Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

Course Title Introduction to Experiments in Flight

Lecture- 13 Estimation of Stick-free Neutral point and Stick-free Maneuvering Point

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Yeah today we will be discussing about a stick free neutral point you have already done how to find a stick fixed neutral point through a limited deflection right we'll be talking about stick free neutral point and before we talk about the experiment they test recapitulate what is a stick free neutral point and how it is different from a stick fish neutral point and what is the relevance of it okay.

Please understand if IC c inverse s alpha or fear graph it is something like this right and this point is a stream point.

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Rochas now suppose you want to fly at this CL that CL 1 you want to fly here.

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So what is the action the pilot should do now you know from the static stability of the airplane the moment you try to change the sea and that means you want to change the angle of attack then it will automatically generate a negative moment because it is statically stable right.



So it will have a tendency to come back to this original CL at which it was flying just to give you a scenario suppose I am flying at an altitude let us say one kilometre flying at a CL point to the speed v1 0 SE CL point2 and we let us say he's 100 meters per second list at that point is this, this corresponds to CL equal 2.2 and reach 1 200 meters per second.



When I am saying is a pilot desires to fly at a new CL with a CL 1 let us say now pilot wants to fly at CL equal to 0 point 3 and if we have to maintain a level flight the same altitude so he has to do what reduce the speed number one and also the L&O deflection he has to do something right because why he has to reduce the speed because he'd be flying at a multitude

Now the moment that increased CL 2.3 the lift will become more than the weight because left is equal to half Rho v square HCL if I am increasing the CL and this is equal to W if I am increasing the sphere then this half Rho v square SPL will increase unless and until you reduce the speed.

So he has to reduce the speed that means what is happening is going on some angle which corresponds to scalar point to you know increasing the sea at the point 3 by raising the angle of attack but then he has to also throttle that it was the speed otherwise we'll start climbing okay and you also know that if I have to fly at this pl 1 it will generate a negative moment.

So I have to either generate a positive moment by giving elevator deflection right that is why if you see this graph Delta ie., watch the CL trim for a given cg location X is e 1 you have definite value of a limited deflection required if you want to fly at the CL ad vcl address field or a GCS of different value of Delta required.



So the pilot if you want to fly the airplane at different feel how should I develop field for you in eastern / field house looks like so one ways you make a chart Delta e + CL or CL means you can always relate to speed by giving density,



And he sees that chart or this much of VI put this letter Delta this much as we pull this much of Delta or sometime you know that for the given Delta there may be a rotating shaft I will you cannot rotate this many combinations were there the basic understanding is you are developing field of the airplane for the pilot through delta e and the speed 3 develops will this much altitude this much speed this much all over deflection I will get but that may not be very good way of giving him a field right.

For example if you are driving a motorcycle if for every speed there is a marking put this March it will take this much as quick put this mark this will you give this much of speed do think that is a correct way of getting a feel how do you get a feel when you are driving a scooter as you accelerate you get that tall right and then you know it as getting more and more talk you are getting is a feel for the airplane a sudden further sorry feel for the motorcycle and then reduce that is how you get the field okay for airplane also what is done.

If I somehow can give the field to the pilot in terms of stick force right if you have to reduce the speed it pulls it like this it is going to increase the speedy pushes like this right and this feel of the force or the gradient will help him in getting the feel for the airplane right and that is where you need to define something called stick force and you need to use that concept of a stick force to define a stick free neutral point okay but be very clear if you seem y last the module the airplane has the only neutral point right it is stick free neutral point we are defining.

So as to develop a mathematical model which will help to give a feel for the pilot that's all okay so now the question is we want to find out the streak-free neutral point through the experiment if you see the expression for a strike force you know C regan refer my lectures or in a textbook from there you can easily see that these excess by q VAR q bar the pressure dcl well 20 and sticks free neutral point is defined at x PG location at which the DFCS by Q Bar a DC l is equal to 0 this is the definition or this is the mathematical back up to determine the NM bar on n-not bar sorry repeat n-not bar stick for a neutral point and generally for speak free we put an ash here for the sticks fries you do not put it here right.

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How do I find 60 neutral point? I need to find that CG location at which DFS by Q Bar by DC 1 is equal to 0 right if I understand this then let us see how do i do experiment first question comes how do I measure stick force.



You know this is basically based on strain gauge the of the stick let's just stick like this the strain gauges are on the stick so as I pull it so there will be a bending there is the stress developed and from that so the strain gauge measurement I can find out how much the forces have been applied in terms of pool or a push right so use strain gauge principle you also use wisdom brief.

But that is what through strain gauge we make sure the thick force and now if I want to conduct an experiment to find out strictly neutral point is what I do I go for a cruise right and again I look for altitude I note down the altitude I note down the outside air temperature alright, then four different we listen we I am choosing you note down what is the stick force and again for v2 v3 v4 you note down all those stick force whatever being applied so you just need this two measurement.

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So you know what is the stick force for dynamic pressures how you calculate dynamic pressure what information is required for this half Rho v square all right.



How will you get Rho density through outside air temperature and the standard table how do you get V we as we indicated then you correct it for true air speed right so all the information available but we need to also find out CL because I am which see the change this gradient with respect to CL, so far CL what additional information I should have? the weight of their in fact so you will also make sure which you are doing anywhere weight of the airplane.

You can take the average weight during the cruise you get an initial weight final weight average or takeoff weight, then landing where take the average or the carrier stop watch see how much time it was not cruising how much time it was cruising, so you can you know the full consumption rate so you can find out the average weight that is your choice.

So once you have this V and Fs and you can easily calculate what is CL CL will be 2W by L by Rho v square correct luscious we are closing but this experiment will be done responding to it xpg location that is there will be fewer student and the pilot fly which corresponds to a given cg location so this should be repeated for different cg location.

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So you can always manipulate the weight of the passenger and swell wait we cannot go on changing so I can generate this sort of a data for number of CG location let's play from XCg 12 x cg 556 points we generate that means.

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I have this measurement corresponding to x PG configuration when either batch goes it generate this experiment again that data corresponds to x PG to XC g $3 \times 3 4 \times 55$ so what we have now? What will have FS in all this process is by Q Bar. So you can put as a column here and you can calculate what is the value of Q Bar go to half Rho v square.



So this information is available to you when you plot SS by Q versus CL let's say dependable speed let's say they look like this is for XC b 1similarly there could be another 4 x cb to solar look for another x cd3 like that you can have n number of points right.

The upper this point is clear, now what is our aim our aim is to see what is that CG location for which the offense by Q Bar by bcl equal to 0 that's digit affectionate with DFS x cube IDC le 0 it is called a stick free neutral point right.



Now what I should do I should plot from this data I put it corrects seedy bar and here i put DFS by Cuba by dcl which essentially means the slope of this line isn't it right. Now you have to plot DFS by Q by dcl versus x eg and you take one graph x is e 1 take the slope ,slope is negative at this point the second one you take this third one you take this and then you joined by a straight line and this point is what? this is the ecstasy location at which the offense by 2 by dcl is 0 so this becomes you know a stick free Neutron was yes because Ross check with 66 neutral point earlier we did that was d delta e by d CL vs XE g and the XC location at which d delta e by d silver 0 right.

So this is the way to do stick free experiment to find out a strictly neutral point so i will just write the device table but this is you are having an altitude to note down outside air temperature you note down you know down the weight, then fly at different V v1 v2v3 v4 like that and measure stick force1 2 3 4 5 you also find q bar equal to half Rho v square you calculate CL 2 W by L always wear then you find out DFS Mike you buy dcl and this should be four different city locations right xdd one two three cross plot and get difference.

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So this table will correspond to one deliberation xcg one similar terminal be there for others configuration x32 it was a devil over there for EXO III so you have to pick up the slopes and cross blood respect to TV and see where after accelerating this point where this line cuts that is your streak free neutral what as simple as that okay here now to end this part we will also see how to find a stick free manual in point? This whole point is over like you have a stick fix to turn point.

You have a stick free to third point or a strictly neutral bind you are talking in dance or stick force right similarly a stick free man moaning point we'll be talking in Tulsa again stick force what mastic six neutral point? what was the condition for stick? fixed which we did earlier six fixed neutral point NM bar was defined as xcg location at which d delta e by dn equal to 0 isn't that is how it is now you should look for tix free manoeuvring point it's free NM bar prime that is the exes II location at which DFS by d n equal to 0 what is in here is a load factor.

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So what sort of an experiment we do we do not go for a pull-up manoeuvre what do we? do we go for a turn steady coordinator turn like this and you turn like this and same time we maintain that it doesn't lose the height that is if I draw the diagram here if you see when the airplane was not having any bank and if this was a lift then the lift was balancing the weight that is how it is not losing the height now suppose if I blanket like this what will happen?

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Now the component of lift will try to balance the weight say L cos Phi will try to balance the weight so if the lift was same then it would not be able to balance the works it will start sinking right okay but we when we do this manoeuvre we ensure that altitude is same it is steady co-ordinated turn that mean for that to happen you can see I have to ensure that L cos Phi is able to balance the weight component of lift should go to balance the weight.

So here I could see I by w equal to 1 by cos phi and what is I by w load factor so n so I know n equal to 1 x plus 5 so if the pilot is flying the Machine and taking a bank of 45 degree and making a steady colony return so what is the load factor you're experiencing? let's say 30 degrees then one by cos 30 all right okay if it is 60 degrees in let's factor off not for us to say very large number right okay do not understand my load factor of two.



So this is to tell you how we generate this n because we have to find out a condition where from I can extrapolate to get the city location for which DSS by DN becomes 0 then it could be a stick free manoeuvring point right so what do we do again using the experiment we go and note down altitude outside air temperature and then wait in the pilot goes for it steady call in a turn a different speed right.

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So he does that one, two, three, four, five, six, seven, eight each time we measure what is the stick force applied? This is all the measurement required Bank angle you get from the ton bank indicator a stick force will get from the strain gauge based sticks we from the air speed indicator and it goes without saying you know that that speed is equivalent air speed we have to correct it for a true air speed by using the relationship.



So once I have this now I see what I will do I will simply again conduct this experiment for a given x PG x XE g one configuration so then I will plot FS versus end and how will I get the value of n and I will get from here n equal to1 by cost five right so i get the value of n I plot FS by n and let's say this values for different speed again this is shay xpd-154 another xpg to where Ican get for another xcg 3 like this and go on generating once I do this then what is the next step it should be smart enough to not tell me how do I get a stick free manoeuvring point.

I will do cross plot between XCG and here DFL by n what is the SS by n for a given X 2 g's occasion let us say X eg1 what is the SS by n there is the slope of this line right, so I pick x cg 1 and hen whatever slope I note it down here early for XC g 2 I again do this XC g 3 like there are few points I will get I will try to fit it to the best fit and what is this point this would be that'll be stick free manoeuvring point it is understanding clear any doubt anybody have it okay. Thank you.

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