Research on High Precision Carbon Fiber Reinforced Plastics Reflector Panels for Dome A 5m Terahertz Explorer

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Dome A 5m Terahertz Explorer (DATE5) is a proposed telescope to be deployed at Dome A, Antarctica to explore the excellent terahertz observation condition unique to the site[1,2]. The low expansion property of carbon fiber reinforced plastics (CFRP) makes it more superior for the material of DATE5 antenna in such an extremely environment with large temperature difference.

In order to meet the high surface accuracy requirement of 10 microns rms for DATE5 primary reflector, there are two key challenges need to be settled in the development of high precision CFRP panel, which are the high precision molding accuracy and the high thermal stability respectively.

The research on high precision CFRP sandwiched panel has been developed by Purple Mountain Observation (PMO), CAS since 2014[3]. In order to achieving high replication efficiency from the mold to improve initial surface accuracy of panel, process of additional replication by resin layer is also applied [4]. Huge surface error such as fiber print though on surface, residual curvature error caused by difference of CTE between panel and mold appeared after the first molding process with high press and temperature. As a treatment, a layer of room-temperature curable resin with low curing shrinkage (2.5%) is slightly pressed in front of sheet after the first molding process. The surface of the rich resin coating with a thickness of 0.1mm~0.2mm is well adequate to eliminated most of the surface error, as shown in Fig.1.

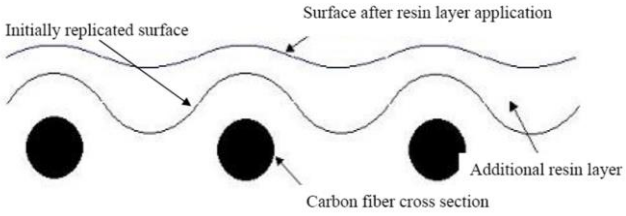


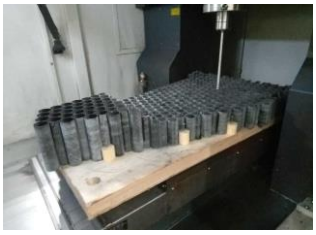
Fig.1 Primary reflector of microwave satellite

Meanwhile, A parametric finite element model (FEM) of DATE5 reflector panel is established base on the basic material properties of carbon fiber and resin used to predict its thermal deformation behavior at low temperature. The material properties are test at full temperature and the thermal deformation of the prototype panels are measured in a climate chamber. The thermal deformation behavior of the panel can be predicted more accurately by FEM after parameters corrected by experiments.

Three types of panels with different core structures have been studied by PMO in the past five years, which are CFRP sheets collocated with aluminum honeycomb core, CFRP tubes array core and CFRP lattice core respectively, as shown in Fig 2. The initial surface accuracy of prototype panels with 1 meter size can be kept within 10 microns rms stably now. The curvature of surface shape of panel with aluminum honeycomb core will change easily at low temperature caused by the thermal deformation in the normal direction of aluminum honeycomb. And the thermal stability of all-CFRP panel structures are much better, the thickness and fiber volume content of sheets are key performance parameters which affect the thermal stability.

（a）Aluminum honeycomb core

（b）CFRP tubes array core



（c）CFRP lattice core

Fig.2 Three types of prototype panels

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