Aircraft Stability and Control
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Lecture- 31
Reversible Control Stick Free and Trim Tabs

Good morning friends we are inside cockpit of sesna 206 and we could see here this is the stick and using this stick, we try to fly an airplane and we will be more focusing, on stick free concept and you could understand this is stick free concept is strictly true for reversible control, that is if I pull this stick towards me, and I am trying to reduce the speed and the elevator will go up and if I push this stick then and try to increase the speed so the elevator go down and that is the way we understand.

When I am trying to maintain lift = weight if I am increasing the speed, then I need lesser CL so the elevator goes down and if I am decreasing the speed, then to maintain lift = weight it needs more CL so, the elevator will go up because it needs more angle of attack. So, I repeat again if I am trying to decrease the speed and still maintain lift = weight I need more CL so, the angle of attack has to increase or CL has to increase,

So the elevator goes up please try to understand this stick as you know that the convention wise pull is negative and push is positive and this concept is true for reversible control what is the meaning of reversible control that when I am pulling the stick as I am reducing the speed so, it needs more CL to maintain lift = weight and hence more angle of attack so, the elevator go up now if I want to increase the speed so I will push the stick so to maintain lift = weight it need lesser CL so angle of attack has to go down so, the elevator will go down right?

So, that negative moment is there and you know the elevator going down like this is the positive convention positive Delta E but then we are trying to talk about the stick free concept the stick free concept means it is strictly valid for reversible control what is the reversible control that if I pull the stick if elevator goes up now what I will do I will see, that if I put the elevator up what is happening to the stick, see elevator is put up and it is coming towards me that is as if I am reducing the speed again elevator down.

So elevator they are putting down and now the stick is going forward so, that is the concept of reversible control right? So, what I do with the stick and same thing if I do from the elevator there reversible okay? and whole stick free concept is valid for a reversible control on me. Now you will see basic question we asked was if I want to fly at a particular CL I need particular Delta E as you know Delta E = Delta E 0 + D Delta E by DCL into CL trim and to do that what the message.

I get is from DCM by DCL fixed the stick fixed DCM by DCL stick fixed will decide elevator will required right? When we talk about DCM by DCL free this only to develop a model so, that I can give a feel to a pilot and design the control so, that the feel to the pilot is given right? Okay? Let as again revisit MFD let is revise it this is true air speed this is the air speed you get from this display and this is your artificial horizon okay?

You can see the attitude also on what is the status of the wing which way it is flying this is the alti and this is the altitude recordings or you will be displaying what is the altitude you are flying and this is the vertical speed okay? Which I can link to rate of claim or rate of design this you can see this will give with a direction which way you are going would related to north, south, east, west coordinate system of earth so, this is typically important for navigation this you could see they standby here magnetic compass why the word magnetic compass.

Because after all this directions as says magneto meter which uses the fact that earth has its magnetic field okay? The statement which I am giving repeatedly is that there should be redundancy with the advancement with the new, new technologies we need to keep standby this is the radio compass and that gives the direction which way you are going and it uses the magnetic field characteristics of a earth and the redundant for this is if we see this is this is magnetic compass this is redundant to this magnetic compass display here.

And then you also have the air speed indicator here true air speed indicator, and you also have redundant as SI or airspeed indicator analog here okay? And they you could see this is artificial horizon for the redundancy here this is artificial horizon redundant as compare to the MFD then you have got altimeter here altitude indicator and redundant for this is altimeter which is here

and then this is vertical speed indicator and like this all of this are designed with the two things in mind one is it should comfort to the pilot after giving maximum information.

We should able to see a group of data information together which are extremely important it should not happen high the temperature is given here and the cylinder head temperature is given here right? Because they are not correlated right? So, they very difficult so they are correlated so, they are very difficult so, that is the part of ergonomics so, they will bunch out all the relevant information together because the together they make sense okay?

It's extremely important to understand the ergonomics part of it you have to make the pilot comfortable as we have decided that S I need to know what is the stick force gradient for the pilot and the roll of trimmer so, that pilot can fly hands off. But if there are no trimmers then if the pilot is flying at some angle pulling some force as soon as he leave it goes out right? So, he will be too tired so, that is the roll of a trimmer and here is the elevator trimmer here.

To see it can trim the elevator using this lever so, this is general discussion of the cockpit but we will come back again here what we have done in stick free number one that how much stick force I have to apply to deflect the elevator by certain amount and then also we know if I release it like this it will again go back so that means if I am flying all the time I have to hold it like this that is it will make the pilot totally tired of the whole exercise so, what is the remaining the remaining come from tabs.

I repeat if I have to give elevator deflection suppose some angle have give a elevator up and I have to fly but how much angle has to be given please remember that is given by DCM by DCL fixed but now you see if I leave it again goes back so, I have to hold it but imagine the pilot holding this for hours together what will happen to the pilot so, what is when invented an wonderful design of tabs we call elevated trim tab and you could see here this is the elevated trim tab lever okay?

So, I can rotate it I can do like this an elevator will go up and down and at a point when this stick force is zero I will released it. And then I can hold the airplane the stick will remain here and it

will give desire Delta E required on that is what we call the hands off flying is it clear? I repeat if I have to give five degree of elevator up I pull it but if I leave it automatically go back so, to ensure that does not go back I use a trimmer the trimmer will do the necessary deflection.

And give that much of hinge moment so, that elevator is kept there and then the pilot can fly hands off and that is why it is call elevator trim tab okay? With this will go out so, and will try to see few more things from outside and before we aim this just for a completion please remember this one is for throttle, this is for propeller and this is for setting the mixture that is fine mixture or course mixture or lean mixture so, this is the pilot decide the along with engineer and the manufacturing guidelines manufacturer's guidelines so, these things are adjusted okay?

Sometime you fly the machine with a different propeller pitch and what is this is course or fine pitch that decided that is decided by the operation okay? And we should wonder what is this this is this is a copilot can sit here you can come here and when do an experiment you can hold the stick and actually fly okay? So, pilot is there will try to help you will get a feel of what is the stick force imagine if stick force was too high how the pilot will fly so, the extremely important that is stick force per elevator right?

The sticks force per elevator angle or a stick force or stick force per acceleration right? That is DFS by DN then understand the gradient is important right? if I want to change the speed a trim speed from 1 V do another V trim what is that gradient what is that DFS by DV. So, that will give a comfort index for the pilot and you could understand human being they land more to the gradient okay? The similar thing will find when the pilot is banking and turning.

We talk about DFS by DN that is stick force per G there is a limitation beyond that I cannot be able fly because of so, many constraints it comes from center of gravity location it comes from physical limit of the pilot okay? With this we will go out again and see what is the true meaning of a reversible control and we will also discuss today about all movable control I will show you that okay? All movable elevator surface okay let's go out.

We are going to discuss are try to see what is the meaning of reversible control and you could see this is basically the horizontal tail and part of this horizontal tail is elevator and this is elevator up this is elevator down as we have discussed meaning of reversible control is if I pull the stick the elevator has to move up and if I push the stick elevator has to go down reversible means if I do the other way that is if I put this elevator up right? That means I need more CL so, I am going to fly at a lower speed so, you will see the stick is coming towards you okay?

If I put this elevator down that means I am trying to reduce CL so I am going to increase speed to maintain same lift = weight you see the stick will go for what a sign conventional as we are following the pull is negative please understand that pull is towards the pull means I am trying to reduce the speed and push means I am trying to increase the speed so, the concept of reversible is as I pull the stick I am trying to reduce the speed the elevator will go up.

And I the push the stick the elevator will go down reversible means if I know put the elevator up the stick also will move according to this definition. Similarly if I put the elevator down the stick will follow same as per the definition so, that is the concept of reversible control, in modern aircraft we will find they are not reversible because there are motors, accelerators etcetera and so, there is no direct reversible concept for modern aircraft okay? So, you have seen here horizontal tail and part of horizontal tail behaving as an elevator okay?

Now we will see a case where complete horizontal tail is an elevator you have just seen the part of the horizontal tail being used as an elevator for this (()) (13:20) this is the horizontal tail and this whole horizontal tail moves up and down this is to behave like an elevator okay? remember we have seen you have put the elevator up and elevator down depending upon what short of flying mode you are there but here you could see interestingly there is a trimmer right?

And this trimmer is going to give you a moment so, that this whole horizontal tail which is all movable tail works as a elevator as will a stabilizer and you have to hold it. So, this trimmer will produce enough moment so, that any position you can trim right after giving a deflection by that stick okay? And that is extremely important for a trimmer and in this airplane you could see the trimmer very clearly.

But where I could not show there you could see as it going down the trimmer is going up like this as it goes down like this so, this trimmer concept will we solving some problem try to understand how to solve a problem but note down that part of horizontal tail can conveniently we use as a trimmer and its location could vary depending up on what sort of design you have thank you very much!

You have seen that so, far we have shown you the stick will we pull it we will push it and how does it move the elevator right?

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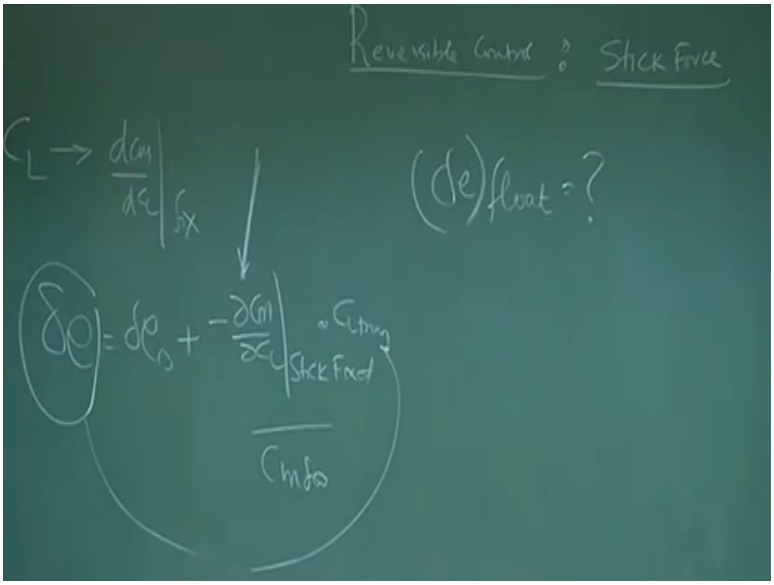

And we have been over stressing point that reversible control for simple reason that when you say reversible control say for example if I push the stick forward to increase the speed then the elevator will go down and similarly if I put the elevator down we have seen the stick goes forward so, that sort of a reversible control we are talking about why we are talking about reversible control because this is the revision session for stick force right?

And why did we spent so, much time on a stick force because we know that for reversible control driven airplane I can give a better feel to the pilot in command for flying the machine because he is the most important person for us because he going to be the pilot in command. And when you say the stick force if we recall we have defined something called Delta E float right? Before you come to this please understand if I am going to fly at a particular.

CL then this CL will be decided by DCM by DCL fixed if we recall we have expression Delta E = Delta E 0 + - DCM by DCL this is stick fixed divided by CM Delta E then into CL trim so whatever Delta E required for a given CL trim is decided by this DCM by DCL fixed there is nothing to do with DCM by DCL free please understand this concept whatever the Delta E required to trim the airplane for a particular CL trim is decided by DCM by DCL fixed okay?

Through reversible control base (()) (17:07) airplane we are trying to develop a model for a stick force what happens you have seen practically if I pull the stick and the and holding the stick so, the Delta E will be deflected but moment I leave it then it has a natural tendency to go out so, during you flying I have to constantly hold the stick so, that is also very dangerous you know very tiring for a pilot.

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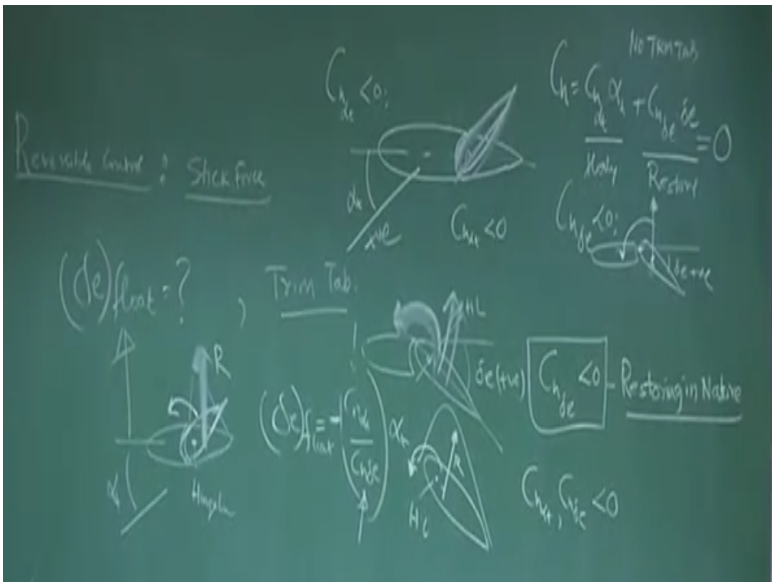

So, we wanted to know how to handle that hence that trim tab concept was introduced so, we will see what is Delta E float Delta E float is very simple that we know that this the tail plane right? And this is the elevator and you know if this is the Alpha T a tail angle of attack then because of pressure distribution know about here the reaction force over the elevator if this reaction R is behind the hinge line. Then this will give a moment the leading edge of the elevator will go down and we say it has floated up you could understand very well that.

This floating will be strong function of tail angle of attack and you know that this is Delta E float is nothing but CH Alpha tail by CH Delta E into Alpha tail now for this a minus sign right? Which tells as for a positive Alpha T there are negative floats of positive Alpha T so the elevator will float like this okay? Now please try to understand very important thing what is the basic different between CH Alpha T and CH Delta E? Which one of them is restoring in nature?

And you could see that very clearly as I deflect Delta E this is a hinge line okay? So, there is a reaction force here so, this will give a moment like this nose down CH Delta E negative so, you could see the for a positive Alpha this manual will be generated negative so whenever I am trying to deflect it by Delta E which is positive which actually means there is a change in the cambered so, this will always try to ensure that it is opposing this right?

It tries to correct it so, it is a restoring type so we have to put effort to put the elevator down that is why CH Delta E negative there is a interpretation of CH Delta E negative so, it is restoring in nature is this part clear? I repeat see I am flying and I want to really deflect this elevator down what will happen as soon as I deflect the elevator down there will be a pressure distribution over it. This is the hinge line and let's say the hinge line located such a way the resultant of this pressure distribution via force that reaction R is behind this hinge line,

So when I am trying to pull it down this R will give a moment opposite direction. So, it will try to resist that is why the CH Delta E hinge moment per unit elevator deflection have a sign negative so, as we interpret this as restoring in nature.

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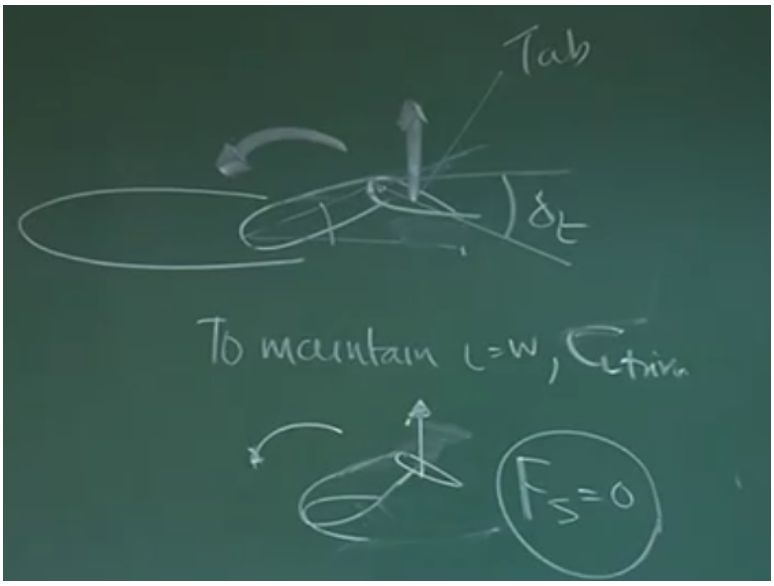

Now let as see what is trim tab is going to do let us say that you need to hold this elevator at an angle of let say five degree up which is negative to maintain so, lift = weight so all corresponding we will have a CL trim right? Now imagine if I have to throughout my flight we have to keep this Delta E up by five degree so, I have to go on holding the stick but if I leave it so, this will start going down what that will be make me tired so, what the trick has been done is take some part of it which we call a trim tab.

So as I deflect the elevator like this trim tab deflect like this so this is the Delta T trim tab angle and this is the tab this what is? elevator is going like this a tab trim tab is going down coming down like this what happens if it comes like this then this zero into force here which gives a moment and that moment is use to hold the elevator at particular position now the pilot need not apply any stick okay?

I repeat here how the pilot turn this elevator from here this position to this position by giving, giving a moment so, that it can turn like this okay? This is clear? but because of restoring tendency of the elevator CH Delta E it will try to come down like this we have to hold it here please understand this is very important thing the moment it is kept at as this Delta E new Delta E because of CH Delta E this will try to come down like this as this tries to come down like this.

What will happen is? as it tries to come down I need to have a mechanism to hold it at this position one is I hold the stick, whether is too tiring so, that is where this trim tab which will internal part of this so, that gets deflected like this and this gives rise to a moment which tries to give the moment, which the stick was giving through this stick force so, this is the moment is down when this trim tab is handling the effect of the stick force than I need not bother I can leave the stick I say stick force is zero.

And that is as far as stick free stability is concerned that is the equilibrium point is this part clear? So, at this condition FS stick force is zero that is the primary role of trim tab okay? This one I thought I will share with you and of course you know what are the stick force is big reformulation that's the matter of detail we have to put those numbers conceptually let us revisit from here we realized Delta E float which is I can calculate if there are no trimmer as CH Alpha T by CH Delta into Alpha T and then I also try to understand what is the meaning of CH Alpha T.

Because as long as hinge line is the edge then CH Alpha T and CH Delta E both are negative okay? And negative means CH Alpha T negative means if this is your tail and this is the elevator so, far a positive Alpha T if it is positive the CH Alpha T less than zero means it will have if motion so that this floats like this try to give a hinge moment to negative that is nose down it means positive is nosed up okay?

This a meaning of that and for CH Delta E less than 0 means has I put the elevator down which is positive it should generate a negative moment CH Delta is less than 0 so, it will also generate a nose down moment like this so, if we are try to take it Delta E down it will generate a moment which try restore it right? And that is why CH Delta is restoring in nature remember as long as the hinge line you somewhere here and resultant if somewhere as behind the hinge line okay? So, this the net force coming resulted this is extremely important.

So, because of Alpha T they an because of CH Alpha T present there is natural for it tendency and but, who correct this CH Delta E try to restore it that is why write CH = CH Alpha T into Alpha T + CH Delta E into Delta E if there are no trim no trim tab okay? No trim tab one is restoring and one is floating okay?

So, when they cancel each other that is the time why that equilibrium has CH = 0 and that is how you get this expression as simple as that not at all big, big things okay? I thought these points must be clear to you before you solve some problem we will we solving two problems but this is the understanding, please make sure you understand these things clearly if there is a confusion use the forum ask questions okay?

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