DEVELOPMENT OF A VERY HIGH TEMPERATURE RADOME

By

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With the conquest of 250°F to 350°F sandwich radomes within grasp, planning and investigation of the next thermal plateau had commenced at Zenith. While superficially looking over the avenues of attack, a very real obstacle was placed before us -- an immediate need for a 500°F to 650°F radome able to withstand thermal shock to possibly 1500°F. The two materials available most closely approaching these requirements were Dow Corning's DC 2106 silicone laminating resin and Hexcel's CTL core. The CTL core is glass fabric base high temperature phenolic honeycomb and the DC 2106 laminating resin for the skins was preimpregnated onto fiberglass fabric. The sandwich construction was to be one-half-inch overall thickness with .410-inch thick core. The outside and inside skins were to be .060 and .030 inch, respectively. Several mechanical strength requirements that had been set forth were flexural skin stresses of 10,000 #/in^2 at 500°F after one-half-hour exposure at 500°F and a room temperature bending moment of 200 in-lb/in. width after a one-hour soak at 500°F. Of these requirements Zenith was only to perform the room temperature tests as a quality control measure.

A pre-production development program was started without delay. Autoclave molding with vacuum bags on the part in female tooling was the apparent approach. This was adopted after initial investigations and consultation with vendors. Beside the actual problems related to obtaining optimum properties from the constituents, the auxiliary materials for achieving the process had to be investigated. Release from the platens and molds was readily obtained with a thin coat of wax paste followed by a film of silicone release agent. Conversely, several investigations were necessary to find a releasing material for covering the top side of the lay-up. It was painfully discovered that cellophane and mylar would tend to fuse into the silicone skins at cure and postcure temperatures. Perforated teflon-impregnated glass fabric was finally accepted as the topside releasing agent. On top of this, industrial glass mat was used as a bleeder layer for achieving effective vacuum overall.

Polyvinyl alcohol was initially used both singly and doubly as the bagging material. Possible bag leakage necessitated a search for another bagging material. The outcome of this was the adoption of silicone rubber coated glass fabric. This was mechanically sealed to the mold using a gasket of high temperature zinc chromate.

Several combinations of flow and resin content in glass cloth preimpregnated with DC 2106 were tried. The combination that finally evolved as best suited to fulfill the molding requirements was a resin content of 34% to 38% and a flow of 14% to 16%. The flow is determined under 100 #/in^2 at 340°F. The volatile content to which this material is treated is below 1½%. The gel time of the resin under these conditions should be around 2½ minutes at 340°F.

In laying up the first test panels it was found that due to the bulk factor it was necessary to place the top skins in position when the build-up was level with the core. The bulk factor referred to is a ratio of the uncured to cured thickness. When the top skins were in place the build-up was completed. This gave a burying effect of the skins on the molded part, which became desirable as upon finishing the edges for attachments the danger of cutting through the top skins was lessened.

After testing the first sets of panels it was evident that an improvement of the core bond was necessary. Commercially available adhesives were avoided as their electrical properties as well as their ability to withstand the thermal shock were questionable. A core treatment was developed from which the flatwise tensile properties were improved as much as 65%. This treatment consists of etching the core in a 20% caustic soda solution for one-and-three-quarter minutes at 140°F. The core is immediately neutralized and rinsed in water. After complete drying of the core it is coated with silicone resin to the original density of 6.5 $\#/ft^3$. Curing of this resin coat is critical, as too rapid a cure causes boiling of the toluene solvent which in turn causes a weakening bubbling effect.

Under pressure molding the dimpling of the skins between cell walls of the core was excessive. This was true even when molding pressures were reduced from 95 to 45 $\#/in^2$. Another problem was filling of core cells with resin which drained from the skins. A novel idea of placing a precured ply of material one ply away from each side of the core was adopted. This, for the greatest part, eliminated dimpling as well as excessive flow of resin into the core. It was discovered that the secondary bond obtained to the precured ply was equal to a wet lay-up interlaminar bond. Initially the precured plies were cured between teflon sheets and then sanded. Sanding was later eliminated by curing between unimpregnated sheets of a fine glass fabric and tearing them away after cure.

Another very important factor is that upon completion of cure it was found necessary to maintain pressure until the temperature has been reduced to 150°F. Otherwise an unbonding or delamination of the skins is likely to occur. It may be noteworthy at this point to mention that silicone skins of this type are porous. This is probably advantageous as indications are that the CTL core gives off a degradation gas even though fully cured. In addition, any residual toluene would boil off at approximately 250°F. Either of these gases or a combination thereof could cause unbonding of the skins were they not porous.

At this stage tests were conducted on parts fabricated by the evolved process. These tests gave values equal to or exceeding the required bending moment. Values ranged from 200 in-lb to 250 in-lb/in. width. The process was then adopted for production fabrication of radomes. Production schedules were such that the time required for heating and cooling of the autoclave made it necessary to investigate the feasibility of vacuum bag molding. Investigations revealed that the use of augmented pressure was not necessary. A corollary advantage of the use of lower pressure vacuum bag techniques was the elimination of the need for precured plies. Production processes were finalized by adapting all the previously discussed developments using vacuum bag molding in conjunction with oven heating for cure. In addition, the construction was modified such that the inside and outside skin thicknesses were .050 and .040, respectively. Thus the meeting of production schedules was essentially accomplished without sacrificing surface conditions or structural integrity.

With radomes flowing off the production line research is far from complete. Evaluation of new materials is already in progress. Preliminary results obtained with a new silicone impregnated core material look very promising. Production problems such as warpage developed during cure and postcure are obstacles to overcome. Investigation of core bond improvement has barely been scratched, and a thorough investigation of the empirically derived flow-resin content-pressure relationship is imperative.

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