**NOC: Introduction to Airplane Performance**
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**Lecture - 27**
**Flaps: High Lift Devices to Reduce Take off / Landing Distance**

Good morning dear friends, as what we will be discussing today and guys, the topic is on Flaps.

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Now, I am drawing an attention to Cessna 206 airplane, you could see that these are the aileron and this is a flap. So, see we are now putting the flap down, what is happening. Please look here, look here, this aerofoil now locally is having a chamber. Could you see this? By putting the flap down, it keeps adding chamber to this section and we know cambered airfoil will produce more lift. So, that is how the C L max is increased, the lifting characteristic increased, so that you can reduce the take off speed.

During takeoff, the pilot will be setting the flap deflection by, let us say 10 degrees. So, kindly deflect the flap by 10 degrees, you could see that flap was being deflected down by 10 degrees. Now, there is another angle also you can deflected, which is 20 degrees and during landing, as I am telling it goes to the maximum. So, it will go to 40 degrees and as a very evidence, now you see during landing 40 degrees we are putting, actually, primarily we are trying to increase the drag that helps in breaking the airplane to a

shorter distance, because this is also important that we should need to have a shorter touchdown distance.

Please understand, when I say by putting the flap down we are increasing the lift, but that is at the cost of drag. So, that is while take off we have to put lot of throttle, almost power on and the C L by C D max reduces. So, this is a primary function for a flap and now we will go to the classroom and we will discuss about the theory behind this flap and what types of flaps are there. How do maximize the flap effectiveness and how the history of aviation has seen such development and what is practically being used now.

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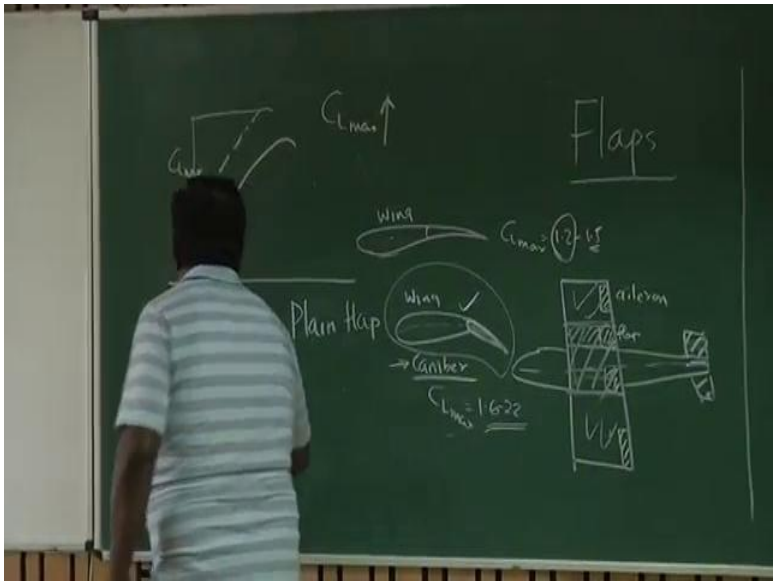


I am demonstrated you one simple flap, which is Cessna 206, this is tall width, so topic I am giving as flap. What is the purpose of flap? Purpose is, I want to increase C L max. Typically, if you take a normal wing, the C L max is in the range of 1.2 to let us say 1.5, little bit high, but yes, you can customize it. As a designer, we do not take more than 1.2, so preferably I will prefer the number 1.2, because this schematic number.

Now, there is a flap which is nominated as plain flap which is nothing but, this is the same aerofoil and then, this portion can go down. Please understand, this is a wing, if I draw the top view, this is the wing, central line, let us say this is the fuse large, this is the tail here or tail here means, it will not go to like this, the tail here, the horizontal tail. When I am saying flap, this portion this is aileron, this is used for what, I demonstrated that ((Refer Time: 04:19)).

If I put this aileron down; that means, cambered of my right wing has changed, so more lift here. So, it will give a bang, left bang like this; however, we are talking about this flap, this is the flap. So, if I take this flap area, the moment I put, similarly flap is here, the moment I do this, already these two flaps they are going down, understood. So, locally the camber of this portion of the wing is changed and that portion will be giving more lift that will enhance the C L max value. Is it clear now?

And why C L max is increased? Because, by doing this you are seeing that yourself, it has added camber and we know for camber aerofoil, let us say this is plain flap and for camber aerofoil, the moment that I put a plain flap, since it has change the camber. It will be something like this and there is an increase in C L max. Typical number, if I give you for plain flap, the C L max will go from, to lie between 1.6 to 2.2. These are all representative number, we can customize.

So, this is typically the principle of plain flap, our Cessna 206 is having this plain flap and I have demonstrated, I can deflect the plain flap for 10 degree for takeoff and 20 degree sometime. But, for full maximum flap deflection I am sure that, now I have touch the ground that is primarily used for increasing the drag to reduce the touchdown distance, so this is plain flap. So, what is the principle being used in this plain flap, that to increase the C L max use the concept of adding artificial camber to the whole wing.

But, we also understand it does not change the camber of this portion or that portion, only change the camber for the area which has flap installed and the flap is not full for a wing, part is on the flag. At the end whatever we have, these are called aileron, this is very, very important. Then, after this flap concept, there was another effort. You know, you again change the camber by different thought process. What was done?

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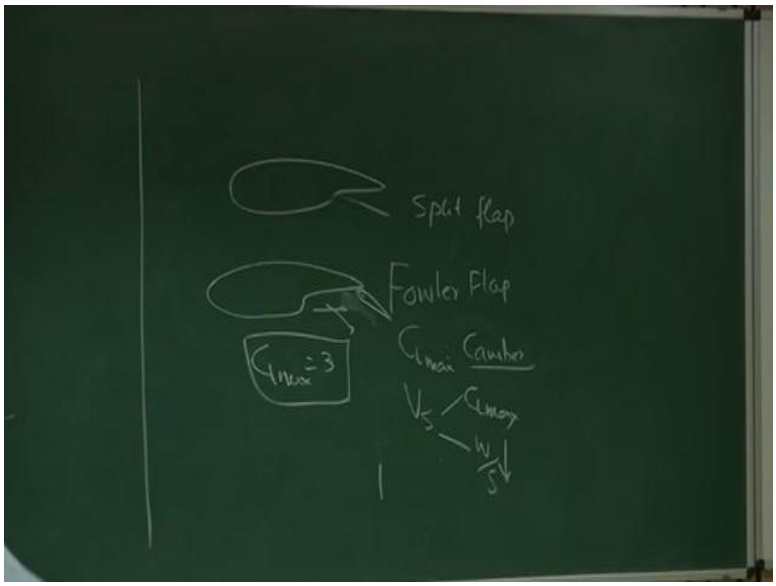


You take, this is a wing and make, something like this and it is called as split flap. You understand what is it, it is otherwise it is touching this portion and whenever required, it will split from this portion. What is this doing? This is also changing the camber, but this was also used and for some time it was also popular. But, remember one thing, this design have improved with a primary aim it include C L max, but this designs where benchmark after this you question, are you having appropriate C L by C D max or not.

So, we have to see ii totality not only increasing C L max, but also see what is the drag penalty and with that in mind, every design has some limitation and that is how there is design of flaps as evolved today. So, from split flap there is a concept which is very popular, propeller using it fowler flap. What is the concept here? Remember, I told you if I want to increase C L max, what are the options I have got?

I have the option is camber, change the camber, but if I want to increase the V stall I have a option not only you increase C L max, but also reduce wing loading. May it be low, it does not matter, slight increase is good enough. So, that concept is used in fowler flap, what is done it is like this, this portion has two motions. One is it will go this side and then, turned this side. Are you getting my point? So, if I really draw it correctly, it will go here and do it like this. Is it clear to you?

If it is not clear, let me draw it again. This is very important, so you need to understand what a wonderful way or designers or aeronautical designers have wants this flap and this still they continually doing it.

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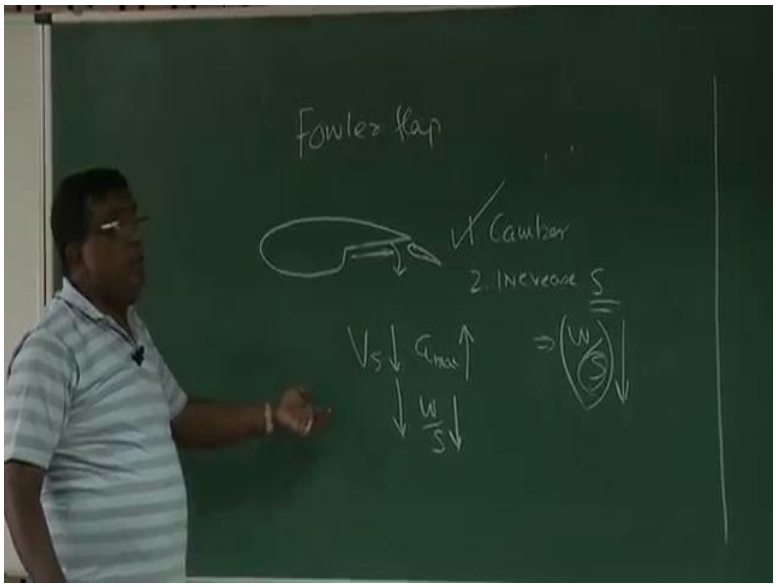


So, we are talking about fowler flap, this is basically the concept is based on split flap, but now this unit has this motion as well as rotational motion. It is just not splitting like this, it is moving backward and doing like this. So, what was happened in the process, which has increased cambered, also it has increased area of the wing. And area of the wing, it has increased means actually it has low polar regions, wing loading and you know V stall will decrease if I decrease wing loading.

Please understand, with this fowler flap the two motions one is going like this and then rotation. By rotation which has increase the camber, so if I help C L max, by going backward it has increase the area. So, wing loading has goes down and you know that V stall goes down if C L max increases, it also goes down if W by S decreases. So, increasing the area W by S has gone down, so it has also helped in decreasing V stall.

What a wonderful design, simple aileron, but you should also appreciate this idea ((Refer Time: 11:32)) and this idea have to be complemented each other and that is what is a fowler flap.

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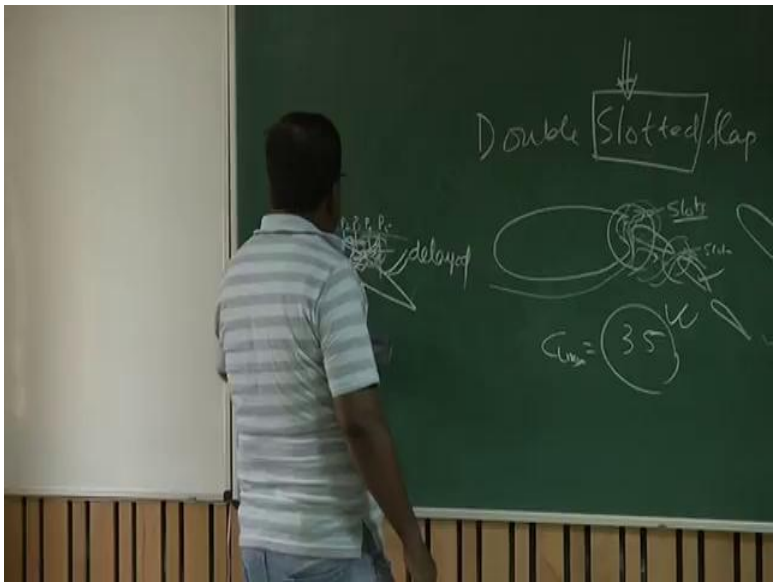


Let us talk about double slotted flap. In double slotted flap, that if I draw a diagram, it will be very clear to you. Please understand this new term slotted. Why slot was necessary? Before I go for this, let me complete this part ((Refer Time: 12:14)), this C L max up to 3 is 3. But, these are numbers I repeat again and again, this are some representative number, you can Google and find out what is happening in different, different configuration.

Now, I have introduced another term slotted flap that is this portion, concentrate this portion, these are slots. Can you guess why this slot is there? Let us go back and you remember that as angle of attack increases, you have seen that the pressure here p 3, p 2, p 1, because area is increasing the speed is decreasing, so static pressure will increase. So, there is an adverse pressure which will discuss the fluid motion forward, moreover there is a friction. So, there is something called separation.

In language of flight mechanics; that means, I will not be able to use beyond that angle, where flow separation starts. So, in flap mechanics I will ask a question do you have a mechanism to ensure that, this separation is delayed that is I can use further angle of the flap. By simple commonsense, what does it mean to us? If this friend of ours, the boundary layer is having a divide of energy, I supplying energy. What I do?

I, this is some fluid with high energy, I pump into this area. So, that energy will revitalize this fluid particle and this separation point from here, it may come here, effectively I can

further increase this angle. Is this clear? Now, with this understanding comeback here, here this slot, this slot means if this is a fluid particle, it will come like this, fluid will go like this, you will go like this. Now, if the earlier separation point was somewhere here, now this fluid particle they will energize locally this fluid particle here.

So, there separation will be delay, so this flap will be very effective. Further what happens? Further, I have got another slot here, so now, fluid particle comes from here, so this also becomes effective. So, I can go on putting such multiple slotted flaps. What is a difference? One is I put multiple slotted flap and one, one you could ask me, why do not you put a single flap like this, same angle. Answer is obvious, if I put a single flap like this, flow will separate.

So, I have separate this in 3 or 4 multi flaps and provided a slot. So, that local separation is delayed and this is very efficient way of increasing C L max and with this, you can get anything up to 3.5 C L max. I am just mentioning few types of flaps and as then, we required I will be more specific on a particular type of flap for a particular airplane. There is another type of flap which is also has drawn lot of attention.

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Just for completion I am mentioning that Krueger flap and that is something like this. Please understand this is, this portion will be inside the wing, but it is not a part of the wing, so it is the leading edge. So, it will come out and change the camber and you will

get lift and when it is air bone, this will go inside; however, this will not become the part of the wing that is very important.

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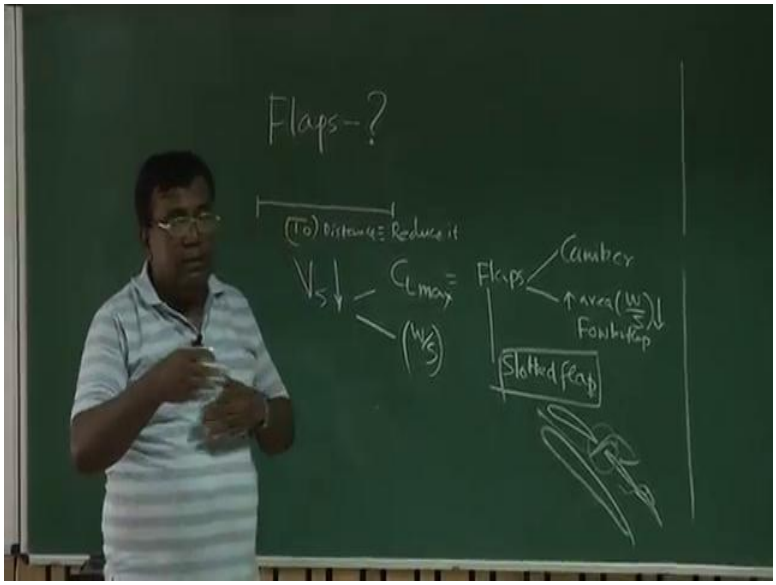


So, many things we have spoken, summaries we need to understand few things very, very clearly. Why we are discussing about flap? Why flaps, question is this. Our aim is we want to reduce mistake of distance. Our aim is to reduce it, reduce it means I need to reduce V stall. How to reduce V stall? One is increased C L max or decrease wing loading. How to increase C L max? They are turning flaps and what is a concept behind it, change the camber or increase area, so that W by S decreases which is typically fowler flap.

And in flap, you also have seen slot, slotted flap. Why slotted flap? Because, by using slotted flap we can further put the flaps down and it will not face the problem of separation or the separation points will be delayed and that we have put multi flaps like this, instead of putting one flap such large angle. Because, I know this fluid particle come from here will energize this, V stall will be delayed. Similar thing will happened here and that way I can efficiently designing a multi airfoil flaps and that is, how we are trying to increase C L max, so that V stall is reduced and we have shorter takeoff distance.

Thank you.