Parr Instrument Company

Stirred Reactors and Pressure Vessels

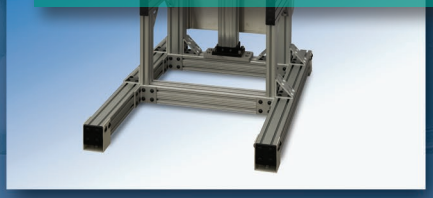
Bulletin 4500 | Volume 14

Designing and Building Quality Pressure Apparatus for Over 100 Years

Start

Chapter Five

This pdf is just one chapter from our Catalog 4500. Please refer to all eight chapters to make the proper equipment choice for your needs.



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Chapter 5

Specialty & Custom Reactor Systems

Inside this chapter you will find:

Introduction to Specialty Custom Reactors

Parr Instrument Company designs and builds a wide variety of specialty and custom reactor systems. These reactor systems embody the spirit of innovation that has made Parr the world leader in laboratory pressure apparatus. Our technical sales, engineering and production teams are happy to work directly with our customers' scientists and/or engineers to very quickly, accurately, and economically proceed from concept to manufacturing. The following pages illustrate several examples of specialty and custom reactor systems designed and built using exactly this collaborative process.

To facilitate collaboration between Parr and our customers as well as to support the high quality of our equipment, we have invested heavily in both design and manufacturing technology. All custom reactor systems are designed with 3D modeling software to create a virtual prototype prior to manufacturing. This model supports clear communication between the customer and Parr and shortens the design phase of such projects. On the manufacturing floor, state of the art, five axis, computer controlled machines programmed and operated by Parr's highly skilled machinists allow rapid and accurate production of even the most complex parts.

To match the variety of reactor systems available, our control design and programming team offers multiple types of control systems, ranging from simple, manual temperature control to completely automated and integrated PC-based control, developed to each customer's specification. Control systems are discussed more completely in Chapter 6.

If you have an idea for a reactor system that is not described in this catalog, please contact Parr's world-class technical sales department — there is a very good chance we can build a reactor system to meet your needs.

Custom-designed Stirred Reactor System for a proprietary process.

Pressure vessel with multiple 1-inch diameter windows installed.

Parr uses the latest technology in milling and manufacturing techniques to produce your custom system to the highest level of precision possible in the field today.

Bio-Fuels and Alternative Fuels Research Systems

Custom Reactor Systems like the above Bio-Fuels Research System are a product of collaboration between the researchers and the Engineers at Parr Instrument Company.

Parr Instrument Company manufactures non-stirred vessels for the decomposition of biomass in ammonia and steam. Parr stirred reactors, including a new horizontal reactor technology, have been designed for research processes that include hydrogenation, isomerization, and metathesis reactions. In addition, fully customizable continuous-flow tubular reactor systems have been developed with continuous reactant feed and product handling capabilities.

The above photo illustrates a complete pilot scale plant used for hydrogenating feedstock that originates from a proprietary fermentation process. The system is used to develop and optimize the process conditions necessary for a much larger demonstration-scale system, ultimately leading to full-scale production of renewable fuels.

The system is comprised of five major subsystems: from left to right, a gas and liquid feed system, the jacketed tubular reactor module including a reactant pre-heater and circulating bath, product recovery and backpressure control, an auto-sampler and a Parr 4871 Control System (not pictured). The system is completely automated and includes an auto-sampling subsystem that periodically samples the reactor output stream in order to accurately monitor product quality.

Horizontal Stirred Reactors

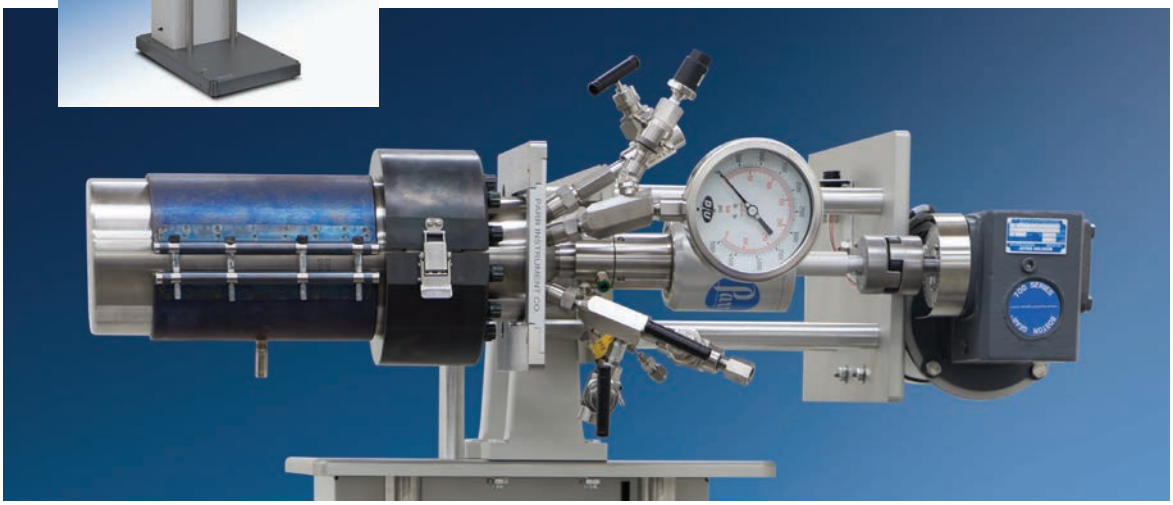
Stirring biomass is not easy to do in a vertical reactor. A line of reactors has been developed by Parr Instrument Company to function horizontally.

Horizontal reactors enable researchers to mix bio feed stock and other cellulosic materials such as:

- straw
- corn stover
- sugar cane
- grasses
- plants
- wood pulp
- wood chips
- fibers

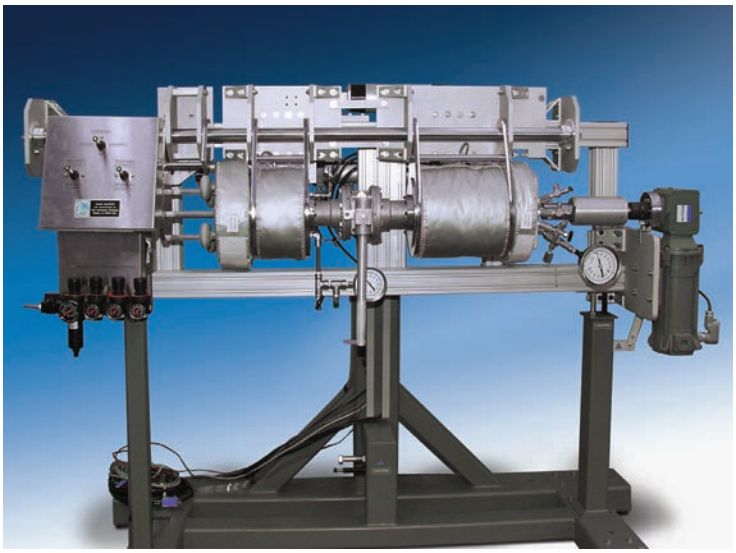
In the horizontal position, the internal stirrers tumble the material rather than try to stir it with a standard vertical stirrer. These custom reactors are secured vertically for loading and then safely tilted horizontally for stirring. They can also be designed to be operated in both a horizontal and vertical position.

One Liter Horizontal Stirred Reactor with heavy-duty stirring motor in its upright position. A 4848 Controller is used to monitor the system pressure and control the temperature and stirring speed.



The 4578 Pressure Reaction System shown above is a 1.8 L, fixed head reactor is mounted on a floor stand and is rated for temperatures up to 500 ˚C with a maximum pressure of 5000 psig. In the horizontal position, the internals stirrers tumble the material rather than try to stir it with a standard vertical stirrer. These custom reactors are secured vertically for loading and then safely tilted horizontally for stirring.

This one liter reactor can be oriented vertically for loading or tilted horizontally for stirring. A heavy-duty stirring motor and double anchor stirrers are used. Another option would be to tilt upside down for discharge. An optional flexible mantle heater (not pictured) can be used to obtain temperatures up to 350 C. Maximum pressure is 1900 psig for this system.



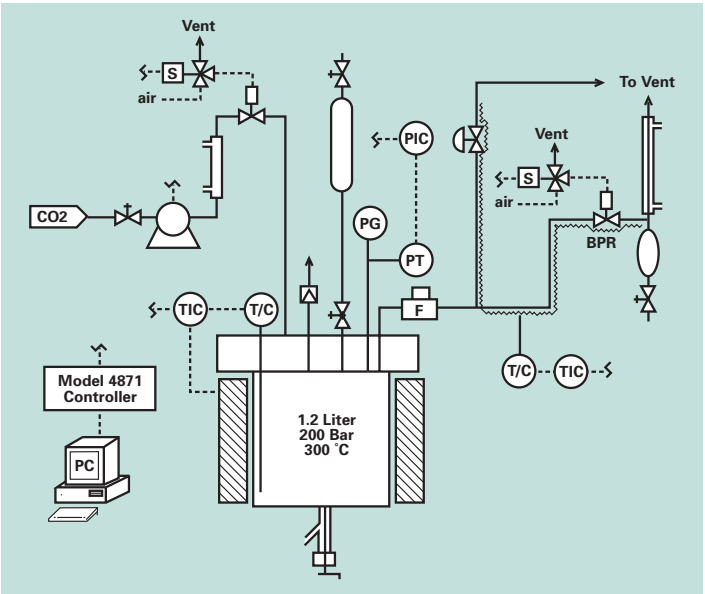
The reactor shown in the two images above and right has a five gallon capacity, and is used for stirring horizontally. Pneumatic controls on the left can tilt the system upright to open the bottom drain valve. The product is filtered and collected in the lower heated sample collection vessel. This system is used for producing synthetic fabric from biomass as an alternative to a petroleum-based process.

The batch supercritical extraction vessel pictured above is designed for use to 5000 psi (345 bar) at 350 °C. This 600 mL vessel was equipped with a liquid CO2 pump capable of delivering up to 24 mL/min.

A supercritical fluid is any substance at a temperature and pressure above its critical point. Such fluids can diffuse through solids like a gas and dissolve materials like a liquid. Near the critical point, small changes in pressure or temperature result in large changes in density, allowing many properties of a supercritical fluid to be "fine-tuned". Supercritical fluids are often suitable substitutes for organic solvents in a range of industrial and laboratory processes.

Carbon dioxide is one of the many commonly used supercritical fluids. It is relatively simple to exceed its critical point (31 °C , 1057 psi). Applications that involve supercritical fluids include extractions, nano-particle and nano-structured film formation, supercritical drying, carbon capture and storage, as well as enhanced oil recovery studies. Parr has provided systems at one time or another for all the aforementioned applications.

Water is another substance that is often used in its supercritical condition (374 °C, 3185 psi). its excellent thermal conductivity properties make it the fluid of choice in pressurized nuclear reactors for electricity generation. The extremely aggressive and reactive nature of supercritical water makes it an excellent choice for the oxidative destruction of some hazardous waste materials.



The supercritical fluid extraction system pictured left and diagramed above incorporates a 1.2 liter vessel rated for use at 3000 psig (200 bar) at temperatures to 300 °C. The system includes an automated inlet valve and an air-piloted back pressure regulator which is used to facilitate a controlled pressure release at the end of the test. The vessel is heated with a 1500W flexible mantle heater.

GTO (Gas-To-Oil) System

Parr GTO System

This system incorporates three tubular reactors that can be configured as required to operate in a strictly parallel fashion or in a cascade arrangement where the products from one reactor are immediately directed to a second reactor. This type of system can support reaction schemes including but not limited to the Fisher-Tropsch process, methanation reactions, steam reforming and other similar processes.

The Fisher-Tropsch process converts carbon monoxide and hydrogen into oils or fuels that can substitute for petroleum products. The reaction uses a catalyst based on iron or cobalt and is fueled by the partial oxidation of coal or wood-based materials such as ethanol, methanol, or syngas. This reaction scheme offers a promising route to producing economical renewable transportation fuels. By carefully controlling the temperature and oxygen content, resulting products can range from syngas to "green diesel".

One of the unique features of this system is a gas blending subsystem capable of mixing up to four reactant gases followed by a controlled delivery of this blended mixture to each of the three reactors via dedicated mass flow controllers.

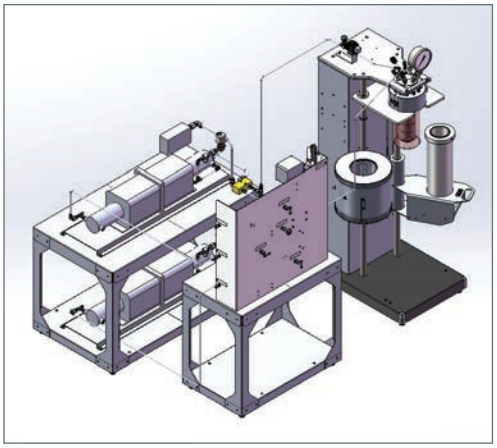
Downstream components for each reactor include a heat exchanger/condenser, a gas/liquid separator (product receiver) and a fully automated back pressure regulator. The system includes support for introducing liquid reactants via a high pressure metering pump. The system comes completely automated with the addition of the highly versatile 4871 Process Controller (not pictured).

Other Specialty and Custom Reactor Systems

Apparatus for Vapor Pressure Determination

This custom dual vessel system is used for the accurate determination of the saturation pressure of specialty organic materials as a function of temperature.

All of the associated head fittings, valves and plumbing, including the pressure transducers, are enclosed in a heated, temperature controlled, aluminum block to minimize temperature gradients and to ensure that the average system temperature closely matches the temperature of the vessels, including their screw cap closures, housed in the lower temperature controlled block. The system is shown with the exposed valves and fittings which are covered by an aluminum plate during normal operation of the system.



Disbonding Apparatus for ASTM G146

This automated reactor system is used for performing hydrogen induced disbonding (HID) tests. This system is capable of attaining the conditions necessary for treating samples consisting of bimetallic plate typically used in refinery High Pressure/High Temperature hydrogen gas service. The tests run in this apparatus can be used to assess the effects of material composition, processing methods, fabrication techniques, and heat treatment as well as the effects of hydrogen partial pressure, service temperature, and cooling rate.

This system can be used over a broad range of pressures, temperatures, cooling rates, and gaseous hydrogen environments where HID could be a significant problem. These typically range from 14 to 20 MPa hydrogen gas pressure and temperature from 300 to 500 °C. This testing regime is fully described in ASTM Standard Practice G 146.

Apparatus for Corrosion Studies

This custom vessel was designed specifically to be used for long term (up to 4000 hours) corrosion testing of zirconium alloy samples in aqueous solutions near the critical point of water.

The vessel illustrated is a non-stirred, fixed head design with a volume of 3.7 liters with a maximum working temperature and pressure of 450 °C and 275 bar, respectively.

The vessel is heated with three clamp-on style band heaters. The system is capable of maintaining a uniform temperature of ± 1 °C over a working zone of 30 cm. Valves are provided on the head of the vessel for purging with inert gas prior the start the test as well as periodic sampling of the contents of the vessel. The controller is equipped to record temperature and pressure data for the duration of the test.

For more information on any of these custom systems please visit www.parrinst.com or contact the Parr Technical Service Department.

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