Introduction to Aircraft Design
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Lecture – 56
Flaps as High Lift Devices

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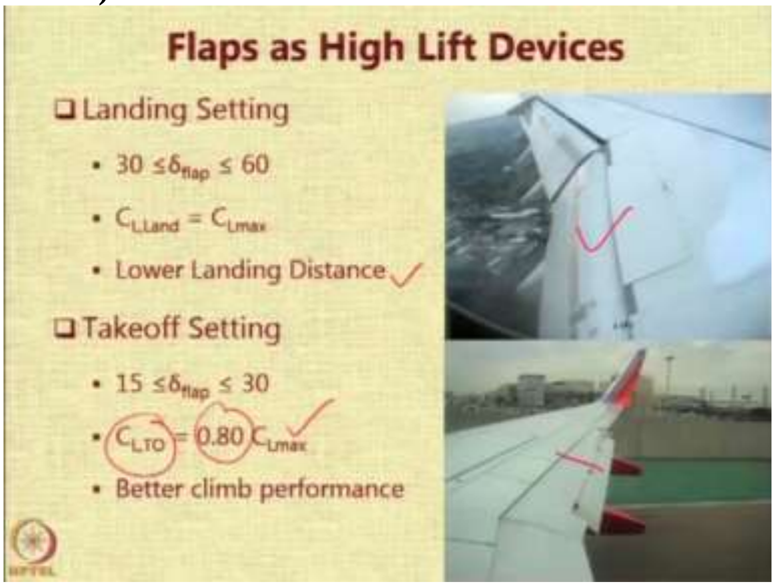

Flaps as we all know are using high lift devices, and during landing we have a very large deflection as can be seen here there is a very large deflection typically between 30 to 60 degrees, and the C_L at landing is normally the $C_{L_{max}}$ and the aim is to lower the landing distance during takeoff the flaps are deflected at lower angles as you can see here, the deflection angle of these flaps are lower than that you see in the landing typically, the angle of flap deflection would be 15 to 30 degrees.

So, one can assume that the C_L at takeoff is going to be 80% of $C_{L_{max}}$, because the deflection of the flaps is at a lower angle and the purpose of using flaps during takeoff is to have a better climb performance.

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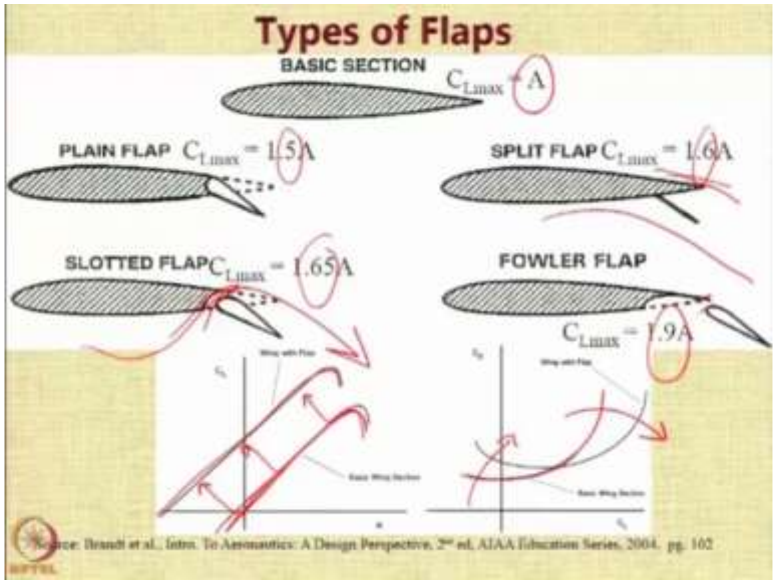

But, there are also many different types of flaps and each of them has got a different effect on the lift coefficient. These are some of the standard flap sections that you would use. So, for example, if you have a basic flap, basic aircraft suppose you have a basic wing whose $C_{L_{max}}$ is equal to A this is our baseline let us see how the usage of flaps and that 2 different type of flaps increases the value of $C_{L_{max}}$ from A. So, with a plain flap you can have 50% higher value of C_L just by deflecting a plain flap.

If you have a split flap you can get slightly better up to 60% higher, this is because we are not spoiling the flow on the upper surface we are only creating a deflection of the flow on the downward surface as compared to the plain flap. If you have a slot in the flap then you are allowing the air from here to actually go and flow over it. So, you can get slightly higher you can get maybe 65% higher value of the C_L and if you use a Fowler flap in which not only does the flap deflect down with a gap.

But also moves backward resulting in an effective increase in the surface area then you can almost double the C_L coefficient of to order 1.9. And if you have a basic wing section like this, if this is the left corner of the basic wing section, using a flap is going to lead to a parallel line and at all angles is going to affect the increase in the lift. Similarly, if you look at the C_D versus C_L curve, so, if you have a basic wing line as shown here, then you go for a tilt when you include flaps in the aircraft.

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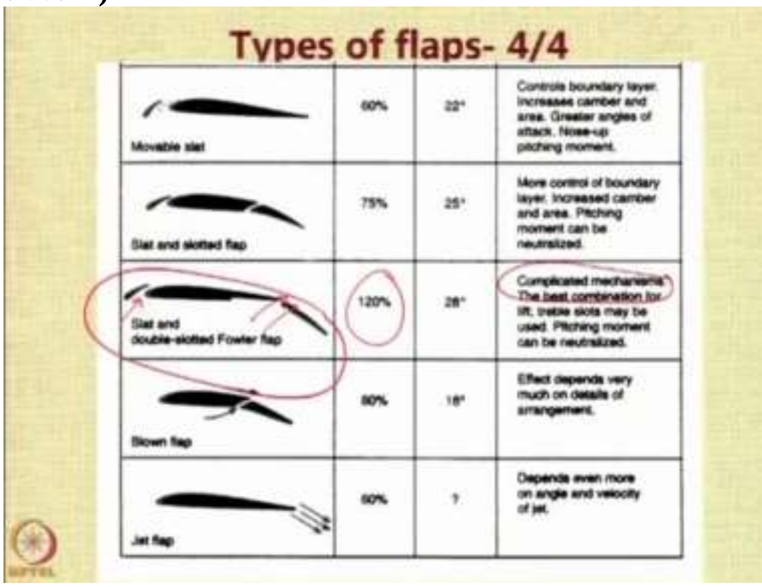

Now, if we want to sequentially look at the effect of different type of flaps. So, if the basic airfoil you know this is the same information but now placed in a more detailed fashion. And as I mentioned a Fowler flap can lead to almost 90% increase in the in the lift coefficient. Notice that these are only approximations because the actual increase depends on the geometry of the airfoil also. If you go further and if you start putting now slots in fowler flaps, you can go for a higher increase.

Let us look at now some leading edge devices. So by using a Kruger flap, which is basically a flat curved plate with some kind of rounded leading edge, you can get 50%, if you put a slot you get 40%, a fixed flat with a gap in between can give you around 50% increase and as you keep on moving and as you keep on increasing the complexity of the system you get more and more benefits. For example, if you look at this configuration, where you have a slat and you have a double slotted Fowler flap, you can get around 120%; increase in the lift coefficient. But this is basically a complicated system. So, you have to be careful about use of flaps.

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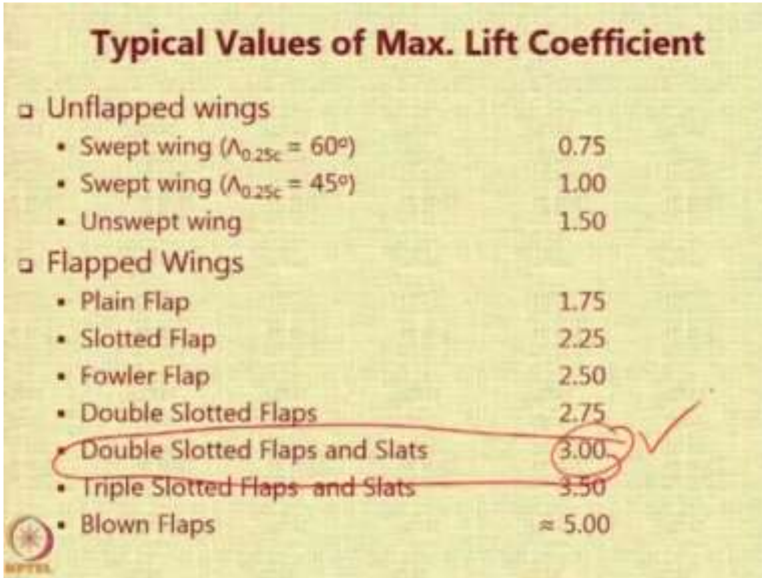

Because improvements do not come without any problem improvements always come up with some kind of a compromise. So, this table sums up the typical values of the maximum lift coefficient. So, if you do not have the actual data available, and if you just know the type of the flap for example, if you are told that the aircraft is using double slotted flaps and slats, you can just use this value as a good starting value to calculate the to estimate the max lift coefficient.

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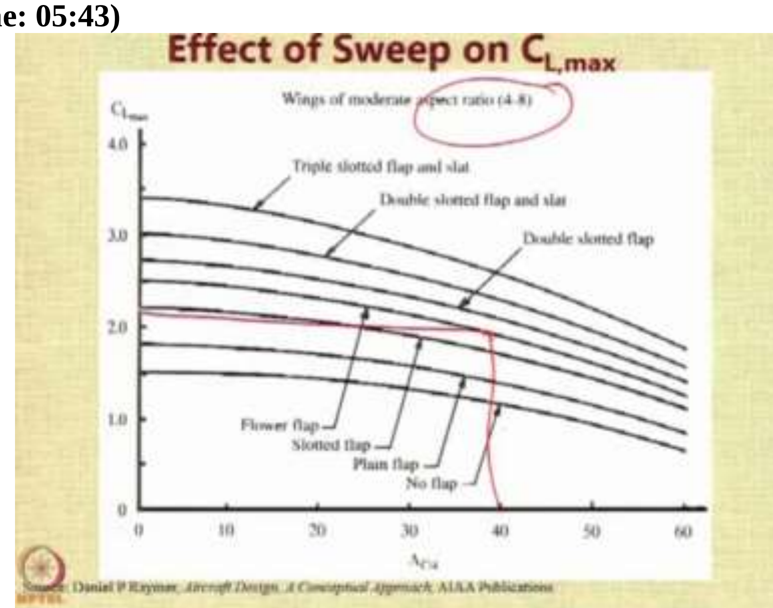

This graph from Raymers textbook shows 2 things. It shows that different flaps types have higher values of $C_{L_{max}}$. And it also shows how these values reduce with the increase in the quarter chord sweep. So you can use this graph for the wings of moderate aspect ratio only. And with this graph, you know you can probably get something like if the sweep is 40 degrees, and the flap type is

Fowler, then you can get the value of $C_{L_{max}}$ that you can take from the graph. Thanks for your attention. We will now move to the next section.