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Finite Element Analysis

Description:

Finite element analysis (FEA) is a computer simulation technique for modeling and analyzing the effects of mechanical loads and thermal stresses applied to a part and/or material used in a product or system. FEA is a powerful method for identifying areas of stress concentration that are susceptible to mechanical or thermal failure before manufacturing and test-

How It Can Benefit You:

A thorough FEA can be time consuming, so that candidates for analysis should be carefully selected. Typical criteria for selection includes devices, components or design concepts which (1) are unproven, and for which little or no prior experience or test information is available, (2) utilize state-of-the-art or unique packaging and design concepts, (3) will encounter severe environmental loads, or (4) have safety-critical thermal or mechanical performance and behavior constraints. The most labor-intensive portion of the FEA is creating an appropriate model, which is being addressed by the development of intelligent modeling software and automated mesh generators.

Conventional mechanical analyses, such as the use of stress-strength interference curves relating material life to applied stress, become intractable when the structure is complex, or when it is composed of many different materials which do not lend themselves to direct analysis. These same factors confound the estimation of temperatures within the structure. These issues also apply to structures that may be too large to test economically. FEA can address these issues

ing begin, thereby providing valuable information during product/system design and development, and reducing or eliminating the costs associated with materials scrap and rework. FEA has been used to analyze mechanical systems ranging in size from a portion of a microcircuit chip to a large space antenna.

by revealing areas at risk of failure from mechanical and/or thermal stress.

A realistic test of a large object such as a large antenna tower cannot be done without going to the expense of building the structure. While being too costly to build the structure, it is also too risky to commit the design to production without some assurance of its reliability. FEA can provide this assurance at significantly reduced cost. It can also be used when a test may be impossible, such as when the structure is intended for space applications.

It is conventional to design mechanical systems with large reliability safety margins. Many applications, however, preclude this. For example, the need for airborne structures to be lightweight limits the selection of the type and amount of material used. To accommodate these types of constraints requires a comprehensive stress analysis. Even when large safety factors are possible, the knowledge provided through FEA will permit significant cost savings by allowing robust designs to be achieved using an optimum amount and type of material.



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RAC Capability:

Mechanical R&M engineering is one of the core areas of expertise of the Reliability Analysis Center (RAC). RAC engineers are proficient in a broad spectrum of mechanical R&M techniques and methodologies, and have provided consulting services in these areas to a large number of customers. One of the major tools employed by RAC is finite element analysis (FEA).

RAC has a versatile family of FEA tools resident on its computers, including a large and diverse library of model elements. It also encompasses linear, non-linear, static, dynamic and thermal analysis capabilities. The FEA tools support both shape and structural optimization, as well as fluid flow, fatigue and fracture analysis. RAC can perform both composite solid and shell analysis. Computed stresses and deformations can be tabulated, depicted by the graduation of colors on a display, or pictured by animation of the display.

Implementing these capabilities effectively requires requisite skills in R&M engineering. RAC engineers have developed and presented numerous training courses dealing with mechanical reliability theory and applications. RAC has also developed a guidance document entitled "Mechanical Applications in Reliability Engineering", and solved real-world reliability problems for military and commercial customers.

RAC engineers have applied FEA techniques for thermal gradient and stress/strength analyses to solve problems or validate designs for ignition and power conditioning systems produced by one RAC customer for both military and commercial aircraft.

In another application, RAC engineers used FEA techniques to determine a component failure cause and, subsequently, to aid the customer in the redesign of the component. The component was an alternator that failed during a jet engine test. The thermal FEA that was performed indicated that parts of the alternator field coil would separate under high temperature. A replacement for the coil was created through the use of a FEA "what-if" analysis in which the effects of different part dimensions and materials were evaluated until a satisfactory, and ultimately successful, field coil design was identified.

Finite element analysis possesses a wide range of capability, from analyzing the thermal stresses in a microcircuit solder connection, to predicting the potential distortion of a large antenna in space. RAC expertise can assist its customers by providing information on life-limiting failure mechanisms that can highlight effective trade-offs of design alternatives, thereby avoiding the expense of costly breadboarding and testing.

Point of

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