Introduction to Aircraft Design
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Lecture - 50
Subsonic Parasite Drag Estimation

Let us have a look at what method can be followed by a conceptual aircraft design team to estimate the aerodynamic lift coefficients.

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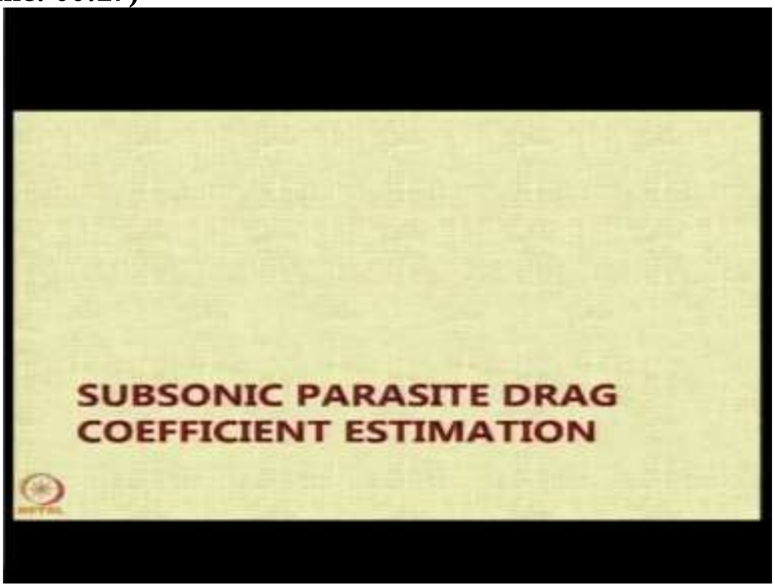

C_L and C_D for configuration. We assume here that some kind of a configuration and layout has already been arrived at by the design team. And now they are interested to go for some analysis. So we will discuss only about the subsonic parasite drag coefficient estimation in this particular presentation. And the information that is relevant to transonic or supersonic aircraft will be provided in the form of notes. This kind of approach is mostly applicable to transport aircraft.

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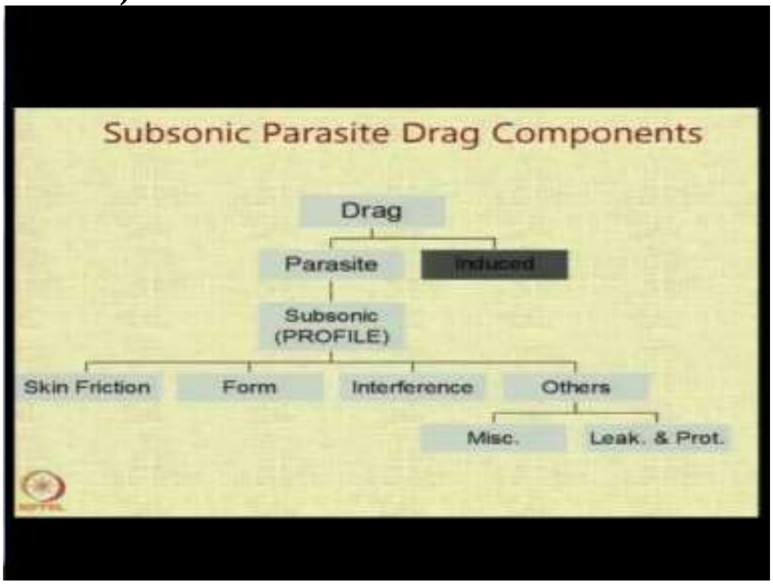

The components of the subsonic parasite drag you know will not look at induced drag right now, we will look at it a little bit later. It consists of basically skin friction drag, form drag, interference drag and others. The others would consist of miscellaneous drag due to various items which are mounted on the aircraft and they will drag due to leakages and protuberances.

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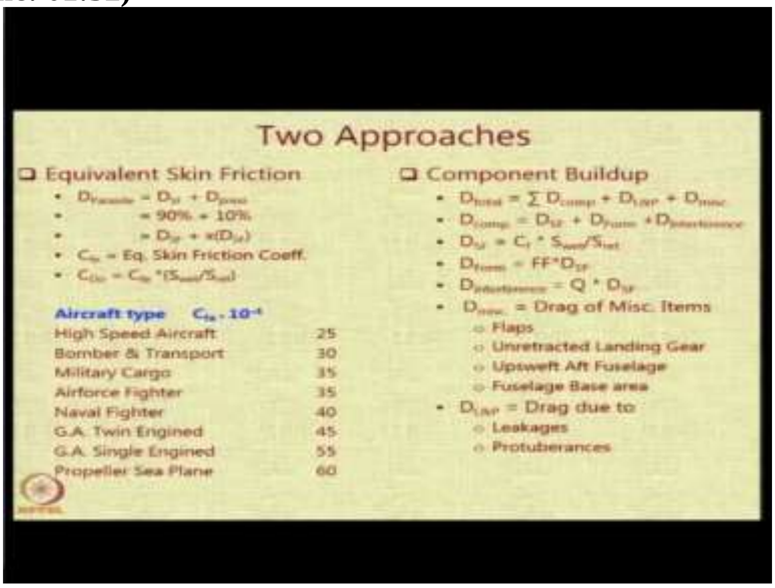

There are 2 approaches commonly suggested for estimation of the subsonic parasite drag coefficient. One method is called as the equivalent skin friction method and the other is called as a component buildup method. The equivalent skin friction method essentially looks at a very simplistic approach in which the whole aircraft is replaced by an equivalent flat plate and certain coefficients are specified based on the aircraft type.

And using them you can get a very quick, very basic first cut estimate of the parasite drag coefficient. The logic that is followed in this particular approach is as follows. The parasite drag is supposed to consist of skin friction drag and the pressure drag and the skin friction drag in a well designed aircraft would probably be 90% of the total drag. In a well designed aircraft the pressure drag would be kept less maybe around 10%.

So, since it is a small fraction, we replace its accurate estimation by just a factor X. So the parasite drag will be equal to the skin friction drag plus a small factor of skin friction to replicate the parasite drag. We define the term called as the equivalent skin friction coefficient C_{f_e}. And we assume that the C_{D_0} value of the aircraft is equal to this C_{f_e}, which is a fixed number for a specific aircraft type into the wetted area ratio or ${S_{wet}}/{S_{ref}}$ of that particular aircraft.

So there is a list given to what would be the appropriate value of the C_{f_e} for various types of aircraft. And the list varies from high speed aircraft to propeller sea planes, which have notoriously high drag values and based on past data and experience, the C_{f_e} values range from 0.0025 to 0.0060. So to calculate C_{D_0} using this method is very straightforward, get the ratio of ${S_{wet}}/{S_{ref}}$ using the chart that Raymer has given in his textbook.

Which we discussed about, when we discussed about the initial sizing, we showed that graph. So from there, you get the wetted area ratio by eyeball parking, how the aircraft looks and multiply by the corresponding value of C_{f_e} for a aircraft type. With this you will get a very crude estimate of the C_{D_0} value. In the component built up method, we go into slightly more detail.

We say that the total drag of the aircraft is because of the summation of drag of each component plus drag due to leakages and protuberances, which we will discuss and drag you to certain miscellaneous items. And for each component, the drag of the component is going to be its skin friction drag plus its form drag plus the interference drag that occurs because of the proximity of various components.

So for the skin friction drag, we use a similar formula as we use in the equivalent skin friction, the difference is that we have a different value of C_f for different components of the aircraft. By component, I mean only the main assemblies, the wing, the fuselage, the tail, and nacelles. So, it is identical in formulation, but more specific in detail. So you calculate the S_{wet}/S_{ref} for each component.

And you also then calculate the value of C_f formula or given for estimating C_f for various types of bodies. The form drag is considered to be you can say related to the skin friction drag through a form factor. So once you know the shape of the body, you can get a form factor and again there are formulae available for it and then you multiply that form factor with the skin friction drag.

The interference drag is also considered as a factor applied to the skin friction drag through an interference factor Q. And this factor Q is 1, when there is no perceptible interference between 2 bodies. This will happen when the 2 bodies are actually separated by a large distance or there is no flow field interaction between them or not much flow field interaction between them.

And when they are operating in close proximity when the drag of one, the presence of one affects the drag of the other, then the Q value becomes higher. And miscellaneous drag is the drag of items such as the flap, the landing gear when it is un retracted, the upsweep aft fuselage and the fuselage base area. We will discuss all of these and then finally you have this drag due to leakages and protuberances. Thanks for your attention. We will now move to the next section.