Aircraft Maintenance
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Lecture – 08
Basic Aircraft Design

Good morning friends, I am really happy that this course is being offered, primarily for my friends who are involved in maintenance. You all will understand that how important it is to keep an aircraft air worthy. You must be knowing me if you are attending performance and stability control course offered by NPTEL MOOCs; I am professor Ghosh; I am heading Aerospace Department IIT Kanpur and I have a long association with flight laboratory.

Where we have got so many aircraft, I will do experiments for teaching and research purpose. The basic question is when my student or me; sits in the aircraft, they need to feel assured that best has been done as far as maintenance is concerned so, that airplane is not only air worthy it is safe and comfortable. So, who is the task force? It is the maintenance team, my chief engineer Mister Vipul Mathur is taking primarily this course with an aim, that when you go for license exams, you are well prepared on the seriousness of the maintenance protocols.

Why I am here? I understand maintenance becomes a manual driven activity, although I do not agree completely, but it is a fun; it is highly enjoyable if you understand why we are doing? Or Why we are following those instruction given in the manual; there is a purpose to that and it has been evolved after serious considerations, where a large time period lot of testing's. In doing that, there is a possibility that we forget or we do not pay attention on the basic question how does an aircraft fly?

So, to bridge that gap; I am taking module which will give some sort of an understanding for you, how does an aircraft fly. If we know how does an aircraft fly? Then the next question comes; how do we ensure that I should be able to maintain that status of an airplane where it can fly safely. I can maintain the status where the passenger, the pilot feels comfortable, that is biggest role of an maintenance engineer.

So, if I ask this question to myself how does an aircraft fly? I will simply start thinking; if I throw a stone like this because of gravity, it has a natural tendency to come down.

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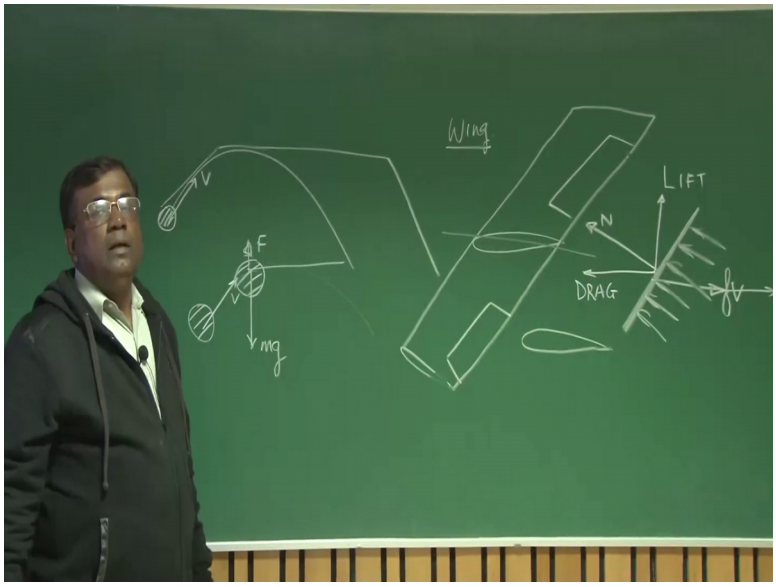

But when I am talking about any aircraft; I want it should go up and go certain distance and when I desire, it should come down. So, this is different from just throwing a stone and if you see now here, if I want this stone to go up once I have given a velocity V.

If I want that it should not just come like this; that means, the moment it tries to come down, I need to have a force upward. So, if I draw it like this is the mg gravity force, I need to generate a force F here; which should cancel this pull of the earth so that it can go straight, this is simple thinking. The question is, how can I generate this force? And that is what the concept of a fixed wing aircraft, and you all know who generates that force? And that is wing.

If you see a wing it will be something like this, this is aerofoil and if I draw it like this is typically cro a wing, where at each cross section you have an aerofoil typical shape which is primarily to accelerate the lift generation, what is lift? Let us see if I take a plate like this, and if I somehow move it with speed V.

How can I move it with speed V? Let us say I put an engine gives a thrust. So, I can always go the forward direction if I do this like this then, because of reactions offered by the resistance by air, it will have a normal force N right. Now if I resolve this normal

force, one in the opposite direction of V and one perpendicular to the V with the component which is perpendicular to the V or the speed is called lift.

Because, it is lifting the body and this opposite which is trying to reduce the speed, we call it drag as and lift and drag are two important things. The primary lift, I get from the wing. Larger the area more the lift larger the speed more the lift, better this contours more the lift. So, if it is better this contour that means, once you fix a contour of an aerofoil, a maintenance engineer will always inspect that the contour is maintained or not.

Over a time is there any possibility that contour has been deformed, then you lose the lift. If it is the area is looking after you will see because, there is a large span whether wherever the joints are there the rigidity is there or not over a period of time, whether there are some corrosion or some small failure has started occurring. So, that is again maintenance man looks for it. Then you have seen there are surfaces called aileron which moves up and down like this.

So, maintenance man we look for whether as per the manual, how much deflection you should have for a particular stick movement, whether there have having or not or there are some misalignment right, because if there are some misalignment then the pilot will have a different feel. So, once we have a wing and we know that I need to generate a lift we should balance weight.

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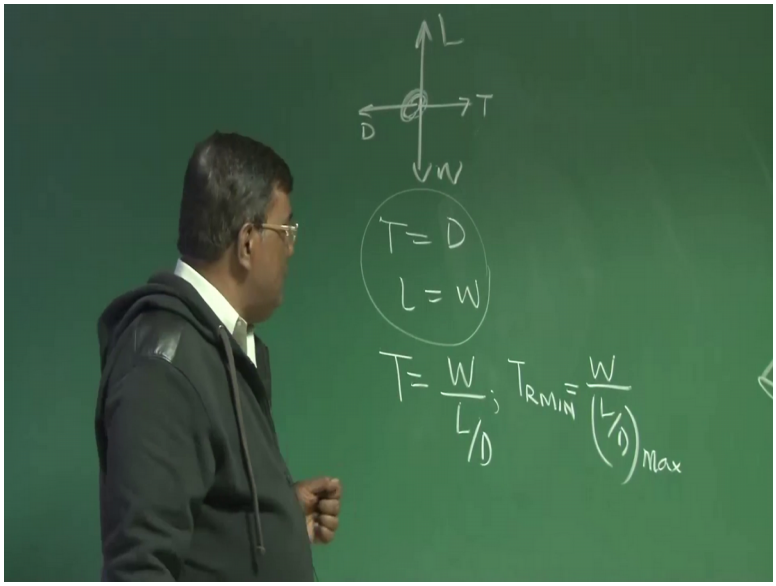

So if I see like this, I somehow should generate lift we should balance the weight and whatever drag it is experiencing, I should have enough thrust to counter it. Once I ensure thrust and drag are equal a lift and weight are equal, that means, net force acting on this airplane is 0.

So, as per Newton's law it will maintain whatever state it has. So it was moving with let us say 100 meter per second, and if you somehow can manage lifting all the weight and thrust equal to drag, then it will keep on moving at 100 meter per second right is the inertia.

But once I write like this, what happens? I get more information, the thrust will be equal to I can use these 2 equation, I can thrust equal to weight by L by D that is weight by lift to drag ratio. That is if I am a designer of an airplane, I should always want thrust required should be minimum, which means for a given weight L by D lift to drag ratio should be maximum, simple? To keep lift to drag ratio maximum I need to ensure that the contour of the wing is maintained and thoroughly checked, that there are no deformations, something which you know that it comes under your subject of rigging.

This is one you need to understand and second thing what is more important that when I thinking of an airplane how does it fly, one thing I have realized that.

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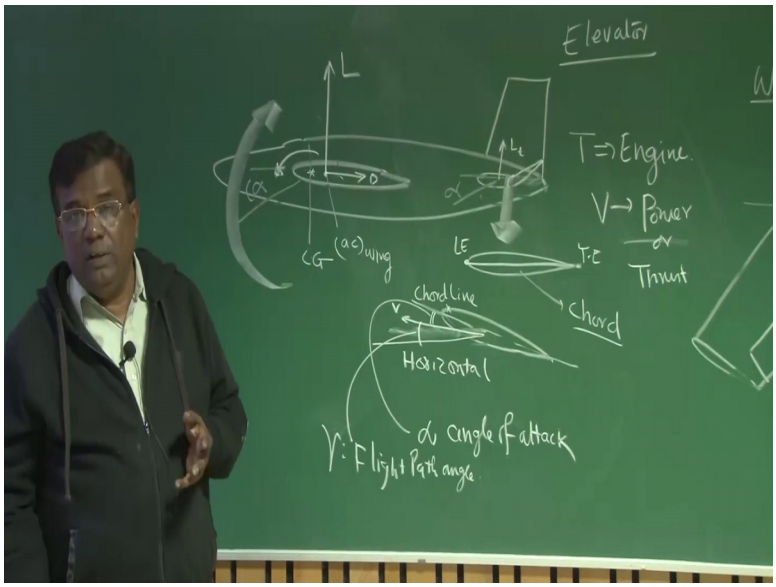

If this is my first lodge, this is my wing right, let us say this is somewhere CG is here center of gravity of the airplane, and this is your horizontal tail, this is a vertical tail and let us say this is the aerodynamic center of the wing. Now what will happen if I want to fly I need to have some angle between the velocity vector and the wing right, which we call angle of attack. If I typically draw if this is my aerofoil cross section of the wing, and if this airplane is going with speed let us say climb being with a speed V and let us say this is the horizontal.

Then the angle between the chord line, what is chord line? If this is my aerofoil this is the leading edge, this is the trailing edge, if I join them by straight line this becomes the chord of the wing chord of the wing. The angle between the chord line and the velocity vector is what we talked about alpha the angle of attack.

The angle between the velocity vector and the horizontal we call it gamma, which is flight path angle. Now you understand the lift on the wing depends upon this alpha angle of tag and the speed velocity. Who decides their speed for a given configuration? How much thrust you are generating? That is from a mentor this point of view, the thrust who produces thrust it is the engine right.

So, for a particularity V, I need a particular power or thrust power or thrust from the engine. So, as I a maintenance man you will need to ensure that your engine is in the perfect condition, so that when the pilot flies, he gets exactly that amount of thrust or power, what is expected in the design or given by the manufacturer. It is possible initially it is giving same and if you are not doing proper maintenance, some time you find the thrust expected it is not happening, and then there is a problem.

So, who are you sure that everything is what the, is being prescribed is a maintenance engineer. Once you understand the importance of a maintenance engineer for maintaining the engine in the perfect condition, you also should realize the lift on the wing depends upon the angle of attack. What is angle of attack? It is a angle between chord line and the velocity vector. So, as a maintenance man you need to check whatever way you have installed the wing, whether it is maintaining that position or not.

Also you physically check is there any deformation on the wing surfaces right, was that the chord line generally will not change, because originally fixed, but you never know. So, there are drills you have to check, and those things come under the topic of rigging

right. Now the question is let us say the lift force is acting somewhere here right. So, drag is also acting opposite what is moving this is a (Refer Time: 13:59) thermodynamic center, where I can represent the forces acting on the wing.

Now, see if this is the lift and CG is a head. So, this will give a nose down tendency it will try to push down the airplane. Now attach the push down the airplane that is not the way to fly, it will never always try to come like this. So, somehow you have to ensure that this nose down pitching moment is not there or even if it is there it is nullified; who can nullify this you see, this is a horizontal tail right.

If this is seeing some angle alpha which is giving the lift, it will also see some alpha which gives you a lift upward like this lift content. This also will give a noise down moment about CG, this although they will give lot of lift upward for same time it will try to take the aircraft down like this. So, you have to nullify that, how do you do that? If you see our until tail, that is elevator. So you put the elevator, up.

The moment you put the elevator up it generates the force downward, and this downward force will give a moment in the opposite direction. So, this elevator deflection should be sufficient enough to generate a downward force which will marginalize or neutralize the nose down moment because of lift on the wing, and lift on the tail for these configurations. So, now you understand is not it just not wing it is the elevator, you have to check.

From maintenance point of view, you have to check when the pilot is giving particular pull or push, whether that is correctly translated into deflection by dastardly into deflection the elevator or not. Suppose in the design or during the days a couple flying high, you find for a particular force deflection is 2 degrees or 3 degrees over a period of your negligence, you find same force deflection is only 1 degree, so the pilot will be confused.

He would not be able to fly? That is where the maintenance people put their best effort to see all the control deflections are or not. And if you recall whenever you go for any flight; initially pilot will do checks. He will move all the converse surface and he knows how many did we supposed to come like this everything is fine, then only flies as a pilot does that check. So, then again I see the maintenance becomes important.

In general please understand whenever something is moving parts, the maintenance become very critical honestly very cautions right. For a fixed the level of maintenance is effort wise is not that much generally, but rotary component anything moving, we see up to very careful right. Since we are talking about elevator, you see this is our tail horizontal tail and part of it when it moves up and down; we call it this is elevator moving up and down, how does it move?

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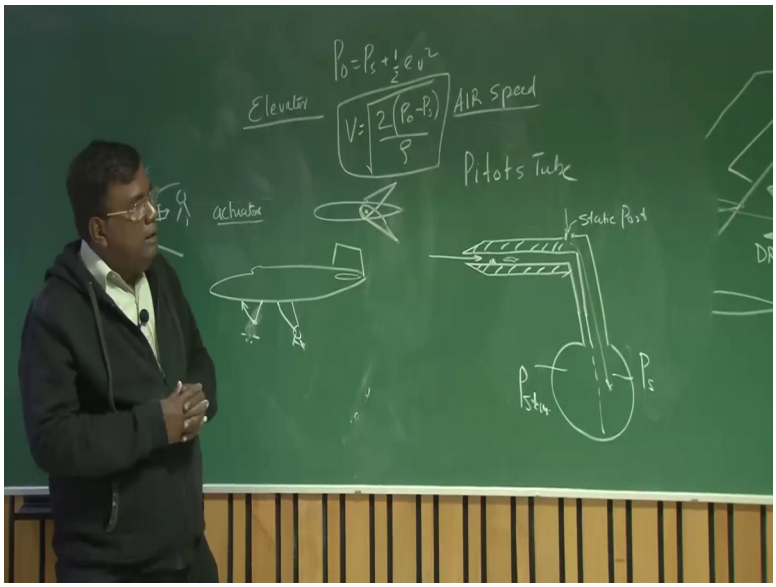

Pilot is here somewhere, pilot is sitting somewhere else some stick is there, you pulling it or pushing it and there are in a smaller aircraft, this pull or push motion gets translated into deflection through a cable and a pulley system. So, if it is a simple cable and pulley system, then the main test engine it has to check, what is the status of cable whether they are overhang or not.

Sometimes what happens once you put a cable initially it may be taught, but with the time there may be sag. So have to ensure that there is no sagging. So, again the maintenance engineer checks those things in a proper manner, which is defeated by the manual. Then there are hired in aircraft where there could be actuators, which could be electric actuators sometimes there would be electro hydraulic actuators.

So, again you have to ensure that the maintenance of elect electro hydraulic actuators or the actuators are proper. So, that finally you are able to get what you desired from the deflection point of view right. Another important thing you understand that as I am

flying, initially I have a landing here right; here somewhere let us say, but if I fly like this in the air, this will offer a lot of drag correct lot of resistance.

So, what is the better way of doing is? As soon as you take off you may take them just inside in belly. So, we call it retractable landing area, that is landing here was like this, now it comes back to the belly and this motion is achieved by hydraulic, Electra hydraulics all those combinations. Imagine if this system fails I am going to land now right the landing gear instead of coming full it came half, how difficult it is to land or sometime landing gear may not come out, then you have to belly landing so risky everything is fine.

But if landing gear is misbehaving, you are in a very serious accident situation. So, who ensures that the possibility of this is minimal, it is only maintenance engineer? They do thorough checkup and then we feel very assured in airplane, I know whenever I press a button or press stick that surface or the landing it will come out. So, gear maintenance becomes very important and for that you need to know the principles of actuators, understand the systems hydraulic systems; some part of avionics, and those little bit of understanding will be required, so that you appreciate overall maintenance philosophy, why we are doing all these things?

There is another very important thing which should also understand, when a pilot is flying, one of the most important input he gets is air speed right, he to know what speed is flying right; like your car when the action is more critical due to the air speed, how a speed is measured?

It is Pitots tube, you all must be knowing; Pitots tube and simply if you see the diagram is schematically, there is something like this, if I join something like this just to make for understanding, I see I have put a small gap here, this is called static port.

So, from here this part of this chamber will see P static, but when the air goes from this here I get P stagnation right and you know P stagnation or P naught is P static plus half rho v square. So, I know v equal to 2 P naught minus Ps by rho under root.

This understanding we convert in calibrating the airspeed right. Now imagine suppose you have a poor maintenance and some deformation has come here or some insect may be lying here right. So, it will not give you correct speed at which you are flying. So, say

there are some obstructions and you are flying at actually 100 meter per second or 50 meter per second, it is showing you are flying at 30 meter per second. What pilot do? Look pilot will immediate try to increase angle, so that he gets more lift, and either process, it may lead us to a stall situation.

So, small item, we just do so important from maintenance point of view, you have to be very thorough in seeing that, which has to be clean and functional right, very important aspects if you are a maintenance engineer do not think is a small thing, small hole; what is the problem? Hole problem is here and if there is a problem is a serious problem right.

So what I thought of as this course progresses I will come intermittently and we will stress on few things, which will have more understanding about the physics of the situation so that you can connect yourself why we are doing all these things right. And for more details those who are interested they can always do my course on airplane performance, well in exhaustive manner you will get an understanding, all a as well as there is a course on stability and control you can do that. But you will find me coming intimately in this course, wherever I think some elements of physics has to be added which strengthens your maintenance understanding.

Thank you very much.