Types of FEA

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There are many different types of analysis supported by the finite element method. Below is an explanation of the main types of FEA and their applications:

Linear or Nonlinear

All analyses can be classed as being linear or nonlinear. Whenever the 'initial conditions' change during an analysis, non-linearity exists.

Imagine you are blowing up a balloon; as the balloon fills its diameter rapidly changes. The balloon material stretches significantly, becoming thinner and stiffer. Hence the effort required to inflate the balloon changes as it is inflated. A non-linear analysis can take this into account while a linear analysis cannot. Essentially a nonlinear analysis makes accounts for the change in the stiffness matrix of the material throughout the entire stress process.

Linear analysis have the ability to be directly 'scaled' ... for example, if the load is doubled then the results (stress, deflection, etc) will simply double. The use of this knowledge can significantly reduce the number of FEA analysis that need to be undertaken.

Static or Dynamic

Are the loads applied slowly or fast? (Like snow loading on a roof or a cell phone dropping to the ground?) When loads vary rapidly with respect to time, the mass and stiffness of the structure start to have an influence on the results. Using the example of a cell phone dropping; the heavier the phone is, the greater the structure needed to support it.

Comparative or Absolute

Does the analysis need to provide 'accurate' results or is a percentage change all that is required? You may have an existing successful product with uncertain loading conditions that you would like to change. For example, it might be a coil spring from a car suspension. Without knowing anything about the load that the spring undergoes on the car, with a comparative analysis it may be possible to see whether design changes to the geometry (for example) are going to improve or reduce the performance of the unit.

Subtypes of FEA

Vibration and Impact: These are types of dynamic analysis that can be used to assess how a product will perform. For example, will the car steering wheel vibrate while driving? Would my product survive a drop onto floor from one metre up

Buckling: A length of wire can hold much less load in compression compared to tension due to a phenomenon called 'buckling'. It can occur in any object that is relatively thin/narrow in one

direction, such as beams and sheet-metal parts. FEA can be used to predict the load at which an object will partially or fully buckle.

Contact: This nonlinear technique analyses the effect of parts contacting each other. For example, a car crashing into a flexible safety barrier or a bolted 'friction-grip' joint.

Fatigue: FEA is a powerful tool for assessing the complex effects of cyclic loading (fatigue) on components. A product life can be estimated in years and areas likely to crack highlighted.

Heat transfer and Thermal Deflections and Stresses: FEA can be used to calculate the effect of heat on a components strength and temperature distribution.

Creep and Relaxation: A lot of engineering materials will tend to gradually stretch over time and can eventually rupture in a process called 'creep'. This is a key consideration for most plastic designs and is highly influenced by temperature. FEA can predict this behaviour.

What type of FEA is best for your project?

Static studies are cost effective and acceptable for most general engineering scenarios. Structural, vibration, fatigue, heat, flow, etc are common types of analyses that can be run.

Non-linear studies are more complicated and expensive to perform. If you are looking for analysis of deforming structures, complicated contact conditions, creep etc, then you may need to take this route.

Solids, shells and beams are all mesh (or element) options in a general FEA package. In general, beams should be used for frames and section structures, shells for sheet metal components, and solids for complicated geometry.

All options have their pros and cons as well as limitations, so make sure your analyst is competent and has done their research!