Quasi-isotropic braid reduces cost in large composite tooling

The National Research Council of Canada – Herzberg Institute of Astrophysics' (HIA) Dominion Radio Astrophysical Observatory (DRAO) won a JEC Award 2009 in Paris for the "Composite Applications for Radio Telescopes" (CART) project, together with its partner Profile Composites Inc. from Sidney, BC, Canada. Profile Composites chose a hybridized form of A&P Technology's QISO™ braided triaxial fabric for the development of its composite tooling, which is ultimately intended for large radio antenna applications.

GEOFF WOOD
PRESIDENT
PROFILE COMPOSITES INC

This antenna tooling is about 12-15 metres in diameter and requires quasi-isotropic properties over a large, curved surface where dimensional control and heat transfer are critical. The properties that make A&P Technology's QISO™ an excellent choice for the fabrication of advanced composite parts in the aerospace, recreation and infrastructure markets, make it an equally superior choice for composite tooling applications.

Right design

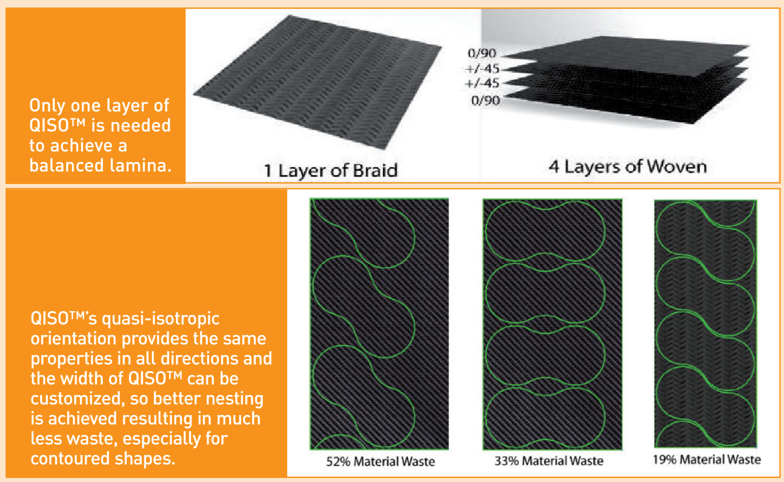
DRAO has developed 10-metre diameter prototypes supported by Profile, while Profile has been working with DRAO to develop a high-volume production technology for these antennas.
The observatory has just won the coveted JEC Innovation Award in the Aerospace category for their antenna technology development. This award was presented at the 2009 JEC Asia show.

To date, only development tooling has been used considering that the various reflector designs and production methodology are still in the process of being selected and evaluated. Production tooling requirements demand very precise tolerances over the surface, excellent surface finish and minimal local deviations, in addition to high dimensional stability across the process temperature range and a lifespan of 1,000 cure cycles.

An all-carbon tool or a hybrid woven carbon/glass fibre material was considered for such purposes. Longevity requirements on the tool, which will be fabricated by resin infusion, dictate a very low void content and minimum interlaminar shear stresses in order to limit resin microcracking and retain vacuum integrity. Moreover, fine fabrics on the tool surface are required to minimize eventual print-through of heavier back-up tooling fabrics. Building the tool with conventional woven fabrics or stitched materials would work, though it would be preferable to find a solution providing a faster build, better intrinsic layer-to-layer property match, and capability to use fabrics of different weights. Quadraxial stitched materials and cross-plied wovens were investigated, but fabric weight, conformability, thermal performance, and cost were all deemed inferior to a triaxial

Focus ...

QISO™ is quasi-isotropic and balanced in a single layer making it thinner and lighter than most laminates while allowing for a decreased lay-up time. Furthermore, the waste associated with ply cutting is greatly reduced with QISO™.

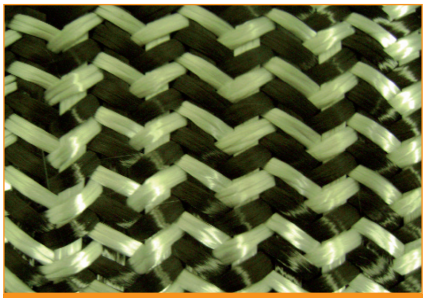


The braid's quasi-isotropic orientation provides the same properties in all directions. Its width can be customized to achieve better nesting, which results in much less waste, especially for contoured shapes.

braided fabric. A&P Technology supplied their carbon/glass hybridized version of QISO™ to eliminate the drawbacks of these conventional tooling fabrics.

Isotropic layers of braid

QISO™ braid with an in-plane quasi-isotropic architecture – like metal – provides thermal expansion properties that are the same in all directions. These isotropic layers of braid provide a more uniform thermal growth across the tooling surface than competing materials while greatly reducing manufacturing times. The hybridized version of the braid used by Profile has alternating glass and carbon fibres in the bias and axial positions. The hybrid material has all the benefits of the quasi-isotropic architecture while saving material costs associated with an all-carbon tool. The carbon/glass construction still maintains good thermal conductivity over an all-glass tool, and can be tailored as needed to match actual part coefficients of thermal expansion (CTE). Carbon fibre braided through the thickness alongside the glass tow bundles effectively transmits heat through the QISO™ tool surface in a manner more like metal tooling than an all-glass tool construction. Stitched multiaxial tooling materials that alternate glass and carbon cannot duplicate the improved thermal conductivity of the hybrid braid since the layers are alternating between glass and carbon and are therefore effectively insulated by the glass layers.
Since QISO™ is a single-layer balanced lamina, the significant labour costs associated with the cutting and placement of other 0/90 and +/-45 fabric styles which are required to maintain a uniform tool surface CTE are eliminated.
Waste factors on a full-scale tool are estimated to be about only 5% as compared with an estimated 12% when using woven fabric materials. For the large tools used in the manufacture of wind turbines and satellites, this reduction in waste coupled with the reduced lay-up time found with QISO™ result in significant savings.



Hybridized form of A&P's QISO™ customized for tooling application

The finished tool surface is balanced for CTE without regard to precise ply placement, which is extremely useful for contouring over a large symmetrical or asymmetrical dish surface. A fast build-up of the tool surface is achieved thanks to its superior drapability and heavy braid thickness. The superior inherent thermal stability and uniformity of the quasi-isotropic braided tool surface reduces the need for a heavy backup structure. This means the toolmaker can reduce both the cost and weight of the finished tooling.
Since the braid yields the same properties in every direction, the build-up of properties is also consistent within each layer of the tool build. With this consistent build-up of properties and the capability of the braid to be fabricated with different denier input fibres, it is possible to build the tool from very light through to very heavy QISO™ and not suffer any detrimental effects in performance. In fact, the heat transfer also becomes progressively better as the fabric weight decreases, improving thermal distribution near to the tool-part interface.

Results

Additional savings are made in the tool moulding process as tool fabrication times are reduced by the improved infusion and wet-out of the hybridized braid. The resin flow is aided by both the glass fibre in the braid and the reduced classic fabric tow crimp. Wet-out is achieved much faster and more completely compared with an all-carbon fabric alternative. This will result in a longer tool life and improved vacuum integrity as the void content is expected to be lower.

Composite tooling surfaces built with carbon/glass QISO™ braid materials result in superior laminating tools that have optimized thermal expansion properties without the time-consuming process of having to plan, cut and apply anisotropic fabric plies to achieve the same result. This optimum thermal stability and control will result in much less risk of thermal mismatch with the actual part, therefore reducing moulded-in stress and potential warpage. Parts moulded with QISO™ hybrid braid tooling will achieve the highest level of dimensional accuracy possible.
This is especially critical as composite parts continue to grow in size, alongside the increasing need for precision and accuracy. This is the case for radio antennae, wind turbine blades and similar large 3D lofted components.

The A&P Technology QISO™ quasi-isotropic braid is the logical choice for both composite parts and tooling applications. It can be customized in terms of width, areal weight, yarn type, fibre orientation and strategic axial placement. ■

More information: www.braider.com

More information ...

The "Composite Applications for Radio Telescopes" (CART) project is an ongoing effort to investigate the application of composite materials to radio telescope structures to provide a cost-effective collecting area for the Square Kilometer Array (SKA). The result of this effort – the CART Mk 2 reflector – clearly demonstrates the potential of composite materials for the construction of radio antennas in the 10-15 m size range. The project research focuses very specifically on technology development for the SKA, which will require several thousand 12-m class reflectors to be fabricated over a period of several years. Space communication ground arrays are another potential application where a number of reflector antennas are required.