Fibre metal laminates: An evolution based on technological pedigree
Leo J.J. Kok
Bombardier Aerospace

The development of fibre metal laminates (FML) as a class of structural materials is the culmination of the coalescence of various well-developed technologies in the aircraft industry, with the basis of some of them dating back to the early days of flight. The process of bonding thin metal laminates reinforced with pre-impregnated fibres spliced together to make large fuselage panels has arisen from previous lessons and the economic drivers of airframe production, airline operations and shareholders expectations. The anthem of ‘higher faster farther’ applied during the development of the Comet 4 still applies today – with one caveat of course, i.e. reduced cost!

‘The greatest difficulties lie where we are not looking for them.’– Johann Wolfgang von Goethe

The early days (recent history for some)
The use of construction techniques in the aircraft industry has largely been based on the innovative use of resources and practices that were readily available. The 1903 Wright Flyer embodied canvas, spruce, metal, fasteners, glue and paper and proved to be more than somewhat successful, albeit from a technical point of view. This first aircraft relied on technology from other industries and their practices, especially the bicycle. As designs developed, the use of wood adhesives became more prevalent, again a practice borrowed from another industry, in this case furniture manufacturing.
Tinkering with wood and metal

The world’s first all-metal aeroplane, the Junkers J1, flew in 1915 using a stressed-skin construction in the form of corrugated aluminium. In 1919, Alcoa started producing sheet for aeroplane fuselages and wings [1].

When the United States of America entered World War II in December 1941, it was faced with an uncertain supply of strategic materials needed to produce large quantities of military aircraft. A solution forwarded by the Edward G. Budd Manufacturing Company of Philadelphia, Pennsylvania, the manufacturer of munitions and railroad rolling stock, was the Budd Conestoga, which made extensive use of stainless steel. After its first flight on October 31, 1943, this aircraft was delivered to the USN in March 1944. It later crashed during testing and the test pilot swore that the plane's stainless steel construction saved his life. The flying characteristics of the RB-1 were poor and problems with the use of stainless steel further delayed production and caused the price to rise. In any event, an adequate supply of aluminium and the availability of the C-47/R4D resulted in the USAAF cancelling their order for this aircraft and the USN reducing their order from 200 to a total of 26. All in all, the Budd Conestoga is not a well-known affair in the annals of aviation history [2].

More widely known is the very successful de Havilland solution to the same problem using wood. The result was 6,710 Mosquito bombers, fighter-bombers and night fighters used extensively during WW II. Not only did this allow for increased production of other planes, a significant amount of hot-bonding research was done in the aircraft industry, a technique which had lain dormant for some 30 years. Work at Hatfield, UK, in the mid-1930s focussed on the use of laminated wood veneers of birch, hickory beech or acacia arranged longitudinally to have high specific strength and stiffness for use in wing spars. Such a technique of fabrication is shown in Figure 1 with a stressed-skin wing shown in Figure 2 [3]. This research led to widespread use of synthetic glues for wood on the Mosquito production line with the classic picture of lifting the half shell moulds shown in Figure 3.

Figure 1: Wood laminating at de Havilland.