Function of Spars

When talking about aircraft wings, we must also discuss spars. They are the long, span-wise beams in a wing. Spars have as main function to carry the bending loads in the wing generated as a result of the aerodynamic forces on the wing. A spar has an I-shaped cross-section of some sort with a web perpendicular to the wing skin and flanges parallel and attached to the skin.

The attachment of the spars to the fuselage can best be explained as if the spar is clamped in at one end. Due to the bending of the wing, the spar also deforms; with the deformation increasing away from the wing root where the spar is clamped. Each part of the spar wants to become diamond-shaped. If we consider the spar as a frame, we can see here that it must contain diagonal elements to counteract the deformation as shear is acting on it. This is why the spar is often made out of a sheet material.

If we look at a typical wing of a large passenger aircraft, you can observe that larger aircraft have multiple spars: primary spars to carry bending loads, and also, they sometimes have auxiliary spars, or false spars, to create closed sections, as can be seen here to fold and store the undercarriage in.

An example of a spar can be seen in this photo. This is a close-up of a spar and you easily recognize the flanges and the web. You can also see that a spar is optimized over its length becoming thinner towards the tip.

To design a spar, you must take into account that the loads vary over its length. The forces acting on it at the root are much greater than at the tip, meaning that the spar must be much thicker there. This makes it difficult to use extruded profiles as spar caps. The solution is found by using adhesive bonded or riveted built-up layers of sheet metal, allowing you to optimize the spar design along its length and, thus, provide a lighter, yet affordable solution.

There are many different types of spars. In this example, you see quite a few different options and ways they are manufactured. Every option from a truss web, to fully machined, and everything in between. As you can see here, choosing the right design for the wing of your aircraft or spacecraft really is a balancing act of material choices, manufacturing options, and structural design. Each change in one of these, impacts the others.

Let me now zoom in on two frequently used spar caps, and how they are built up. First, a spar based on extruded flanges, as shown here. Extrusion is a process whereby metal is pushed through a die to get its shape. Plate metal is the attached to form the web and the skin is attached on top.

In the next example, the flanges are made up of sheet metal that is formed by pushing sheet material by a punch into a die, which is then layered to get the correct thickness along the spar and again attached to the web.

Each solution has its pros and cons. Which one works for your design is up to you!