ARI’s Unique Laser Gas Analyzer

ARI manufactures, installs and services a unique laser-based eight gas analyzer (LGA) combined with a computer controller that rapidly monitors heat treating and other industrial furnace operations. The analyzer technology is based on frequency “shifting” of laser light impinging on the gases being measured. This shift is caused by the gases’ molecular composition. The “Raman scattering” effect has been used to detect and quantify solid and liquid chemicals in industrial operations. However, the ARI instrument is the only commercial instrument to analyze gases using this principal. Changes in gas composition can be detected in as little as 50 milliseconds and the analyzer can detect any combination of eight gases by selecting appropriate optical filters. Proprietary software programs have been developed to automatically operate the detector, control sampling, display results, and log collected data.

The LGA System is the only gas analyzer on the market that combines high-speed gas analysis of so many species at such a low price. The basic model has the capability of analyzing eight gas species sufficient for monitoring or controlling most industrial process gas applications. The system is designed for continuous operation with minimal maintenance, and all systems include the ability to remotely monitor and assess system performance. The LGA can be easily modified to detect gas species of interest to other industries. In addition, the system has a detection range of 50 parts-per-million to 100%. This contrasts with infrared based technology (the closest competing technology) which typically analyzes no more than three gases and has limited range. In addition, the LGA contains a built in general purpose computer, a gas sampling pump, and a control system that results in an overall system price approximately equal to the three gas analyses systems currently available.

Multiple Industrial Sector Applications

The initial applications for ARI products have been batch or continuous furnace heat treating operations that use gas “atmospheres” in metal manufacturing processes. However, any industry having processes that use gas at a sufficiently high volume or cost to justify the savings generated is a potential candidate. Such industries include: metal refining, petrochemical operations, food processing and semiconductor production, glass manufacturing, natural gas combustion, and fertilizer production. Due to dramatic increases in energy prices, natural gas monitoring and multi-fuel combustion optimization have also become attractive applications for this ARI technology.
The 45 cm (18 in.) detector module incorporates a safe, low-power laser and chemically specific optical filters to quantify gas composition (see schematic). Any particles are first removed in a filter and then the gas sample enters the detector module passing directly through the laser beam. Any tiny fraction of laser light striking the sample gas molecules is absorbed and re-emitted at a light frequency higher and lower than that of the laser light. The molecular bonds of each gas species uniquely determine the resulting “Raman shift” frequency. The shifts are so precise that the intensity of the light at each shifted frequency directly determines the amount of each gas component. The detector uses eight independent optical windows that each pass light at only the specific frequency of the eight gas species measured. Light measurement electronics behind the windows provide digital quantification of the concentration of each gas component.

ARI’s Laser Gas Analyzer has its roots in the medical device industry. The company that patented the use of internal cavity Raman Spectroscopy technology for anesthesiology spent millions of dollars on its development. ARI has modified the medical instrument for industrial process gas markets and has developed a unique sampling system for harsh industrial environments. Several Fortune 500 companies are currently using the LGA to improve their on-line processes as well as for Research & Development. These companies include US Steel, ADM, Dow Corning, Wyeth, Cerro Copper Tube, John Deere, Air Products & Chemicals, Hoeganaes, and Borg Warner.

ARI provides sampling systems that will connect an analyzer to multiple gas-sampling ports via a valve/manifold system. All gas sample are filtered through ARI designed filters prior to entering the valve manifold. Sample scheduling is generally set to continuously cycle through the sampling ports in a user selected sequence. Sample time at each port is typically 10 to 15 seconds. ARI also offers a system to continuously monitor gas pressure and temperature from multiple locations.

The sampling system includes a multi-port purge system that uses an auxiliary pump to simultaneously pre-purge one or more sample lines while simultaneously analyzing the gas in a specified line. This shortens the time between port-gas measurements by keeping the sample lines filled with fresh sample gas. The system also includes ARI’s nitrogen back-flush system. Should any of the sampling lines become restricted or plugged, pressurized nitrogen can be forced backwards down the line to clean it.

A PC-based control system is required to operate the sampling system. The PC uses Microsoft Corporation’s Windows 2000 as the operating system with standard user interface devices (monitor, keyboard, mouse).

ARI’s Sampling System will work with any gas analysis device. ARI provides design support to its customers to achieve the best possible total system performance.
Process Performance Improvements for Heat Treating

Many heat treating and other industrial processes require reactive, reducing or inert gas mixtures supplied to the furnaces to protect or change the surfaces of parts or material being processed at elevated temperatures. Such atmospheres are widely used in heat treating operations including carburizing (gaseous case hardening), annealing, powdered metal sintering, and nitriding. Typically heat treating atmospheres consist of eight significant gas constituents produced on-site by one of two methods: customer-owned thermal reactors using fuel and air mixtures, or vendor supplied process gas and liquids. In both cases most heat treating furnaces analyze and control atmosphere quality based on only a single gas (oxygen or water vapor). Part quality suffers and processing costs (including rework and scrap) often result. To improve part quality, many furnace operators add a three gas analysis of the furnace atmosphere to improve processing accuracy. However, certain gases of primary process control importance, such as hydrogen, nitrogen, and ammonia, are not monitored because the technology has been too costly, complicated or slow. ARI’s LGA technology allows the cost-efficient control that has been missing. It not only provides the process information needed to improve part quality, but enables new ways of gas processing that increase furnace production rates and lower operating costs.

ARI’s Process Audit Service

ARI will visit a customer site with the monitoring equipment. Fittings are installed on the process equipment to attach up to four 1/8” stainless steel sample gas tubing lines which are connected to the Laser Gas Analyzer. Other sampling connections may also be installed for temperature and pressure monitoring. The system is then operated through normal process cycles to collect operational baseline data. The data includes gas composition for as many runs as can be completed in the contracted time. The gases measured typically include CO, H2O, NH3, O2, N2, CO2, H2, CH4, and H2S. The accuracy for these measurements is typically less than .25% of full scale. ARI then provides an in-depth analysis of the results based on extensive experience with monitoring industrial gas processes. ARI will then meet with the customer to review the findings and make recommendations for process improvements. At the end of the test, ARI removes the monitoring system and caps the sensor ports in the process equipment. The results and recommendations are included in a formal report.

Gas Process Real-Time Control for Heat Treating of Metals

ARI’s atmosphere control system combines the LGA with the customer’s process gas control valves and safety systems. The system monitors furnace conditions and adds process gas in response to reaction needs in real-time. This ability results in “tighter” control of reactive processes inside the furnace as well as the opportunity to significantly reduce process gas consumption. Because the system measures all types of reactive gases, atmosphere control of some furnace processes (such as nitriding) becomes feasible for the first time! Typical quality improvements in carburizing (as measured by “case-depth” uniformity) have been improved by a factor of five. When used with non-standard atmosphere mixtures developed and tested by ARI, the sophisticated control enables improvements in processing speed from 20 to 50%, with enhanced “bottom-line” profits at heat treating facilities of 25% or more. These improvements require high-speed monitoring and control of all significant furnace processing gases not cost-effective with other technologies.

“ARI can help you optimize your industrial gas processes with on site consulting services.”
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Atmosphere Recovery, Inc.—A Brief History

Atmosphere Recovery, Inc. (ARI) was incorporated in Minnesota in 1994 to research, develop and produce systems for recovery, reprocessing and reuse of high temperature industrial furnace and refining process gas. The intent was to produce a system to contain the furnace process off-gas in order to reduce energy use and nearly eliminate off-gas air emissions. Funding for the initial prototype was provided by Dana Corporation (a major tier one automotive components supplier) and the U.S. Department of Energy. From 1994 through 1997, ARI invented, developed and operated a full scale prototype of its proprietary technology for recovery and recycling of heat treating furnace atmosphere exhausts. The new system reduced process air emissions more than 96% and saved more than 25% of the process energy.

During the project, it was recognized that the key to operating a process of this type was rapid and reliable gas sensing. Therefore following the DOE grant, from 1997 through the end of 1999, ARI modified a medical device and tested its operation as a production gas sensing system. After extensive modification, this product became ARI’s Laser Gas Analyzer. During the same period of time, ARI tested its process gas control systems approach and developed the technology to improve the speed and quality of furnace-related processes through gas blending.

ARI is a provider of cost-effective and environmentally responsible industrial and commercial process gas management systems. We serve fortune 500 customers in multiple industrial markets, including metal processing and petrochemical sectors.

Gas measurement leading to process cost savings, product quality improvement, and pollution reduction

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