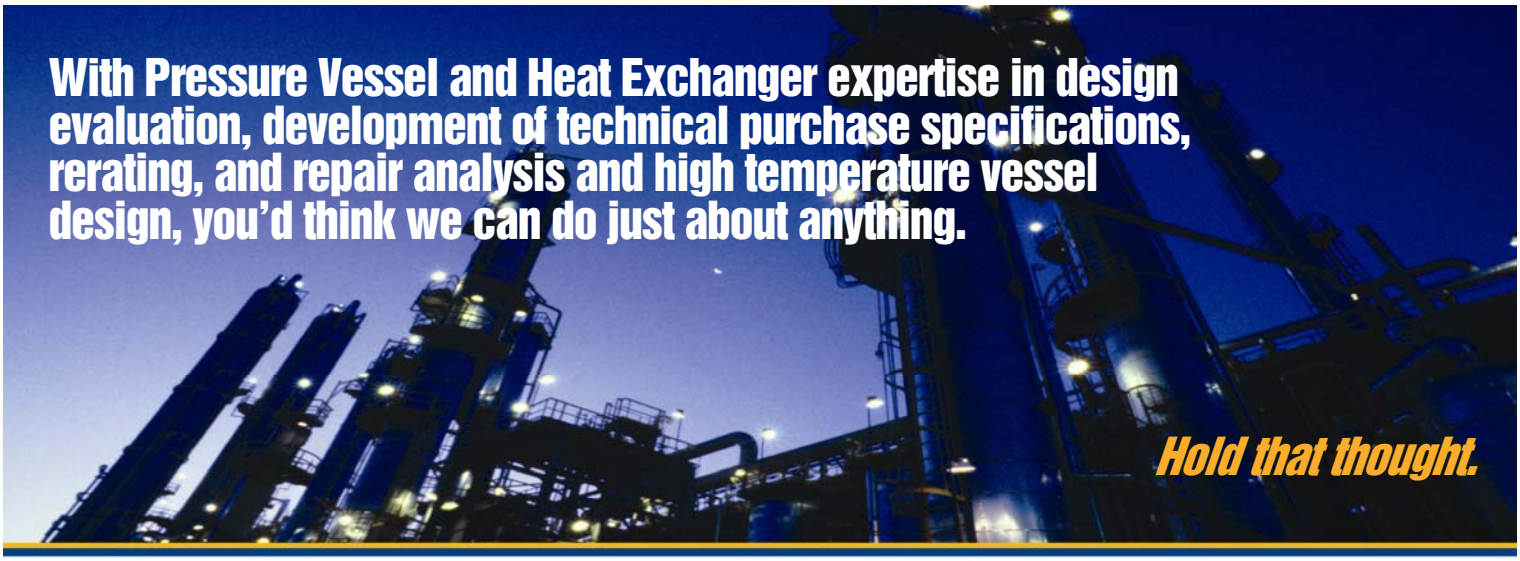

Pressure Vessels and Heat Exchangers

How Carmagen Engineering Can Help

Carmagen Engineering, Inc. can assist with the following:

- Design evaluations
- Compliance with ASME Code and specification requirements
- Development of technical purchase specifications
- Design details for high temperature, internally lined equipment
- Engineering design details
  - ⇒ Catalyst support grids
  - ⇒ Plenum chamber and cyclone systems
  - ⇒ Fluidized solids distribution grids
  - ⇒ Hot/cold nozzle intersections
  - ⇒ Support skirt intersections
  - ⇒ Outlet collectors
- Rerating and repair analysis
- Tall vessel design
  - ⇒ Wind
  - ⇒ Earthquake
  - ⇒ Process or wind induced vibration
- Shell-and-tube heat exchangers
  - ⇒ Flange leakage
  - ⇒ Vibration evaluation

Work Examples

- Evaluation of existing pressure vessels and heat exchangers for revised design conditions. Demonstrated that vessels were acceptable without changes.
- Analysis of locally corroded regions of existing pressure vessel. Demonstrated that vessel was acceptable for unrestricted operation.
- Reviewed vendor design of large, horizontal pressure vessel intended for hazardous waste storage. Found major errors in saddle support design and minimum use temperature limit.
- Developed mechanical design purchase specification for a large, high temperature steam generator. Performed bid conditioning review of vendor designs and participated in vendor selection.
- Performed design analysis of cyclone plenum systems for vessels containing fluidized solids. Initiated changes to vendor proposed design to adequately carry design loads.
- Design and stress analysis of distribution grids for large, fluid-solids unit vessels. Prepared design specifications for vendor quotation.
- Failure evaluation of distribution grid supports in fluid-solids unit vessels.
- Onsite turnaround assistance in inspection and evaluation of fluid-solids unit vessels.

All the right people in all the right places.℠

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We've successfully designed, developed, analyzed, investigated, evaluated, and maintained piping systems for dozens of satisfied clients all over the world.

You're next.

Piping Systems

How Carmagen Engineering Can Help

Carmagen Engineering, Inc. can assist with the following:

- Compliance with ASME/ANSI B31 requirements
- System design and stress analysis
  - ⇒ Machinery systems
  - ⇒ Storage tank systems
  - ⇒ High temperature, refractory lined piping
  - ⇒ Safety relief systems
- Component design
  - ⇒ Expansion joints
  - ⇒ Supports and restraints
- Field problem evaluation
  - ⇒ Failure investigation
  - ⇒ Vibration evaluation
  - ⇒ Flanged joint reliability
- Valve design and selection
- System component specifications
- Design and installation procedures
- Maintenance and reliability evaluations

Work Examples

- Analysis of combination lined/unlined high temperature system in an FCCU plant
- Evaluation of existing system based on removal of expansion joints to improve reliability
- Analysis of existing multi-pump system for stress and nozzle load acceptability after major piping additions
- Design of new piping systems for installation to existing tall towers by hot tapping
- Development of new and revised engineering standards and specifications
- Development of nozzle hot tapping guidelines and procedures
- Failure evaluation of 1500°F furnace outlet piping
- Development of spring support design specification
- Development of engineering specification for piping flexibility analysis

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Storage Tanks

How Carmagen Engineering Can Help

Carmagen Engineering, Inc. can assist with the following:

- Development of inspection and maintenance guidelines and procedures
- Review of new tank designs for compliance with API-650 or API-620 requirements
- Evaluation of existing atmospheric storage tank condition for compliance with API-653 requirements
- Analysis of locally corroded regions of tank shell for suitability
- Evaluation of shell and bottom differential settlement
- Evaluation of fixed and floating roof systems

Work Examples

- Evaluated the design of an API-620 tank intended for hazardous waste storage. Found fundamental error in vendor's nozzle design computer program which directly affected the required reinforcement.
- Analyzed 50 year old pressurized storage spheres for continued operation. Identified fill height limitations based on measured thicknesses.
- Developed fill height limitations for API-650 tanks based on corroded shell measurements.
- Demonstrated by stress analysis that severe local shell corrosion at the bottom-to-shell junction did not require downrating of an API-650 tank.
- Developed design and installation details for adding new nozzles to existing storage tanks.
- Prepared design and installation specification for a double bottom, secondary containment system for retrofit into atmospheric storage tanks.
- Prepared inspection and maintenance checklists for field personnel.
- Performed bid conditioning review and later engineering followup for two new crude oil storage tanks.
- Evaluated the condition of storage tank bottoms to determine their suitability for continued service in accordance with API-653 criteria. Developed repair recommendations as required.
- Performed beta testing of new tank analysis computer program.

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Mechanical Engineering Experience Related to FCCU and Other Fluidized Solids-Type Units

The following is a partial list of work that Carmagen's mechanical engineers have done with respect to the mechanical engineering aspects of FCCUs and other fluidized solids-type units. This work has been done either while employed at Carmagen or before joining the company.

Work Done By Carmagen

- Team leader and technical consultant for a major incident investigation involving failure of refractory lined transfer-line piping system that caused an unscheduled shutdown of a FCCU located in the US Gulf Coast.

- Team leader for a major FCCU unit reliability study for a US Gulf Coast refinery. Problems identified included piping vibration and high maintenance cost.

- Developed technical specifications for several grid, cyclone, and/or plenum chamber replacement projects. Also provided bid conditioning support, engineering quality control of the contractor and supplier's work, and turnaround assistance.

- Performed study of a regenerator grid that enabled a refinery to increase operating flexibility in running their FCC while still maintaining reliability. The study consisted of a creep-life evaluation of the regenerator grid based on past operations and accounting for various potential combinations of operating temperature and pressure differential across the grid. In the study we used finite element analysis to determine the grid stresses as a function of the differential pressure across the grid. We then used the remaining life provisions of API 530 to produce a set of curves that provided the remaining life of the grid for a given operating differential pressure and temperature above the grid.

- Performed piping flexibility analysis of FCCU regenerated catalyst transfer line to determine the benefits of replacing the existing line that had experienced hot spots. The project involved using a larger diameter pipe and thicker refractory system. The piping analysis showed that the replacement pipe reduced the probability of the suspected cause of the hot spots while maintaining acceptable system stresses and equipment loads.

- Conducted a piping stress analysis to revamp high temperature, refractory lined, Flexicoker transfer lines. The analyses included calculation of the metal temperatures for a variety of operating cases, calculation and evaluation of the pipe stresses and the loads on connected equipment.

- Performed numerous engineering audits of piping stress analyses that were done by contractors on major capital projects.

- Developed technical specification for performing piping stress analyses for use on capital projects.

Work Done Before Joining Carmagen

- Worked on over 50 FCCUs in grass root and revamps in the mechanical design of reactors, regenerators, and piping layout and stress analysis for major transfer lines, feed piping, and aeration piping. This also included the materials selection, specification, and refractory systems design (done for Exxon, CPC, BP Spain, Lagoven, Sakai, Mobil, Caltex, etc.).

- Conducted Engineering Audits on approximately 7 different FCCUs to identify opportunities to improve profitability through improved reliability and reduced maintenance. Audits of mechanical hardware typically include major vessels, piping, slide valves, and refractory systems to identify opportunities to improve individual component performance as well as the overall unit profitability.

- Overall piping experience includes layout, materials specification, refractory lined systems, stress analysis, acoustic noise (vibration) attenuation, surge, and other forms of vibration attenuation for a variety of systems in virtually all types of refining units.

- Led the overall mechanical design for the revamp of the Caltex Model IV FCCU in Australia including the design and specification of major transfer lines, feed piping, and aeration piping.

- Provided technical consulting for a bulged section of refractory lined pipe in a FCCU transfer line.

- Provided field re-engineering for poorly designed piping systems in fluid solids units to accommodate thermal expansion (at Pemex, Syncrude, Benicia, Ingolstadt).

- Eliminated acoustically induced vibration in a large flue gas line in a fluid solids unit.

- Redesigned a flue gas line to eliminate vibrations induced by surge forces in the fluid bed.

- Eliminated small piping vibration failures by redesigning to eliminate cracking caused by pressure pulses at a Hydrogen compressor.

- Developed designs for large transfer lines to prevent cracking of stainless steel components (several FLEXICRACKING Units).

- Investigated cause of failure and developed fix to prevent piping failures around Hydrogen reformer furnaces (Lagoven, Toa Nagoya).

- During start-up of fluid solids units, developed field fixes to eliminate piping vibration and thermal expansion problems (Benicia, Pemex, Syncrude).

- Participated in a root cause failure analysis of an expansion joint in a FCCU transfer line standpipe.

- Participated in a team effort as a technical specialist to identify the cause of continuing failures of an expansion joint in a feed riser.

- Performed a piping flexibility analysis of a FCCU flue gas piping system that included a turbine expander and expansion joints. The analysis model had piping in the range of 72" to 108" in diameter. The purpose of the analysis was to design constant effort pipe supports to increase the reliability of the turbine expander.

- Performed piping flexibility analysis of a 96" diameter lined FCCU spent catalyst piping system as part of redesign of hinged rotation joints to improve their reliability. The existing rotation joints contained angled disc elements instead of bellows. This did not permit adequate inspection of the rotation joints for cracking at turnarounds. The redesigned hinged rotation joints were included as part of the piping system analysis to determine the required rotation at each joint.