of the flow phenomenon, further experiments were conducted that involved flow visualizations to determine vortex location and breakdown positions. These results were conjugated with the surface pressure measurements to support the results.

Carlson and Mack (1978) conceptualized a numerical method for the leading edge thrust prediction for supersonic wings. It has been structured as an inclusion to an existing high-speed digital computer analogy for estimation of wing pressure distributions. The accuracy of this concept is analyzed by comparison with linearized-theory results for flat delta wing and its series. Application of the method to wings, both flat and cambered is illustrated. A simple local-sweep approximation is shown to provide sufficient estimation of thrust for certain classes of flat wings of arbitrary plan form and to permit the design of a wing leading edge for a certain thrust distribution.

Chaderjian and Schiff (2001) experimented on 65° delta wing for pressure and force measurements along with varied conditions of flow. Thus, different levels of corresponding code validations were made use of by the Computational Unsteady Aerodynamics researchers. In the given work, for selected flow conditions, a variety of Computational Fluid Dynamics results are given for the 65degree delta wing.

Gai, et al (2004) conducted water and wind tunnel studies. The study was to attempt to simplify the fluid mechanics of interface between the wing vortices and strake of a 76degree/40degree DD wing can result in bursting of vortex. Passive control with the use of fences at the region of kink and apex are also explained in some of the studies. A number of methods for diagnostic -laser sheet flow visualization, pressure sensitive paints, and fluorescent dyes have been used. The apex fences showed some initial instability but strengthened the strake vortices. Two mechanisms including interaction were studied to operate in the events of apex-fenced and plain models. These

mechanisms include the spiraling and enveloping interactions. Each of the above interactions had differing effects on the flow of vortex.

Galinski, et al (2004) conducted experiments with different leading edge configurations (LEX) and elevon deflections on MAV delta wing. The Micro Aerial Vehicle was light weight (150-200g), small hand launched, inexpensive and simple. It was for over the hill reconnaissance and direct unmanned flying vehicle. Tuft flow visualization was conducted for a series of MAV configurations and forces were measured. To measure the quantitative data an experiment was undertaken at low Reynolds numbers vortex effectiveness about leading edge as it were not available. LEX was used to test the model of four shapes of different types: circular, triangular, polynomial and trapezoidal. In each of the cases the area remained same and the span always being slightly more than length of slot. Both the experiments were conducted for exploring propulsion efficiency. In two parts the experiment was divided into. Firstly, for each LEX shape, lift/drag polars were assessed in steady flight. Secondly, the test for selected steady flight conditions was completed with running propeller, All experiments were performed for Reynolds numbers of 1.38×10^5 and 1.55×10^5 which corresponds to motor off and motor on conditions.

Gursul (2004) studied the phenomenon of fin buffeting by various measurements of acceleration of fin tip acceleration, flow visualization, and velocimetry image of particle image over a variety of delta wings. The effect of fin location had strong asymmetry on the buffeting response. The major response occurred for the slender wings at inboard fin locations. For locations at outboard fin the buffeting was small, even when the vortex bursting is well upstream at high AOA. Taking in account the locations at inboard fin, the major fin vibrations were found for bursting locations. It was concluded that twin-fin buffeting can be as important as single fin buffeting. In place of vortex breakdown, vortex shedding can become the mechanism responsible for a low sweep angle wing. The interaction of wing vortices with strake vortices has main impact on the buffeting characteristics for a Double Delta Wing. When angle of fin is non-zero it does not have much effect on the results achieved in this study.

Hamidi and Rahimi (2011) studied the steady state and incompressible flow numerically on a 76degree/45degree swept DD wing with at higher aoa with FLUENT software. The study comprised of numerical investigation of the vortex flow on the above mentioned DD wings as well as aerodynamic loads using FLUENT (v6.3.26) which is a computational fluid dynamic (CFD) solver and the computational grid around the DD wing was generated. The freestream velocity was 30m/s.

Heuy-Dong Kim, et al (2001) performed experimental as well as computational study on the flow of vortex of a delta wing with sharp edge along with a leading edge extension. Experimental study was done with the use of a wind tunnel at low speed. At a free stream of speed of 20m/sec, the AOA ranged from 10degree to 30degree corresponding to 0.88×10^6 Reynolds number. In order to comprehend the complex vortical flow over the delta wing, contained 3Dimensional Navier-Stokes equations with averaged mass were applied. The standard k-e turbulent model was utilised. The computational and experimental results were compared.

Hsu and Liu (1990) investigated vortical flows over an AR of 2.05 with 80/60-deg sweep, round edged thin Double Delta Wing with chord 1m and thickness 0.006m. 3-Dimensional computations were obtained utilising an implicit scheme of upwind-relaxation finite difference. Studies were done on the AOA and grid effects on the Navier-Stokes computations. Calculations of coarse-grid was unable to foresee the structural details of the vortical flow fields for an insufficient resolution of grid. In contrast, formation and interaction is shown by the fine-grid computations and simulation of the breakdown is processed.

Kaurinkoski and siikonen (1992) scrutinized the effect of transonic flow past a cropped delta wing with round leading edge. The Navier-stokes equations with averaged Reynolds were applied for calculation. The angle of attack is either 10 or 20 degrees in the calculations. The flow was assumed to be totally turbulent or totally laminar. Three algebraic turbulence models were incorporated. A Roe's flux-difference splitting with cell-centered approach is applied. With the Mach being 0.85, with the Reynolds number is either 2.38×10^6 or 4.5×10^6 based on the root chord. The scheme depended upon the finite-volume concept. The equations were solved using a DDADI-factorized

implicit time integration technique. A multi grid system was used to accelerate the convergence. The results were compared with experiments and were held good.

Khrabrov and Greenwell (2002) experimented dynamic vortex bursting effects' influence on un-steady aerodynamics for 70° and 65° delta wings in unsteady effects. The experiments were conducted in steady and unsteady case at TSAGI low subsonic wind tunnel. Three 70degree Delta wing models were tested. The large model had planform area $S=0.4224\text{m}^2$. The model was made from the duralumin plate of thickness 12.5 mm. The wing were consisted of perfectly rounded leading edges. The trailing edge was symmetrically beveled at an angle of 20°. The second 70° delta wing model was made from the plywood of thickness 12 mm. The reference area of the model is $S=0.2\text{ m}^2$. The shape of the model is same as the previous one. The difference of the third 70° delta wing model from the second one is only the shape of leading edges. It has beveled leading edges with a symmetric bevel angle of 20°. The reference area of the model is $S = 0.2\text{ m}^2$. The second and third models have balance housing. The dimensions of the wind tunnel are 2.33x4.0m (elliptical cross-section). The flow velocity is varied from 5 m/sec up to 70 m/sec. Level of the turbulence is about 0.3% in the empty wind tunnel. Dynamic tests are performed usually at 30-50 m/sec, so the Reynolds number is approximately 106 for the model with the chord around 1 million. When there is rotation of the turntable, the mean angle of attack or sideslip can be changed in dependency of the aerodynamic orientation of the model. Similar time and nonlinear lag effects are seen in several types of executed wind tunnel dynamic experiments: oscillatory coning motion, plunge oscillations, free-to-roll experiments etc. The presented experimental data for small and large amplitude forced oscillations of DD wings in the event of zero sideslip demonstrates the importance of vortex burst development and dynamic interactions. These effects must be taken into account in flight dynamics simulation at high incidence.

Kumar (2010) investigated flow field over 80°/45° DD wing with leading edge as blunt by both computational and experimental methods at different Re and aoa. An observation is carried out on major components of RLV like DD wing and fuselage. The result of presence of fuselage over the aerodynamic characteristic like vortex breakdown, and the effect of interference of the combined double delta wing and

fuselage is studied. The normal coefficients and side force coefficients are investigated using the strain gauge facility. A qualitative data of the model is produced using the flow visualization techniques like oil flow visualization and tuft flow visualization. The computational data obtained from using GAMBIT and FLUENT is validated with experimental results.

Kumar (2010) performed investigation to understand the effect of leading edge shape on the flow field over delta wing with a leading edge extension at a Reynolds number of 2.54×10^5 . Three double delta wings of increasing leading edge radius were taken. The experiments have been conducted at Low Subsonic Wind Tunnel. Qualitative techniques like Oil Flow Visualization and Quantitative technique like Force measurement and Static pressure calculations have been used to investigate the effect of angle of attack, effect of leading edge shape on strake and wing vortex break down location. 3-D simulations were performed using FLUENT over the double delta wing. With increase in leading edge radius of double delta wing, vortex breakdown location travels further downstream and normal force coefficient slightly increases. The results obtained through experiments and computations were in reasonably good.

Lee and Kim (2004) examined the vortical flows over delta wings with sharp edges consisting of a leading edge extension and also in the absence of the leading edge extension using computational fluid dynamics methods. The angle of sweep is 65° . 3 Dimensional compressible Navier-Stokes equations with averaged Reynolds number were resolved to deliver a study of the effects of the aoa and the yaw angle on aerodynamic characteristics as well as development and vortices' interactions at 20m/s velocity at freestream of the delta wing. There is much reduction in the significant change of the peak of the suction pressure in the chordwise direction at a mentioned aoa in the presence of an extension in the leading edge. This extension in the leading edge can possibly steady the vortex on the wing on the lower side at yaw angles which are dominating the vortical flows over delta wings which are yawed.

Liu Zhitao (2005), investigated the vortex flow over a Delta Wing Body combination and unsteady aerodynamic characteristics at high aoa. The experimental results were obtained from CARDC $\Phi 3.2\text{m}$ subsonic wind tunnel. The PIV application was used to

obtain the structure of flow field above wing. The unsteady aerodynamic features of delta-wing-body combination undergoing large amplitude pitching and rolling oscillation were obtained respectively. To control vortex separation, application of spanwise blowing over the wing was also examined. The effect of spanwise blowing is more significant with higher momentum coefficients of blowing.

Luckring (2004) conducted experiments on a 65° delta wing for Re number, effects of compressibility and bluntness effects of the leading edge. Both vortex flow aerodynamics and attached flow are addressed by this literature on the basis of a unique set of data obtained in the Langley National Transonic Facility for Mach speeds varying from subsonic to transonic, Re numbers varying from conventional wind tunnel to values of flight. In order to isolate the effects, the data were utilised. As they also posed numerous challenges for studies of CFD. These Mach number and Re number effects could be compared in magnitude and were revealed for maneuvering conditions to be noteworthy at incidence angles.

Moreira and Johari (1997) investigated the primary vortex of stationary delta wings encompassed by the closed path circulation of 60degree and 70degree using ultrasonic pulses. Propagation of ultrasonic pulses was in counterclockwise and clockwise direction laterally a closed and fixed path perpendicular to the root chord lines of the delta wing. A turntable, elevated tunnel floor, and ultrasound reflecting system were designed, machined and installed in an open circuit wind tunnel consisting of a test section of 0.91 m length and 0.61 m $\times$ 0.46 m cross sectional area. The wings in the study were of 25.4 cm (nominal) root chord length which resulted in a Reynolds number of 1.9×10^5 . Circulation in the closed path plane was determined from the difference in transit time between the counterclockwise and clockwise pulses. Examination of the circulation behavior was done as it relates to the above mentioned parameters as well as to the location of primary vortex breakdown. AOA for which the breakdown points endured downstream of the planform of the wing saw nonlinear growth of Circulation. Then with the increasing AOA till the breakdown point reached the kink vicinity, the circulation increased in a linear manner. It was also noticed that circulation approximately escalated linearly as there was increase in the chordwise location at constant AOA. This method has yielded various insights. Circulation has

been shown to increase in a nonlinear fashion with ascending angle of attack for given pre-breakdown chordwise locations corresponding approximately to angles of attack of 15° or less. Circulation then increases in a linear fashion with escalation in AOA for given chordwise locations in vortex breakdown regions. The rate of circulation escalated with increasing AOA and the rate of increase of circulation becomes slightly nonlinear after vortex bursting.

Mudkavi (2012) performed a review of current literature on the phenomenon of vortex breakdown. It has been cited that for more than 30 years of research in this area has not shed light upon this very basic fluid dynamics phenomenon. Some exciting criteria to predict the vortex breakdown were predicted. For vortex breakdown to occur, the helix angle for velocity must be greater than that for vorticity. An alternative criterion would be that the non-dimensional number N_{cr} or circulation number must exceed unity for breakdown.

Muller (1987) simulated a 65° delta wing using 3D Navier-Stokes compressible laminar flow solver. The wing had cropped tips and rounded leading edges. The finite volume solver is active for spatial discretization for the fluxes in viscous. For the integration of time, an explicit Runge Kutta scheme of order 3 is used by considering local time steps in accordance to the conditions of linear stability which are derived from the application of the Navier Stokes equations. In order to compute secondary and primary separation of vortices, the code is employed at transonic speeds. The results were correlated with experimental data and Reynolds number effects and Euler solutions were investigated. The experiment and computation were performed for angle of attack 10° and Reynolds number 2.38×10^6 . The results which were gained directed that the vortices induced due to the secondary and primary separation lie closer to the leading edge for greater Re numbers.

Nath, et al (2009) investigated the delta wing which vortices at the leading edge causing the huge non-linear moments and forces. There was bursting of vortices over the surface at high aoa and therefore an additional study is introduced in the aerodynamics. The understanding of aerodynamics of the aircraft on the wing with detached flows will allow project for enlarged manoeuvrability in next generation of

vehicles for aerospace. In order to obtain the complex field of flow both numerical and experimental surveys were carried out on a 65 degree delta wing. The α varied from 5degree to 40degree whereas the angle of side slip varied from 0degree to 20degree. The observations were done for the effects of α , angle of side slip, and variation of speed on surface pressure. Approximate location for the breakdown of the vortex was taken. Three dimensional numerical simulation using FLUENT were performed. Because of the asymmetry and side slip a strong pressure was captured on the surface flow.

Nettelbeck (2008) examined the issue of fluttering and wing rock on slender wings with high sweep at α ranging from moderate to high. The wind tunnel used for the experimental investigation is an open circuit, subsonic, low turbulence wind tunnel capable of generating free stream velocity up to 30 m/s. The square test section is 457 mm x 457 mm and height of 910 mm. This analysis required the manufacture and design of a new model incorporating 28 pressure taps over the top surface of the slender wing orientated along the chord of the wing. So as to report for vortex displacement with ascending angles of attack, the models were designed with a slight offset over either side of the wing. This arrangement provided a larger footprint over the plan form to make sure that surface pressure measurements could be taken at the presence of a dynamic flow field. Unsteady surface pressure values were collected as the model transitioned through predetermined angles of attack with when the wing exhibited wing rock motion. To augment the analysis of vortex behavior and to verify the pressure measurement results flow visualization using laser sheet imaging was conducted. The design of a special purpose pressure acquisition system showed that it is possible to capture characteristics of dynamic field of flow over the wing surface. The data obtained from it and the use of this system will help future research.

Polhamus (1996) designed the idea of calculating the vortex lift of a delta wing with sharp edge with result comparison with the experimental data. It is done with the relation between the lift because of generation of vortex and the suction at the leading edge because of the potential flow. This method provides excellent calculation of the total lift for a variety of delta wings structures for up to AOA of 20degree or higher,

when aligned along with theory of potential flow together with the non-linearities linked with the exact boundary condition and the lift component loss of the leading edge suction.

Schutte and Ludeke (2001) focused on the topology of the flowfield around the VFE-2 rounded-leading edged delta wing at various Re numbers and α . In order to approximate the correct flow physics of the round-leading edged delta wings consisting of a flow field topology which is highly complex by using by unstructured coding, this research was done. The code is on the basis of an approach of a hybrid grid which is unstructured therefore making use of the beneficial prismatic grids for the tenacity of shear layers which are viscous near the walls, and the grid generation flexibility which is offered by grids that are unstructured. Hybrid grid generator Centaur (Centaur Soft) generates the grids that are utilised for simulations.

Singh, et al (2009) performed Euler numerical computation for transonic flow simulation over a cropped delta wing with the aileron deflection by the means of mesh less solver which was specially developed. Monitoring of the results was done for the flow past the wing with 6degree aileron deflection, a 0.9 Mach number at free stream, at 1degree and 3degree α . The experimental data and available computed results are compared and also Euler computation of finite volume solvers (National Aeronautics Limited and Beijing University of Aeronautics and Astronautics, China). The computations of BUAA as well as JUMBO are also analogous to the present results up to the extent of main wing. Although on the deflected aileron portion, much higher pressure coefficients than experiments were predicted on BUAA computations. It does not also synchronize well with the experiments in this region. But the current computations synchronize better with both experiments and JUMBO calculations. Their computations do indicate that there are further advancements to capture the suction peak more accurately near the leading edge region. It was noted that the comparisons of the computational studies are only indicative of the relative performance.

Soemarwoto and Boelens (1996) examined ONERA 70° delta wing at subsonic flow and at an AOA of 27 degree. K- ω turbulence model along with the application of

Computational Fluid Dynamics methodology on the basis of unsteady Navier-Stokes (RANS) equations with Reynolds Averaged was adopted. A $k-\omega$ turbulence model variant was used to avoid enormous eddy viscosity. For diverse order of magnitude of two no dimensional time steps were performed by time accurate simulations. Both of the simulations foresee vortex bursting. Self-sustained oscillation occurred by the smaller time steps. Experimental data and results of computation were compared.

Sohn and Chang (2010) investigated the effect on the vortex flow with the existence of a center body of a Double Delta Wing which is uniquely shaped. Wing surface pressure measurements were performed simultaneously along with off surface flow visualization for the experimental investigation of the double delta wing body. Results of the visualization indicates the existence of a center body in the double delta wing model situated under the lower surfaces. Also, unconventional interaction coiling of the wing can be seen slightly along with downstream chord consisting of LEX vortices at those positions for the AOA of 24 degree. Quantitative analysis of measurements of pressure of the wing surface exposed the center body effects to be distinct for higher angles of side slip and AOA.

Sreenivasulu (2009) conducted the experiment and computational studies to obtain the complex flow field characteristics on $81^\circ / 45^\circ$ blunt leading edge DD wing. The experiments have been conducted at Subsonic Wind Tunnel facility. 'Tuft Flow Visualization' and 'Oil Flow Visualization' are Qualitative techniques and various Quantitative technique of Static pressure measurement have been used to study the effect of aoa, effect of velocity variation and aoa effect on strake and location of wing vortex break down. A comparison of results obtained from the present double delta wing with a single delta wing having same thickness to chord ratio also made.

Verhaagen (2010) focused his study on the 50degree swept delta wing models and contribution of the radius at the leading edge for the flow over it. There were 3 models which were taken into account and tested; the first model consisting of a sharp leading edge and the other two models comprising of a leading edge which is semi-circular but of differing radius. Stereo Particle Image Velocimetry (SPIV) technique and oil-flow visualization were used to study the models and vortical flow on and off the surface.

The radius of the leading edge was seen to modify the vortices' locations and size as well as the location of vortex breakdown over the models. This resulted in the radius of the leading edge affecting the moments and forces acting on a 50 degree delta wing.

Verhaagen, et al (1995) performed research at a wind-tunnel with low speed 76 by 40 degree Double Delta Wing on the flow for AOA variations from -10degree to 25 degree and Re Number with 0.5 to 1.5M variations. The experiment was performed for the purpose of validating Computational Fluid Dynamics methods and understanding the behavior of the vortical flow. With the usage of a 5-hole probe (thin) flow field at a 10 degree angle of attack the surveys were conducted. The Basic Aerodynamics Research Tunnel (BART) is where the tests were conducted situated in the NASA Langley Research Center (LARC). Numerical Solutions of the compressible Navier Stokes equations in thin layer were conducted and compared with the experimental data.

Wang and Tu (2010) conducted flow visualization tests in water tunnel for cropped delta wings with low aspect ratio at low Reynolds number. The result from the experimentation displayed that the sweep angle Λ of the model alters the development and formation of the vortex at the leading edge. Considering wings with $\Lambda = 0^\circ$, transverse vortex flow structure is dominant. Considering $\Lambda \geq 26^\circ$, observation was made of a dual vortex structure which was confirmed to be of distinct flow structure over wings with low aspect ratio at low Reynolds number. For wings with $\Lambda \geq 56^\circ$, for large range of angle of attacks, it was observed that the dual vortex structures were present.

Yuvaprakash (2013) conducted experiments and computations on a sharp edge of 81/45 degrees on a DD wing at subsonic low speed. Experimentation with qualitative and quantitative techniques involved the Oil Flow Visualizations and the Static pressure and measurements of Force, which have been experimented to observe the effect of attack on the given model. A comparative study of the results obtained from the given double delta wing with rounded edges have been analyzed which reveals

that the sharp edge double delta wings generate less force than the rounded edge models of equivalent flow and geometric properties.

CHAPTER 3

AIM AND SCOPE

3.1 AIM

The purpose of this project is to develop the conceptual design synthesis as well as statistically survey the design space of the blended wing body commercial passenger aircraft. The purpose of this project is to develop data for the estimation of several variables inside an aircraft design synthesis. The purpose of this project is to analyze and survey the blended wing body commercial passenger aircraft. The purpose of this project is to inspect the design space of the blended wing body aircraft configuration. Study the aerodynamic forces of baseline blended airplane. Find the opportunity to reduce the overall weight/wing area without affecting aerodynamic performance. Increase the Lift to Drag ratio on modified design.

3.2 SCOPE

The benefit of this aircraft mainly arises because of distributed structural and aerodynamic load, which lead to better aerodynamic performance and provide lighter structural weight as well. It is exacting to design blended wing body with high lift devices especially trailing edge devices because of its inability to prevent the noteworthy pitching moments. The purpose of this project is to inspect the design space of the blended wing body aircraft configuration. Study the aerodynamic forces of baseline blended airplane. Find the opportunity to reduce the overall weight/wing area without affecting aerodynamic performance. Increase the Lift to Drag ratio on modified design. The purpose of this project is to develop the conceptual design synthesis as well as statistically survey the design space of the blended wing body commercial passenger aircraft. The purpose of this project is to develop data for the estimation of several variables inside an aircraft design synthesis. In concise, the blended wing body aircraft type, has the ability to offer many benefits on account of its structural concepts. If we consider an example, the low interface drag, huge L/D ratio, structural span loading which is beneficial, and last but not the least its contribution in drop in emissions of greenhouse gas.

CHAPTER 4

RESEARCH METHODOLOGY

4.1 INTRODUCTION TO COMPUTATIONAL TECHNIQUE

Computational simulation in three dimensional flow field is a necessity in order to understand the aerodynamic bodies with their complex flow field in free flight and ground effect condition. This can be achieved by developing a code, another option would be using commercial softwares i.e., FLUENT, CFX etc. In this project, Ansys commercial software is used for computation and is available online from its website. This chapter describes briefly about the

1. Creation of Geometry
2. Pre-processing
3. Solution methodology
4. Solver setting
5. Post processing

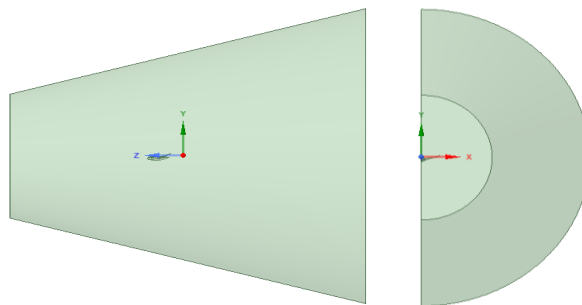


Fig: 4.1 Computational domain

4.2 COMPUTATIONAL FLUID DYNAMICS BACKGROUND

Navier-Stokes equations written in partial differential equations. Momentum, mass, and energy equations of fluid motion is converted into the integral form, which is then approached using Finite-Volume (FV) technique. In order to make numerical computation it is transformed into algebraic equations so can be applied within a specified physical or computational domain. Final computations are made using steady 3-D, viscous, compressible flow conditions with second order accurate.

4.3 CREATION OF GEOMETRY

The model is designed and the geometry is created in CATIA V5R19. CATIA (Computer Aided Three-dimensional Interactive Application) developed by the Dassault Systems is a multi-platform computer-aided design (CAD)/ computer-aided engineering (CAE) / computer-aided manufacturing (CAM) software suite. It makes use of C++ programming language in which it is written.

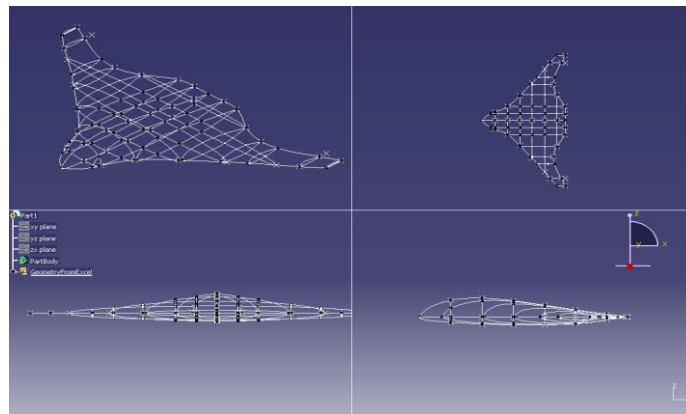


Fig: 4.2 Grid view of Basic BWB model

4.4 SOLUTION METHODOLOGY

FLUENT uses a control-volume-based technique in order to convert the governing equations to algebraic equations as conservation of mass, conservation of momentum and conservation of energy which can be numerically solved. The mentioned control volume technique consists of integrating around each control volume the given governing equations, which results in discrete equations preserving the quality on a basis of control volume. The two FLUENT solvers are coupled solver and segregated solver. FLUENT will solve the governing integral equations by using either of the methods. Other scalars which include chemical and turbulence species can also be solved. In both of the cases the technique used is based on a control volume. The governing equations of momentum, continuity, and energy along with species transport is simplified by the coupled solver simultaneously. Using the procedure explained for the segregated solver, for additional scalars the governing equations will be resolved sequentially. Numerous solution loop iterations have to be performed until a converged solution is gained since they are nonlinear governing equations. In each iteration fluid properties are updated on the basis of the existing solution. The discrete

governing equations which are nonlinear are linearized to yield a system of equations in every computational cell for the variables which are dependent in both the methods namely segregated as well as in the coupled solution. To produce a field of flow solution which is updated, the solving of the resultant linear system is done. With the usage of the previously updated values of the other various variables, then the scalar equations (radiation and turbulence) are solved. Until the convergence criteria are met these iterations are continued. Residual plots from where we can determine convergence of continuity and X momentum in O-O Domain. An 'Explicit' or 'Implicit' form is taken by the linearized governing equations with respect to the set of variables of interest or the dependent variable.

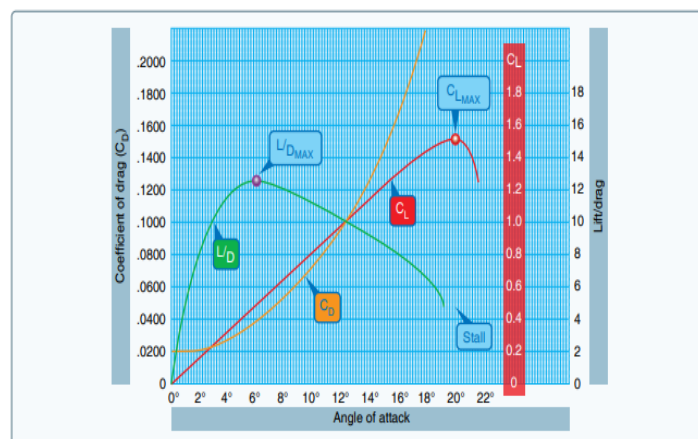


Fig: 4.3 $C_d-\alpha$

4.4.1 GOVERNING EQUATIONS

In straight and level, steady flight, the forces that can be seen acting are given below-

- Thrust: It is an aerodynamic force which is produced by jet engines or propellers in order to move the aircraft forward.
- Drag: It is an aerodynamic force which acts in the direction of the relative wind. It offers resistance to the forward motion. It can also be defined as the aerodynamic force which acts in the direction opposite to the motion or flight path.
- Lift: It is an aerodynamic force which acts perpendicular to the relative wind or it can be said as perpendicular to the flight path direction. It can be either static lift or dynamic lift.

- **Weight:** It is the force which acts opposite to lift vertically downwards and is a result of gravity.

Lift to Drag ratio: It is the ratio of lift and drag and is also known as aerodynamic efficiency.

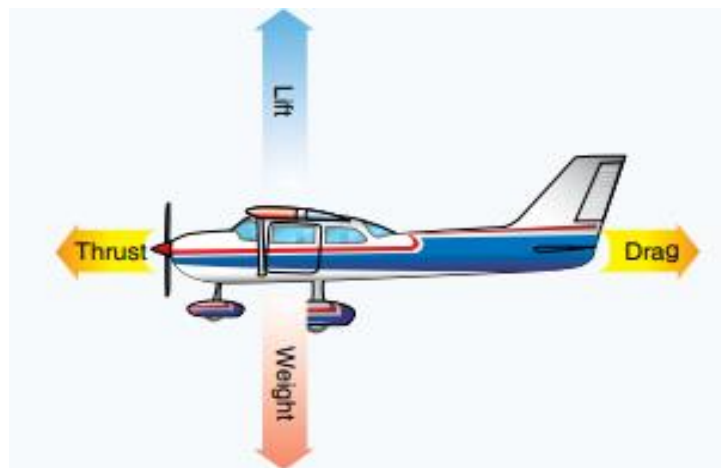


Fig: 4.4 Aerodynamic Forces

4.4.2 TURBULENCE MODELLING

The turbulence modelling used in the project in Ansys is given below-

4.4.2.1 SST k-Omega Model

SST k-Omega Model is an eddy-viscosity two equation model and an extension of Menter's *k- ω model*. It is used for a number of aerodynamic applications. It is a combination k-epsilon models and the Wilcox k-omega which makes it a hybrid model.

4.5 BOUNDARY CONDITIONS & SOLVER SETTINGS

Assumptions made -

- CAD Model is designed based on available scaled model from open resources.
- Engines and its supporting components are not considered.
- Cruise condition is considered to study the aerodynamic forces.
- The Aerodynamic results and design modification is based on relative comparison between the designs.

- Model is symmetric about vertical mid-plane.

Table 4.1 Boundary Conditions

Parameter	Cruise Condition
Mach No	0.64
Ambient Pressure	42.110 kPa
Ambient Temperature	-30 C
Angle of Attack	0 deg

Solver Settings -

- Steady flow
- Compressible flow
- Ideal Gas law
- Turbulent flow with SST K-Omega model
- Symmetry about vertical plane
- Cruise altitude is considered as 30000ft.
- Solver: ANSYS CFX V19.0

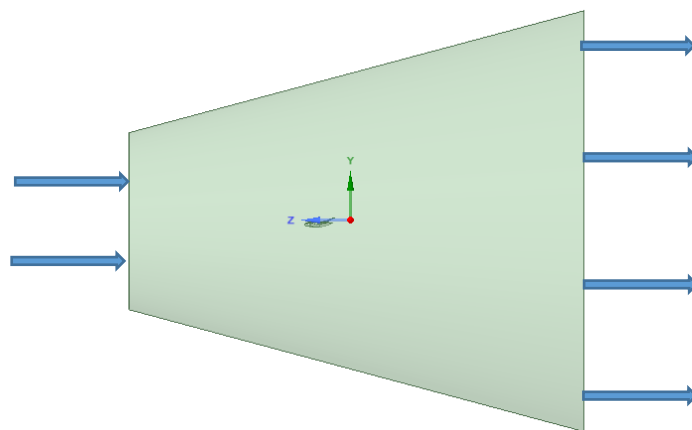


Fig: 4.5 Boundary Conditions

Computational Domain –

- Computation domain is considered as more than 8 times the characteristics length.
- Tetra mesh with ~3millions cells.
- 15 inflation layers are considered to maintain Y^+ less than 30.

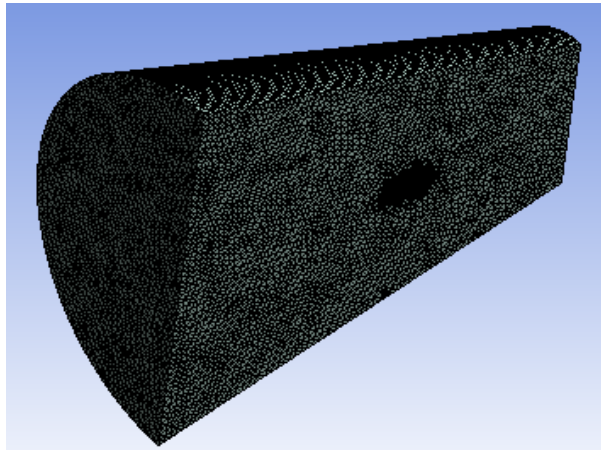


Fig: 4.6 Computational Domain Mesh

Computational domain is the portion of space where the solution of the CFD simulation is calculated. The computational domain needs to be discretised into a computational grid (or mesh) to solve the discretised equations of fluid flows.

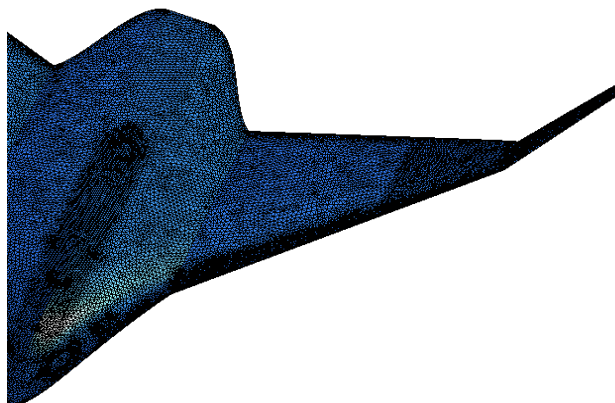


Fig: 4.7 Basic BWB model

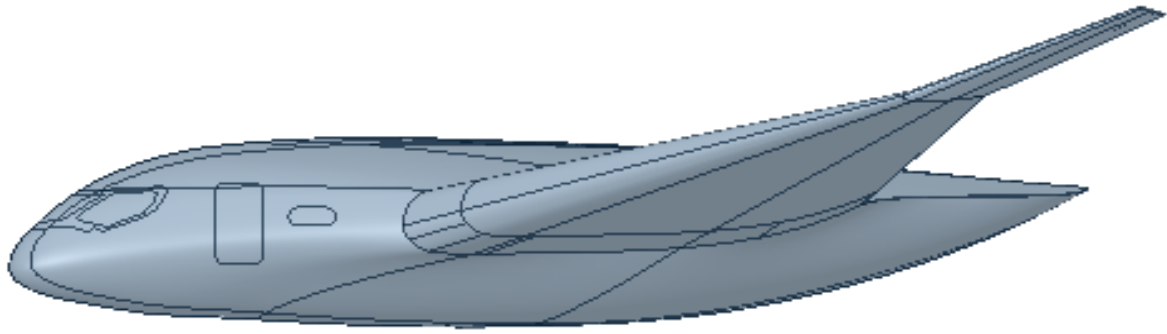


Fig: 4.8 Basic BWB Model Side View

The views are positioned relative to each other. In each, the appearances of views may be thought of as being projected onto planes. Usually three views of a drawing give enough information to make a 3D object. These views are known as front view, top view, and end view.

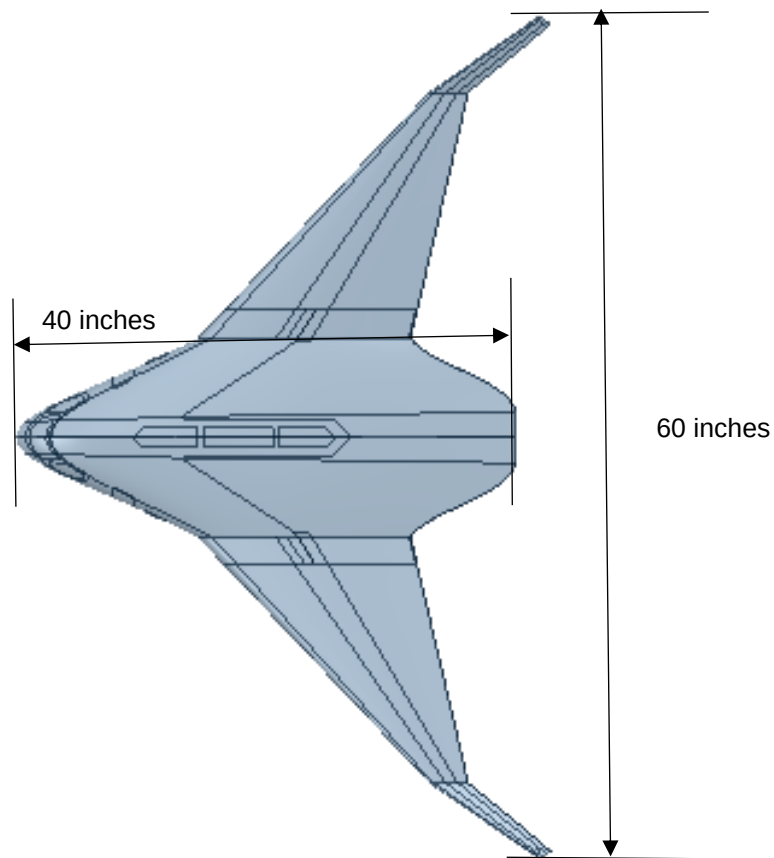


Fig: 4.9 Base BWB Model with measurements

With the reduction of 25% in the wing surface area and introducing the wing fences resulted in a slight improvement in lift to drag ratio. With the reduced wing surface area the aerodynamic efficiency decreased.

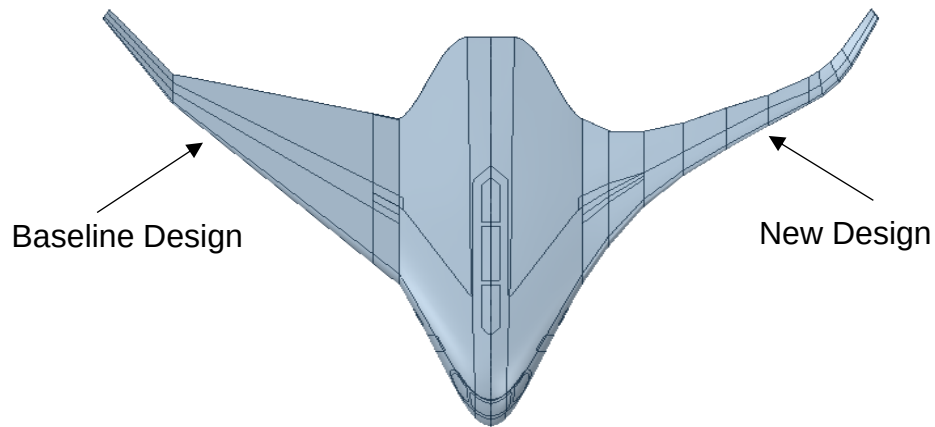


Fig: 4.10 Proposed Design

Table 4.2 Wing Design Difference

Design	Baseline	Proposed Design	% Diff
Surface Area (in ²)	442	331	-25.11

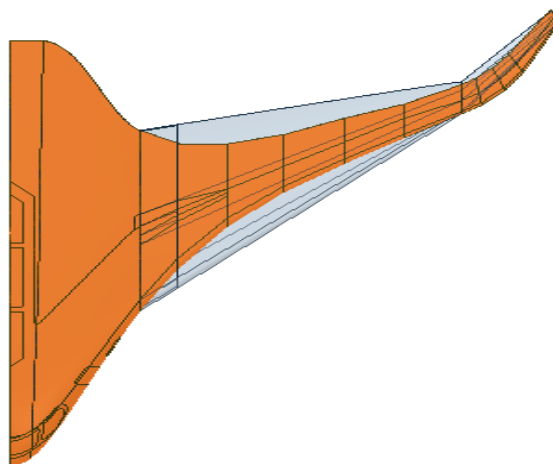


Fig: 4.11 Proposed Design Overlapping Basic Design

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 COMPUTATIONAL RESULTS

The benefit of this aircraft mainly arises because of distributed structural and aerodynamic load which lead to better aerodynamic performance and provide lighter structural weight as well. When compared to with the conventional wing and fuselage design, Blended Wing Body design has been proved to have significant enhancements in terms of aerodynamic efficiency. It is exacting to design Blended Wing Body with high lift devices specially trailing edge devices because of its inability to prevent the note-worthy pitching moments. Measurement of force was carried out to observe the effect of decreased wing surface area and the introduction of wing fences. 3-D numerical analysis were performed using the commercial software Ansys.

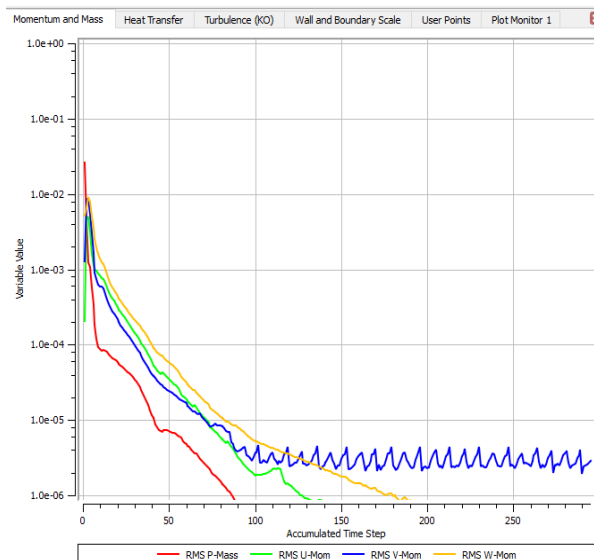


Fig: 5.1 Convergence Check (Momentum and mass)

Reasonably good results were obtained from computations. With the reduction of 25% in the wing surface area and introducing the wing fences resulted in a slight improvement in lift to drag ratio. With the reduced wing surface area the aerodynamic efficiency decreased. But with the application of wing fences, the aerodynamic efficiency was seen to be increased as compared to the base model. A finite difference scheme is convergent if the solution of the finite difference equation approaches that

of the partial differential equations as the grid size approaches zero. The solution of the finite difference equation provides the values of the dependent variable at each grid point. The objective here is to study the various schemes to approximate the partial differential equations by finite difference equations.

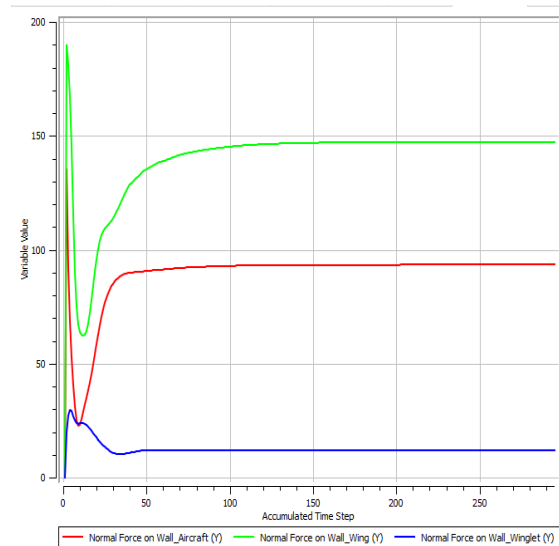


Fig: 5.2 Convergence Check (Normal Forces)

5.2 BASELINE MODEL RESULT

5.2.1 Pressure Contours

- A line connecting points of equal height of a given barometric pressure; the intersection of a constant pressure surface by a plane parallel to mean sea level.
- Negative or suction pressure are observed on upper surface.

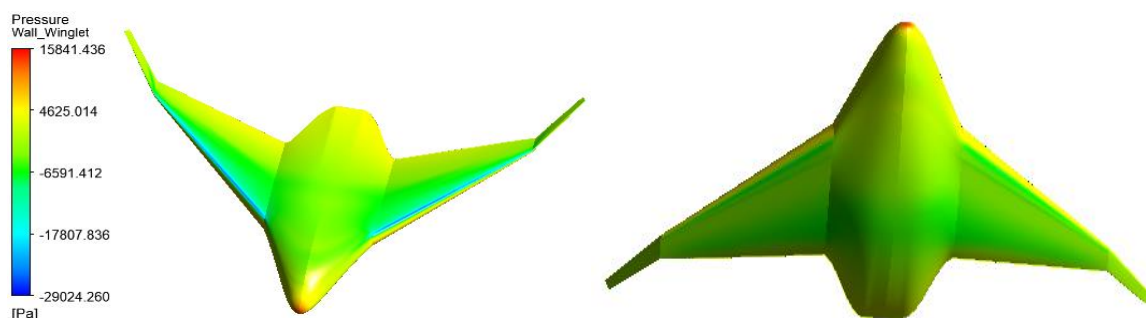


Fig: 5.3 Pressure distribution on aircraft surface

5.2.2 Velocity Contours

- A method of measuring stream discharge in which point velocity measurements are translated into average cross-sectional flow velocities by contouring the point velocities.
- These averages are then multiplied by the areas of the cross sections to give the discharge.
- Max velocity is observed at upper surface due acceleration.

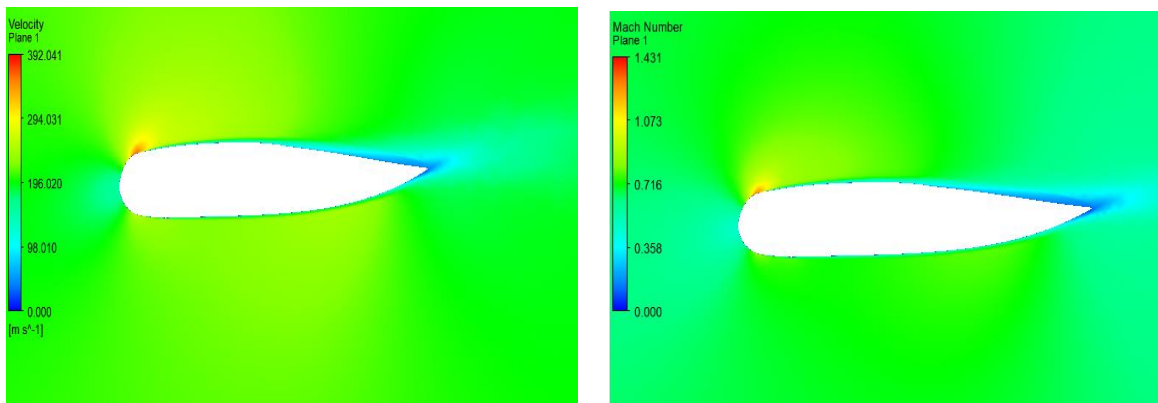


Fig: 5.4 Velocity Distribution over the wing section

5.2.3 Streamline Plot

- A streamline is a line which lies in the direction of flow at every point at a given instant.
- The flow is attached at fuselage and wing surface.
- Cross flow due to high sweep is observed over the wing trailing edge.

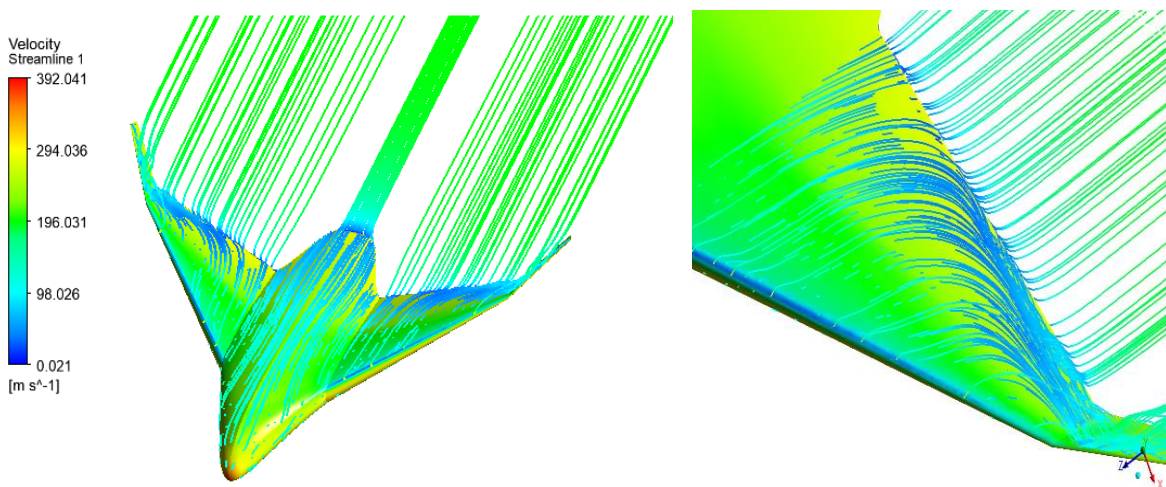


Fig: 5.5 Velocity Streamlines over the aircraft

5.2.4 Aerodynamic Forces

The table consists of the drag, lift and the aerodynamic efficiency of the baseline model over fuselage, wing, winglet as well as the whole aircraft.

Table 5.1 Aerodynamic Forces on Baseline design

Baseline Design			
Components	Drag (N)	Lift (N)	Lift/Drag
Fuselage	34.114	96.694	2.83
Wing	2.475	148.36	59.94
Winglet	3.03	12.414	4.10
Total	39.619	257.468	6.50

5.3 PROPOSED MODEL 1 (25% REDUCED WING AREA)

- Possible wing size reduction with increase in L/D ratio are the primary objective for this study.
- Reduction of 25% in wing surface as compared to the baseline model.

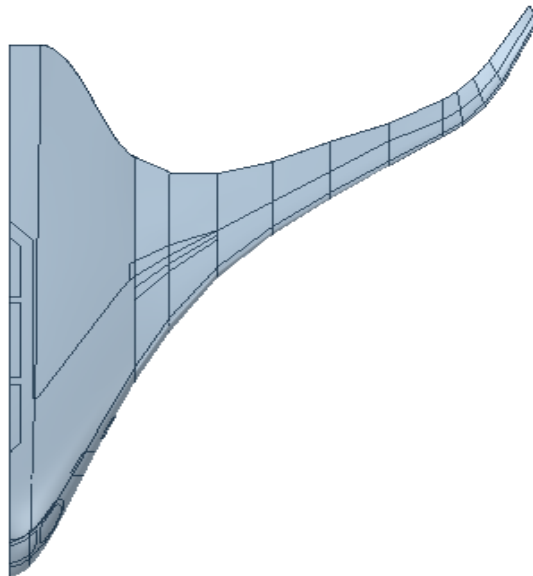


Fig: 5.6 Proposed Design with reduced wing surface

5.3.1 Pressure Contours

- A line connecting points of equal height of a given barometric pressure; the intersection of a constant pressure surface by a plane parallel to mean sea level.
- Negative or suction pressure are observed on upper surface.

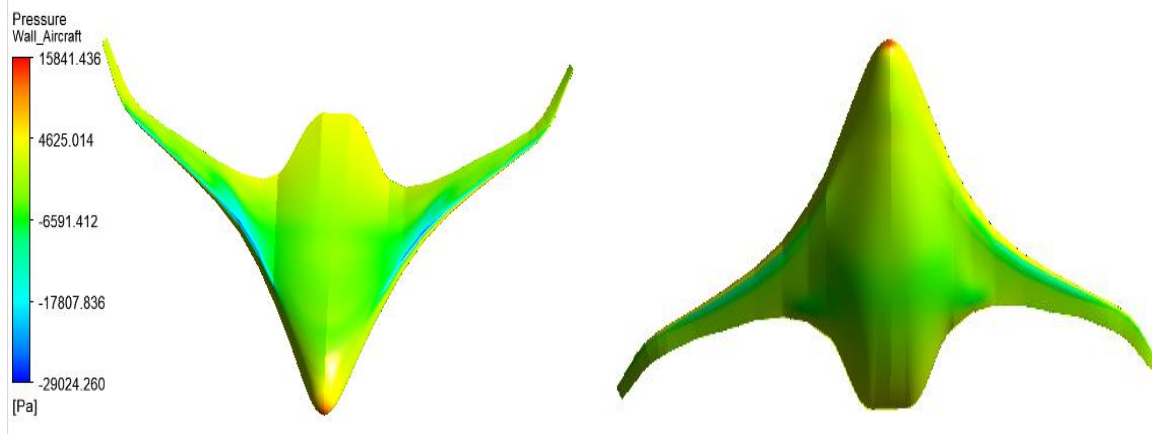


Fig: 5.7 Pressure distribution on aircraft surface (Model with reduced wing surface)

5.3.2 Velocity Contours

- Max velocity is observed at upper surface due acceleration.
- The airfoil shape is altered due to modified sweep and hence flow normality.
- Flow separation is observed on upper surface.

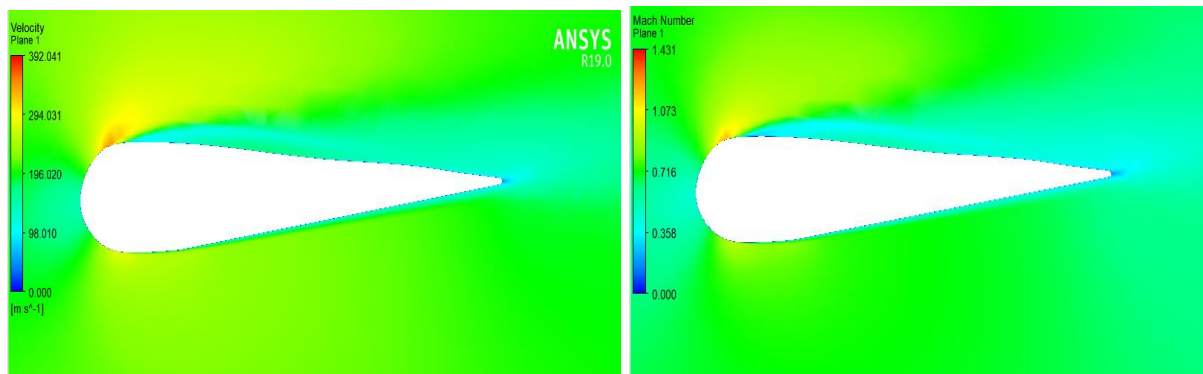


Fig: 5.8 Velocity Distribution over the wing section (Model with reduced wing surface)

5.3.3 Streamline Plot

- A streamline is a line which lies in the direction of flow at every point at a given instant.
- The flow is attached at fuselage and separated over the wing surface due to the cross flow.
- High variable sweep near the root causes the flow separation.

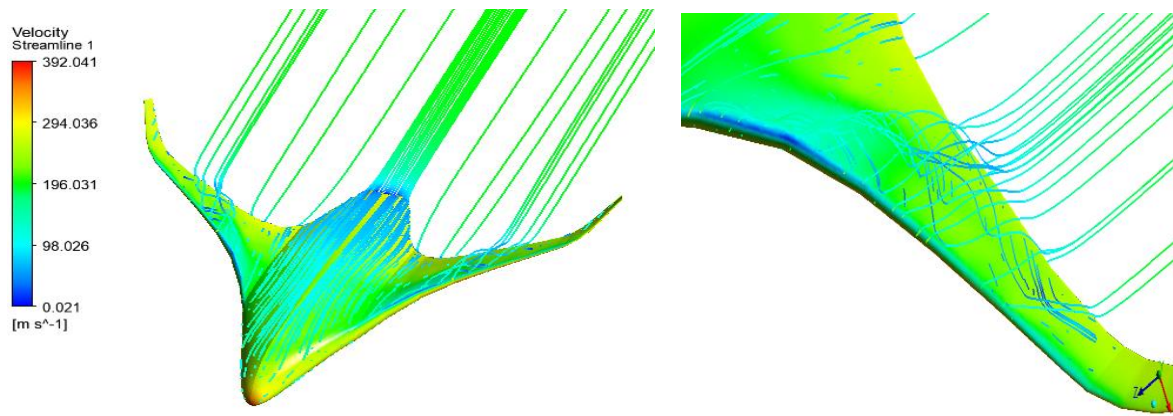


Fig: 5.9 Velocity Streamlines over the aircraft (Model with reduced wing surface)

5.3.4 Aerodynamic Forces

The table consists of the drag, lift and the aerodynamic efficiency of the baseline model over fuselage, wing, winglet as well as the whole aircraft.

Table 5.2 Aerodynamic Forces on Proposed Design (Model with reduced wing surface)

Proposed Design Model 1			
Components	Drag (N)	Lift (N)	Lift/Drag
Fuselage	25.065	92.4	3.69
Wing	17.224	140.33	8.15
Winglet	2.93	5.53	1.89
Total	45.219	238.26	5.27

5.4 PROPOSED MODEL WITH FENCES

- Reduction of 25% in the wing surface area and introducing the wing fences.

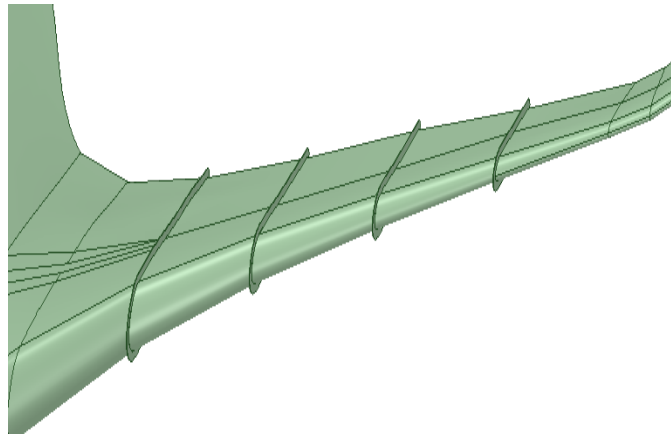


Fig: 5.10 Proposed Model with Fences

5.4.1 Pressure Contours

- A line connecting points of equal height of a given barometric pressure; the intersection of a constant pressure surface by a plane parallel to mean sea level.
- Negative or suction pressure are observed on upper surface.

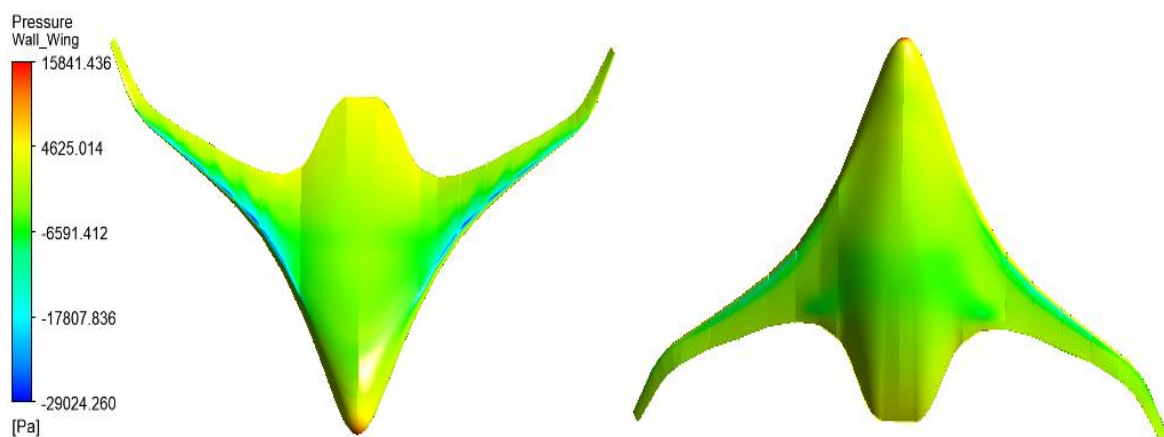


Fig: 5.11 Pressure distribution on aircraft surface (With Fences)

5.4.2 Velocity Contours

- Max velocity is observed at upper surface due acceleration.
- The airfoil shape is altered due to modified sweep and hence flow normality.
- Flow separation is observed on upper surface.

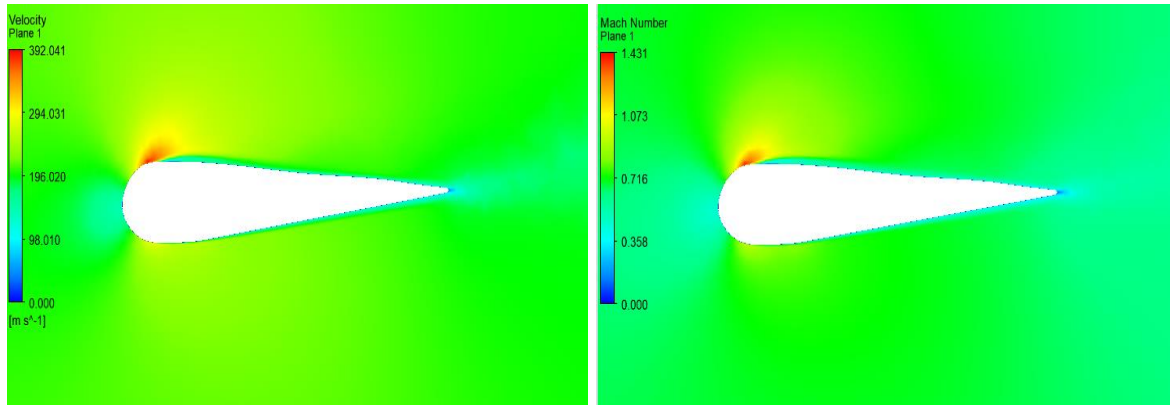


Fig: 5.12 Velocity Distribution over the wing section (With Fences)

5.4.3 Streamline Plot

- A streamline is a line which lies in the direction of flow at every point at a given instant.
- The flow is attached at fuselage and wing surface.
- Cross flow is arrested due to fences.

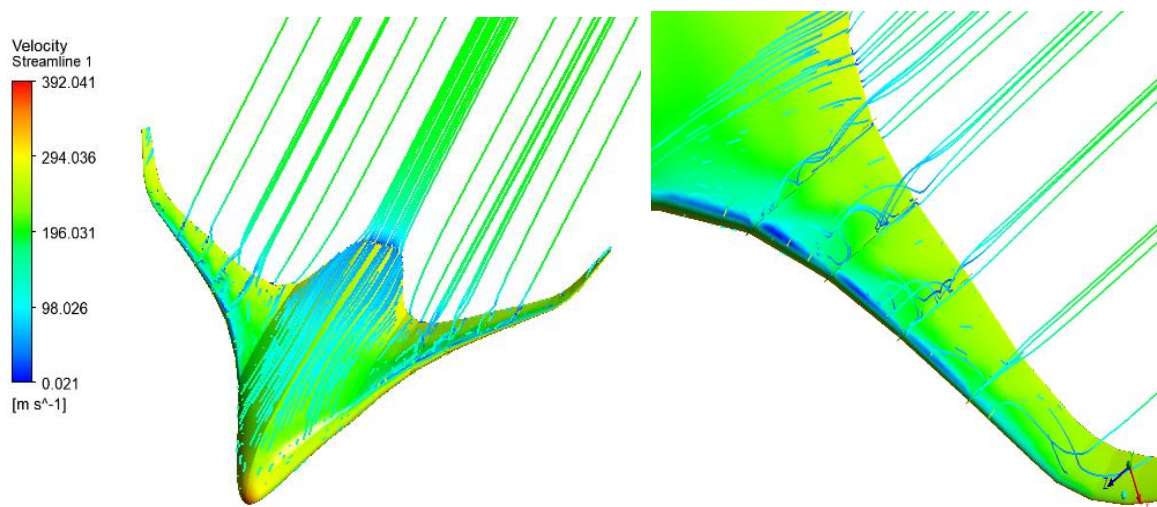


Fig: 5.13 Velocity Streamlines over the aircraft (With Fences)

5.4.4 Aerodynamic Forces

The table consists of the drag, lift and the aerodynamic efficiency of the baseline model over fuselage, wing, winglet as well as the whole aircraft.

Table 5.3 Aerodynamic Forces on Proposed Design with Fences

Proposed Design with Fences			
Components	Drag (N)	Lift (N)	Lift/Drag
Fuselage	25.18	93.07	3.70
Wing	9.07	178.028	19.63
Winglet	3.8	2.47	0.65
Total	38.05	273.568	7.19

5.5 RESULT COMPARISON

With the reduction of 25% in the wing surface area and introducing the wing fences resulted in the slight improvement in lift to drag ratio.

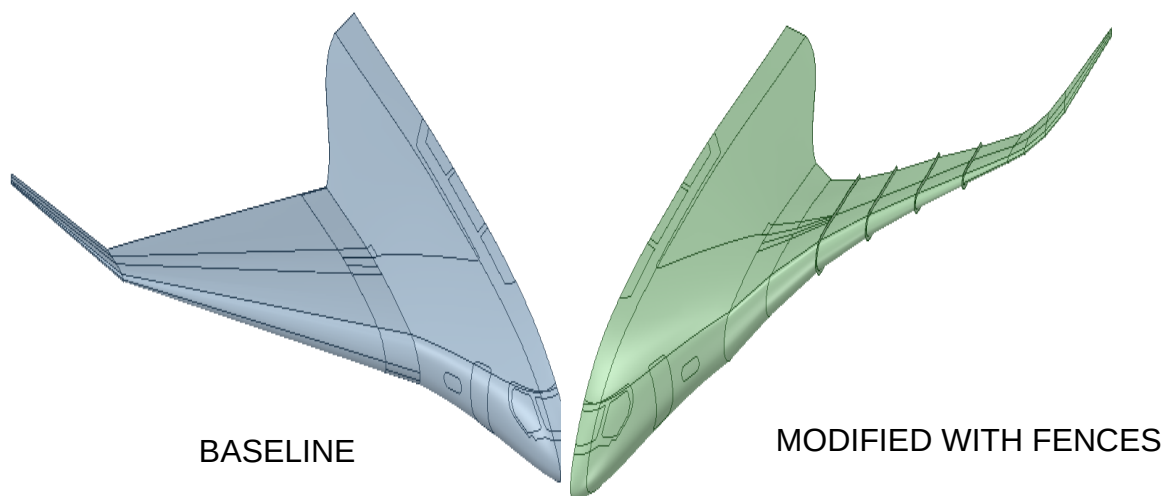


Fig: 5.14 Result Comparison

5.5.1 Pressure Contour

- A line connecting points of equal height of a given barometric pressure; the intersection of a constant pressure surface by a plane parallel to mean sea level.
- Negative or suction pressure are observed on upper surface.

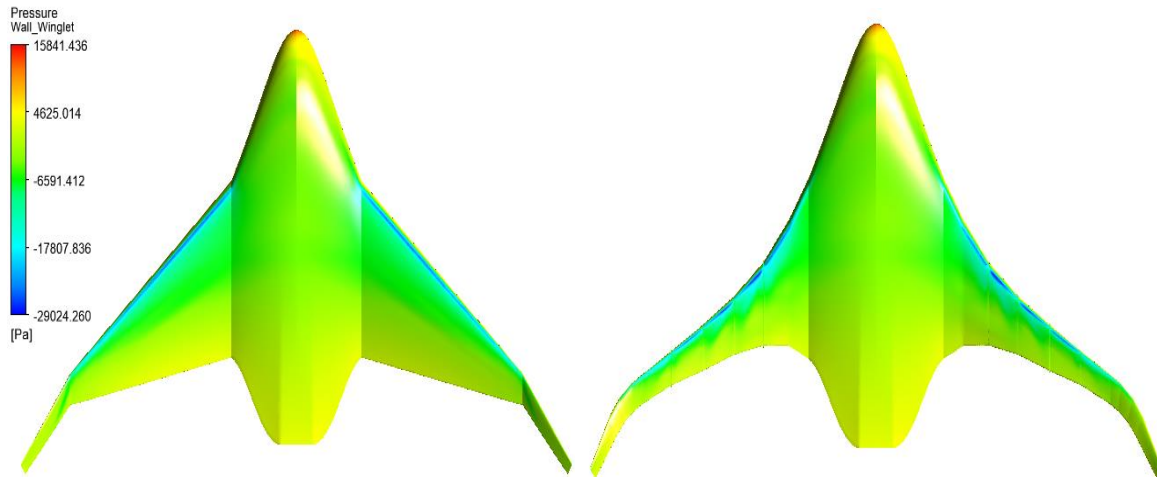


Fig: 5.15 Comparison of Pressure distribution on aircraft surface

5.5.2 Velocity Contours

- Max velocity is observed at upper surface due acceleration.
- The airfoil shape is altered due to modified sweep and hence flow normality.
- Flow separation is observed on upper surface.
- The airfoil shape is altered due to modified sweep and hence flow normality.

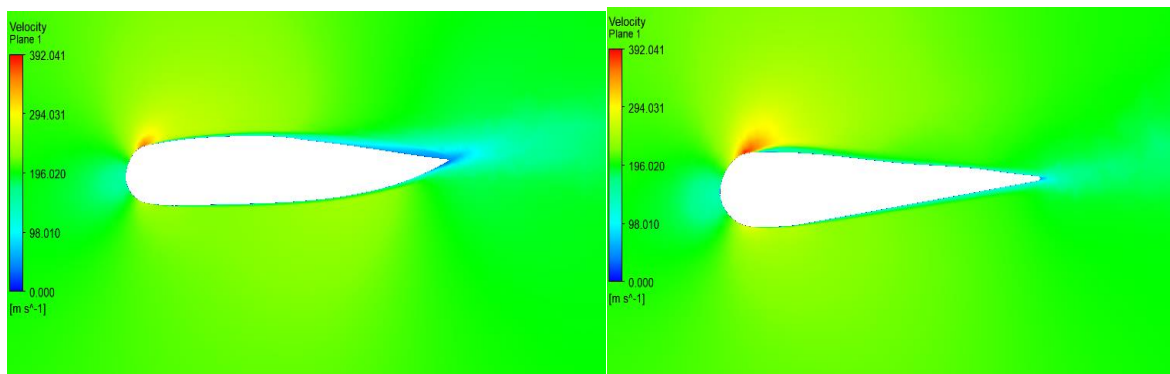


Fig: 5.16 Comparison of Velocity Distribution over the wing section

5.5.3 Streamline Plot

- The flow is attached at fuselage and separated over the wing surface due to the cross flow.
- The flow is attached at fuselage and wing surface.
- Cross flow is arrested due to fences.

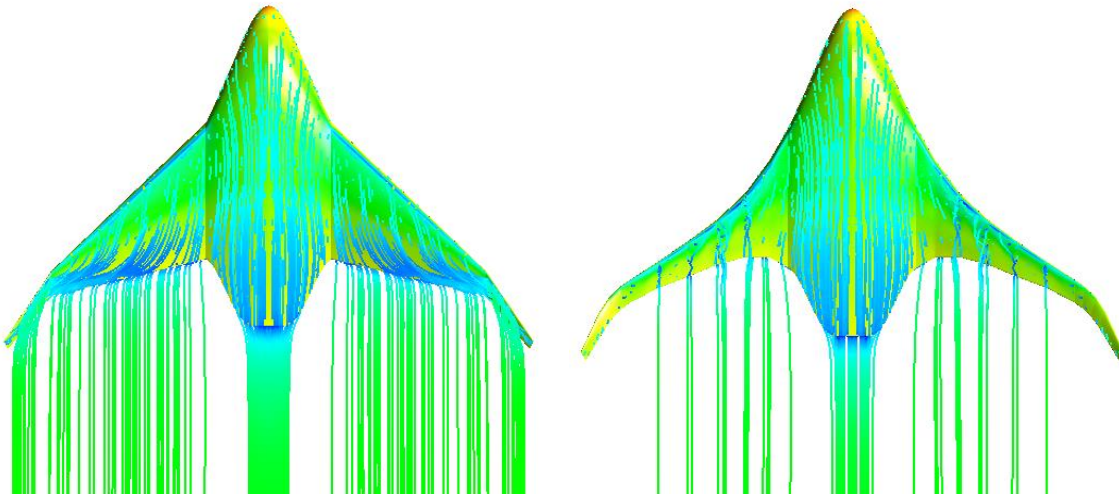


Fig: 5.17 Comparison of Velocity Streamlines over the aircraft

5.5.4 Aerodynamic Forces

- 25% reduction in wing area leads to 19% reduction in L/D ratio as compared to Baseline.
- Adding wing fences leads to 10% increase in L/D ratio as compared to Baseline.
- Cross flow is arrested due to fences. The aerodynamic efficiency of the Baseline Design is found to be 6.50 (L/D ratio).
- Overall, 25% reduction in Wing area resulted in the L/D ratio to be 5.27.
- With the introduction of fences there was 10% increment in L/D ratio which was 7.19 are observed with new modified design.

Table 5.4 Comparison tables among designs

25% Reduced Wing Area	Baseline Design			
	Components	Drag (N)	Lift (N)	Lift/Drag
	Fuselage	34.114	96.694	2.83
	Wing	2.475	148.36	59.94
	Winglet	3.03	12.414	4.10
	Total	39.619	257.468	6.50
With Wing Fences	Proposed Design Model 1 with reduced wing surface			
	Components	Drag (N)	Lift (N)	Lift/Drag
	Fuselage	25.065	92.4	3.69
	Wing	17.224	140.33	8.15
	Winglet	2.93	5.53	1.89
	Total	45.219	238.26	5.27
	Proposed Design with Fences			
	Components	Drag (N)	Lift (N)	Lift/Drag
	Fuselage	25.18	93.07	3.70
	Wing	9.07	178.028	19.63
	Winglet	3.8	2.47	0.65
	Total	38.05	273.568	7.19

CHAPTER 6

FABRICATION

6.1 SELECTION OF MATERIAL

Understanding the material selection process is the key to engineering any application and/or part design. Material selection is the foundation of all engineering applications and design. This selection process can be defined by application requirements, possible materials, physical principles, and selection. The design or function of the part/application is the application requirements. The application requirements are specific given the application. The possible materials are simply the only materials that can be used in the application. Possible Materials are defined by the application requirements.



Fig: 6.1 Material Selection

6.2 CASTING

Given the application requirements, possible materials, and physical principles we can select the best material. Thus in the selection of a material: First, we decide on the requirements of the application. Second, we decide on the possible materials we can use in the application. Third, we decide what changes in the material properties are needed. Lastly, we decide which material out of the possible materials best fulfills the requirements of the application given possible changes in the material properties.



Fig: 6.2 Wing and fuselage attachment (Top view)

To achieve a nice smooth finish, it's essential to sand to help prepare the area for painting application, by sanding you are removing imperfections (also known as pimples), creating a nice smooth finish while at the same time adding adhesion by developing small, rough ridges for the paint to stick to.



Fig: 6.3 Smooth body after Sanding

First take a container and pour some water and Fevicol then mix both water and fevicol with the help of spoon or brush. Take some tissue paper then tear it big and small pieces. Mix the fevicol and tissue bits properly. Now, apply the mould into the desired shape on the wings.



Fig: 6.4 Tissue mould fence (Left Wing)

After applying the mould, leave it for 3-4 hours. Now, take some warm water and brush the surfaces with it and gently dab the surfaces so that it becomes smooth.

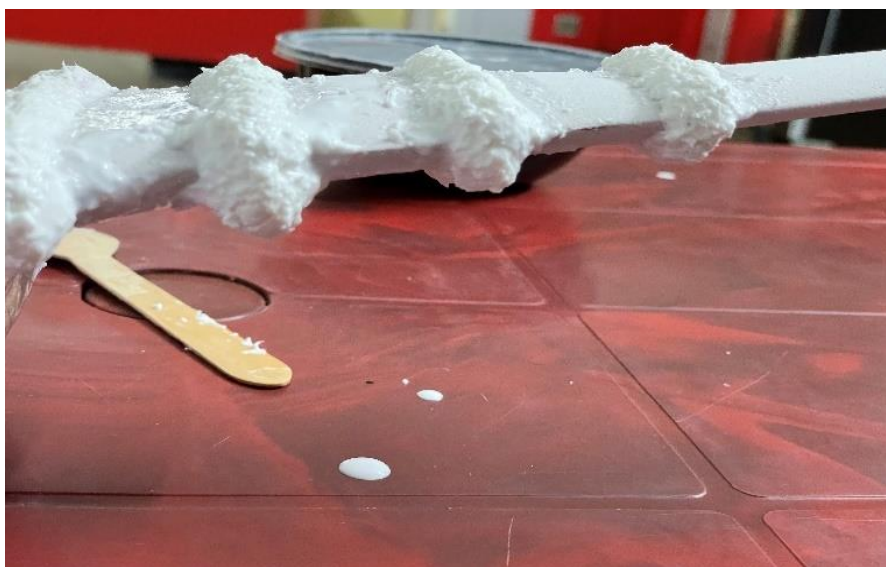


Fig: 6.5 Tissue mould fence (Right Wing)

Afterwards, leave the model to dry for 24 – 48 hours. To make the surface smoother repeat the above process 2 – 3 times. You can also use fine tissue rolls to make the surface smooth instead of paper napkins. Fevicol and water proportion should be 3:1.



Fig: 6.6 Tissue mould fence (Left Wing, bottom view)



Fig: 6.7 Tissue mould fence (Right Wing, bottom view)

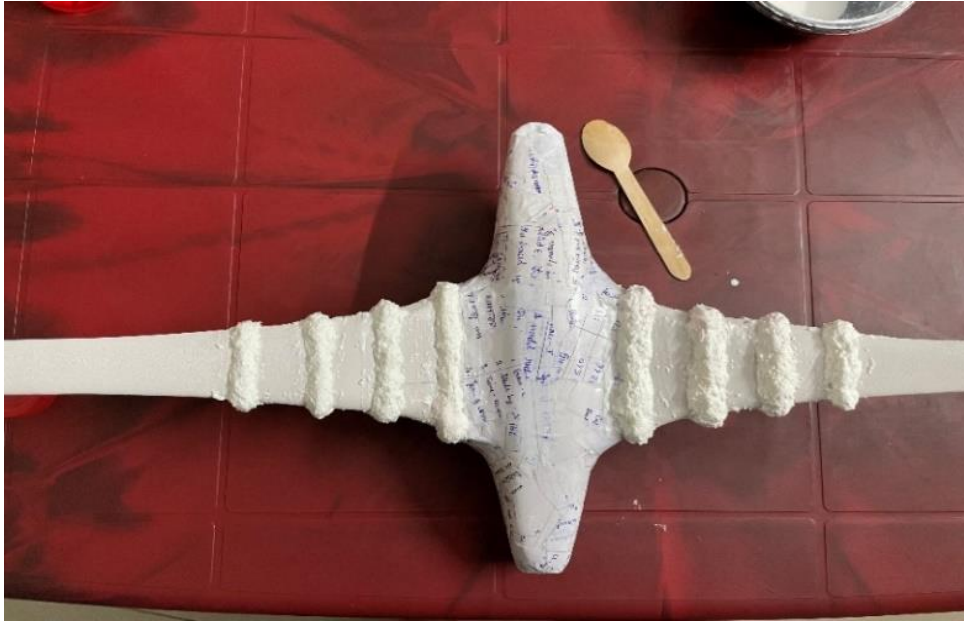


Fig: 6.8 Full body

6.3 PAINTING

Painting is a protective layer of base metal, which is also a cost-effective method to keep metal from rusting and corrosion. It can prolong the service life of the base metal. It also helps to smoothen the surface hence providing the necessary smooth surface.



Fig: 6.9 Final Model with fences (Side view)



Fig: 6.10 Final Model with fences (Fuselage)

Acrylic paints are water-based, and oil paint is made from drying oils with a medium of animal fat, linseed, or synthetic polymer. Acrylics can be thinned and brushed just like watercolors. Acrylics dry to a hard finish and tend to be easy for students to use.



Fig: 6.11 Final Model with fences (Top view)

CHAPTER 7

EXPERIMENTAL ANALYSIS

7.1 PROCEDURE

Wind tunnel is a facility for creating a uniform wind of known value in a test section where fluid flow phenomena can be investigated, models, of Aircrafts etc., can be tested from their performance, and also students training/teaching in fluid mechanics/aerodynamics. The facility can also be used for industrial aerodynamics testing and simulation studies on many of fluid problems. The line fetch of facility is given in the lab. The main part of the tunnel is Honey comb section, screens, contraction cone, test section, diffuser, safety screens, fan section, fan, motor and speed control drivers. Flow visualization is the study of methods to display dynamic behavior in liquids and gases. An advance in photography has also helped extend our understanding of how fluids flow under various circumstances. More recently, computational fluid dynamics (CFD) have extended the abilities of scientists to study flow by creating simulations of dynamic behavior of fluids under a wide range of conditions.



Fig: 7.1 Subsonic Wind Tunnel

The result of this analysis is usually a 2-D or a 3-D grid of velocity vectors, which may be uniformly or non-uniformly spaced. The goal is then to analyze this vector field to identify features such as turbulence, vortices, and other forms of structure.

7.2 EXPERIMENTAL SETUP

The subsonic wind tunnel consists of mainly honey comb, inlet mesh screen, diffuser, axial flow fan, and motor with speed control unit.

7.2.1 Inlet Duct

Inlet duct (effuser) is aerodynamically contoured section with contraction area ratio 9:1. The axial and lateral turbulence are reduced and smooth flow of air entering the test section is achieved by installing the honeycomb and screens for most efficiency and efficiencies of the air inlet. The ratio of length to wall size of the honey comb is maintained as per the recommended standards. The wire mesh is also fixed to smoothen the flow further. This is particularly, useful for obtaining laminar flow. The duct is secured to the test section by flange.



Fig: 7.2 Inlet Duct

The provision is also made for easy removal of diffuser and diffuser for possible separation from the test section, when required. It is also highly smothered and painted.

7.2.2 Test Section

The central portion in the tunnel is the test section sandwiched between the inlet duct and the diffuser using the flange. It has square 300mmx300mm cross sectional inside, and length 1000mm.



Fig: 7.3 Test Section

This test section has been designed to provide the space for setting up of experimentation and visualization, and ready access to the experiment's region. The test section is also printed with 4 Perspex windows two on each side. One wooden window is also provided for mode mounting. A hole, a plug is provided on the wooden window, the plug can be rotated and the rotation angle read out from an angular scale, around the plug. This plug can there be used to rotate the model in the pitch direction.



Fig: 7.4 Attachments

7.2.3 Diffuser

The downstream portion of the tunnel is diffuser. To the end of this is attached on axial flow fan. The diffuser starts with 300mmx300mm square section at the test section end and enlarges to 420mm diameter round at the fan drives end. It is flanged and bolted to the test section.

7.2.4 Axial Flow Unit

Axial flow unit consist AC Motor and variable speed AC drive. The 6 bladed propellers are connected to the motor through keyways. AC motor is connected to the variable drive which is used to vary the speed of the propellers from 100 rpm to 1500 rpm.

7.2.5 Propellers

The propeller should ideally be situated as far as possible from both ends of the working section, so as not to cause more turbulence than necessary. It is usually placed in a section whose area of cross section is some 1.5 to 2 times that of working or test section. The propeller must be of variable speed and sometimes the blades of variable pitch, to give good speed control in the tunnel.



Fig: 7.5 Propeller

7.2.6 Bell Mouthed Entry

A bell mouthed entry with honeycomb network and screens with smooth settling length provided before the test section. Air flow is generated by a suitably designed axial flow fan, by a D.C motor of 5H.P, 2800 RPM and a thyristor drive for speed control. The approx. Volume flow rate 10,000 cm³/h with static pressure of 50 mm of W.C, under free running condition. The sturdy angular stand is provided for vibration free running.

7.2.7 Smoke Generator

This unit is meant for creating the streamlined dense white smoke in the direction of air flow and across the model. All accessories are provided for completion of this unit. A smoke rake can be inserted in the contraction CMC for visualizing flow pattern on the blocks. For flow visualization it is advised to keep one side block to see the smoke with contrast of the black background. The user of the tunnel may keep a black paper or a black painted plywood sheet of appropriate size which fits exactly the side wall. The block color must let be shining. This would enhance line flow visualization which would enable to take good pictures.



Fig: 7.6 Smoke Generator Apparatus

7.2.8 Multi Tube Manometers

This Manometer is used for studying the pressure distribution across the various models. A Prandtl pitot tube is provided to measure the velocity of air flow.

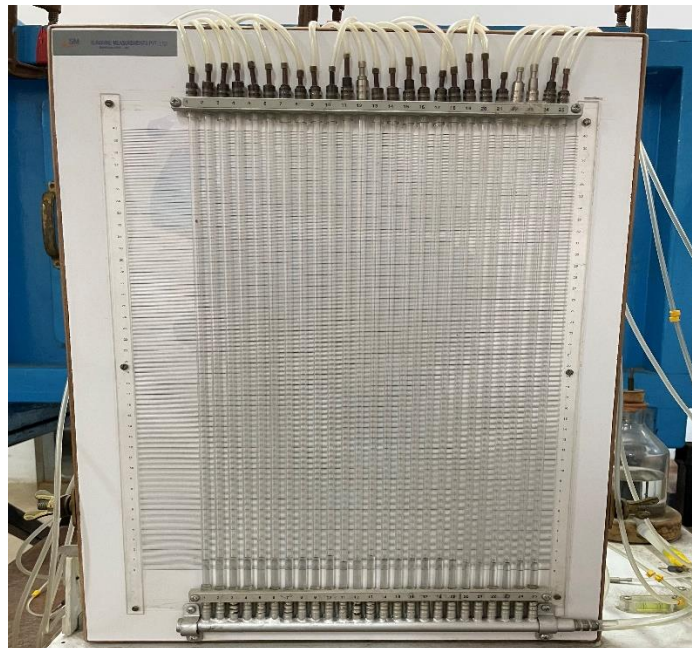


Fig: 7.7 Multi Tube Manometer

CHAPTER 8

CONCLUSION

From the above done investigations numerous evidence can be seen as a result that can be concluded and summarized as follows. Measurement of force was carried out to observe the effect of decreased wing surface area and the introduction of wing fences. 3-D numerical analysis were performed using the commercial software Ansys. Reasonably good results were obtained from computations. With the reduction of 25% in the wing surface area and introducing the wing fences resulted in a slight improvement in lift to drag ratio. With the reduced wing surface area the aerodynamic efficiency decreased. But with the application of wing fences, the aerodynamic efficiency was seen to be increased as compared to the base model. Numerical analysis is performed on Blended wing aircraft to study the aerodynamic performance. Possible wing size reduction with increase in L/D ratio are the primary objective for this study. Minimal design change with maximum benefits is obtained. The aerodynamic efficiency of the Baseline Design is found to be 6.50 (L/D ratio). Overall, 25% reduction in Wing area resulted in the L/D ratio to be 5.27. With the introduction of fences there was 10% increment in L/D ratio which was 7.19 are observed with new modified design. This performance can be further improved with more detailed wing design modification. Modification with a greater number of fences with detailed wing design can improve the performance further. With the reduction in the wing surface area and introducing the wing fences resulted in a slight improvement in lift to drag ratio. With the reduced wing surface area the aerodynamic efficiency decreased. But with the application of wing fences, the aerodynamic efficiency was seen to be increased as compared to the base model.

CHAPTER 9

FUTURE SCOPE OF WORK

The necessity to design a budget and a conservative aircraft which produce high L/D ratio and, is aerodynamic efficient have directed the designers to develop the Blended Wing Body (BWB) aircraft concept. The benefit of this aircraft mainly arises because of distributed structural and aerodynamic load, which lead to better aerodynamic performance and provide lighter structural weight as well. When compared to with the conventional wing and fuselage design, Blended Wing Body design has been proved to have significant enhancements in terms of aerodynamic efficiency. It is exacting to design blended wing body with high lift devices especially trailing edge devices because of its inability to prevent the note-worthy pitching moments. The purpose of this project is to inspect the design space of the blended wing body aircraft configuration. Study the aerodynamic forces of baseline blended airplane. Find the opportunity to reduce the overall weight/wing area without affecting aerodynamic performance. Increase the Lift to Drag ratio on modified design. The purpose of this project is to develop the conceptual design synthesis as well as statistically survey the design space of the blended wing body commercial passenger aircraft. The purpose of this project is to develop data for the estimation of several variables inside an aircraft design synthesis. The purpose of this project is to analyze and survey the blended wing body commercial passenger aircraft. Owing to its huge wing area plus greater L/D ratio, it was seen that high lift devices could be effectively used in BWB aircraft, with reference to longitudinal stability, such that it meets the take-off and landing needs for a field length comparable to that of conventional aircrafts. In concise, the blended wing body aircraft type, has the ability to offer many benefits on account of its structural concepts. If we consider an example, the low interface drag, huge L/D ratio, structural span loading which is beneficial, and last but not the least its contribution in drop in emissions of greenhouse gas.

REFERENCE

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