IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Impact Factor: 6.252

Volume 2, Issue 3, May 2022

Forward Swept Wing RC Aircraft

Bemil A. P[1], Farthima N[2], Nivetha N[3], Madesh D[4], Mr. Madesh D[5]

Students, Department of Aerospace Engineering[1,2,3,4]

Assistant Professor, Department of Aerospace Engineering[5]

Dhanalakshmi Srinivasan Engineering College (Autonomous), Perambalur, India

Abstract: *Till today there are many aircraft that are flying over the world. There are many configuration of plane such as wing configuration, tail configuration, fuselage configuration etc. So we have planed to design arc plane using forward swept wing configuration. This configuration has a high maneuverability at high speeds and drag production is low compared to backward swept wing aircraft. The characteristic sweep angle is usually estimated by drawing a path from root to tip, twenty five percentage of way back from the leading edge ,and matching that to the perpendicular to the longitudinal axis of the aircraft. Wing sweep has the effect of delaying the shock waves and accompanying aerodynamic drag caused by fluid compressibility. So this is our project idea, which will help full in the pilot for controlling and use of forward swept wing aircraft.*

Keywords: RC Aircraft

I. Introduction

1.1 Aircraft

An aircraft is a vehicle or machine that is able to fly by gaining support from the air. It counters the force of gravity by using either static lift or by using the dynamic lift of an airfoil, or in a few cases the downward thrust from jet engines. Common examples of aircraft include airplanes, helicopters, airships (including blimps), gliders, paramotors, and hot air balloons. The human activity that surrounds aircraft is called aviation. The science of aviation, including designing and building aircraft, is called aeronautics. Crewed aircraft are flown by an onboard pilot, but unmanned aerial vehicles may be remotely controlled or self-controlled by onboard computers. Aircraft may be classified by different criteria, such as lift type, aircraft propulsion, usage and others.

1.1.1 History

Flying model craft and stories of manned flight go back many centuries; however, the first manned ascent — and safe descent — in modern times took place by larger hot-air balloons developed in the 18th century. Each of the two World Wars led to great technical advances. Consequently, the history of aircraft can be divided into five eras:

- Pioneers of flight, from the earliest experiments to 1914.
- First World War, 1914 to 1918.
- Aviation between the World Wars, 1918 to 1939.
- Second World War, 1939 to 1945.
- Postwar era, also called the Jet Age, 1945 to the present day.

1.1.2 Methods of Lift

A. Lighter than Air – Aerostats

Figure 1.1: Hot air balloons

Aerostats use buoyancy to float in the air in much the same way that ships float on the water. They are characterized by one or more large cells or canopies, filled with a relatively low-density gas such as helium, hydrogen, or hot air, which is less dense than the surrounding air. When the weight of this is added to the weight of the aircraft structure, it adds up to the same weight as the air that the craft displaces.

Small hot-air balloons, called sky lanterns, were first invented in ancient China prior to the 3rd century BC and used primarily in cultural celebrations, and were only the second type of aircraft to fly, the first being kites, which were first invented in ancient China over two thousand years ago. (See Han Dynasty)

Figure 1.2: Airship USS Akron over Manhattan in the 1930s

A balloon was originally any aerostat, while the term airship was used for large, powered aircraft designs — usually fixed-wing. In 1919, Frederick Handley Page was reported as referring to "ships of the air," with smaller passenger types as "Air yachts." In the 1930s, large intercontinental flying boats were also sometimes referred to as "ships of the air" or "flying-ships".— though none had yet been built. The advent of powered balloons, called dirigible balloons, and later of rigid hulls allowing a great increase in size, began to change the way these words were used. Huge powered aerostats, characterized by a rigid outer framework and separate aerodynamic skin surrounding the gas bags, were produced, the Zeppelins being the largest and most famous. There were still no fixed-wing aircraft or non-rigid balloons large enough to be called airships, so "airship" came to be synonymous with these aircraft. Then several accidents, such as the Hindenburg disaster in 1937, led to the demise of these airships. Nowadays a "balloon" is an unpowered aerostat and an "airship" is a powered one.

A powered, steerable aerostat is called a dirigible. Sometimes this term is applied only to non-rigid balloons, and sometimes dirigible balloon is regarded as the definition of an airship (which may then be rigid or non-rigid). Non-rigid dirigibles are characterized by a moderately aerodynamic gasbag with stabilizing fins at the back. These soon became known as blimps. During World War II, this shape was widely adopted for tethered balloons; in windy weather, this both reduces the strain on the tether and stabilizes the balloon. The nickname blimp was adopted along with the shape. In modern times, any small dirigible or airship is called a blimp, though a blimp may be unpowered as well as powered.

B. Heavier-Than-Air – Aerodynes

Heavier-than-air aircraft, such as airplanes, must find some way to push air or gas downwards so that a reaction occurs (by Newton's laws of motion) to push the aircraft upwards. This dynamic movement through the air is the origin of the term. There are two ways to produce dynamic upthrust — aerodynamic lift, and powered lift in the form of engine thrust.
Aerodynamic lift involving wings is the most common, with fixed-wing aircraft being kept in the air by the forward movement of wings, and rotorcraft by spinning wing-shaped rotors sometimes called rotary wings. A wing is a flat, horizontal surface, usually shaped in cross-section as an aerofoil. To fly, air must flow over the wing and generate lift. A flexible wing is a wing made of fabric or thin sheet material, often stretched over a rigid frame. A kite is tethered to the ground and relies on the speed of the wind over its wings, which may be flexible or rigid, fixed, or rotary.

With powered lift, the aircraft directs its engine thrust vertically downward. V/STOL aircraft, such as the Harrier Jump Jet and Lockheed Martin F-35B take off and land vertically using powered lift and transfer to aerodynamic lift in steady flight. A pure rocket is not usually regarded as an aerodyne because it does not depend on the air for its lift (and can even fly into space); however, many aerodynamic lift vehicles have been powered or assisted by rocket motors. Rocket-powered missiles that obtain aerodynamic lift at very high speed due to airflow over their bodies are a marginal case.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 3, May 2022

C. Fixed-Wing

Figure 1.3 An Airbus A380, the world's largest passenger airliner

The forerunner of the fixed-wing aircraft is the kite. Whereas a fixed-wing aircraft relies on its forward speed to create airflow over the wings, a kite is tethered to the ground and relies on the wind blowing over its wings to provide lift. Kites were the first kind of aircraft to fly and were invented in China around 500 BC. Much aerodynamic research was done with kites before test aircraft, wind tunnels, and computer modelling programs became available.

The first heavier-than-air craft capable of controlled free-flight were gliders. A glider designed by George Cayley carried out the first true manned, controlled flight in 1853.

The practical, powered, fixed-wing aircraft (the airplane or aeroplane) was invented by Wilbur and Orville Wright. Besides the method of propulsion, fixed-wing aircraft are in general characterized by their wing configuration. The most important wing characteristics are:

- Number of wings — monoplane, biplane, etc.
- Wing support — Braced or cantilever, rigid, or flexible.
- Wing planform — including aspect ratio, angle of sweep, and any variations along the span (including the important class of delta wings).
- Location of the horizontal stabilizer, if any.
- Dihedral angle — positive, zero, or negative (anhedral).

A variable geometry aircraft can change its wing configuration during flight.

A flying wing has no fuselage, though it may have small blisters or pods. The opposite of this is a lifting body, which has no wings, though it may have small stabilizing and control surfaces.

Wing-in-ground-effect vehicles are generally not considered aircraft. They "fly" efficiently close to the surface of the ground or water, like conventional aircraft during takeoff. An example is the Russian ekranoplan nicknamed the "Caspian Sea Monster". Man-powered aircraft also rely on ground effect to remain airborne with minimal pilot power, but this is only because they are so underpowered—in fact, the airframe is capable of flying higher.

Figure 1.4 Aircraft parked on the ground in Afghanistan

D. Rotorcraft

Figure 1.5 An auto gyro

DOI: 10.48175/568

Rotorcraft, or rotary-wing aircraft, use a spinning rotor with aerofoil section blades (a rotary wing) to provide lift. Types include helicopters, autogyros, and various hybrids such as gyrodynes and compound rotorcraft. Helicopters have a rotor turned by an engine-driven shaft. The rotor pushes air downward to create lift. By tilting the rotor forward, the downward flow is tilted backward, producing thrust for forward flight. Some helicopters have more than one rotor and a few have rotors turned by gas jets at the tips.

Autogyros have unpowered rotors, with a separate power plant to provide thrust. The rotor is tilted backward. As the autogyro moves forward, air blows upward across the rotor, making it spin. This spinning increases the speed of airflow over the rotor, to provide lift. Rotor kites are unpowered autogyros, which are towed to give them forward speed or tethered to a static anchor in high-wind for kited flight.

Cyclogyros rotate their wings about a horizontal axis. Compound rotorcraft have wings that provide some or all of the lift in forward flight. They are nowadays classified as powered lift types and not as rotorcraft. Tiltrotor aircraft (such as the Bell Boeing V-22 Osprey), tiltwing, tail-sitter, and coleopter aircraft have their rotors/propellers horizontal for vertical flight and vertical for forward flight.

E. Other Methods of Lift

Figure 1.6: X-24B lifting body

A lifting body is an aircraft body shaped to produce lift. If there are any wings, they are too small to provide significant lift and are used only for stability and control. Lifting bodies are not efficient: they suffer from high drag, and must also travel at high speed to generate enough lift to fly. Many of the research prototypes, such as the Martin Marietta X-24, which led up to the Space Shuttle, were lifting bodies, though the Space Shuttle is not, and some supersonic missiles obtain lift from the airflow over a tubular body.

Powered lift types rely on engine-derived lift for vertical takeoff and landing (VTOL). Most types transition to fixed-wing lift for horizontal flight. Classes of powered lift types include VTOL jet aircraft (such as the Harrier Jump Jet) and tiltrotors, such as the Bell Boeing V-22 Osprey, among others. A few experimental designs rely entirely on engine thrust to provide lift throughout the whole flight, including personal fan-lift hover platforms and jetpacks. VTOL research designs include the Rolls-Royce Thrust Measuring Rig.

The Flettner airplane uses a rotating cylinder in place of a fixed wing, obtaining lift from the Magnus effect. The ornithopter obtains thrust by flapping its wings.

F. Jet Aircraft

Figure 1.7 Lockheed Martin F-22A Raptor

Jet aircraft use airbreathing jet engines, which take in air, burn fuel with it in a combustion chamber, and accelerate the exhaust rearwards to provide thrust. Different jet engine configurations include the turbojet and turbofan, sometimes with the addition of an afterburner. Those with no rotating turbomachinery include the pulsejet and ramjet. These mechanically simple engines produce no thrust when stationary, so the aircraft must be launched to flying speed using a catapult, like the V-1 flying bomb, or a rocket, for example. Other engine types include the motorjet and the dual-cycle Pratt & Whitney J58.

Compared to engines using propellers, jet engines can provide much higher thrust, higher speeds and, above about 40,000 ft (12,000 m), greater efficiency. They are also much more fuel-efficient than rockets. As a consequence nearly all large, high-speed or high-altitude aircraft use jet engines.

G. Rotorcraft

Some rotorcraft, such as helicopters, have a powered rotary wing or rotor, where the rotor disc can be angled slightly forward so that a proportion of its lift is directed forwards. The rotor may, like a propeller, be powered by a variety of methods such as a piston engine or turbine. Experiments have also used jet nozzles at the rotor blade tips.

Other types of powered aircraft

Rocket-powered aircraft have occasionally been experimented with, and the Messerschmitt Me 163 Komet fighter even saw action in the Second World War. Since then, they have been restricted to research aircraft, such as the North American X-15, which traveled up into space where air-breathing engines cannot work (rockets carry their own oxidant). Rockets have more often been used as a supplement to the main power plant, typically for the rocket-assisted take off of heavily loaded aircraft, but also to provide high-speed dash capability in some hybrid designs such as the Saunders-Roe SR.53.The ornithopter obtains thrust by flapping its wings. It has found practical use in a model hawk used to freeze prey animals into stillness so that they can be captured, and in toy birds.

1.1.3 Design and Construction

Aircraft are designed according to many factors such as customer and manufacturer demand, safety protocols and physical and economic constraints. For many types of aircraft the design process is regulated by national airworthiness authorities.

- The key parts of an aircraft are generally divided into three categories:
- The structure comprises the main load-bearing elements and associated equipment.
- The propulsion system (if it is powered) comprises the power source and associated equipment, as described above.
- The avionics comprise the control, navigation and communication systems, usually electrical in nature.

A. Structure

The approach to structural design varies widely between different types of aircraft. Some, such as paragliders, comprise only flexible materials that act in tension and rely on aerodynamic pressure to hold their shape. A balloon similarly relies on internal gas pressure, but may have a rigid basket or gondola slung below it to carry its payload. Early aircraft, including airships, often employed flexible doped aircraft fabric covering to give a reasonably smooth aeroshell stretched over a rigid frame. Later aircraft employed semi-monocoque techniques, where the skin of the aircraft is stiff enough to share much of the flight loads. In a true monocoque design there is no internal structure left. With the recent emphasis on sustainability hemp has picked up some attention, having a way smaller carbon foot print and 10 times stronger than steel, hemp could become the standard of manufacturing in the future.

The key structural parts of an aircraft depend on what type it is.

B. Aerostats

Lighter-than-air types are characterised by one or more gasbags, typically with a supporting structure of flexible cables or a rigid framework called its hull. Other elements such as engines or a gondola may also be attached to the supporting structure.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

Volume 2, Issue 3, May 2022

Impact Factor: 6.252

C. Aerodynes

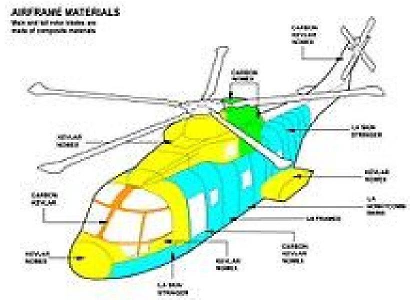

Figure 1.8 Airframe diagram for an agustawestlandAW101 helicopter

Heavier-than-air types are characterised by one or more wings and a central fuselage. The fuselage typically also carries a tail or empennage for stability and control, and an undercarriage for takeoff and landing. Engines may be located on the fuselage or wings. On a fixed-wing aircraft the wings are rigidly attached to the fuselage, while on a rotorcraft the wings are attached to a rotating vertical shaft. Smaller designs sometimes use flexible materials for part or all of the structure, held in place either by a rigid frame or by air pressure. The fixed parts of the structure comprise the airframe.

D. Avionics

The avionics comprise the aircraft flight control systems and related equipment, including the cockpit instrumentation, navigation, radar, monitoring, and communications systems.

Flight characteristics

Flight envelope

The flight envelope of an aircraft refers to its approved design capabilities in terms of airspeed, load factor and altitude.[46][47] The term can also refer to other assessments of aircraft performance such as maneuverability. When an aircraft is abused, for instance by diving it at too-high a speed, it is said to be flown outside the envelope, something considered foolhardy since it has been taken beyond the design limits which have been established by the manufacturer. Going beyond the envelope may have a known outcome such as flutter or entry to a non-recoverable spin (possible reasons for the boundary).

E. Range

Figure 1.9 The Boeing 777-200LR

Is one of the longest-range airliners, capable of flights of more than halfway around the world.

The range is the distance an aircraft can fly between takeoff and landing, as limited by the time it can remain airborne. For a powered aircraft the time limit is determined by the fuel load and rate of consumption.

For an unpowered aircraft, the maximum flight time is limited by factors such as weather conditions and pilot endurance. Many aircraft types are restricted to daylight hours, while balloons are limited by their supply of lifting gas. The range can be seen as the average ground speed multiplied by the maximum time in the air.

The Airbus A350-900ULR is now the longest range airliner.[citation needed]

F. Flight Dynamics

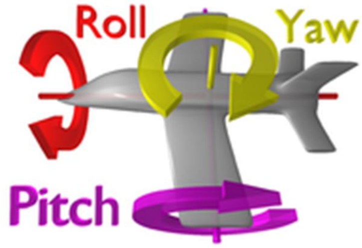

Figure 1.10 axis of plane

Flight dynamics is the science of air vehicle orientation and control in three dimensions. The three critical flight dynamics parameters are the angles of rotation around three axes which pass through the vehicle's center of gravity, known as pitch, roll, and yaw.

- Roll is a rotation about the longitudinal axis (equivalent to the rolling or heeling of a ship) giving an up-down movement of the wing tips measured by the roll or bank angle.
- Pitch is a rotation about the sideways horizontal axis giving an up-down movement of the aircraft nose measured by the angle of attack.
- Yaw is a rotation about the vertical axis giving a side-to-side movement of the nose known as sideslip.
- Flight dynamics is concerned with the stability and control of an aircraft's rotation about each of these axes.

G. Stability

Figure 1.11 The empennage of a Boeing 747-200

An aircraft that is unstable tends to diverge from its intended flight path and so is difficult to fly. A very stable aircraft tends to stay on its flight path and is difficult to maneuver. Therefore, it is important for any design to achieve the desired degree of stability. Since the widespread use of digital computers, it is increasingly common for designs to be inherently unstable and rely on computerised control systems to provide artificial stability.

A fixed wing is typically unstable in pitch, roll, and yaw. Pitch and yaw stabilities of conventional fixed wing designs require horizontal and vertical stabilisers, which act similarly to the feathers on an arrow. These stabilizing surfaces allow equilibrium of aerodynamic forces and to stabilise the flight dynamics of pitch and yaw. They are usually mounted on the tail section (empennage), although in the canard layout, the main aft wing replaces the canard foreplane as pitch stabilizer. Tandem wing and tailless aircraft rely on the same general rule to achieve stability, the aft surface being the stabilising one. A rotary wing is typically unstable in yaw, requiring a vertical stabiliser. A balloon is typically very stable in pitch and roll due to the way the payload is slung underneath the center of lift.

H. Control

Flight control surfaces enable the pilot to control an aircraft's flight attitude and are usually part of the wing or mounted on, or integral with, the associated stabilizing surface. Their development was a critical advance in the history of aircraft, which had until that point been uncontrollable in flight. Aerospace engineers develop control systems for a vehicle's orientation (attitude) about its center of mass. The control systems include actuators, which exert forces in various directions, and generate rotational forces or moments about the aerodynamic center of the aircraft, and thus rotate the aircraft in pitch, roll, or yaw. For example, a pitching moment is a vertical force applied at a distance forward or aft from the aerodynamic center of the aircraft, causing the aircraft to pitch up or down. Control systems are also sometimes used to increase or decrease drag, for example to slow the aircraft to a safe speed for landing. The two main aerodynamic forces acting on any aircraft are lift supporting it in the air and drag opposing its motion. Control surfaces or other techniques may also be used to affect these forces directly, without inducing any rotation.

1.2 Forward-Swept Wing

A forward-swept wing is an aircraft wing configuration in which the quarter-chord line of the wing has a forward sweep. Typically, the leading edge also sweeps forward.

Figure 1.12 forward swept back plane

1.2.1 Characteristics

The forward-swept configuration has a number of characteristics which increase as the angle of sweep increases.

A. Main Spar Location

The rearward location of the main wing spar would lead to a more efficient interior arrangement with more usable space.
Inward spanwise flow

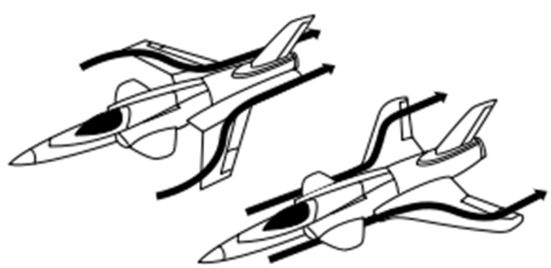

Figure 1.13 flow of wing

Spanwise airflow over a forward-swept wing is the reverse of flow over a conventional swept wing.
Air flowing over any swept wing tends to move spanwise towards the rearmost end of the wing. On a rearward-swept wing this is outwards towards the tip, while on a forward-swept wing it is inwards towards the root. As a result, the dangerous tip stall condition of a rearward-swept design becomes a safer and more controllable root stall on a forward-swept design. This allows full aileron control despite loss of lift, and also means that drag-inducing leading edge slots or other devices are not required.

With the air flowing inwards, wingtip vortices and the accompanying drag are reduced. Instead, the fuselage acts as a very large wing fence and, since wings are generally larger at the root, this raises the maximum lift coefficient allowing a smaller wing.

As a result, maneuverability is improved, especially at high angles of attack. At transonic speeds, shockwaves build up first at the root rather than the tip, again helping ensure effective aileron control.

Yaw instability

One problem with the forward-swept design is that when a swept wing yaws sideways (moves about its horizontal axis), one wing retreats while the other advances. On a forward-swept design, this reduces the sweep of the rearward wing, increasing its drag and pushing it further back, increasing the amount of yaw and leading to directional instability. This can lead to a Dutch roll in reverse.

Aeroelasticity

One of the drawbacks of forward swept wings is the increased chance of divergence, an aeroelastic consequence of lift force on forward swept wings twisting the tip upwards under increased lift. On a forward-swept design, this causes a positive feedback loop that increases the angle of incidence at the tip, increasing lift and inducing further deflection, resulting in yet more lift and additional changes in wing shape. The effect of divergence increases with speed. The maximum safe speed below which this does not happen is the divergence speed of the aircraft.

Such an increase in tip lift under load causes the wing to tighten into turns and may result in a spiral dive from which recovery is not possible. In the worst case, the wing structure can be stressed to the point of failure.

At large angles of sweep and high speeds, in order to build a structure stiff enough to resist deforming yet light enough to be practicable, advanced materials such as carbon fiber composites are required. Composites also allow aeroelastic tailoring by aligning fibers to influence the nature of deformation to a more favorable shape, impacting stall and other characteristics.

Stall characteristics

Any swept wing tends to be unstable in the stall, since the wing tips stalls first causing a pitch-up force worsening the stall and making recovery difficult. This effect is less significant with forward sweep because the rearward end carries greater lift and provides stability.

However, if the aeroelastic bending is sufficient, it can counteract this tendency by increasing the angle of attack at the wing tips to such an extent that the tips stall first and one of the main characteristics of the design is lost, on a conventional wing the tips always stall first. Such a tip stall can be unpredictable, especially where one tip stalls before the other.

Composite materials allow aeroelastic tailoring, so that as the wing approaches the stall it twists as it bends, so as to reduce the angle of attack at the tips. This ensures that the stall occurs at the wing root, making it more predictable and allowing the ailerons to retain full control.

II. History

2.1 Prewar Studies

Belyaev, the author of the below mentioned DB-LK project, tested forward-swept wing gliders BP-2 and BP-3 in 1934 and 1935. Other prewar design studies included the Polish PWS Z-17, Z-18 and Z-47 "Sęp" series.

2.2 World War II and Aftermath

Forward-swept wings designs, some whose design had begun during the prewar period, were developed during the Second World War, independently in Germany, Russia, Japan, and the US.

An early example to fly, in 1940, was the Belyayev DB-LK, a twin-boom design with forward-swept outer wing sections and backwards-swept tips. It reportedly flew well. Belyayev's proposed Babochka research aircraft was cancelled following the German invasion.

The American Cornelius Mallard flew on 18 August 1943. The Mallard was powered by a single engine, but it was followed by the Cornelius XFG-1 prototypes, which were flying fuel tanks, unpowered and designed for towing by larger aircraft. These Cornelius designs were unusual for being not only forward swept but also tailless.

Meanwhile in Germany, Hans Wocke was studying the problems of swept wings at the near-sonic speeds of which the new jet engines were capable. He recognised many of the advantages that forward sweep offered over the backwards-swept designs then being developed, and also understood the implications of aeroelastic bending and yaw instability.

Figure 1.14 A model of the Ju 287 V1

His first such design to fly was the Junkers Ju 287, on 16 August 1944. Flight tests on this and later variants confirmed the low-speed advantages but also soon revealed the expected problems, preventing high-speed trials. Wocke and the incomplete Ju 287 V3 prototype were captured and, in 1946, taken to Moscow where the aircraft was completed and flown the next year as the OKB-1 EF 131. The later OKB-1 EF 140 was essentially the same airframe re-engined with a pair of Mikulin-design Soviet jet engines of greater thrust.

In 1948 the Soviet Union created the Tsybin LL-3. The prototype would subsequently have a great impact on the Sukhoi SYB-A, which was completed in 1982.

When the German research reached the United States after the war, a number of proposals were put forward. These included the Convair XB-53 supersonic bomber and forward-swept variants of the North American P-51 Mustang, Bell X-1 rocket plane and Douglas D-558-I. The Bell proposal reached the wind tunnel testing stage, where the problems of aeroelasticity were confirmed.

The structural problems confirmed by the Ju 287 series and the Bell X-1 studies proved so severe that the materials available at the time could not make a wing strong and stiff enough without also making it too heavy to be practical. As a result, forward sweep for high-speed designs was abandoned, until many years later when new structural materials would become available.

Throughout World War II, numerous fighter, bomber, and other military aircraft can be described as having forward-swept wings, due to the average chord of their wings being forward-sweeping. However, these designs almost always utilized a rearward-swept leading edge, which would technically render them as high aspect ratio trapezoidal wings.
The Nakajima Ki-43 is notable for being the only successful fighter aircraft with a truly forward-swept wing, although the forward sweep of its leading edge is nearly unnoticeable.

2.3 Postwar General Aviation

Figure 1.15 LET L-13 two-seat glider

Figure 1.16 ARV Super2

Small amounts of sweep do not cause serious problems and even moderate forward sweep allows a significant aft movement of the main spar attachment point and carry-through structure.

In 1954 Wocke returned to the German Democratic Republic, moving to West Germany shortly afterwards and joining Hamburger Flugzeugbau (HFB) as their chief designer. In Hamburg, Wocke completed work on the HFB 320 Hansa Jet business jet which flew in 1964. The forward sweep enabled the main spar to be moved aft behind the cabin so that the spar did not need to project into the cabin.

Moderate forward sweep has been used for similar reasons in many designs, mainly sailplanes and light aircraft. Many high-wing training gliders with two seats in tandem have slightly forward-swept wings in order to enable the wing root to be located further aft to prevent the wing from obscuring the rear occupant's lateral visibility. Typical examples are the Schleicher ASK 13 and the Let Kunovice LET L-13 Blaník.

Other examples include:

- Cessna NGP, a prototype single-engine aircraft intended to eventually replace the Cessna 172 and Cessna 182.
- CZAW Parrot
- Saab Safari, Bölkow Junior & ARV Super2 all have shoulder wings for increased visibility, necessitating forward-swept wings to maintain correct CofG.
- Scaled Composites Boomerang, a prototype piston twin design which would allow for safe handling in the event of a single engine failure.
- SZD-9 Bocian and PZL Bielsko SZD-50 Puchacz, multi-purpose two-seat sailplanes designed and built in Poland.

2.4 Return of the Fast Jet

Figure 1.17 Grumman X-29 displaying forward-swept wing configuration

Figure 1.18 KB SAT SR-10 trainer

The large angles of sweep necessary for high-speed flight remained impractical for many years. In the late 1970s, DARPA began investigating the use of newer composite materials to avoid the problem of reduced divergence speed through aeroelastic tailoring. Fly-by-wire technology allowed for the design to be dynamically unstable and improved maneuverability. Grumman built two X-29 technology demonstrators, first flying in 1984, with forward swept wings and canards. Maneuverable at high angles of attack, the X-29 remained controllable at a 67° angle of attack.

Advances in thrust vectoring technology and a shift in air combat tactics toward medium range missile engagements decreased the relevance of a highly agile fighter aircraft. In 1997, Sukhoi introduced the Su-47 fighter prototype at the Paris Air Show. It did not enter production, although it underwent a series of flight tests and performed at several air shows.

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 3, May 2022
Impact Factor: 6.252

The KB SAT SR-10 is a prototype Russian single-engine jet trainer aircraft, fitted with forward-swept wings. It first flew in 2015

III. RC Plane Designing Calculation

3.1 Chord Length

While designing an RC plane, we usually start by fixing the Chord length or the Wingspan. Let's start by fixing the chord length. So,

Chord length "C" = 8 inches

Airfoil Thickness, Flat bottom type:

Airfoil thickness should be 12 to 15% of the chord length. So,

Airfoil thickness = 12% X 8inches = .96 inches

Airfoil thickness = .96 inches

Figure 1.19 RC Plane Modeling

3.2 Wingspan

There are a few thumb rules which are used in aero modeling. So, according to these rules the Wingspan should be 5 to 6 times of the chord length. As, our chord length is 8 inches. So

Wingspan = 8 x 5 = 40 inches

Wing Length = Wingspan = 40 inches

Total Wing Area for Rectangular type Wing:

As we are using a rectangular type wing, so its area can be calculated by multiplying the wingspan with the chord length.

Wing Area = Wingspan X chord length = 40 X 8 = 320 square inches

Wing Area = 320 square inches

3.3 Aspect Ratio

The Aspect ratio determines the gliding performance of the RC plane. Wingspan is directly proportional to the aspect ratio. So, as the wingspan increases your aspect ratio also increases. That is as the wingspan increases the gliding performance of your wing increases. So, for this particular RC plane the Aspect ratio is 5.

Aspect Ratio = $(\text{Wingspan})^2$ / Wing area

Aspect Ratio = (Wingspan X Wingspan) / (Wingspan X Chord length)

Aspect Ratio = Wingspan / chord length

Aspect Ratio = 40 inches / 8 inches

Aspect Ratio = 5

3.4 Fuselage Length

Fuselage should be 75% of the Wingspan. So,
Fuselage Length = 75% X 40 = 30 inches
Fuselage Length = 30 inches

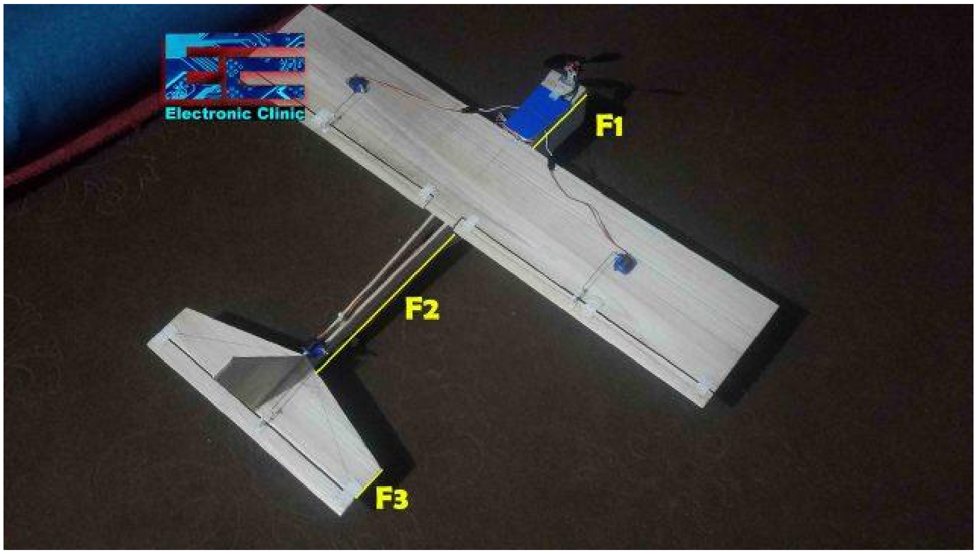

Figure 1.20 Flight Parts

The fuselage is further divided into three parts F1, F2, and F3. F1 is from the start to the leading edge of the wing. F1 should be 20% of the fuselage length, this is called the nose length. And F2 which is the tail length from wing trailing edge to leading edge of the horizontal stabilizer and it should be 40% of the fuselage length. F3 is the remaining length of the fuselage and this is the width of the horizontal Stabilizer. So, the nose length is 6 inches, the tail length is 12 inches, and the horizontal stabilizer width is 4 inches.

F1 = Nose Length:
F1 = 20% X 30 inches = 6 inches
Nose length = F1 = 6 inches

Tail length:
Tail length = F2 = 40% X 30 inches = 12 inches
Tail length = F2 = 12 inches

So fuselage total length = 6 inches nose length + 8 inches chord length + 12 inches trailing edge to the stabilizer leading edge = 26 inches
While the calculated value was 30 inches. So 30 – 26 = 4 inches
So, these 4 inches is the Stabilizer width.

Stabilizer Width = F3 = 4 inch

3.5 Fuselage Height

Figure 1.21 Fuselage height

The fuselage height should be 10 to 15% of the fuselage length. So,

Fuselage Height = 10% X 30 = 3 inches

Fuselage Height = 3 inches

You can play around with the Fuselage design, you can see clearly on the tail side I cut some wood, this will reduce the weight and will also improve the aerodynamics.

3.6 Sizing of the Control Surface, Ailerons

Next on the list is the sizing of the control surface Ailerons. It should be (1/8) X chord length. This is for the strip type ailerons. So,

Aileron size = (1/8) x 8 = 1 inch

Aileron size: 1 inch

3.7 Horizontal Stabilizer Area

The horizontal stabilizer area should be 15 to 20% of the Wing Area.

Our calculated wing area was 320 square inches, So

Wing Area = 320 square inches

Horizontal Stabilizer area = 320 X 15% = 48 square inches

3.8 Horizontal Stabilizer Length

We know the Horizontal stabilizer width and area, so now we can easily calculate the Horizontal stabilizer length which is 12 inches.

Horizontal Stabilizer width = F3 = 4 inches

Horizontal Stabilizer Area = 48 square inches

So, for the rectangular type stabilizer

Stabilizer area = width X length

48 = 4 X length

Length = 48/4

Stabilizer Length = 12 inches

3.9 Elevator Sizing

The Elevator area should be 20 to 30% of the horizontal stabilizer area. While we assume the elevator length is the same as the stabilizer length.

Elevator length = stabilizer length = 12 inches

Elevator area = 48 X 20% = 9.6 square inches

As, Elevator area = width X length, so, we can find the width of the elevator

9.6 = width X 12

Elevator width = .8 inches

3.10 Vertical Stabilizer

Area of the vertical stabilizer should be 33% of the Horizontal stabilizer area. So

Vertical Stabilizer area = 33% X 48 square inches = 16 square inches

Vertical Stabilizer area = 16 square inches

Let's keep the width same as the horizontal stabilizer width, so

Vertical Stabilizer width = 4 inches

Vertical stabilizer is as tall as its width

So

Vertical Stabilizer Height = 4 inches

3.11 Rudder Area

Rudder area should be ½ X vertical stabilizer area. So, the rudder area is 8 square inches.

Rudder area = (1 / 2) X 15.84

Rudder area = 8 square inches

Length of the Rudder is same as the vertical stabilizer height

Height of Rudder = 4 inches

We know

Rudder area = height x width

So, 8 = 4 x Width

Rudder Width = 2 inches

3.12 Center of Gravity "CG":

CG should be set at 25% to 33% of the Chord length from the leading edge of the Wing. Our chord length is 8 inches So, our CG is at 2 inches from the leading edge.

CG = 25% X chord length

CG = 25% X 8 inches

CG = 2 inches

3.13 Angle of Attack

Angle of attack should be 3 to 4 degrees. For now, I didn't add any angle of attack; because I want to check how this affects the flight.

Dihedral:

Dihedral if you want should be 2 to 3 degrees

Wing Loading:

This determines how much load your wing can take

Wing Loading = All of weight of your aircraft / wing area

320 square inches is wing area.

Micro RC Plane:

Figure 1.22 Micro RC Plane

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 3, May 2022

Before designing the bigger RC Plane I decided to start with the micro version of the RC plane to test my calculations. I also designed a 3d model of the same micro airplane. The reason I started with this micro version of the RC plane is to understand the effect of the CG or Center of gravity, the angle of attack, and also to test my design calculations.

I checked the gliding performance of this micro airplane without adjusting the center of gravity, which you can watch in the video given at the end of this article. You will see, when I throw this micro airplane in the air it starts rolling, because its tail heavy. As I already explained the CG should be set at 25% to 33% of the Chord length from the leading edge of the Wing. Our chord length is 2 inches So, the center of gravity is at .5 inches from the leading edge. Currently this micro airplane is tail heavy which is not good. Let's add some weight to the nose side. Place your fingers below the wing at about .5 inches from the leading edge of the wing. I explained this in the video. Anyhow, I adjusted the center of gravity. Remember your RC plane should be a little nose heavy, never fly an airplane with tail heavy. Tail heavy airplanes are hard to control. In the video you will clearly see the difference in flight when the center of gravity is not adjusted and when the center of gravity is adjusted. Seriously, from my personal experience, as I have been working on these RC planes, no matter how cool your RC plane is, if you have not adjusted the center of gravity, your RC airplane will crash. So, it's considered to be the good practice, if you check the center of gravity each time you fly the RC Plane.

Anyhow, after I was done with my initial tests. It was time to start working on the bigger version of the RC airplane. I started off by designing my 3d models in Solidworks2016.

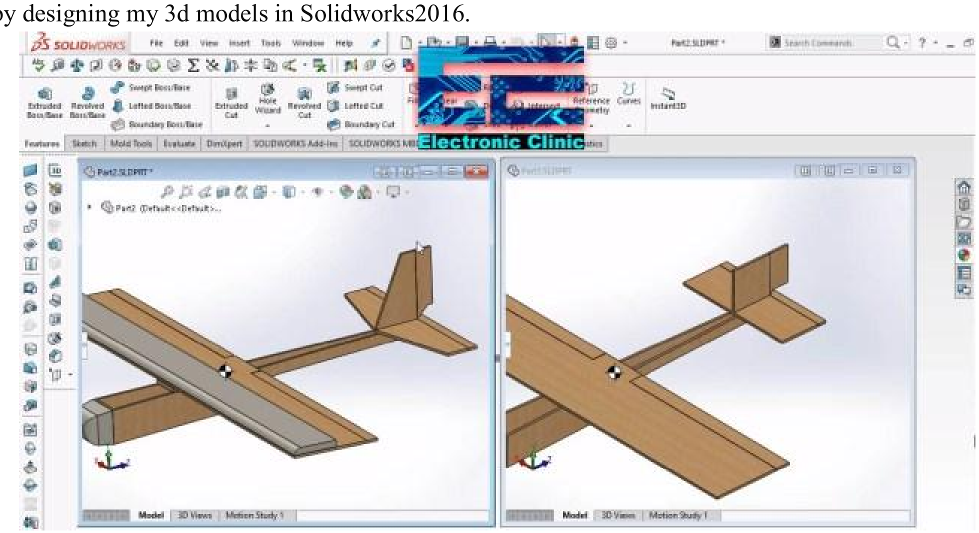

Figure 1.23 Flight Dimensions

I have these two models, the one on the right side is with the actual dimensions and the one on the left side is also as per the actual dimensions but with some aerodynamics. You can clearly see the horizontal stabilizer and vertical stabilizers are modified and so airfoil is added. The surface areas are exactly the same even after cutting these portions. Now, I will explain how I did it.

You can clearly see, on the right side the horizontal stabilizer and vertical are rectangular type while the horizontal stabilizer and vertical on the left side are not rectangular. But both the models has the same surface areas.

As I explained earlier we need to keep the aspect ratios same. To keep the surface area same even after cutting portions of the vertical and horizontal stabilizers we have two options, as we cut any part, then we should accordingly increase the length or the width. In my case I kept the width constant and I changed the length. So, the vertical stabilizer in both models shares the same surface area of 16 square inches. So, you can increase or decrease the height or you can change the angle, and the surface area will change accordingly, this way you can set the aerodynamics, you can cut some portions, and at the same time you also keep the same surface area. So, if you are designing any part, I highly recommend you should use a designing software to check and confirm your design parameters.

Anyhow, after the calculations and 3d designing, the next part was to build the RC Airplane as per the values we just calculated. The building part is really simple when you have all the dimensions. In my last tutorial, I have already explained how to fix the servo motors, how to attach the ailerons, and how to setup the Flysky FS i6 Transmitter and Receiver.

IJARSCT
ISSN (Online) 2581-9429
IJARSCT
Impact Factor: 6.252
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Volume 2, Issue 3, May 2022

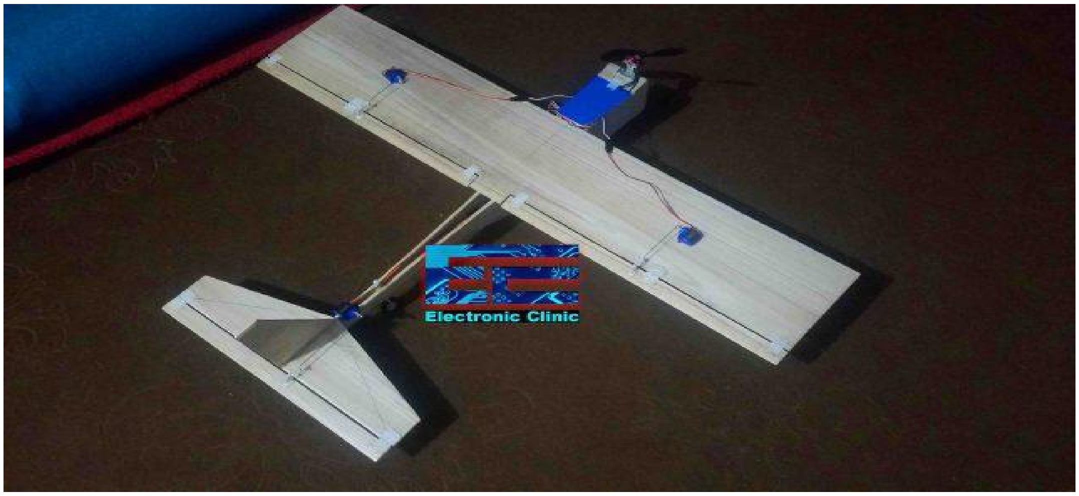

Figure 1.24 Flight with Transmitter and receiver

So, this is RC Plane designed as per the calculations. Just a simple model with flat nose, a brushless motor is connected to the nose of the airplane, and there is no airfoil. I tested it but the 2600kv brushless DC motor wasn't able to lift this RC airplane. I decided to use two of these motors.

Figure 1.25 Weighting The Plane

I installed two brushless motors on the leading edge of the wing. These are 2600kv brushless motors. The airfoil is not yet added.

The overall weight of this RC Plane after adding all the electronics is 1306 grams. This is the reason I am using two brushless motors. These are Skywalker 2600kv brushless motors. Each motor is capable of producing over +1000 grams of thrust. As the overall weight of this RC plane is 1306 grams. So, these brushless motors with over +2kg thrust will easily lift this RC plane.

I am using 30A ESCs, 2200mAh lipo battery, 6 channels FS i6 Receiver and Transmitter, small servo motors for controlling Ailerons and the Elevator. One more thing, I am using the same channel 3 for controlling both the Brushless motors.

The last step is to check the center of gravity. You can add some weight on the nose side if it's tail heavy. My RC plane is ready for the first take off.

I did perform some tests and the results were pretty bad as I was expecting, this was due to the lack of airfoil, and the nose front was pretty flat. So, I decided to add the airfoil and also decided to round the nose side.

Anyhow, I selected the KFm-2 type Airfoil as this is easy to build and add more strength to the wing. Previously I did calculations for the Flat bottom type Airfoil, which of course you can use. But for now, I will continue with this KFm-2 type Airfoil. Because the KFm2 type airfoil is good for heavier models, this gives higher lift, and gives nice stability.

The KFm-2 type airfoil should be 50% of the wing chord.

As you know the wing chord is 8 inches, so 50% X 8 inches = 4 inches

Its thickness should be 7% to 9% of the chord, so,

The KFm-2 Airfoil thickness = 7% X 8 inches = .56 inches.

There is a whole family of the KFm type airfoils, you can select anyone as per your requirement.

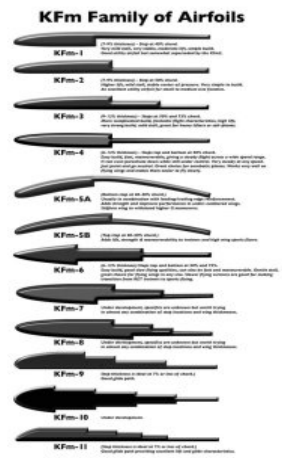

Figure 1.26 Wing Section

Balsa Wood Dual Brushless Motor RC Airplane Flight Test:

After modifying my RC airplane, once again I checked the center of gravity. So, let's start with the final Fly test. For the flight test watch video given below. You can see the RC plane is quite stable, the KFm2 airfoil is simply amazing, All my calculations are correct, the center of gravity is perfect. The control surfaces are just cool and quite responsive. I successfully made the left turn, then the tree blocked the view, I got nervous and I pushed the stick all the way to the left, the plane rolled, it was upside down, and I crashed it. This was completely destroyed; I am a bad pilot. I was supposed to move the stick a little to the left. So, I really don't know what to say, I just crashed it, I am really good at destroying RC planes. Now I can make my own RC planes but I don't know how to fly them, for me every flying mission is a kind of one-way mission. But I won't stop here, I will improve my piloting skills. I hope you guys will learn a lot from my mistakes.

So, one lesson from this crash is never move the control stick to the extreme limit, otherwise, the plane will roll and if you are a beginner like me then there is high probability of crashing your RC Plane. But seriously I am really happy; I did my own calculations and flew this 1.5kg RC plane with such a nice stability. So, after flying this Heavy version of the RC plane now I will confidently work on the lighter versions of the same model. But before I am going to make another model, first I will improve my piloting skills. Anyways I hope you have learned something new from this article.

.

IV. Literature Survey

4.1 Research On Aerodynamic Characteristics Of Forward Swept Wing With Inclined Basic Airfoil.

SU Xinbing,jiang Wen, Zhao Xiwei And Zhang Junyi (16 May 2020)

From the experiment they have came to know that the numerical simulation and simulation calculation of, the change in aerodynamic characteristics of cross section of different angle between the basic airfoil and the wing root. There are many different in different wind section of aircraft the forward swept wing dives a good aerodynamics characteristic and better performance and low drag.

4.2 Study On The Influence Of Swept Angle On The Aerodynamic Characteristics Of The Cross-Section Airfoil of a Variable Swept-Wing Aircraft.

SU Xinbing,jiang Wen and Zhao Xiwei (January 2016)

This journal shows that the change of cross section airfoil during the swept process ,the angle of attack changes, the lift coefficient decrease with increase of forward swept angle. When the angled of attack changes the drag coefficient increase with increase in forward swept. For the change of the cross-section airfoil during the swept process, the following conclusions are obtained.

(1) When the grazing angle of the wing changes, the relative thickness of the section airfoil and other parameters will also change, and the aerodynamic characteristics will change accordingly;

(2) When the angle of attack changes, the lift coefficient decreases with the increase of the forward sweep angle for the cross-sectional airfoil with larger relative thickness; the lift coefficient with the forward sweep angle is the relative airfoil with the relative thickness less than 6%. The increase is slightly increased; when the Mach number changes, the lift coefficient of the cross-section airfoil decreases as the forward sweep angle increases.

(3) When the angle of attack changes, the drag coefficient of each airfoil increases with the increase of the forward sweep angle; when the Mach number changes, the drag coefficient of the cross-section airfoil also appears with the increase of the forward sweep angle. Increase the trend.

(4) When the angle of attack changes, the pitching moment coefficient decreases with the increase of the forward sweep angle for the cross-sectional airfoil with larger relative thickness; the pitching moment coefficient with the relative thickness is less than 6% of the cross-section airfoil The angle increases and increases.

4.3 Aeroelastic Tailoring Of A Forward Swept Wing

Tobias Wunderlichand SaschaDahne(16 june 2016)

This journal gives us the information of aero elastic tailoring for structural mass reduction is a trade off between aerodynamic load reduction and fiber orientation in internal direction. The result of design studies shows that the global orthotropy angle allows the control of bending torsion coupling.

The main feature of the process chain is the hierarchical decomposition of the problem into two levels. On the highest level the orthotropy direction of the composite structure will be analyzed. The lower level includes the wing box sizing for essential load cases considering the static aeroelastic deformations. Thereby, the wing box sizing can be performed with a given ply share of the laminate or a ply share optimization. Additionally, the airfoil shapes are transferred from a given NLF wing design. The natural laminar flow is considered by prescribing laminar-turbulent transition locations. The process chain evaluates the wing mass, the lift-to-drag ratio under cruise flight conditions and the corresponding design mission fuel consumption. Results of aerostructural wing design studies and optimizations are presented for an NLF forward swept wing aircraft configuration. The aerostructural wing optimization with 3 orthotropy angles as design parameters shows a wing mass reduction in the order of 8% and a design mission fuel consumption reduction in the order of 4% in comparison to the aeroelastic tailored wing design of the reference aircraft.

4.4 Review And Analysis Of Variable Swept Wing Technology

Yongyue YUAN (June 2019)

This journal shows us that the exiting technology is not enough to play the advantage of variable swept wing. The continuous advancement of new technologies and material ,this technology still has great potential. If the technology of variable swept wing is popularized in small adaptive air craft it will certainly bring a new revolution in this field.

It can bring new development to the traditional large-scale man-made control aircraft. From the point of view of current development, the research of variable swept wing UAV is still in its infancy, and there are many aspects to be improved and deepened. For example, in the aspect of mechanism design, the existing mechanism schemes cannot fully achieve the ideal state of lightweight, precise and high transmission efficiency, which has great room for improvement. We should try to start with new materials, and change the sweep angle mainly by natural aerodynamic drag to make it sweep naturally, and then use computer micro-manipulation to reduce the influence of partial air flow interference, so as to obtain the best sweep angle more accurately.

4.5 Numerical Study Of Aerodynamic Characteristics Of Fsw Aircraft With Different Wing Positions Under Supersonic Condition

Lei Juanmian, Zhao Shuai, Wang Suozhu

This paper investigates the influence of forward-swept wing (FSW) positions on the aerodynamic characteristics of aircraft under supersonic condition (Ma = 1.5). The numerical method based on Reynolds-averaged Navier–Stokes (RANS) equations, Spalart–Allmaras (S–A) turbulence model and implicit algorithm is utilized to simulate the flow field of the aircraft. The aerodynamic parameters and flow field structures of the horizontal tail and the whole aircraft are presented. The results demonstrate that the spanwise flow of FSW flows from the wingtip to the wing root, generating an upper wing surface vortex and a trailing edge vortex nearby the wing root. The vortexes generated by FSW have a strong downwash effect on the tail. The lower the vertical position of FSW, the stronger the downwash effect on tail. Therefore, the effective angle of attack of tail becomes smaller. In addition, the lift coefficient, drag coefficient and lift–drag ratio of tail decrease, and the center of pressure of tail moves backward gradually. For the whole aircraft, the lower the vertical position of FSW, the smaller lift, drag and center of pressure coefficients of aircraft. The closer the FSW moves towards tail, the bigger pitching moment and center of pressure coefficients of the whole aircraft, but the lift and drag characteristics of the horizontal tail and the whole aircraft are basically unchanged. The results have potential application for the design of new concept aircraft.

4.6 Experimental And Numerical Studies On Static Aeroelastic Behaviours Of A Forward-Swept Wing Model Yan Ouyang

Kaichunzeng , Xiping Kou , Yingsonggu

This study has been one of the first attempts to find out the application condition for the medium and high fidelity models in nonlinear static aeroelastic analysis. +e capability of an iterative method in calculating the deformation of forward-swept wing is investigated by comparing experimental data and simulation results. In the given experimental arrangements, the simulation results have an acceptable accuracy compared with the wind tunnel test. +e results show that the proposed method is suitable for the static aeroelastic analysis of the flexible wing undergoing large deformation with high computation efficiency. +e conclusions are summarized as follows:

(1) Although it may underestimate the displacements when large deformation occurs, it is advisable to use the proposed method in the framework of preliminary design and optimization when the computation time is concerned.

(2) For large wing deformation, the high fidelity model generates more accurate results compared to the medium fidelity model; however, its capability is limited by being time-consuming. +e high fidelity model is recommended to be used in the detailed design phase, in which the accuracy of the result is more important than the computation time.

4.7 Theoretical And Experimental Study Of A Forward Swept Wing

Ibtisam Ahmed, Abdul Salam Darwish, HayderJaffal

The aerodynamic characteristics of forward swept wing were studied theoretically and experimentally .In the present work, theoretically a computer program was constructed to predict the pressure distribution about surface of the wing using three dimensional Low Order Subsonic Panel method. The aerodynamic coefficients of the wing were calculated from the pressure distribution which gained from tangential velocities Experimentally ,test were carried out by designing and manufacturing a wing model with special arrangement for pressure tapping, suitable for low wind tunnel testing. The entire wing was rotated rotate about an axis in the plane of symmetry and normal to the chord to produce different sweep and incidence angles for wing, by using rotating mechanism. Wind tunnel test was carried out at ($U\infty$=33.23m/s) for different swept angles and angles of attack. Comparisons were made between the predicted and experimental results. It is good and gave reasonable closeness. It was clear from the present investigation that the lift and drag characteristics for the forward swept wing are less in values compared with the swept back wing, therefore a forward swept wing can fly at higher speed corresponding to a pressure distribution associated for lower speed.

4.8 Supersonic Forward-Swept Wing Design Using Multifidelity Efficient Global Optimization

Yuki Kishi, Masahiro Kanazaki and Yoshikazu Makino

In this paper, the ability of the forward-swept supersonic wing to simultaneously reduce aerodynamic drag and sonic boom under cruise conditions is investigated via the optimization of airfoil distribution. The forward-swept wing is superior to the conventional backward-swept delta wing for reducing sonic booms. To realize optimum aerodynamic characteristics, airfoil distributions for the forward-swept and backward-swept wings were acquired and compared for low-drag, low-boom wing abilities. For sonic boom evaluations, the augmented Burgers equation and multipole analysis were applied to near-field pressure distributions calculated by Euler simulations of both configuration samples. This process was time-consuming, so a multifidelity approach was introduced with a multi-additional sampling. Low-drag and low-boom solutions were obtained for both planforms; the forward-swept wing was found to reduce sonic boom and aerodynamic drag more efficiently than the backward-swept wing. Based on functional analysis of variance, different design variables were noted to contribute toward reductions of the various objective functions. In case of sonic boom reduction via comparison of the low-boom solutions, for the given airfoil geometries at the wing tips for the forward-swept and backward-swept wings, the former had a larger twisted-down angle and the latter had a stronger camber shape.

4.9 Aerodynamic Characteristics Of Canard-Forward Swept Wing Aircraft Configurations

G. Q. Zhang, S. C. M. Yu, A. Chien and S. X. Yang

The aerodynamic characteristics between the canard and wing of the Canard-forward swept wing aircraft configurations have been investigated numerically at low Reynolds number. The variation of the aerodynamic characteristics at different canard positions is the focus of the present investigation. The aerodynamic interference and the mutual coupling effect between the canard and wing will have great influences on the lift, drag, and sideslip characteristics of the whole aircraft. The canard-generated vortex can induce a favorable interference onto the main wing, controlling the onset of the boundary layer separation from the leading edge. At small angles of attack (α<10 degα<10 deg the aerodynamic characteristics are sensitive to the relative position of the canard and the wing, but at high angles of attack (α>20 degα>20 deg they are not only related to the orientation of the canard (forward or backward), but also the features of the vortices generated above the canard and the wing, including their strength and location.

4.10 The Analysis Of Moment Characteristics Of Variable Forward-Swept Wing Mechanism With A Double Slideway

XinbingSua ,HaoyangFengb , BinlinMac , XuWangd

Based on the variable forward-swept wing configuration, this paper utilizes a variable forward-swept wing mechanism with a double slideway, which makes it possible for the aircraft to switch among orthogonal wing, forward-swept wing and delta wing freely. The general configuration of the variable forward-swept wing mechanism with a double slideway is elucidated by means of a three-dimensional model plot and then the mathematic model is also established. The motion characteristics of linear motion are simulated, analyzed and optimized. The results indicate that the variable forward-swept wing mechanism with a double slideway can meet the aerodynamic requirements better. Moreover, there exists a larger moment amplification factor in forward-swept small Angle to provide greater control driving moment. Therefore, this mechanism may serve as a useful reference when developing a morphing aircraft.

V. Project Plan

5.1 Forward Swept Wing

A **forward-swept wing** is an aircraft wing configuration in which the quarter-chord line of the wing has a forward sweep. Typically, the leading edge also sweeps forward.

- We have planed to make a forward swept wing rc aircraft.
- This configuration has a high maneuverability at high speeds and drag production is low compared to backward swept wing aircraft.
- The characteristic sweep angle is usually estimated by drawing a path from root to tip, twenty five percentage of way back from the leading edge ,and matching that to the perpendicular to the longitudinal axis of the aircraft.

- The characteristic sweep angle is usually estimated by drawing a path from root to tip, twenty five percentage of way back from the leading edge ,and matching that to the perpendicular to the longitudinal axis of the aircraft.
- Wing sweep has the effect of delaying the shock waves and accompanying aerodynamic drag caused by fluid compressibility.
- So this is our project idea, which will help full in the pilot for controlling and use of forward swept wing aircraft.

Figure 5.1 forward swept wing aircraft.

5.2 Work Plan

- We have planed to fabricate the forward swept wing aircraft.
- First we have design the 2d structure of the aircraft.
- Then we planed to calculate the dimensions of the aircraft and implant to our rc aircraft.
- The dimensions are plotted in our design.

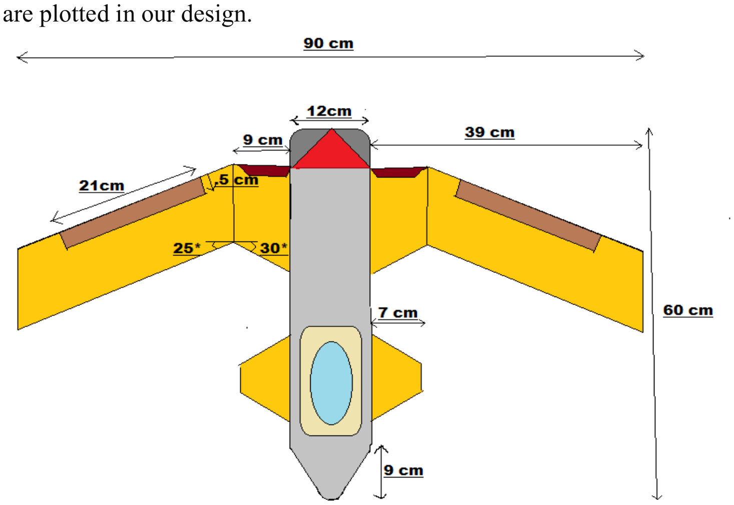

Figure 5.2 2d diagram of aircraft with dimensions

- In the above slide we have shown our 2d top view of the rc aircraft.
- The swept angle and wing span are calculated with the required formula.
- The swept anger is 30 and 25 over both angle in our diagram.
- In later we have planed to fabricate it with ceroplastic material to the outer body and fix the necessary components in it.
- For the components we got an idea from our internship so the components required are given in the next slide.

5.3 CATIA V5

CATIA (an acronym of computer-aided three-dimensional interactive application) is a multi-platform software suite for computer-aided design (CAD), computer-aided manufacturing (CAM), computer-aided engineering (CAE), 3D modeling and Product lifecycle management (PLM), developed by the French company DassaultSystèmes.

Since it supports multiple stages of product development from conceptualization, design and engineering to manufacturing, it is considered a cax-software and is sometimes referred to as a 3D Product Lifecycle Management software suite. Like most of its competition it facilitates collaborative engineering through an integrated cloud service and have support to be used across disciplines including surfacing & shape design, electrical, fluid and electronic systems design, mechanical engineering and systems engineering.

Besides being used in a wide range of industries from aerospace and defence to packaging design, CATIA has been used by architect Frank Gehry to design some of his signature curvilinear buildings and his company Gehry Technologies was developing their Digital Project software based on CATIA. The software has been merged with the company's other software suite 3D XML Player to form the combined Solidworks Composer Player.

5.4 3D Model of a Sectional Wing

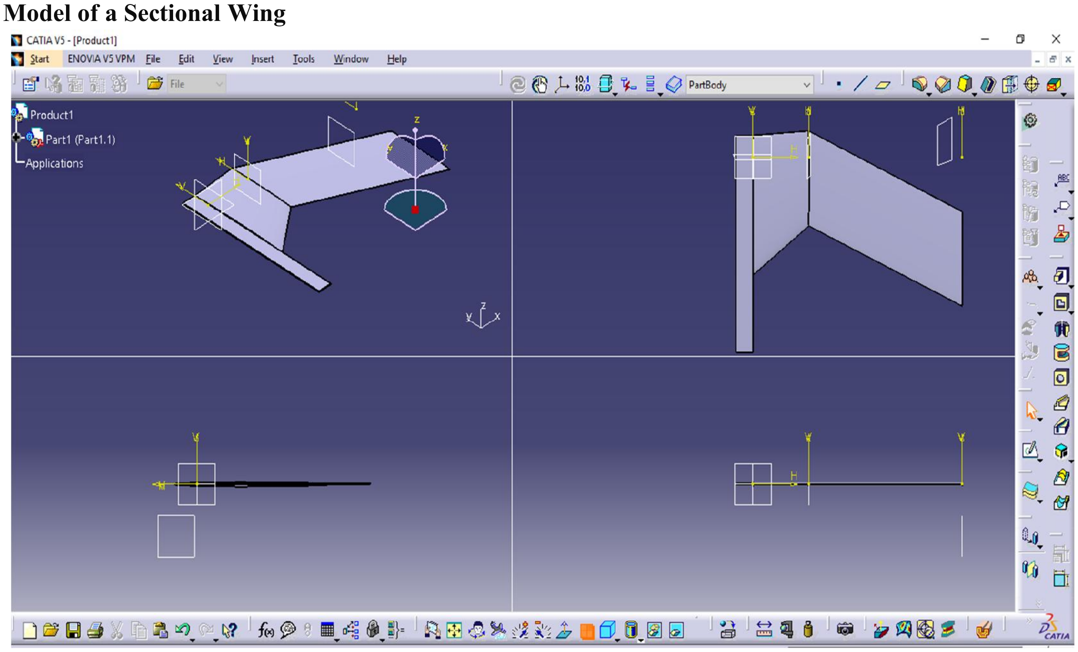

Figure 5.3 wing 3d sectional view

VI. COMPONENTS REQUIRED

6.1 BLDC Motor 2200KV

A brushless DC electric motor (BLDC motor or BL motor), also known as an electronically commutated motor (ECM or EC motor) or synchronous DC motor, is a synchronous motor using a direct current (DC) electric power supply. It uses an electronic controller to switch DC currents to the motor windings producing magnetic fields which effectively rotate in space and which the permanent magnet rotor follows. The controller adjusts the phase and amplitude of the DC current pulses to control the speed and torque of the motor. This control system is an alternative to the mechanical commutator (brushes) used in many conventional electric motors.

The construction of a brushless motor system is typically similar to a permanent magnet synchronous motor (PMSM), but can also be a switched reluctance motor, or an induction (asynchronous) motor. They may also use neodymium magnets and be outrunners (the stator is surrounded by the rotor), inrunners (the rotor is surrounded by the stator), or axial (the rotor and stator are flat and parallel).

The advantages of a brushless motor over brushed motors are high power-to-weight ratio, high speed, nearly instantaneous control of speed (rpm) and torque, high efficiency, and low maintenance. Brushless motors find applications in such places as computer peripherals (disk drives, printers), hand-held power tools, and vehicles ranging from model aircraft to automobiles. In modern washing machines, brushless DC motors have allowed replacement of rubber belts and gearboxes by a direct-drive design.

Figure 6.1 BLDC Moter

6.2 ESC (Electronic Speed Controller)

An **electronic speed control** (**ESC**) is an electronic circuit that controls and regulates the speed of an electric motor. It may also provide reversing of the motor and dynamic braking. Miniature electronic speed controls are used in electrically powered radio controlled models. Full-size electric vehicles also have systems to control the speed of their drive motors. An electronic speed control follows a speed reference signal (derived from a throttle lever, joystick, or other manual input) and varies the switching rate of a network of field effect transistors (FETs).[1] By adjusting the duty cycle or switching frequency of the transistors, the speed of the motor is changed. The rapid switching of the current flowing through the motor is what causes the motor itself to emit its characteristic high-pitched whine, especially noticeable at lower speeds.

Different types of speed controls are required for brushed DC motors and brushless DC motors. A brushed motor can have its speed controlled by varying the voltage on its armature. (Industrially, motors with electromagnet field windings instead of permanent magnets can also have their speed controlled by adjusting the strength of the motor field current.) A brushless motor requires a different operating principle. The speed of the motor is varied by adjusting the timing of pulses of current delivered to the several windings of the motor.

Brushless ESC systems basically create three-phase AC power, like a variable frequency drive, to run brushless motors. Brushless motors are popular with radio controlled airplane hobbyists because of their efficiency, power, longevity and light weight in comparison to traditional brushed motors. Brushless DC motor controllers are much more complicated than brushed motor controllers.

Figure 6.2 Electronic Speed Controler

The correct phase of the current fed to the motor varies with the motor rotation, which is to be taken into account by the ESC: Usually, back EMF from the motor windings is used to detect this rotation, but variations exist that use separate magnetic (Hall effect) sensors or optical detectors. Computer-programmable speed controls generally have user-specified options which allow setting low voltage cut-off limits, timing, acceleration, braking and direction of rotation. Reversing the motor's direction may also be accomplished by switching any two of the three leads from the ESC to the motor.

6.3 Battery 2200 mAH

“Li-Po" and "LiPo" redirect here. For other uses, see Li Po (disambiguation).

A lithium polymer battery, or more correctly lithium-ion polymer battery (abbreviated as LiPo, LIP, Li-poly, lithium-poly and others), is a rechargeable battery of lithium-ion technology using a polymer electrolyte instead of a liquid electrolyte. High conductivity semisolid (gel) polymers form this electrolyte. These batteries provide higher specific energy than other lithium battery types and are used in applications where weight is a critical feature, such as mobile devices, radio-controlled aircraft and some electric vehicles.

Figure 6.3 BATTERY 2200 mAH

6.4 Servo Motor

A servomotor (or servo motor) is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration.[1] It consists of a suitable motor coupled to a sensor for position feedback. It also requires a relatively sophisticated controller, often a dedicated module designed specifically for use with servomotors. Servomotors are not a specific class of motor, although the term *servomotor* is often used to refer to a motor suitable for use in a closed-loop control system.

Servomotors are used in applications such as robotics, CNC machinery, and automated manufacturing. Servomotors are generally used as a high-performance alternative to the stepper motor. Stepper motors have some inherent ability to control position, as they have built-in output steps. This often allows them to be used as an open-loop position control, without any feedback encoder, as their drive signal specifies the number of steps of movement to rotate, but for this the controller needs to 'know' the position of the stepper motor on power up. Therefore, on first power up, the controller will have to activate the stepper motor and turn it to a known position, e.g. until it activates an end limit switch. This can be observed when switching on an inkjet printer; the controller will move the ink jet carrier to the extreme left and right to establish the end positions. A servomotor will immediately turn to whatever angle the controller instructs it to, regardless of the initial position at power up.

The lack of feedback of a stepper motor limits its performance, as the stepper motor can only drive a load that is well within its capacity, otherwise missed steps under load may lead to positioning errors and the system may have to be restarted or recalibrated. The encoder and controller of a servomotor are an additional cost, but they optimise the performance of the overall system (for all of speed, power and accuracy) relative to the capacity of the basic motor.

Figure 6.4 servo motor

6.5 Propeller

A propeller (colloquially often called a screw if on a ship or an airscrew if on an aircraft), is a device with a rotating hub and radiating blades that are set at a pitch to form a helical spiral, that, when rotated, exerts linear thrust upon a working fluid, such as water or air. Propellers are used to pump fluid through a pipe or duct, or to create thrust to propel a boat through water or an aircraft through air. The blades are specially shaped so that their rotational motion through the fluid causes a pressure difference between the two surfaces of the blade by Bernoulli's principle which exerts force on the fluid. Most marine propellers are screw propellers with helical blades rotating on a propeller shaft with an approximately horizontal axis.

Figure 6.5 propeller

6.6 Transmitter and Receiver

In electronics and telecommunications, a radio transmitter or just transmitter is an electronic device which produces radio waves with an antenna. The transmitter itself generates a radio frequency alternating current, which is applied to the antenna. When excited by this alternating current, the antenna radiates radio waves. Transmitters are necessary component parts of all electronic devices that communicate by radio, such as radio and television broadcasting stations, cell phones, walkie-talkies, wireless computer networks, Bluetooth enabled devices, garage door openers, two-way radios in aircraft, ships, spacecraft, radar sets and navigational beacons. The term *transmitter* is usually limited to equipment that generates radio waves for communication purposes; or radiolocation, such as radar and navigational transmitters. Generators of radio waves for heating or industrial purposes, such as microwave ovens or diathermy equipment, are not usually called transmitters, even though they often have similar circuits.

Figure 6.6: Transmitter and Receiver

6.7 Coroplast Sheet

Corrugated polypropylene material

Coroplast is a corrugated polypropylene material used in many industries. It is ideal for indoor as well as outdoor applications. Coroplast is more durable than cardboard and lighter than solid sheet. It is also stain resistant and waterproof. As with all corrugated plastic, it is widely used for signage, plastic containers, and reusable packaging. It is also used by hobbyists in do it yourself projects such as constructing cages for small animals or model aircraft.

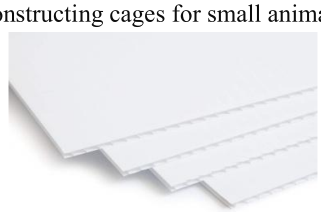

Figure 6.7 coroplast sheet

IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
Impact Factor: 6.252
Volume 2, Issue 3, May 2022

VII. Fabrication Process

7.1 Interior Section of RC Plane

Figure 7.1 Wing section

Figure 7.2 wing close section

Figure 7.3 fuslage section

Figure 7.4 rough model of plane

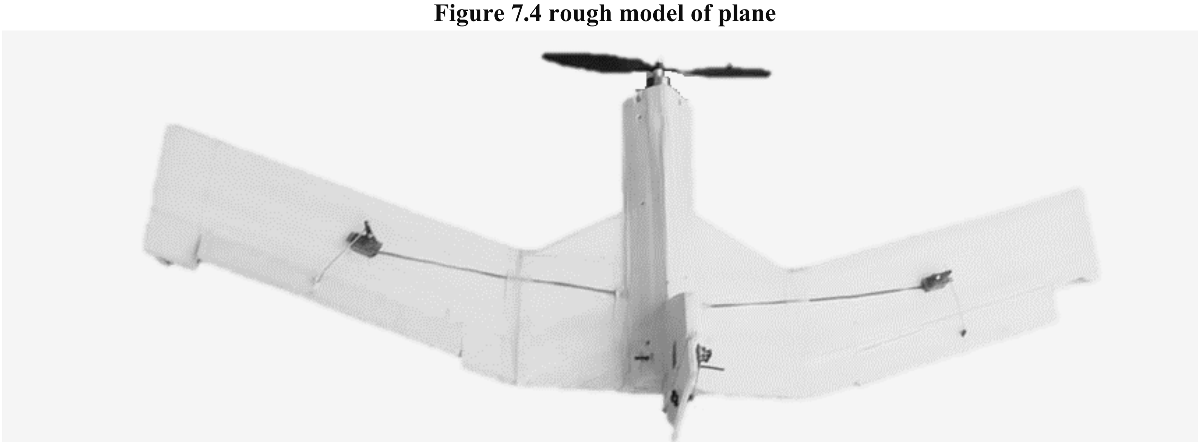

Figure 7.5 assembly of plane view

VIII. CONCLUSION

In this paper the design of the wing which is the swept forward type was fabricated as a radio controlled model and the observation of the flight was done .the result of the observation done ,points out that the radio controlled plane with the swept forward wing has higher maneuverability and slightly difficulty in controlling the radio controlled model. The radio controlled plane has done a flight test for 10 seconds and the result is that the flow over the wing is unstable, so it should be tested in a huge wind tunnel. Then only the radio controlled plane with forward swept wing will fly continuously with high speed. Thus the plane will fly with several tests in the further research.

REFERENCES

[1]. Research on aerodynamic characteristics of forward swept wing with inclined basic airfoil. -suxinbing,jiang wen, zhaoxiwei and zhangjunyi (16 may 2020)

[2]. 2.study on the influence of swept angle on the aerodynamic characteristics of the cross-section airfoil of a variable swept wing aircraft. -suxinbing,jiang wen and zhaoxiwei (january 2016)

[3]. Aeroelastic tailoring of a forward swept wing -tobiaswunderlich and saschadahne(16 june 2016)

[4]. Review and analysis of variable swept wing technology -yongyueyuan (june 2019)

[5]. Numerical study of aerodynamic characteristics of fsw aircraft with different wing positions under supersonic condition lei juanmian , zhaoshuai, wangsuozhu

[6]. Experimental and numerical studies on static aeroelasticbehaviours of a forward-swept wing model yanouyang , 1 kaichunzeng , xipingkou , yingsonggu

[7]. Theoretical and experimental study of a forward swept wing ibtisamahmed,abdulsalamdarwish,hayderjaffal

[8]. Supersonic forward-swept wing design using multifidelity efficient global optimization yukikishi, masahirokanazaki and yoshikazumakino

[9]. Aerodynamic characteristics of canard-forward swept wing aircraft configurations g. Q. Zhang, s. C. M. Yu, a. Chien and s. X. Yang

[10]. The analysis of moment characteristics of variable forward swept wing mechanism with a double slidewayxinbingsua , haoyangfengb , binlinmac , xuwangd