Chapter Seven

SOME CARBON–CARBON SPINOFFS

The work on involute bodies involved studies of carbon–carbon composites, at first as an incidental activity, but later on "spinoff" into a few contributions relating to other specific applications of this composite material. It should be noted that carbon–carbons are primarily used in high-temperature environments and are subject to high temperature gradient and short-time loadings. Key properties of this class of materials are strength retention (Even though the strength may be relatively low), high thermal conductivity, and great susceptibility to oxidation degradation. Because of the extreme conditions under which it is processed, the reinforcement usually consists of 2D cloth or 3 or more orientations in space and the matrix and interfaces contain considerable damage, which seems to impart subsequent "damage tolerance" to the material.

The first paper here was motivated by several issues. The first of these was the fact that laminated turbine blades were being fabricated in an Air Force program, but the structure was being analyzed as a *homogeneous body* through the use of a three-dimensional finite element code. This approach combined the high cost and uncertainty of the 3D code calculations with the imprecise material model. The second issue is more subtle and involves an unusual problem in interlaminar stresses since the blades are made such that the width–to–thickness ratio approaches *zero*, rather than *infinity*, as is the case for structural laminates. This means that there is insufficient width to develop the in-plane stresses assumed in classical lamination theory. For example, treating the blade as being very wide, rather than very deep, leads to computed interlaminar stresses several *orders of magnitude* higher than the corresponding material strength.

The associated phenomenon investigated in the paper is largely responsible for the success of the blades. To the author's knowledge, the importance of this observation has *never* been recognized in practice. The remaining model development is straightforward and combines elements of strength of materials and anisotropic elasticity, but the model itself has never been validated either by experimental correlation or comparison with a more rigorous formulation. Failure to explore this model further is attributed to the highly specialized nature of the application.