

DEVELOPMENT OF FIN FOR LCA USING ADVANCED COMPOSITES

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Introduction

Because of their special and superior Structural Properties advanced composites have attracted many airframe designers to use them. Apart from superior structural properties, these materials have the capability to get moulded to any complex shape. This property of composites need to be exploited for producing cost effective and superior structural parts. This as a main goal, co-curing concepts were developed by many airframe developers throughout the world. For the same reason, we also focused our efforts to develop this technology. In the co-curing concept unlike in metal construction, the sub-structure along with the skins is made in one operation. Keeping this as a main design driver, the Fin for LCA was configured.

Fig. 1 gives the details of LCA fin. This fin is designed with minimum number of parts required for the operation and maintenance. From the operation and maintenance point of view it needs removable tip and nose box. In the same lines the fin is designed with 3 main parts. These are Torsional box, Nose Box and Fin cap. To connect the fin to the fuselage two metal fittings are used. These metal fittings are integrated with the torsion box using root rib. The fin cap is integrated with the torsional box using tip rib. These are the main parts of the fin. The main structural members of the fin are Torsional box, Nose box and Fin cap. All these are made using composite materials and are made using Co-cure technology. Fig.2 is the exploded view of Fin.

Fabrication of Torsional Box

The torsional box is the main load carrying member which is a multi-spar (6) construction with mid-rib. The entire box is made as a single piece in one operation. The material used for this is Carbon-Epoxy Prepreg, which cures at 175°C. To fabricate this co-cured box, inflatable rudder mandrels were used. Fig. 3 gives the details of fabrication technique employed. The tooling for this include a set of female tools made out of composite materials, a set of inflatable Rubber mandrels. The spar lay-up is done on the rubber mandrels as shown in fig.3. The skin lay-up is done on the female moulds using transfer foils.

The rubber mandrels along with the spar lay-up is assembled on one of the skin lay-up (either LH or RH skin). The other female mould along with the skin lay-up is placed on the spar lay-up. The entire thing is vacuum bagged and cured in the autoclave. Vacuum bagging is one of the important activity of this technology. During curing Autoclave pressure enters the inflatable rubber mandrels and forces the mandrels to expand, during this process, the spar lay-up laid on the mandrels will be forced towards the skin lay-up and gets consolidated and also gets bonded to the skin lay-up. This is a very simple and effective way of producing integral structures using Composite materials. This process is successfully implemented and the torsion box thus produced has gone through various NDT checks and got certified to get assembled in to the fin, The torsional box produced using co-cure technology is shown in Photograph-1.

Nose Box

Entire nose box with co-cured ribs has been made as a single piece in one operation. The tooling pattern is similar to that of torsion box except that instead of open inflatable rubber mandrels, closed inflatable rubber mandrels are used. The rib lay-up is done on the closed rubber inflatable mandrels and all the mandrels are assembled on a jig. The skin lay-up is done on the rubber mandrels, assembled on the jig. In the torsional box skin lay-up is done on the female moulds, where as in the nose box skin lay-up is done on the inflatable mandrels. The female moulds are assembled on the lay-up and vacuum bag it and cure in the Autoclave. During the cure, the autoclave pressure enters the inflatable rubber mandrels and mandrels try to inflate due to the internal pressure. The female mould will prevent the inflation and in this process, the lay-up gets consolidated. This method of making the part is successfully implemented.

Fabrication of Fin Cap

In this we have to take a different tooling concept. Instead of inflatable rubber mandrels, solid mandrel method is followed. The part geometry is such that, inflatable mandrels will pose some problems, hence solid mandrel approach is followed. These mandrels were cast using

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aluminium powder and Epoxy resin. Skin lay-up is done on the female moulds and rib lay-up is done on the solid mandrels. These solid mandrels along with the rib lay-up is put on the skin lay-up and the female moulds are closed and vacuum bagged and cured in the Autoclave. When heated these solid mandrels will expand and the outside female mould prevent the expansion, in the process the layers gets consolidated. This is called thermal expansion moulding technique. This method is successfully employed and the fin caps are produced.

Assembly

The composite parts thus produced are assembled with the mechanical fasteners in an assembly jig. Thus assembled fin is shown in Photograph-2.

Conclusion

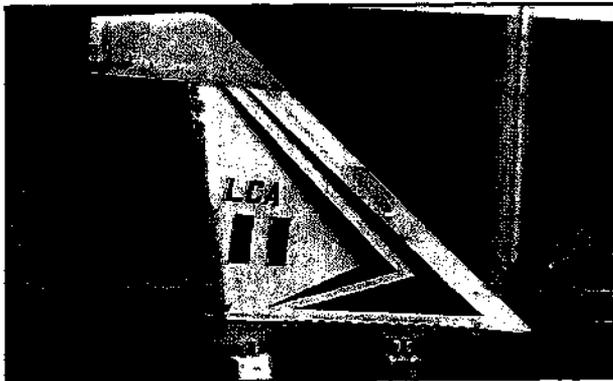
Producing composite parts with integral spars, ribs, stiffeners have many advantages, which includes struc-

tural efficiency and cost effectiveness. These integral structures are produced following co-curing methods. For co-curing one can use inflatable rubber mandrels or solid metal mandrels. Depending on geometry and sub-structure details one has to decide about solid mandrels or inflatable mandrels. For LCA fin both these techniques were successfully employed.

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LCA FIN



Torsional Box

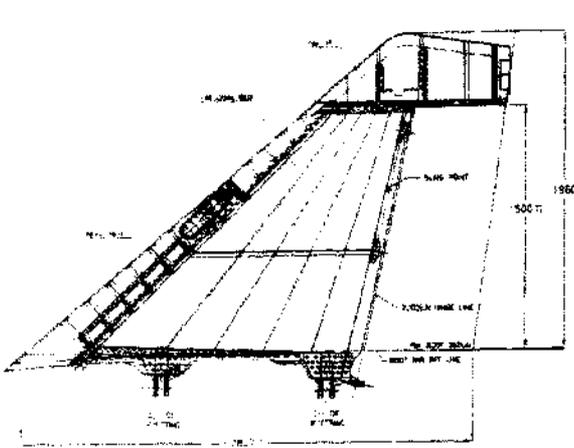


Fig. 1 Fin Assembly

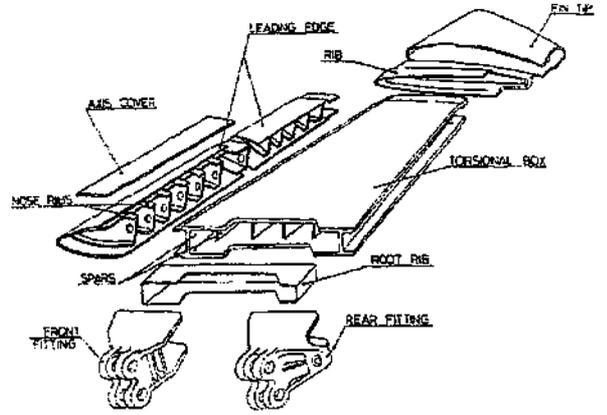


Fig. 2 Exploded view of LCAFin

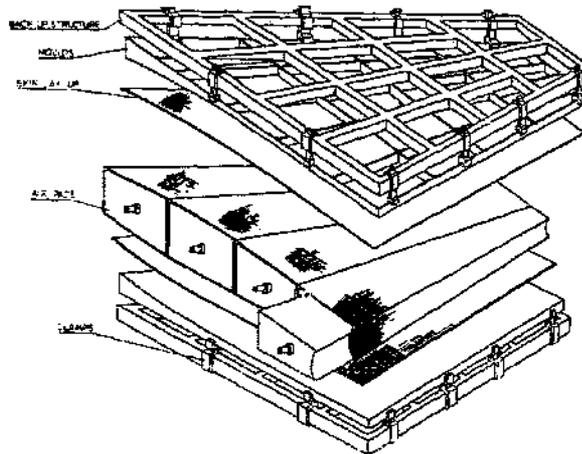


Fig. 3 Schematic view of torsional box tooling

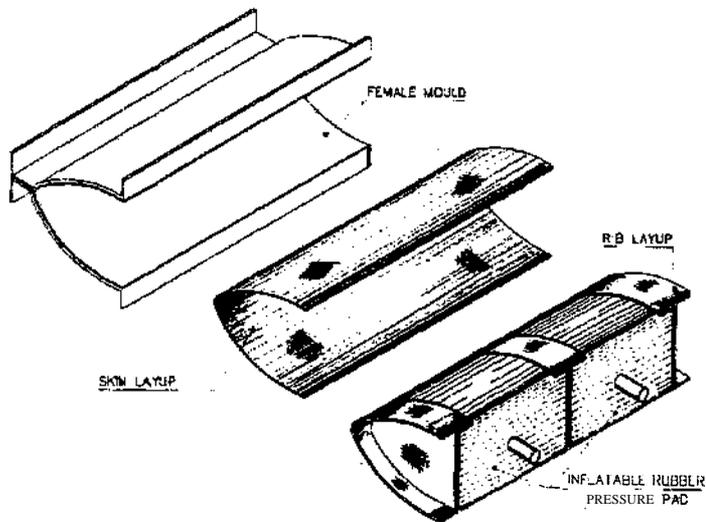


Fig. 4 Nose box fabrication