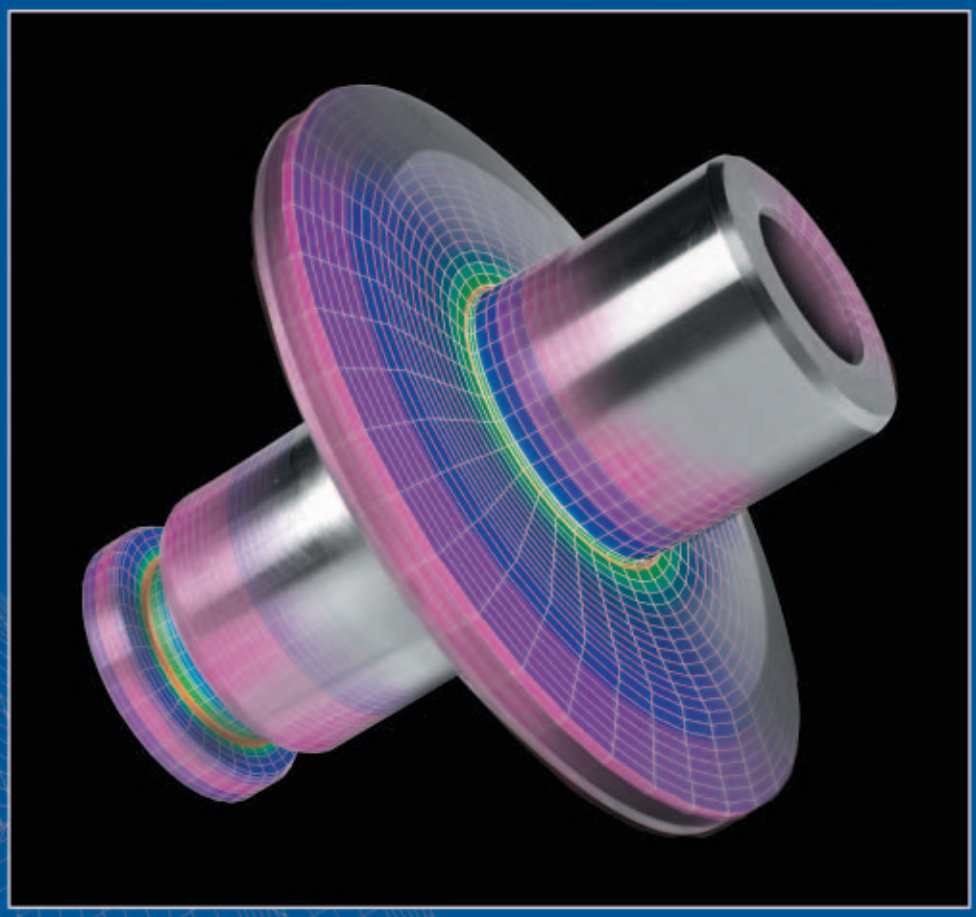
PALMER
ASSOCIATES
INC

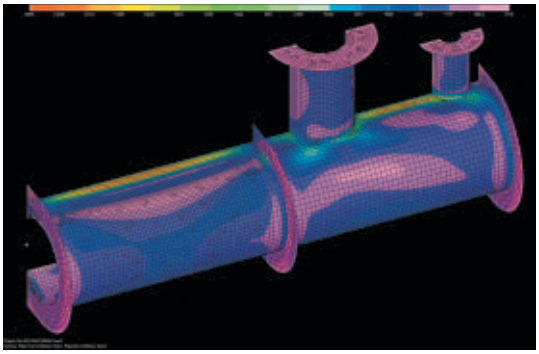


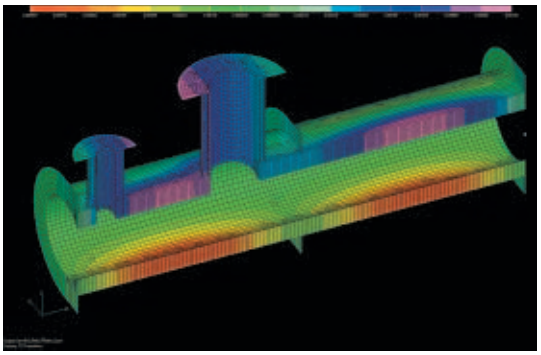
Finite Element Analysis

Using Advanced Tools and Established Test Methods

Palmer Associates has offered Finite Element Analysis for virtual testing of parts and structures for over twenty five years. Our analysis capabilities can be used as an integral part of the whole machine design process. Plus it can also be used for failure analysis investigation of a single component.

When testing and analysis is incorporated into the design process, they provide a clear indication of potential problems…problems that can be corrected before costly production begins. Our Testing and Analysis Group uses advanced tools and established test methods to identify weak areas in a structure or part that indicate the possibility of failure.





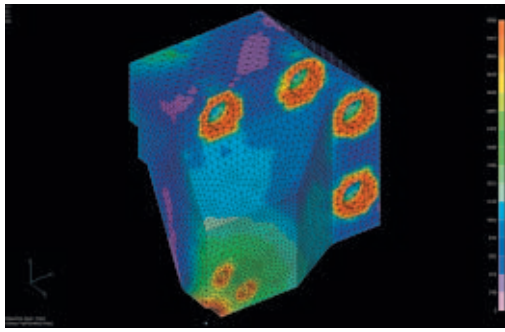
1/2 of a Barrel Shell for a Twin Rotor Mixer

Top: *Von Mises Stress due to internal vacuum and jacket pressure.*
Bottom: *Deflection of shell due to internal vacuum.*

Using the latest modeling, analysis, and post-processing software, we offer static and dynamic analysis capability for complex assemblies such as bolted and gasketed connections and complex assemblies.

We have extensive experience using FEA to design pressure containment equipment to meet the Pressure Containment Equipment codes used throughout the world. The growth in complexity of pressure vessel and process containment equipment design has exceeded the abilities of existing code formulas to serve as a problem-solving tool. FEA serves as a code acceptable solution to problems not specifically addressed elsewhere. In the global design market all code jurisdictions, including A.S.M.E. and the European Pressure Vessel Design Code, recognize FEA as an acceptable design application.

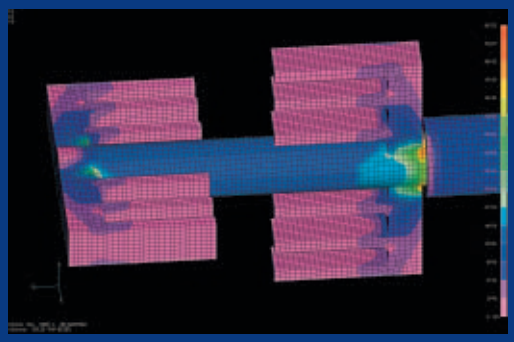
Pressure vessel flange; Von Mises Stress



Though this computer analysis is most cost-effective when done at concept or design stage, it can also be conducted on an existing part to predict or determine failure.

Our practical, design-oriented approach to problem solving provides rapid solutions to stress, deflection, heat transfer, and dynamic response problems. Beyond providing the results of an analysis, our evaluations, conclusions, and design recommendations help you to produce the best product in the shortest time.

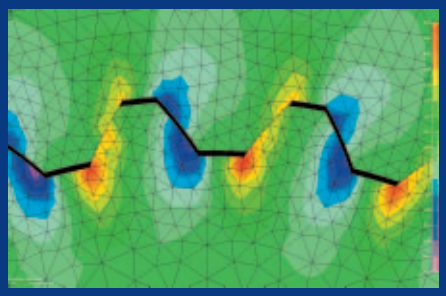
Types of FEA Provided



Mixing tines on a shaft; Von Mises Stress

Linear Static Analysis

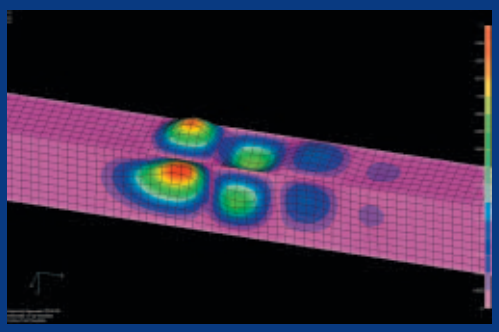
This is the most common type of analysis performed. The analysis produces stress and deflection results of a part or structure. The inputs into the analysis can be forces, pressures, enforced displacement, and temperature differences. This type of analysis is valid for materials that are in their linear range (below their yield strength). Also required for this analysis to be valid are boundary conditions that don't change and loads that are applied gradually.



Involute spline; bending stress

Nonlinear Static Analysis

This type of analysis can generally be categorized into one of three common types: **material** (nonlinear elastic, elastic-plastic, and perfectly plastic), **geometric** (large displacement and rotation), and **boundary non-linearity** (contact). A common type of material non-linearity involves yielding of the material into its plastic range. Geometric non-linearity problems involve problems that have large displacements and rotations. In thin-walled parts, stress stiffening can play major part in the final results of the structure. A common boundary non-linearity problem is when there is contact between parts. A common problem is when the loading condition causes a part of the contact interface to be in compression while another part of the contact interface separates.



Crane boom; buckling analysis

Buckling Analysis

A buckling analysis will calculate the critical load and the mode shape of a structure with compressive loads. Long slender parts and thin-walled parts that have compressive load applied to them are typical examples of problems that require a buckling analysis.

Modal Analysis

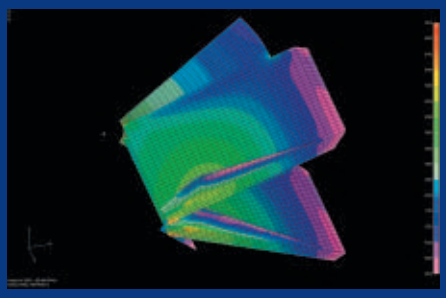
Modal analysis or normal modes analysis determines the natural frequencies and the mode shapes of a structure or part for a given constraint set. A modal analysis is important for parts that experience vibrations from a motor, the road, the wind, or from being dropped or struck with a hammer. Knowing the natural frequencies is an important first step in determining whether a dynamic analysis is needed.

Dynamic Analysis

A dynamic (or vibration) analysis is performed when the input load is time dependent. There are three common types of dynamic analysis: frequency, transient, and random response. A frequency response analysis is performed when the applied loads vary as a sinusoidal function at the same frequency. An example of such a load is an imbalance in rotating machine. The output is the steady-state response of the system. A transient response analysis is performed when the applied loads vary with time. An example of such a load is the impact of a hammer. A random response analysis is performed when the input loads cannot be described fully by either a sinusoidal function or by a time varying time. Examples of random response inputs are road noise for an automotive application or a seismic load for an earthquake study.

Heat Transfer Analysis

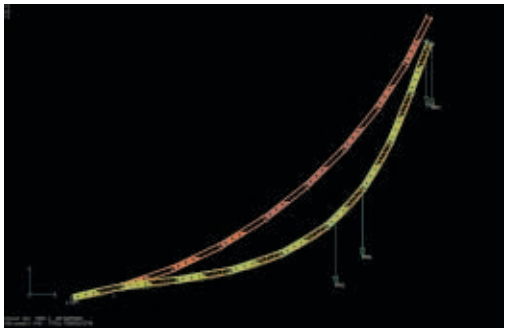
A heat transfer analysis is performed to determine the magnitude and direction of heat flow through a body. Also the temperature and temperature gradients in a body are important cause of stress in a structure. The nodal temperatures in a body can be used as inputs in a thermal stress analysis. Heat transfer analysis can be either steady state (not varying with time) or transient (varying with time).



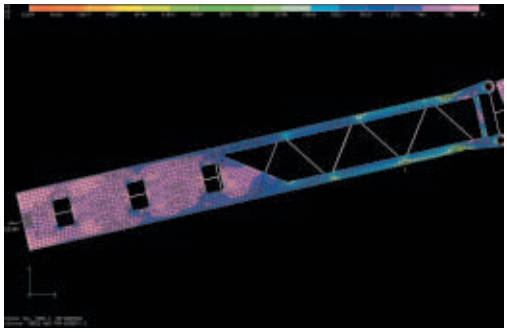
80 degree section of a fan for a heat treatment furnace; Von Mises Stress

Case Study: Stress Analysis – Ship LNG Storage Tank Insulation Boom

Steel boom assembly used to apply insulation for liquid natural gas storage tanks on seagoing ships. The 78 ft. lower hemisphere boom (shown above) is fitted to the 133 ft. diameter storage tank. The boom assembly was designed and analysis provided for TI Marine Contracting, AS of Norway.



Overall deflection analysis for lower hemisphere insulating boom.



Von Mises Stress Analysis for individual section of main insulating boom.

Finite Element Modeling

FEMAP Software

- Geometry Import Capabilities: CATIA, I-DEAS, PRO/E, Solid Edge, Unigraphics, Parasolid, ACIS, VDA, and IGES
- FEA Model Import/Export Capabilities for all major FEA codes

Finite Element Analysis

NE/Nastran Software

- Linear Static
- Linear Stress, Strain, and Deflection
- Thermal Stress and Deflection
- Prestress

Nonlinear Static

- Large Displacement and Rotation
- Nonlinear Elastic, Elastic-Plastic, Thermal Elastic
- Contact with Friction

Normal Modes

- Natural Frequencies and Mode Shapes
- Linear and Nonlinear Prestress

Buckling

- Critical Loads and Mode Shapes

Dynamic Response (Mechanical Vibrations)

- Transient Response
- Frequency Response
- Random Vibration
- Enforced Motion
- Response Spectra Generation
- Linear and Nonlinear Prestress

Linear & Nonlinear Steady State Heat Transfer

- Conduction, Convection, and Radiation
- Temperature Dependent Material Properties and Loads

Nonlinear Transient Heat Transfer

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