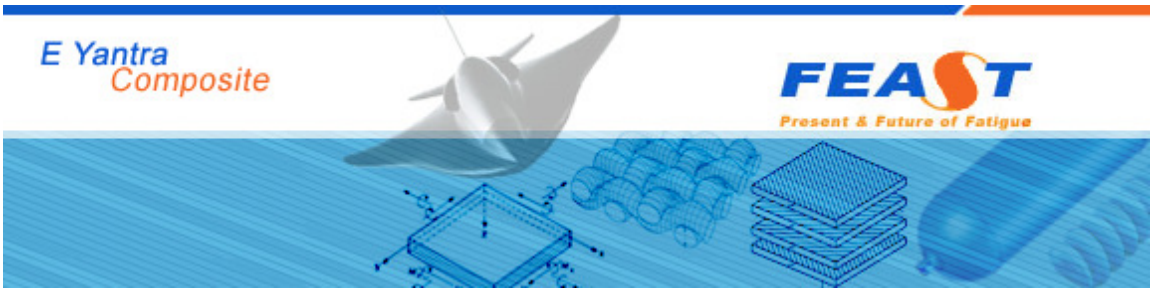

E-Yantra Composite

Polymer matrix composites are finding increasing uses world over in high technology as well as day-to-day applications during the last four decades because of their potential properties. These materials are characterized by high specific stiffness and specific strength and enhanced dimensional stability, impact resistance, fatigue resistance and corrosion resistance. But the potential properties can be achieved only by proper analysis and design of composite materials / structures. The structures undergo various loading conditions such as static, quasi-static, dynamic, impact, ballistic impact, blast and fatigue during their service life. Fatigue is one of the critical loading conditions.

E-Yantra Composite is a unique and efficient software product which can give solutions for fatigue of composites. From this software effective use of polymer matrix composites and their behavior under fatigue loading can be clearly understood. Fatigue behavior can be represented in terms of fatigue damage mechanisms, residual stiffness, residual strength and remaining life of composite structures. Estimating remaining safe life, rehabilitating for extended life and designing the structures for intended life are the important requirements. At the initial stage of analysis and design itself, long term behavior of composite materials / structures can be evaluated. Some typical application areas are: aircraft, aerospace vehicles, windmills, bridges, automotive components, ship structures, pressure vessels, mechanical elements, sports goods and other structural components.

E-Yantra Composite software product consists of an exhaustive data resource on thermomechanical, fracture and fatigue properties of different

composites. Other main components of E-Yantra Composite are: feast-static software for the static analysis of composite materials / structures and feast-fatigue software for the fatigue analysis of composite materials / structures. The fatigue behavior can be evaluated either by stress-life, strain-life or fracture mechanics approach.

Ease of operation with user-friendly Graphical User Interface (GUI), accuracy of results and graphical presentation of the results are the special features of the software. The capabilities of three modules included in E-Yantra Composite namely Composite Data Resource, Composite Analyzer and Composite Fatigue are listed below:

1) Composite Data Resource

Composite Data Resource consists of experimentally obtained thermomechanical properties for different materials. Advanced algorithms are also provided for generating properties for different materials.

Databank1 (DB1) consists of thermomechanical properties for a variety of 3D orthotropic materials. Specifically, nine elastic properties, nine strength properties, nine strain properties, three coefficients of thermal expansion, three thermal conductivities, three coefficients of moisture expansion.

DB1 also consists of thermomechanical properties of fibers and matrices. The thermomechanical properties included are for both transversely isotropic and isotropic fibers and resins.

All the thermomechanical properties can also be generated using micromechanics, inverse micromechanics and feast algorithms. Six methods are included in the micromechanics part of Composite Data Resource.

An important goal of micromechanics is to predict the properties (or nonlinear response) of the composite material on the basis of geometries and properties of individual phases, a task known as homogenization. The benefit of homogenization is that the behavior of composite can be determined without resorting to testing the composite, which can be expensive given large number of permutations (e.g. constituent material combinations, fiber volume fractions, fiber

arrangements, processing histories) represented by composites. Micromechanics also allows for prediction of average elastic properties, hygrothermal properties, strength properties of lamina as a function of its constituent properties and local condition i.e. effects of broken fibers and misalignment of fibers are also considered in the analysis. The special features of this software are: generation of properties at different temperatures as well as with moisture content. Orthotropic properties of lamina can be generated using modified Method of Cell.

Current properties of fibers considering possible degradation of the properties because of hygrothermal effects can be determined using inverse micromechanics. Current properties can be used to determine actual properties of lamina using micromechanics.

DB2 consists of S-N curves for different materials as well as residual stiffness data. Algorithms are provided for the generation of additional S-N curves in a class of materials for different fiber volume fraction, stress ratio, frequency and stacking sequence.

DB3 consists of fracture properties for different materials. Specifically, critical strain energy release rate and critical stress intensity factor for Mode I, Mode II and Mode III as well as for mixed mode are included. Crack growth resistance curves (R curves) for mechanical as well as thermal loading are included. Critical strain energy release rates for Mode I and Mode II as a function of number of cycles are also included.

DB4 consists of strain-life curves and the associated information for different materials.

2) Composite Analyzer

Composite Analyzer is an efficient software for the analysis of laminated composites under general in-plane loading, transverse loading and end moments. Elastic, hygrothermal and strength behavior of composite structural elements can be obtained. The analysis is based on classical lamination theory. The inputs required for the analysis are: laminate configuration, layer elastic, hygrothermal and strength properties and loading conditions. A data bank

consisting of thermomechanical properties for different materials is also a part of the software.

The outputs obtained are: thermomechanical properties of laminates, stress state, strength ratio, tensile, compressive, shear and flexural strengths of the laminates, stress-strain diagrams and failure envelopes. The shear and normal coupling does not have counterpart in the conventional material. Coupling results in more complicated behavior. Our belief is that this as an unique opportunity with composite materials rather than a liability. Composite analyzer gives variation of Poisson's ratios, the shear and normal coupling coefficient with respect to orientation of laminate. They are useful for indication of behavior of off-axis composites.

This software has a capability to obtain stress-strain diagrams and failure envelops in graphical form. Stress-strain curves are plotted considering unit average load acted upon the laminate and load sharing ratio of laminas are obtained to predict each lamina strength. There are six stress-strain curves which give idea about failure stresses and strains in all modes. Ply by ply failure analysis can be carried out with full or partial degradation factor of matrix as well as fiber. This software gives six biaxial 2-D strength envelope plots in stress and strain plane using maximum stress theory, maximum strain theory, and Tsai-Hill and Tsai-Wu quadratic failure theories. The quadratic interaction failure criterion in stress and strain space is recommended for unidirectional and multidirectional composite materials.

The anisotropy of unidirectional composites also manifests itself in the hygrothermal behavior. Because of directional dependence of hygrothermal expansion, residual stresses are induced in composite laminates. The residual stresses in a laminate change the ply failure stresses; the ply strength ratios, dependent on the residual stresses, can be beneficial or deleterious. In addition, the process of curing and environmental effects can be chosen to provide the most desirable prestress. The use of prestress can shift failure modes to more advantageous combinations and locations. Composite Analyzer predicts the residual strength over the different plies for different loading conditions using

strength ratio concept. Strength prediction of symmetric, antisymmetric and unsymmetric laminate considers prestress effect.

Composite Analyzer also predicts governing failure modes i.e. which lamina fails first, in what mode and what would be the failure type. Composite Analyzer helps to make judicious choice of ply material, local property and global or structural property.

3) Composite Fatigue

Composite Fatigue is a unique and efficient software product which can be used for fatigue analysis of composite materials / structures. The fatigue behavior can be evaluated either by stress-life or fracture mechanics approach.

Main components of Composite Fatigue are: feast-static software for the static analysis of composite materials / structures and feast-fatigue software for the fatigue analysis of composite materials / structures.

Feast-static consists of analytical methods based on advanced algorithms. Composite Fatigue is compatible with commercially available finite element analysis software packages. Currently interface is provided with commercially available finite element analysis software package ANSYS. Fatigue analysis can be carried out using Composite Fatigue module.

The stress-life approach provides residual stiffness, residual strength, damage index and remaining life for different composite materials / structures whereas the fracture mechanics approach provides details about transverse crack initiation and formation of additional cracks, crack density, crack saturation state, delamination initiation and propagation at the crack tips and residual stiffness and remaining life.

Composite Fatigue covers structural assemblies, notched composites, temperature effect, environmental effect and effect of composite laminate configuration in addition to different structural elements. Different loading conditions such as uniaxial, general inplane, transverse, block and random can be analyzed using Composite Fatigue.

Composite Fatigue along with Composite Data Resource and Composite Analyzer can be used for fatigue analysis of a variety of structural elements and assemblies.

Special features of E-Yantra Composite

- Unique, efficient, multipurpose and indigenously developed software product by FEAST Software Pvt. Ltd. in association with SINE and IIT-Bombay, Mumbai.
- Consists of micromechanics and inverse-micromechanics to generate property database.
- Consists of an exhaustive data resource of fatigue properties,
- Feast-static consists of analytical methods for static analysis,
- Compatible with commercially available finite element analysis software packages for static analysis,
- Fatigue analysis and design is possible by stress life and fracture mechanics approach,
- Can act as virtual composites laboratory,
- Can act as virtual fatigue engineering laboratory,
- Composite analyzer covers first course on mechanics of polymer matrix composites,
- Composite fatigue along with composite analyzer, composite designer and composite data resource can be used for post graduate and doctorial projects,
- Can be used for academic research and industrial consultation,
- Can be used to analyze design of composite structural elements
- Can be used for fatigue analysis of high performance products made of composite structures / assemblies
- Can be used for the evaluation of current status and remaining life of components in use.

FEAST Software Pvt Ltd

1st Floor, Amartara Plastic Compound

Saki Vihar Road, Sakinaka

Andheri (E), Mumbai - 400 072

Tel No. +91-22-6770 7690 (D)

Fax: +91-22-6770 7555

E-mail: marketing@feastsoftware.com

www.feastsoftware.com