Testing of composites - I

Mechanics Terminology (1)

How is a composite structure analyzed mechanically?

A composite material consists of two or more constituents; thus, the analysis and design of such materials is different from that for conventional materials such as metals.

The approach to analyze the mechanical behavior of composite structures is as follows,

1. Find the average properties of a composite ply from the individual properties of the constituents. Properties include stiffness, strength, thermal, and moisture expansion coefficients. Note that average properties are derived by considering the ply to be homogeneous. At this level, one can optimize for the stiffness and strength requirements of a lamina. This is called the *micromechanics* of a lamina.
2. Develop the stress–strain relationships for a unidirectional/bidirectional lamina. Loads may be applied along the principal directions of symmetry of the lamina or off-axis. Also, one develops relationships for stiffness, thermal and moisture expansion coefficients, and strengths of angle plies. Failure theories of a lamina are based on stresses in the lamina and strength properties of a lamina. This is called the *macromechanics* of a lamina.

A structure made of composite materials is generally a laminate structure made of various laminas stacked on each other. Knowing the macromechanics of a single lamina, one develops the macromechanics of a laminate. Stiffness, strengths, and thermal and moisture expansion coefficients can be found for the whole laminate. Laminate failure is based on stresses and application of failure theories to each ply. This knowledge of analysis of composites can then eventually form the basis for the mechanical design of structures made of composites.

An understanding of stiffnesses, strengths, coefficients of thermal and moisture expansion of the individual constituents of a composite, fiber volume fraction, packing geometry, etc. which is called micromechanics of lamina, helps the designer to select the constituents of a composite material for use in a laminated structure.

Factors affecting strength of composites (pg 221 to 250)

Monolithic laminates (4)

Most composite structures are built up into useful sections by stacking plies of fibre or fabric onto each other. Since the orientation of the fibres can be varied, the properties of the laminate are not consistent through the thickness of the part, and are considered highly anisotropic in all 3 planes.

Rule of mixtures

Whilst deformation of homogeneous, isotropic materials can be described relatively simply by use of Youngs and Shear moduli, which are bulk properties of the raw material simple properties of composite materials can be estimated based on the contribution of each part of the composite. This method is referred to as the rule of mixtures (RoM).

References:

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