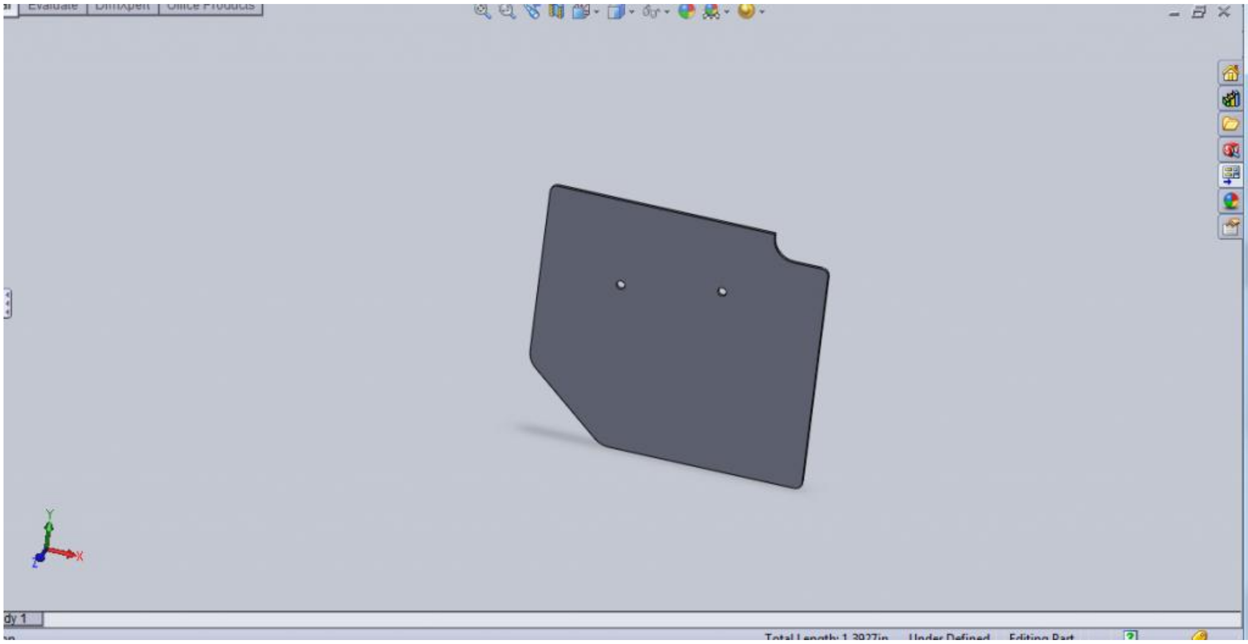
AERO 101

Hi and welcome to the fourth segment of Aero101. This week we will discuss endplates, multi-element wings, and wing mount design. This week's topic is a bit longer than normal, but please don't be deterred by the length. There is a lot of useful information here! Multi-element wings are made up of 2 or more aerofoils, as seen in Formula1 and other televised racing series. Both endplates and multi-element wings are ways of increasing rear downforce, while a well designed wing mount can be both structural and aerodynamic. Remember, if you have any questions, please ask!

Endplates

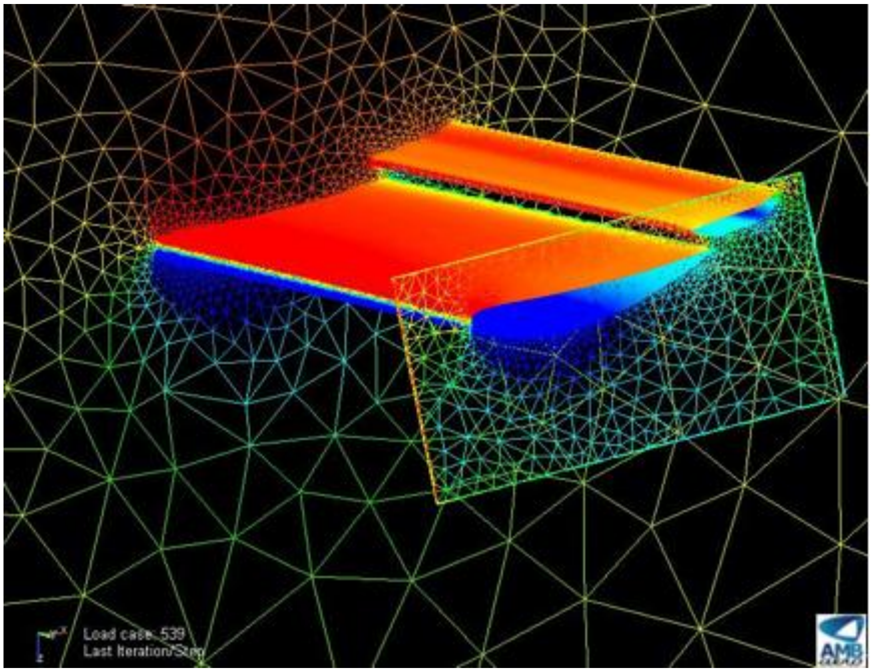
To understand why endplates are needed, we need to understand what happens at the tips of the wing. As you move from the center of the wing out to the tips, there is a loss of downforce. This is due to the fact that air will flow around the wing tip from high to low pressure, creating strong vortices. Thus, endplates are used to maintain the pressure difference between the top and bottom sides of the wing. For endplates, larger is better. There is a simple formula that proves this (if you would like to know the formula, look up Hoerner's method). Larger endplates will increase the effective aspect ratio, which increases downforce, and reduces vortex or induced drag. Another plus to having large endplates is that they move the vortices formed further from the wing, so they don't affect its performance. So how large should an endplate be? That depends on the level of downforce created by the wing. Typically, a low downforce wing creates a smaller pressure difference when compared to a high downforce wing, so you can get away with using a smaller endplate. The pressure difference also means that you need to have more endplate below the wing than above it.



Multi-element Wings

Multi-element wings are useful when max downforce is your goal. Generally speaking, the easiest example of a multi-element wing is the dual-element wing, formed up of a mainplane, and a flap. The basic principle behind a multi-element wing is that you can increase the camber more effectively by using 2 or more elements. As stated last week, more camber equals more downforce. A few other benefits are energizing the boundary layer, which helps keep flow attached, and airflow modification to the whole wing, which is caused by the interaction between the mainplane and the flap.

How large should the flap be compared to the mainplane? Ideally, you want it to be between 25 to 30% of the total chord dimension (the chord is the measurement of how wide the wing is from leading to trailing edge). The shape of the flap is oftentimes a scaled down version of the mainplane, although a simple NACA profile would suffice. Flap location is everything. The leading edge of the flap needs to overlap slightly with the trailing edge of the mainplane, at about 1 to 4 % of the total chord. The size of the slot between the two airfoils should be about 1 to 2% of the total chord. Based on trials an author has done, the ideal numbers he came up with were 3.8% slot gap and 5.2% overlap, with a converging slot gap (this means that the shape of the airfoils lends itself to the narrowing of the slot gap from opening to exit).

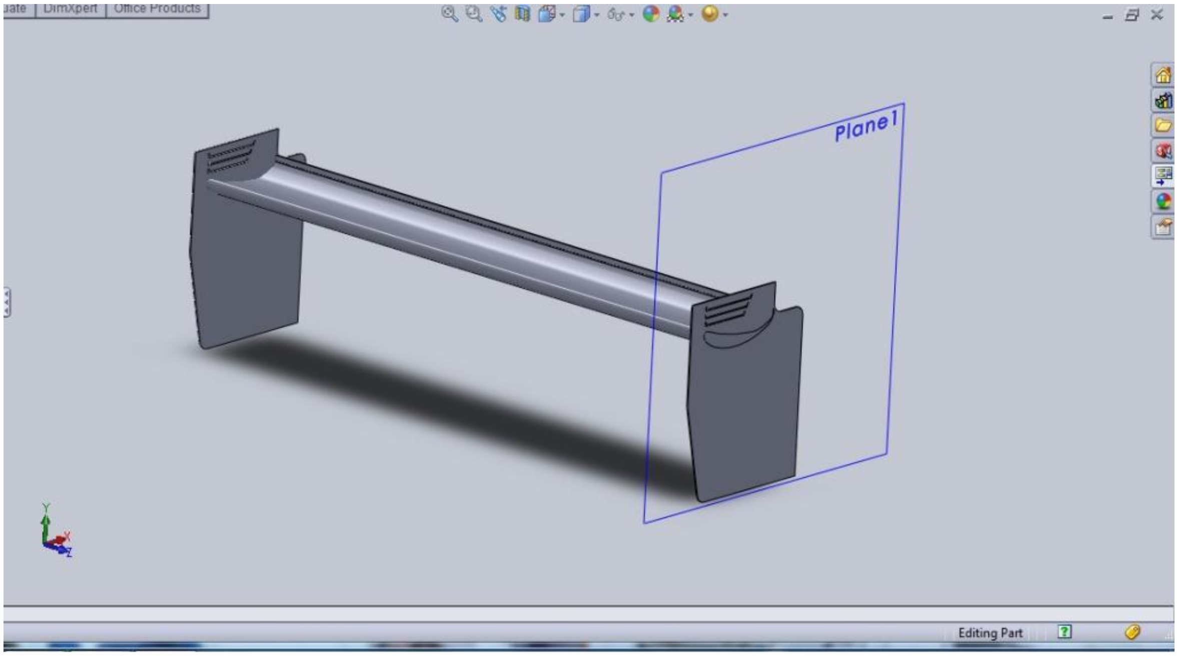


Wing Mount Design

This is a topic which many do not seem to fully grasp. It seems that the general trend is to take as much material out as you can to make the mounts light, which in reality is actually detrimental. First, although cut outs do lower the weight of the mounts, they actually add to drag. That being said, it is best to keep cut outs to a minimum, or to design the mount with the cut outs in an area not affected by airflow. Second, too much material taken out will weaken the wing, and with the massive amounts of downforce that can be created, this will most likely cause damage to the car and the driver. The best advice I can give is if you're going to do wing mounts, keep them as solid as possible. This is better for aerodynamics and for structural integrity. There are generally two types of wing mounts, although these can be broken down into a few other categories: center post or twin post designs, which can be mounted to the top or bottom side of the wing; and the endplate mount design. At KazeSpec Engineering, we prefer to use the endplate mount design, and we'll tell you why in a bit.

Center post wing mounts are the most common, most likely because this makes it easier to create a universal wing to fit many cars. However, with the center post design, you need to be careful with how they are designed, as to not interfere with the airflow on the wing. This brings me to the next type of center post, the swan-neck. The swan-neck design is a fairly recent trend. The reason this design is favored over the typical center post is that it does not interfere with the suction side of the wing, resulting in more downforce. Still, a proper swan-neck must not interfere with air at the leading edge of the wing.

Finally, we have the endplate mount. This is favored by us at KSE because it interferes the least with the wing's airflow. There is nothing in front of, on top, or below the wing, resulting in its maximum performance. Like the other types of mounts, you need to be careful with the design of the endplate mounts as to not affect the airflow near the tips of the wings. Another downside would be that the endplate mounts would need to be thicker than normal endplates, which may eat away at the total span of the wing (if you competed in a series where span is limited).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