GROUP - 1

COMMERCIAL AIRCRAFT

Commercial Aircraft

Term: Spring 2022

Group 1

Submission date:

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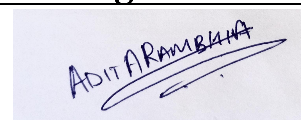
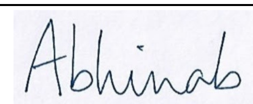
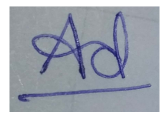
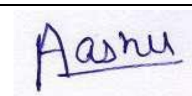
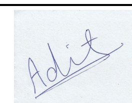
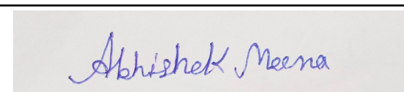
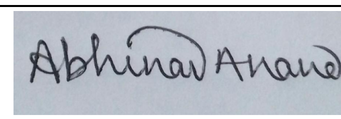
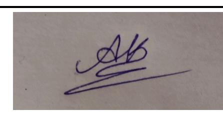
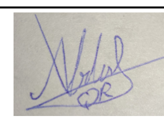
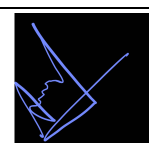
1	Adit Atul Rambhia	
2	Abhinab Mondal	
3	Aaryan Darad	
4	Aashu Singhal	
5	Adit Kaushik	
6	Abhishek Meena	
7	Abhinav Anand	
8	Abhinav Kumar	
9	Abdul Qadir Ronak	
10	Abhay Upparwal	

Motivation

Right from our childhood days, we have been admiring planes. As kids, you might recollect that we used to be fascinated when someone would point up at the sky and show us an aircraft flying miles above us. Soon as we grew up, most of us got a chance to see an aeroplane from a much closer distance, and the gigantic body, the wings, and the engines mesmerised us. Several flights later, every time I sit in a plane and look down at the diminutive buildings from my window seat flying tens of thousands of feet high in the sky, the experience still somehow feels surreal.

Flights have become an increasingly mainstream mode of travel across the world and even in countries with weaker purchasing powers, such as India, thanks to competitive pricing in the aviation industry. India is the world's third-largest civil aviation market in the world. As per credit rating agency ICRA, even amidst sweeping travel bans, India recorded domestic traffic of 274.51 million passengers and international traffic of 66.54 million passengers. As flights gain widespread acceptance, we have perhaps forgotten how impressive a technological marvel they are. Just to step back and think that we can now travel in air at blazing speeds of 700 - 800 km/h feels slightly bizarre.

Arguably one of the most disruptive products of engineering, the aeroplane has proved to be a paradigm shift in the field of transport. From the early days of the humble Wright brothers model of the plane to top of the line commercial aircrafts, there has been tremendous development in shape, design, and utility. Initially, there were only elusive two-seater aeroplanes limited to the affluent classes. However, with groundbreaking progress in technology over the last few years and the increasing air network, even the average person can afford to have a plane journey. There has been a lot of research to modify the aeroplane's range, seating capacity, and efficiency.

Finalising a topic for the project was tricky. As we discussed the possible topics for our project, we stumbled across many machines, including the spot mini robot, a naval warship, Tesla Cybertruck, helicopter, and construction crane. Ultimately we unanimously decided to model the aeroplane. Everyone was interested in modelling the aeroplane as it seemed a bit challenging and new for us. We wanted our project to be complex but not at the cost of attention to detail. As engineering students, the challenge of breaking down a machine into its components, analysing the intricacies of each part and rebuilding the machine ground up thrilled us.

First, we saw a rough sketch of a commercial aeroplane and then broke it into the main sections- the main body, the wings, and the tail. Each section had multiple sub-sections, and we divided them amongst ourselves.

There is a lot of math and physics involved in designing an aeroplane, and each part has its own unique role and is equally vital in the functioning of the plane. Each part is governed by the laws of aerodynamics and fluid mechanics, various principles and theorems like Bernoulli's principle, newtons laws, and Gravitation was used all throughout the designing of the project.

Wings and Slats

by Aaryan Darad

Overview

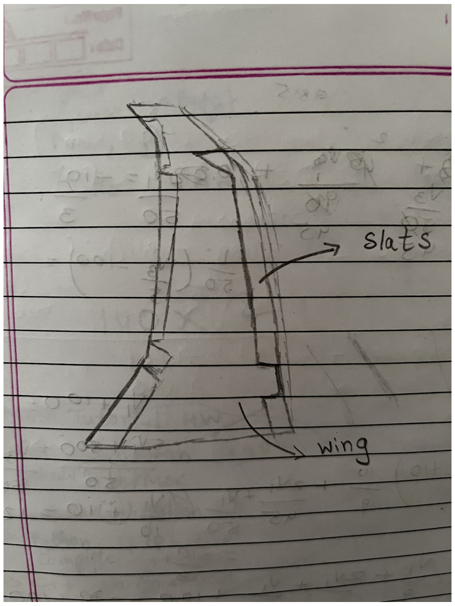
Wings are the most essential component of any aircraft. It is the part responsible for the 'Aero' word in an Aeroplane. Without it, we can't even think of giving flight to an aeroplane. The primary function of the wing is to let the aircraft cruise in the air and let it lift. It uses the difference of air pressure developed on both of its sides due to its shape to generate an upward force to balance the gravitational force and hence the lift. The wings are needed on both of its sides to keep the aircraft torque-balanced.

Slats are also one of the most critical parts of this aircraft. They help the aircraft to increase or decrease the lift at desirable(lower) speeds. *'It helps the aircraft to take off or land at relatively very less (3 to 4 times) speeds. Without the slats, we would require much longer runways for landing.'* [1]
Slats are present on the front edge of the wings, which change their orientation according to the need of the aircraft.

Basic Structure and Working

The Wing of an aeroplane has a peculiar design. The leading edge (with the slats) has a rounded cross-section, whereas the trailing edge (with the flaps) has a sharp cross-section. There are many further parts on the wings itself like the winglets, ailerons, flaps etc. *'The wings are slightly tilted upwards (Dihedral) as shown below which makes the structure laterally more stable.'*[2]

The Slats, which are present on the leading edge of the wing, have a solid but hinged design. Unlike very low-speed flights, the slats are not fixed but are movable. They drop downwards when required lift at low speeds. They have a rectangular shape, free to move according to the movement of the plane.



Wing Sketch

Slats

[2]

The core principle of the flight of a working aeroplane is related to the important branches of physics: Aerodynamics and Fluid Mechanics.
'The shape of the wings is such that the air above the wings moves faster than the lower end. Hence, from one of the most fundamental theorems of Fluid mechanics: Bernoulli's Principle, we know that "P + 1/2pv^2+pgh=constant". Where P=Pressure, p=air density, v=air velocity, h=height, g=gravitational acceleration. As the air above the wing moves fast, the pressure is low. Similarly, as the air below the wing moves slowly, the pressure is high. Therefore, the net force acts upwards which is responsible for giving lift to the aeroplane.'[3]

Another important aspect of the motion of an aircraft is to move forward. It is made possible by the thrust of the engine, which opposes the drag force provided by air resistance.

'The slats work to increase lift when speed is low (e.g. Take off, Landing, Initial Climb, Approach). They achieve it by increasing the surface area and camber of the wing. Camber is the convexity of the wing from the leading edge to the trailing end. Both of these factors combined contribute by deploying outwards and drooping downwards from the leading edge of the wing. Slats are extended and retracted using hydraulically or electrically powered actuators. There are other simplistic designs that use aerodynamic forces or springs but our model has automatically powered slats.'[4]

Challenges

The challenge I feel I will face the most is making the peculiar shape of the wing. I would have to learn how to use the AutoDesk Inventor properly for making non-trivial structures. Currently, we only know how to make some standard shapes and a few others, but to master the kind of shape we have in our aeroplane wings, I would have to have to self-learn many different skills on Inventor. Other than that, I would have to research the various dimensions of the wing parts to make an accurate model. Overall, no matter how complex the challenges are, it will be a fun experience.

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[1]: https://www.quora.com/What-function-do-slats-have-on-an-aircraft
[2]: https://www.aircraftsystemstech.com/p/wings-wing-configurations-wings-are.html
[3]: https://www.grc.nasa.gov/www/k-12/UEET/StudentSite/dynamicsofflight.html
[4]: https://skybrary.aero/articles/slats

Winglet

by Abhishek Meena

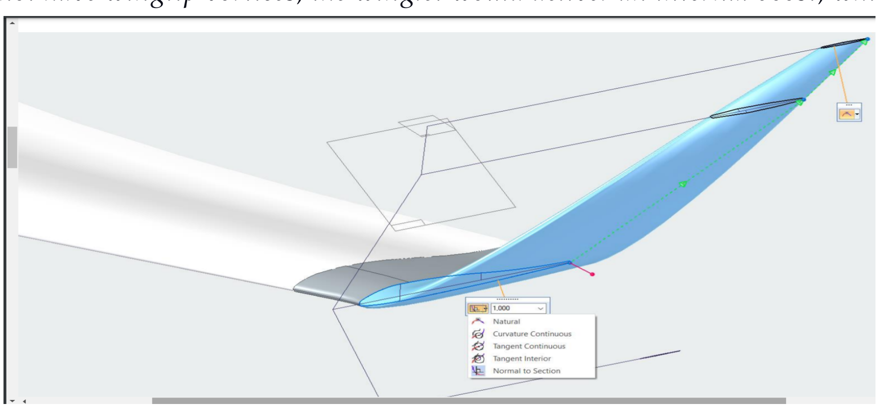
Overview

Our team is working is to model a commercial aircraft, and I will model winglets. Winglets are a crucial part of this project. The small wing that looks up at the top of the wing is called the winglet. Winglets allow the wings to function efficiently in flight, which means that the aircraft needs less energy from the engines. By significantly reducing the size of the wingtips vortex, the winglets reduce drag — the air-induced airfoil that produces the lift. The high pressure at the base of the wing pushes the air outward toward the tip of the wings. Winglets are a proven way to reduce air pollution, save fuel, cut down on carbon dioxide, release nitrogen oxide, and reduce noise. They increase the width and enable the rate of rapid rise. *"Another potential benefit of winglets is that they reduce the intensity of wake vortices"*[1].

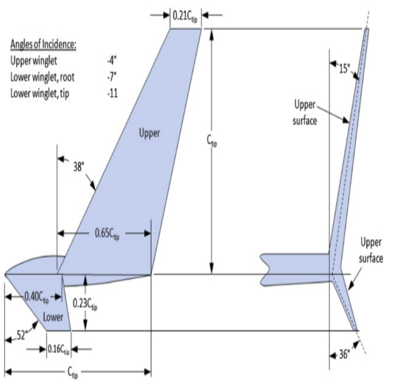
Those follow the plane and pose a risk to other airlines. Minimum requirements for space between aircraft operations at airports are primarily determined by these factors.

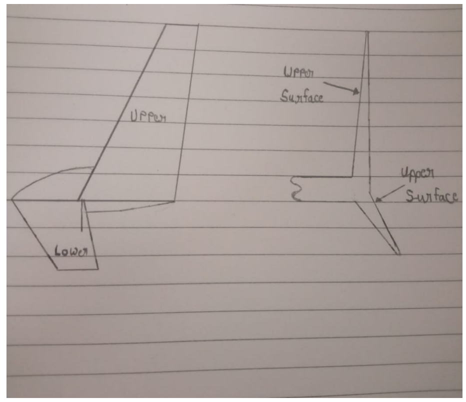
Basic Structure and Working

"The term "winglet" was previously used to describe an additional lift area in an aircraft, such as a short interval between wheels that do not change. The upward (or cant) angle of the winglet, its internal or external angle (or toe), as well as its size and shape, are essential for proper operation and are unique to each application." [1]They are made of high-quality polymers. The wingtip vortex, which rotates from beneath the wing, strikes the joint surface of the wing, producing a force that rotates inward and forward slightly as a sailboat towed nearby. "*The idea behind the winglet is to reduce the strength of the tip vortex and therefore cause the flow across the wing to be more two-dimensional"*. [2] Winglets are actually smaller wings that produce height. "*And, like any other wing, they produce a height corresponding to the relative air. If you did not have wingtip vortices, the winglet would deliver an internal boost, which is not very helpful."*[5]



The fundamental principles of aerodynamics are used for the functioning of the winglet. "*Winglets reduce wingtip vortices, the twin tornadoes formed by the difference between the pressure on the upper surface of an aeroplane's wing and that on the lower surface".[6]* High pressure on the bottom "*surface creates a natural* *airflow that makes its way to the wingtip and curls upward around it. When flow around the wingtips streams out behind the* aeroplane"[3], "*a vortex is formed. These twisters represent an energy loss and are strong enough to flip aeroplanes*"[4] that blunder into them. Winglets are straight extensions of wingtips for an aircraft's fuel efficiency and cruising range.





The winglet converts the other wasted energy in the wingtip vortex to an apparent thrust. "*Winglets and wingtip fences also increase efficiency by reducing vortex interference with laminar airflow near the tips of the wing, by 'moving' the junction of low-pressure (over the wing) and high-pressure (underwing) air away from the surface of the wing. Wingtip vortices create turbulence, originating at the leading edge of the wingtip and spreading back and forth"*[2]. This turbulence 'reduces' the airflow over a small triangular section of the outboard wing, which destroys the elevator in that area. "*The fence/winglet drives the area where the vortex forms at the top from the wing surface since the centre of the resulting vortex is now at the tip of the winglet."*[1]

Challenges

There are a few challenges I might face while designing winglets. As we are new to Autodesk Inventor, we may run into problems. Since we have only had two lab sessions so far, I find it very difficult to model the three-dimensional components. I need to do a lot of research on the details of the winglets and how they work. I need to read and understand the principles of aerodynamics to understand its working. I have to get the proper dimensions for it to work correctly.

Reference

[1]: https://en.wikipedia.org/wiki/Wingtip_device
[2]: https://nasa.fandom.com/wiki/Wingtip_device
[3]: https://www.scienceiq.com/facts/twintornadoes.cfm
[4]: https://www.smithsonianmag.com/air-space-magazine/how-things-work-winglets-2468375/
[5]: https://www.boldmethod.com/learn-to-fly/aerodynamics/how-winglets-work-to-reduce-drag-and-how-wingtip-vortices-form/
[6]: https://electronics360.globalspec.com/article/6558/boeing-s-blended-winglets-have-saved-6-billion-gallons-of-fuel

Turbofan Engine

by Abdul Ronak

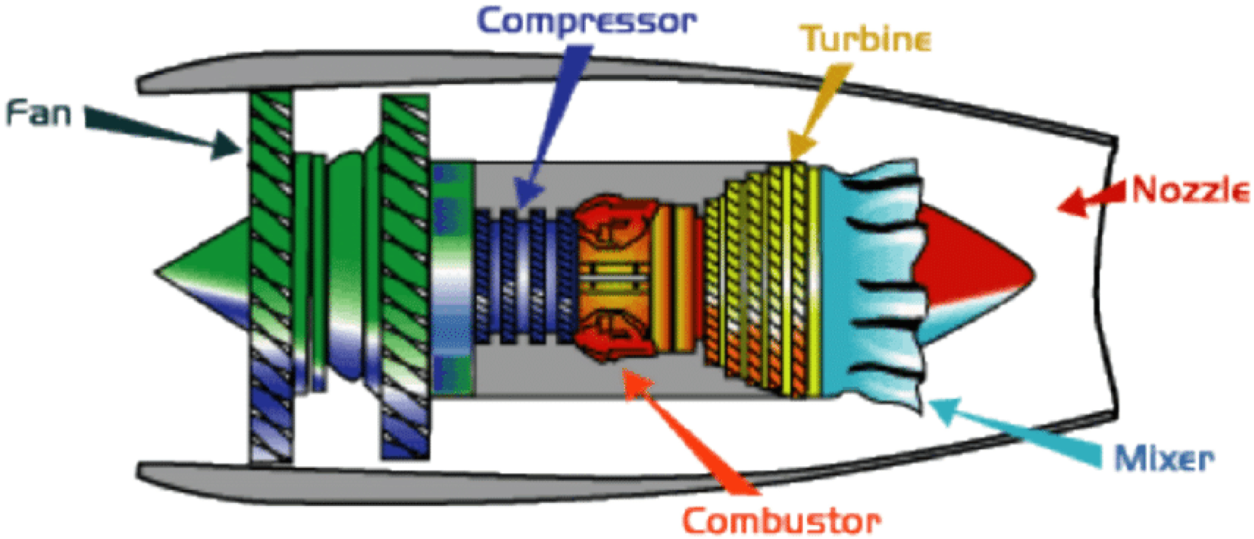
Overview

Our team has decided to design a commercial aircraft. A commercial aircraft normally carries 100-150 passengers and it takes a large amount of force to accelerate this large mass. To move an airplane through the air, thrust is generated by jet engines. Jet engines are mainly of three types- Turbojet, Turbofan, Turboprop The jet engine variant used in commercial aircraft is Turbofan Engine because of its good fuel efficiency and high thrust. The turbofan engines used in commercial aircrafts are of a high bypass ratio. "*Bypass Ratio is the ratio of the mass of air bypassing the engine core versus the mass of the air going through the core engine*".[1] High Bypass Ratio Turbofan engines are quieter, more fuel-efficient, and produce large thrust. The Turbofan engines are attached to and in front of the wings, and are attached symmetrically on both wings. Some aircraft have a total of four engines while some have two. The airplane we are modeling has two engines, one on each wing.

Basic Structure and Working

A Turbofan engine consists of a large low-pressure fan, the core engine, and a fan turbine. This core structure is enclosed in an outer cover called a fan cowl. The Fan Cowl is the smooth conical outer covering of the engine, which provides an aerodynamically smooth surface over the engine, the engine components as well as protect them. The cowl is designed so that it provides minimum drag as a large amount of air strikes it, due to the fan. The fan at the front of the engine is made of large twisted blades. The blades are twisted to increase the aerodynamic efficiency and are twisted in accordance with the bypass ratio. Also, the blades are designed so to withstand extreme pressure exerted by airwaves. The core engine is rather cylindrical and is divided into two sections - compressor and combustor. The next part is the turbine fan, which is connected to the same rotating shaft as the front fan and the compressor blades in the core engine. The accelerated air rotates the turbine which powers the front fan and the compressor. In commercial aircrafts, the turbine also powers the electrical appliances on the plane. The posterior part of the engine has a nozzle which is the exit point for the combusted hot air of the engine. The nozzle area is smaller in size to cause a high-velocity exhaust. The nozzle also contains an exhaust cone at its end. The exhaust cone directs the exhaust from the nozzle into a single jet and its aerodynamic design further increases the velocity of the exhaust.

Turbofan Engines work on the simple principle of Newton's Third Law of Motion which states that "For Every action Force, there is an equal and opposite reaction force" The fan throws the air into the engine, the engine compresses and heats it up, and throws it from the back of the engine with high speed. According to Newton's Third Law of Motion, the air mass pushes against various components of the engine which in turn push the airplane forward. The higher the speed of the exhaust gases, the higher is the speed of the plane. Hence, The reaction force exerted by the exhaust drives the aircraft.



[Image Source: https://www.researchgate.net/figure/Commercial-turbofan-engine-cross-section-showing-components_fig3_24335838]

A turbofan engine produces thrust using a combination of the core engine exhaust and the bypass air which has been accelerated by a large low-pressure fan that is driven by the core engine. The large fan at the front sucks the air inside it. Due to the high bypass ratio, maximum air is moved to the outside of the engine core. The bypass air creates additional thrust and cools the engine. In the modern turbofan engine, the majority of thrust is provided by the bypass air.

Some of the air sucked inside goes to the core engine. The core engine compresses, speeds up, and heats the fuel-air mixture. The heated air from the core engine is then moved through the turbine. The air rotates the turbine which in turn rotates the fan at the front being connected with the same shaft. After running the turbine, the heated high-speed air from the engine mixes with the low-pressure bypass air. The high-speed air then shoots out the back. Here, according to Newton's Third law of motion, the air press against the engine and thus pushes the aeroplane forward.

Challenges

Considering our current knowledge of 3D Modelling, the task seems impossible. Specifically considering the turbofan engine, the challenges I think I would face are:

- Modelling the twisted fan blades would be very much difficult because of their complex shape.
- The shape of the fan cowl will also be difficult to model.

Further, there are more such aerodynamic, curved shapes in the aircraft which would be very difficult to model.

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[2] https://www.youtube.com/watch?v=EoTemziGfis
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[4] https://en.wikipedia.org/wiki/Turbofan

[5]
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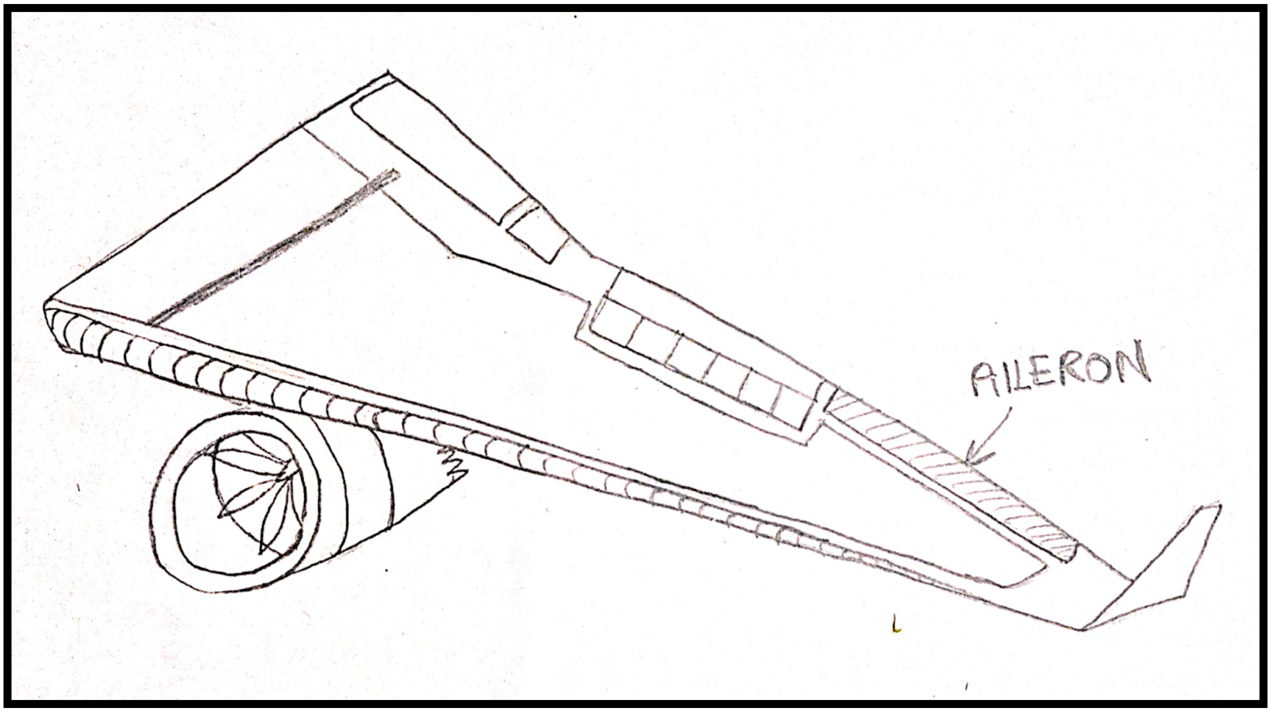
[6] https://www.quora.com

Aileron

by Adit Kaushik



Overview

There are two types of flight controls on an aeroplane- primary and secondary. Primary parts include ailerons, elevators and rudder. Each of these three pilot controls changes the plane's direction through the air. They move the aircraft around one of the three axes of flight. Secondary parts include Spoilers.

Ailerons are one of the primary pilot controls. Aileron is a french word for "little wing" or "fin". It is not a part that many people know of. It is a small but crucial part as it helps the plane take turns during the flight. It is difficult to say who invented this part, but it was so important that the Wright brothers and Glenn Curtiss fought the famous, year-long patent war over it, costing millions of dollars on each side. In modern planes, this part is combined with the flap, and they are together known as the Flaperon.

Basic structure and Working

Ailerons work in pairs. One each is present on the trailing edge of the bigger front wings of an aeroplane. Apart from this, the structure of ailerons is modified according to the needs of different aircraft.

For example, in propeller-powered aircraft, there are smaller-aileron like structures on the trailing edge of the aileron. This is because the "propeller's *rotation induces a counteracting roll movement (due to*

Newton's third law of motion, which says every action has an equal and opposite reaction)" [1]. "*To relieve the pilot of providing continuous pressure on the stick in one direction (which causes fatigue), trim tabs are provided to adjust or trim out the pressure needed against any unwanted movement"*.[2] And in military aviation, ailerons are not on the wings but are separately attached to the aeroplane's body (to provide better control while rolling) and are called tailerons. Tailerons additionally permit wider flaps on the aircraft's wings.

When the aeroplane is flying, a net upward force acts on it due to the difference in air pressure above and below it. Many people who have travelled in a plane know that when the plane takes a turn, it does not do so like a car. Instead, it rolls along an axis parallel to its length and passes through its centre. In this position, that net upward force tilts, and hence, there is a component of that force in the horizontal direction. This horizontal force is responsible for turning the aeroplane. Ailerons help in controlling the plane in such a position.

Ailerons are used in pairs to control the aircraft's movement around its longitudinal axis. Each of the Ailerons can independently flap up and down. They do so in synchronisation to help the pilots control the tilt of the aeroplane. "*Ailerons usually work in opposition: the right aileron is deflected upward, the left is deflected downward, and vice versa"* [3]. When the pilot wants to turn left (or he turns the

control wheel to the left), the left one goes up, and the right one goes down, and when he wants to turn right, the right one goes up, and the left one goes down. If the pilot is turning left, for example, then the right-wing will experience less lift than the left-wing due to ailerons. The net effect will be that the plane will roll along its longitudinal axis, and the horizontal force that we talked about in the "Science behind it" subsection above will make the plane turn left.

But, all this comes with a price- extra drag. Due to the ailerons opening up and the aeroplane tilting towards the left, the aeroplane's body does not remain as aerodynamic as before. As a result, the aircraft would want to turn right along a vertical axis passing through its centre of gravity. To counter that, the aeroplane would use its left rudder and elevators. The right aileron is going up, and the left aileron is going down.

Challenges

The readers might have already understood that the aileron is an important part as it helps the plane make turns. Making the shape correctly is essential. I never studied aerodynamics in detail. Therefore, I might have to learn about the aileron's correct shape. Its length should be such that it perfectly fits its cavity in the wing. Moreover, as I am new to Autodesk Inventor, I don't know how to attach it to the aeroplane with a hinge so that it can flip to and fro. But I am excited to explore new ways on Inventor.

Through this project, I learned how the aircraft turns. Never before I knew how complex it was, and I was amazed that it involves so many parts.

References

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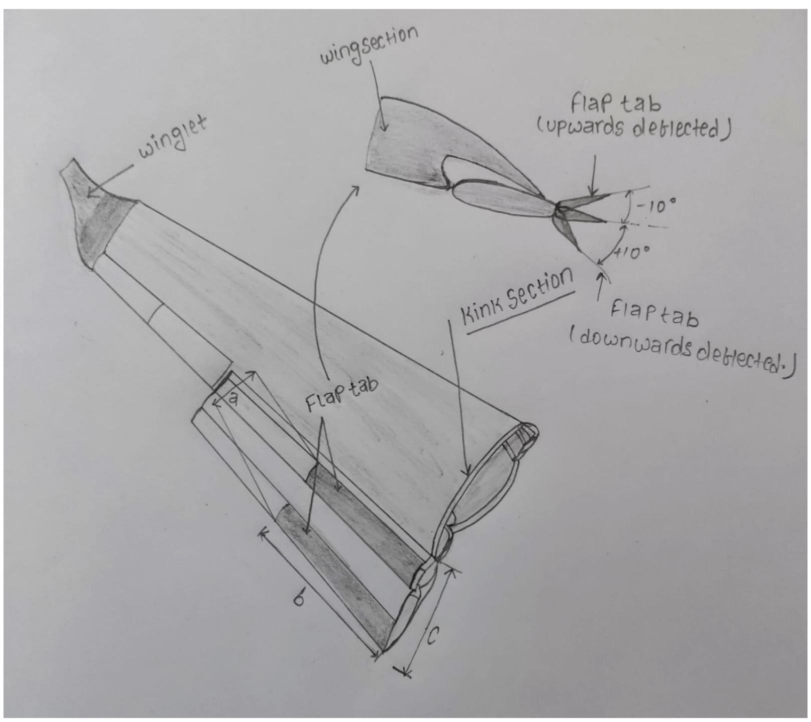
Flaps

By Abhinav Kumar

Overview

Our team decided to make a 3-D model of an airplane. Nowadays aeroplanes are the most useful for travelling and also for transportation for a vast distance in a very short time. First, The Wright brothers invented the aeroplane and flew it in 1903. After them, there were many innovations in aeroplanes to make them faster and more efficient. The Boeing is most efficient in flying with a huge load to a very large distance, from one corner to another corner of the world. It will bring a revolution in the world of aeroplanes. This impressed us so much that's why we decided to make this. Our model has many complex parts. We divided it into 10-15 small parts, and all had to do one or two parts. I got to make flaps, which is one of the main parts of an aeroplane.

Basic Structure



Flaps are on both wings of the aeroplane, which controls the drag as when an aeroplane flies at a very high altitude then it requires very low drag, but when it has to take off and land at a short runway, then it requires a lot of lift out of the wings at low speed now both things are not possible with the same structure, so flaps changes to give required drag. Flaps allow it to change both the shape and size of the wing during mid-flight. It changes the wing's shape from streamlined to curved shape as per requirement it can also be extended to make wings curvature larger, it creates quite a lot of drag which is good during descent to add a reasonably steep angle, when it need not accelerate and also when the runway is short it can be used because more drag is required during takeoff or landing at low speed. There are many different designs of flaps, depending on the size, speed and complexity of the aircraft or according to their use. Some of these are plain flaps, slotted flaps, gouge flaps etc.

I don't know much about the science behind aeroplanes, especially about flaps, but it was always a topic of interest for me to know. Hence, I searched on Wikipedia and got some exciting things about it. I'm attaching a link to that page https://en.wikipedia.org/wiki/Flap_(aeronautics)
The general aeroplane lift equation demonstrates these relationships:

$$L = \frac{1}{2}\rho V^2 S C_L$$

Where:
L is the amount of Lift produced,
p is the air density.'
V is the true airspeed of the aeroplane or the velocity of the aeroplane, relative to the air.'
S is the area of the wing.
CL is the lift coefficient, which is determined by the shape of the airfoil used and the angle at which the wing meets the air.
According to this formula, we can see that increasing the area (S) and the lift coefficient (CL) increases the amount of lift generated at the lower speed (V).

Hence, flaps play an important role in increasing the lift for any given load and airspeed.
As we know, flaps change from time to time, like during takeoff, mid-flight and landing.

1. During takeoff, flaps may be partially extended depending upon aircraft, runway distance and load also.
2. During landing, flaps may be fully extended to retard the aeroplane and also help to land on a short runway.
3. During mid-flight, flaps are adjusted to control the speed of the aircraft.

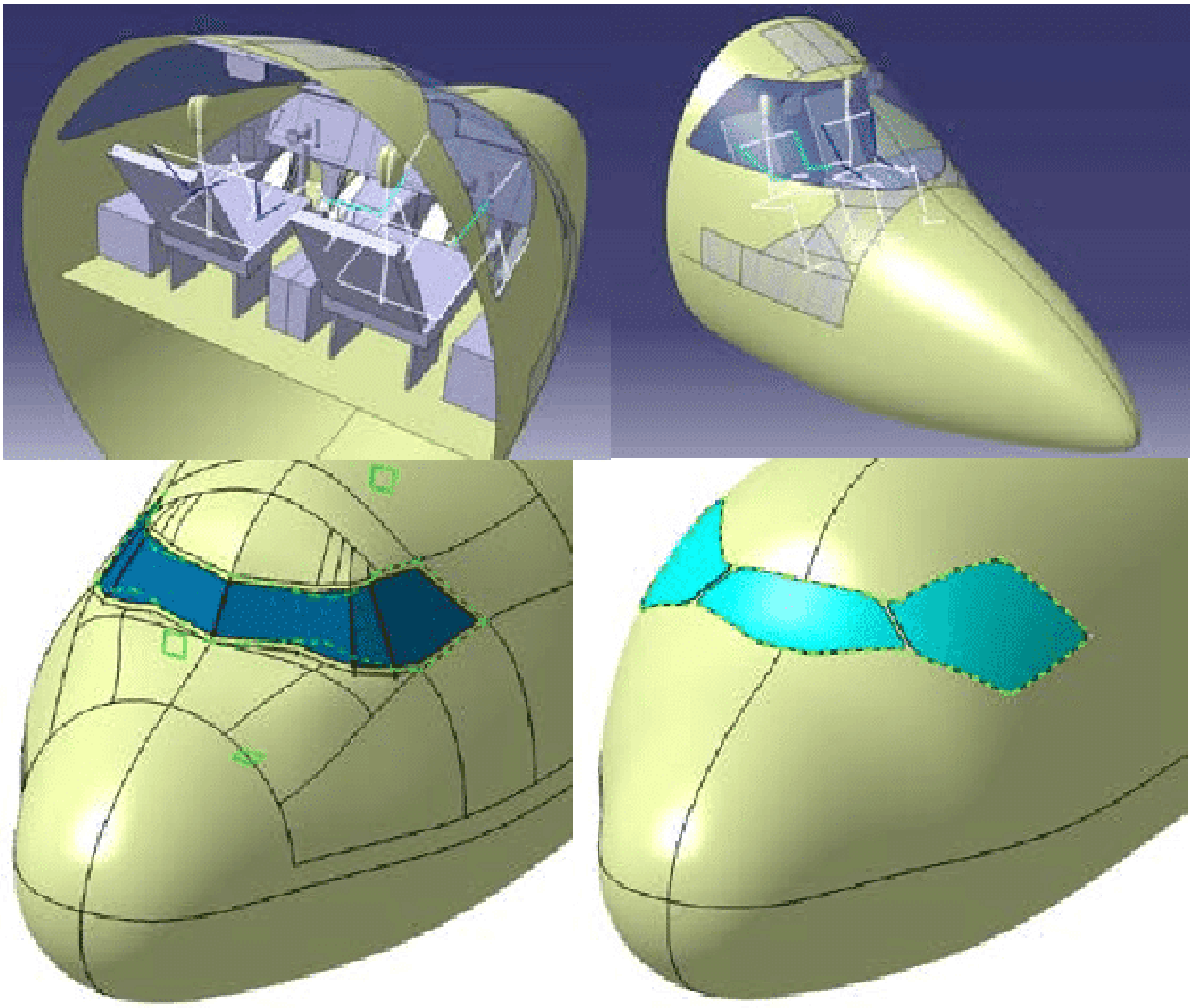
Also, there are many types of flaps named according to their composition and uses. Some of these are plain flap, split-flap, slotted flap, fowler flap, junker flap, zap flaps etc.
And many other scientific theories and calculations are involved in aeroplanes. It will be interesting to learn about that during this project. I'll love it.

Challenges

As we have attended only two tutorials of Autodesk Inventor, we will face some difficulties in forming all parts and also deciding the dimensions of each component. It's a bit difficult, but I think we will complete it with our teamwork and also with the help of our TA it is an interesting thing. Also, we will learn many things.

Cockpit

by Abhinab Mondal



[1]

Overview

Equivalent to the control centre of the aircraft, without the cockpit, the plane would be stuck to the ground. In an aeroplane, the cockpit is the frontal part of the body. Also called flight deck, the cockpit seats the pilot and houses all instruments and control equipment required to monitor and manoeuvre the aircraft. In addition to that, it also contains communication systems for pilots to talk to other aircrafts and air traffic control.

"The word cockpit seems to have been used as a nautical term in the 17th century, without reference to cock fighting. It referred to an area in the rear of a ship where the cockswain's station was located, the cockswain being the pilot of a smaller "boat" that could be dispatched from the ship to board another ship or to bring people ashore. From about 1935, cockpit came to be used informally to refer to the driver's cabin, especially in high performance cars and this is official terminology used to describe the compartment that the driver occupies in a

Formula One car. In an airliner, the cockpit is usually referred to as the flight deck, the term deriving from its use by the RAF for the separate, upper platform in large flying boats where the pilot and co-pilot sat."[2]

Historically cockpits were open air. Pilots would look outside the cockpit to navigate the plane. Open air cockpits also provided an unhindered ground view. Gradually more advanced equipment was developed, enabling pilots to fly in low light and visibility conditions. Today pilots can fly even in poor weather conditions.

Basic Structure

The cockpit consists of a nose, glass canopy and a door. The nose is the frontmost part of the cockpit, which gives it a distinctive conical shape. The nose is made out of a fibreglass composite. It is designed to modulate oncoming airflow behaviours and minimise aerodynamic drag. The door separates the cockpit from the flight cabin. The door is made out of kevlar. Ever since the tragic September 11 attacks, aircraft doors have been reinforced to prevent hijackings. The windows made of six centimetres thick reinforced glass. The glass is multilayered and can handle temperatures ranging from minus 60 degrees to 40 degrees. Anti-glare coating helps pilots naviagate at high altitudes without being blinded by sunlight.

Challenges

The biggest challenge I anticipate in designing a cockpit and perhaps in a greater sense the entire project is working with irregular curved surfaces. Our project involves a lot of intricate and asymmetric curves, many of which I can't perfectly realise in three dimensions at the moment let alone model digitally. Even the slightest deviations in nuances of the design would have significant consequences in the aerodynamics of the model. Working on the first tutorial in the course I struggled a lot modelling seemingly simple and symmetric shapes. I realise the learning curve is going to be steep and this project might prove to be painstakingly difficult. However I am ready for the challenge and expect to learn a lot doing this project.

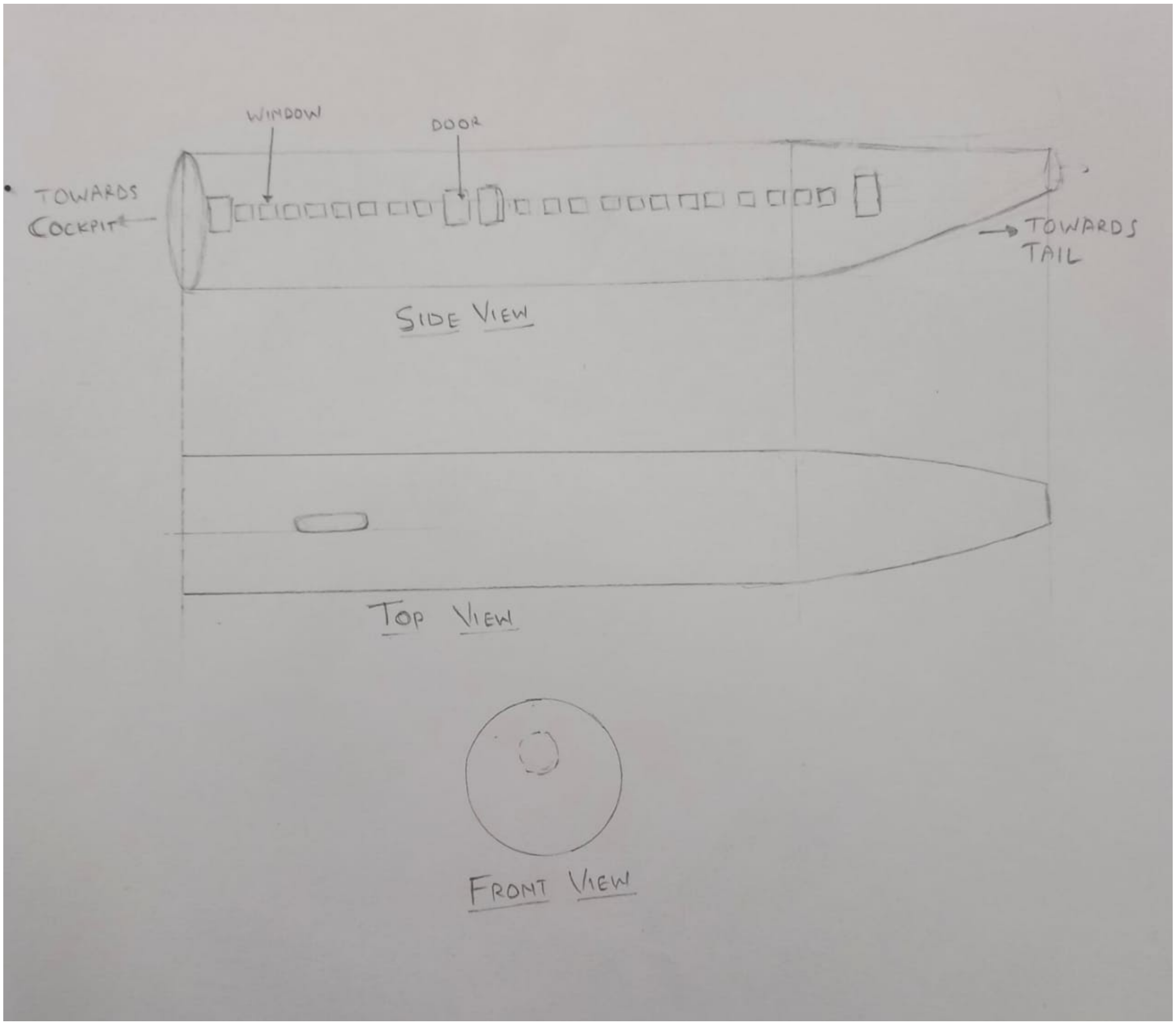
References

[1] - https://www.researchgate.net/figure/Cockpit-and-Windshield-model-16-17_fig5_314389000
[2] - https://en.wikipedia.org/wiki/Cockpit

Fuselages

by Adit Rambhia

Overview



We decided to make an aeroplane since it is one of the best modern-day engineering innovations. Aeroplanes are now one of the fastest and most comfortable ways to travel long distances. Today they are used to transport humans, animals and freight from one corner of the world to another. Throughout the years, there has been tremendous research in bettering the design, selection of materials, and improving fuel efficiency.

The part that is allotted to me is the fuselage. It is evidently the main body of the plane and one of the most critical parts. It is the part that holds all the other components together. In commercial aircraft, the entire weight is left upon the fuselage, whereas the fuel weight is carried upon by the wings. The weight carried by the fuselage is the weight of the people, cargo and baggage.

Basic Structure and Working:

Nowadays, the fuselage is not shaped like a frustum, but it has a regular cost section area throughout (except the cockpit and the tail). This is done to reduce the cost of manufacturing the body and gives the manufacturer many options as they can customize the length of the plane as per the required features (i.e., long-range or better cargo capacity).
The fuselages also contribute to about 25 – 50 % of the total drag received by an aircraft. Hence its accurate design is of utmost importance. Any extra protruded part on the fuselage will increase the drag and will reduce the efficiency of the plane.
Along with the body, I will also have to design the doors and windows. Door are important as they are the gateway between the interior and exterior of the plane. We need to accurately place the doors on the body such that they connect the passenger aisle of the aircraft. Windows provide a better flying experience to the passenger as it shows them unparalleled views from the top.
To design the shape and model the fuselage, I have used-
· Bernoulli's principle
· Aerodynamics
There is a lot of physics and math involved in it. Physics is applied to make the body aerodynamic, and mathematical functions have helped us design the exact shape so as to reduce the drag as much as possible. The concept of fluid mechanics is also used profoundly in the modelling of the body.

Challenges

Since we have attended only two practical sessions of Inventor 3D, I don't know exactly how difficult each part would be. Another challenge that I'll face is to integrate all other parts of the plane and add them to the fuselage. Giving a proper circular shape to the body will also be a difficult task. Designing and setting up numerous small windows and doors will also be pretty challenging with very limited

knowledge of Inventor 3D. Learning new tools and tricks to better our design will also be an important part. All these parts seem too overwhelming and impossible to make right now, but I am confident that with the help of instructors, tutors, and TA's, I will be able to do it.

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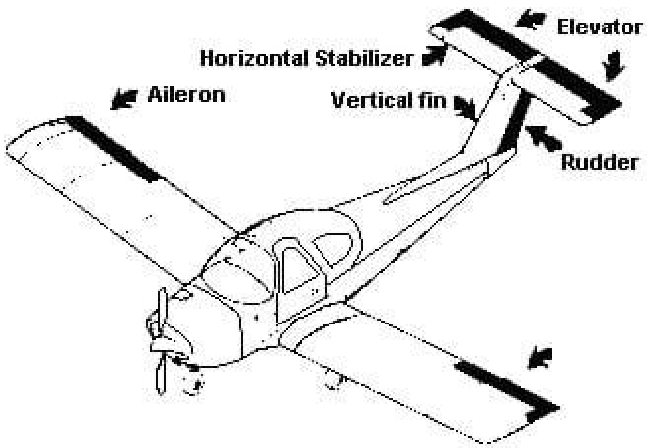
https://www.fzt.haw-hamburg.de/pers/Scholz/HOOU/AircraftDesign_6_Fuselage.pdf

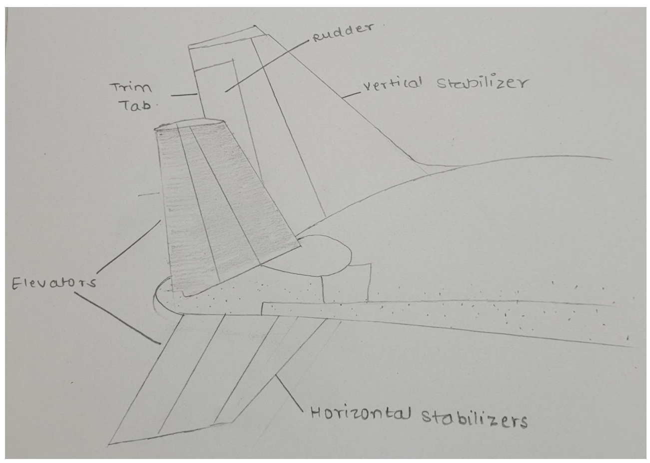
Stabilisers (Horizontal and Vertical)

by Aashu Singhal

Overview

"Boeing 777 which is a passenger preferred aeroplane along with great and superior range and excellent fuel efficiency is a great carrier around the world".[1] It is made up of different parts joined together which are equally important and is very important for the correct functioning of the aeroplane. We decided to take it as a topic of our project because the things we see in our day-to-day life which seems to be so simple actually are made up of different and complex parts. Some of its parts are vertical and horizontal stabilisers which are attached at the tail of the aeroplane. Horizontal stabilisers are a very important part as "*they control the up and down and the motion of the aircraft nose.As the elevator moves, it varies the amount of force generated by the tail surface and is used to generate and control the pitching motion of the aircraft whereas vertical stabilisers enable trim in the yaw(oscillation about vertical axis) direction"* [2].There is an elevator attached to each side of the horizontal stabiliser which also plays a significant role.The basic function of them is to provide stability in horizontal and directional axes during flight.





Basic Structure

The tail of the aeroplane which is also known as empennage consist of the vertical stabilisers, horizontal stabilisers,elevators and rudders.

Horizontal stabiliser

Small horizontal tail which is also known as tailplane. *It consists of a fixed surface fitted with a hinged aft elevator(flight control surfaces) surfaces .They are placed such that they have a downward load to prevent the nose-down movement of the aeroplane. It has flaps (elevators) which can be moved up or down according to our need which ultimately affects the force acting on the stabilisers and help the pilot to move the aeroplane nose up or down in pitch*[3]. Trim tabs are also present on it sometimes which are the small surfaces connected to the trailing edge of a larger control surface. The horizontal stabilisers are critical in compression due to bending.

Vertical stabilisers

(also known as tail fin) is the stationary part of the vertical tail of the aircraft. It is present on top of the rear fuselage at a certain angle to prevent the torque of the engine.*It makes the fuselage to roll in opposite direction to the turning of the propeller* [4]. Rudder, which is the directional control surface, is also hinged to the vertical stabilisers.

Working

Horizontal stabilisers create an upward force which balances the aeroplane horizontally. *When the aeroplane is flying it pushes the air upwards to avoid swings in trim.It is made of material from which the fuselage is constructed and consists of small and thick pieces of that material* [5].
Vertical stabilisers are very important as *they minimise the side slip which basically means to slide sideways in downward direction along a lateral axis by taking it off to its intended course.it consists of a small and thin piece of material that looks like a miniature wing. The vertical stabiliser, however, is installed vertically on the aeroplane's tail, whereas the horizontal stabilisers are installed horizontally on the aeroplane's tail* [6]. Some aeroplanes have multiple vertical stabilisers such as military aeroplanes.

Challenges

We can face many challenges while designing the stabilisers as they have to be present at a certain angle only and any small deviation from it can cause a very big outcome.As the product to be come out of it is very great in size so we have to be careful at each and every step to avoid any error. As this is the first time we are designing a 3-D model so we can face many challenges like the error in measurements or angles between different parts. There are also many curves present in the structure so it is the greatest challenge to construct them as the radius for the fillet has to be accurate.

References

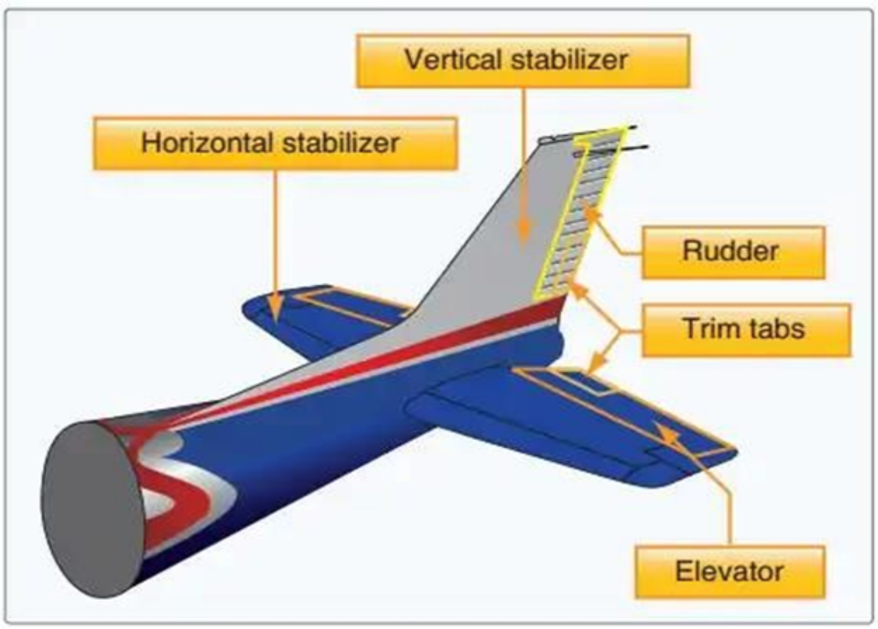
[1]:https://www.boeing.com/commercial/777/
[2]:https://www.grc.nasa.gov/www/k-12/airplane/elv.html
[3]:https://en.wikipedia.org/wiki/Stabilizer_(aeronautics)
[4]:https://en.wikipedia.org/wiki/Vertical_stabilizer
[5]&[6]:https://en.wikipedia.org/wiki/Vertical_stabilizer

Rudder

by Abhinav Anand

Overview

The rudder is an essential part of any aircraft. It helps in steering the aircraft about the vertical axis. It is usually mounted in the back position of the aeroplane. It is a part of the vertical stabiliser. We can compare it with the tail of the buffalo that helps her during swimming to change the direction. It is used in aircraft as well as in ships too.



Basic Structure:

For fighter aircraft like F-16, its size and shapes are somewhat different. The thickness of the rudder is more at the bottom part and very thin at the higher part. This is done as the air drag is more in the upper part. It is controlled by two fixed pedals, left and right.

In ancient times, similar types of things were used in ships to control their direction. The science behind it is almost the same for the aircraft. It works by deflecting the airflow. As the person moves its direction, airstrikes to its side and creates a pressure difference on both sides of it. This pressure difference or the force difference changes the aeroplane's direction. How the directions of the plane are changed can be understood by this picture.

Challenges

There were many challenges during its creation. The earliest type of rudder was controlled by a single paddle. But that was not so effective. Then it was changed to two paddles controlled. Also, there were many improvements in their shape and size. Many research paper has been published on the dimensions of the rudder. A significant level of calculation is done in making this. Majorly the improvement was made according to the weight of the planes, speed and the thrust on the different levels of the rudder.

During the 1990s, some major issues happened with the Boeing plane. Two planes got crashed during the landing. The first accident happened in March 1991. It happened when the pilot was attempting to land the plane. This crash caused the death of all 32people on the plane. The investigation couldn't be able to find the cause of the crash. The second accident happened in 1994 that caused the death of all 132 people on the plane. During the investigation, it was found that the rudder was damaged, but there was not enough concrete evidence. The third incident happened in the same model (Boeing 737), but this time pilot was able to land it after having a problem with the rudder. He explained all the problems faced during the landing. These incidents forced the manufacturer to amend the rudder.

References

[1] https://aerocorner.com/blog/how-airplane-rudder-works/
[2] https://en.m.wikipedia.org/wiki/Boeing_737_rudder_issues
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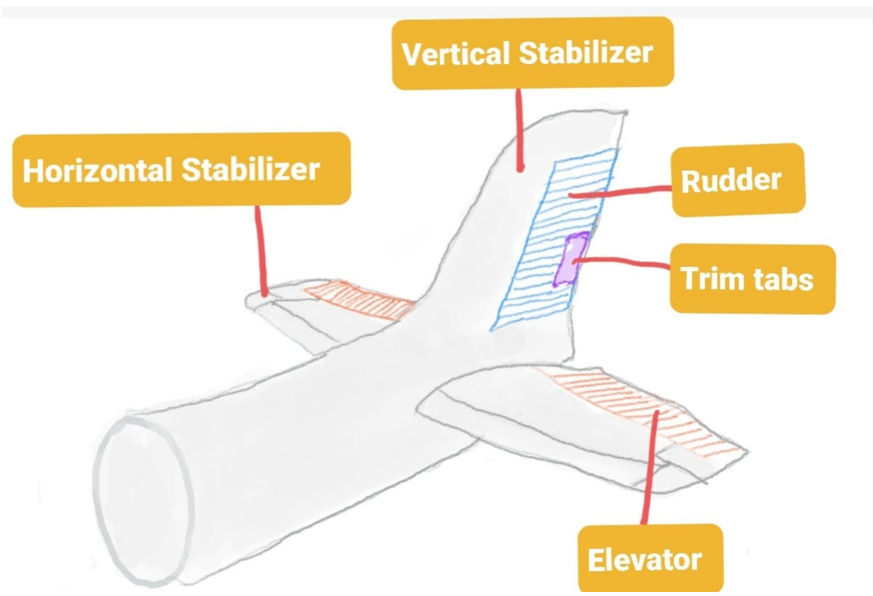
Tail and Elevator

by Abhay Upparwal

Overview

The elevator is one of the most essential parts of an aircraft. It directs the plane in a particular direction as directed by the pilot. When a pilot pulls up or pulls down on the yoke, the elevator moves and makes the nose of an aeroplane go up.

Basic Structure and Working



Our model seems to be complex since it has a large number of parts. Thus, we have divided the parts and then sub-parts under it, and I am going to look after the elevator of the tail. The elevators are the controls of the aircraft, usually the rear of the aircraft, which control the altitude of the aircraft, hence the angle of attack and wing lift. The elevators usually rely on the tail or a horizontal stabiliser. They may be the only existing voice control system and are sometimes located in front of the plane (early planes) or attached to a rear plane, also called a slab lift or stabilator. The elevator is a useful vertical and horizontal machine that controls the plane. A horizontal stabiliser generally creates a vertical force that balances the decreased nose created by way of the wing elevate pressure, generally running at a particular vicinity (centre wing elevate) placed near the toes. The effects of drag and exchange engine thrust can also cause elevations that need to be compensated with horizontal stabilisation.

Both the horizontal stabiliser and the elevator make contributions to the stability of the voice, but only elevators offer voice manipulation. They achieve this by means of reducing or increasing the minimal strength generated via the stabiliser: growing pressure downward, produced through an ascending

elevator, forcing the tail down and the nose up. At steady speeds, the growth in wing attack attitude causes an enormous peak to be generated by using the wing, accelerating the flight to the surface. Traction and strength call for also is increasing; a decrease in the force of the tail that produced through the decreased elevator causes the tail to upward push and the nose to decrease. At a consistent pace, the drop in the assault perspective lowers the altitude, accelerating the flight to the ground.

For maximum low-velocity planes, the deck tab is positioned in the back of the elevator, and the pilot can regulate it to remove strength from the control column at higher altitudes and at the desired pace. Supersonic planes frequently have stabilators due to the fact the shock waves generated inside the horizontal stabilisation zone substantially reduce the efficiency of the extended elevators at some stage in high-altitude flights. Delta winged planes integrate ailerons and elevators - as well as sequential manage inputs - right into a single manipulate factor known as elevon.

Challenges

We may face many challenges while designing the elevator as they are a very crucial part of a plane and need to be made with accuracy and fixed at an exact angle as even a minor defect will cause major problems in directing the plane. As it is the first time we are designing a 3D model,

we may face challenges in designing it, like errors in measurement and angles between different components, as it will be difficult to imagine all the parts in 3 dimensions. The greatest challenge is the body of aircraft as it has a lot of curves and we have to make all these by keeping in mind the aerodynamics which is completely new for us.