Feature

Sulfur recovery gas cleaning

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In petrochemical refining processes, hydrogen sulfide "sour gas" is commonly present in oil and gas formations. With respect to product and environmental requirements, it must be removed from petroleum and natural gas products. Hydrogen sulfide at low concentrations smells like rotten eggs. At high concentrations it is dangerous, as it is heavier than air, and impairs detection since it reduces our ability to smell. Exposure above 500 ppm can be fatal. Also, it is combustible when mixed with air, and can cause fires or explosions.

Three Beltran wet electrostatic precipitators (WESPs) were purchased by a major petrochemical refinery where off-gases containing sulfur compounds are converted to sulfur in sulfur recovery units (SRU) and thereafter the remaining sulfur compounds and particulate are reduced in tail gas cleanup units (TGCU). The TGCUs utilize the Wellman Lord Process where finally the process gases are treated in the Beltran WESPs to remove sulfuric acid mist and particulate before being exhausted from the tailgas stacks. Due to the installation's location in the California San Francisco Bay Area, the emissions must meet the PM 10 requirements and other strict DEQ regulations. SRUs are used to recover sulfur by the conversion of hydrogen sulfide (H_2S) to elemental sulfur. In this application, refining high-sulfur crude oil produces hydrogen sulfide as a by-product. There are many sulfur recover technologies available for different applications, however, the most common conversion method uses the Claus process, which produces 90-95 percent of recovered sulfur. The Claus Process typically recovers 95-98 percent of the hydrogen sulfide feed-stream.

This refinery's SRU is based on the modified Claus Process, which is a multi-step reaction scheme. A portion of the total H_2S is burned in the reaction furnace to form SO_2. Then the H_2S and SO_2 react to form elemental sulfur across the Claus reactor. After each catalytic stage, liquid sulfur is recovered in the Claus condensers. The remaining unreacted H_2S and SO_2 then proceed to the next stage, where the equilibrium-limited Claus reaction continues in the presence of the Claus catalyst.

Oil refineries are required to recover between 95 and 99.99 percent of the total sulfur introduced to the SRU. A conventional three-stage SRU with three Claus reactors is expected to recover 98+ percent. To meet the strict Bay Area DEQ requirements, the SRU must be followed up with a Tail Gas Clean-up Unit (TGCU). The TGCU consists of an SO_2 clean-up system followed by a Beltran WESP to remove particulate and sulfuric acid mist.

The Beltran WESPs are designed to reduce outlet loading of particulates and sulfuric acid mist below 1 and 5 mg/cubic meter, respectively. The WESPs are built of Beltran conductive graphite composites and C-276 internals, with FRP housings, so they are cost effective and corrosion resistant to the collected sulfuric acid.

Industries that generate sulfur oxides and sulfuric acid, including metallurgical and mining, in many cases need a common and cost-effective solution for capturing and utilizing sulfur oxides and corrosive sulfuric acid emissions incorporated in downstream sulfuric acid manufacturing plants. Operators of these facilities can take advantage of the high industrial market value of purified sulfuric acid, a primary industrial chemical.

Sulfuric acid gas cleaning

An efficient sulfuric acid manufacturing process strictly requires the removal of contaminants from the input gas streams, especially fine particulates and acid mists such as those emitted from metal ore roasters and smelters, petroleum refineries, and coal-fired industrial boilers. This is necessary for protecting downstream components such as catalyst beds from corrosion, fouling and plugging, as well as for preventing the formation of a "black" or contaminated acid end-product. Proper gas cleaning also results in lower maintenance and operating costs for the plant.

Beltran WESP operating at Hindustan Zinc, Ltd. smelter plants in Udaipur, India.

For removing fine particulates, acid mists, and other contaminants from the gas stream, the one technology that is almost universally specified for this application is the wet electrostatic precipitator.

Primarily targeted at capturing submicron-scale particulate matter, saturated sulfuric or other acid aerosols, and condensable organic chemicals, a well-designed and correctly operated WESP unit is often incorporated after the gas scrubbers, and can achieve collection efficiencies of these materials of greater than 99.9 percent—far superior to other equipment.

Although the basic principle and design of the electrostatic precipitator have been around since the early 1900s, recent innovations have produced dramatic advances in efficiency, cost-effectiveness, ease of maintenance, and wider applicability. Beltran WESPs in particular have demonstrated a level of performance that environmental and plant engineers appreciate.

However, it is important for engineers to recognize that there are key differences in features and benefits offered by the various precipitator systems. Although they may share the similar operating principles and basic structures, WESPs can vary greatly in design, materials, gas flow rate, durability—as well as collection efficiency.

A basic WESP is comprised of an array of ionizing electrodes such that negatively charged discharge rods generate a strong electric field and corona. These are surrounded by or interfaced with positively charged or grounded collection surfaces that attract and hold the charged particles. In operation, the source gas is passed through the electrode array, which induces a negative charge in even the most minute, submicron-size particles, propelling them toward the grounded collection surfaces, where they adhere as the cleaned gas is passed through. The captured particles are cleansed from the plates by recirculating water sprays and residues, including aqueous sulfuric acid, are extracted for further use or disposal. The cleaned gas is ducted to downstream equipment or to the stack, depending on the application.

Beltran WESPs can process a wide range of gas streams; they are often used downstream from wet or dry flue gas desulfurization units, which cannot capture fine particulates and acid aerosols. They are also superior on high ash content and sticky residues (which may also contain mercury and heavy metals), oily residues/tars, mercury (as condensed oxide), and emissions from municipal solid waste (MSW) in waste-to-energy applications, etc.

Hindustan Zinc, Ltd.

A traditional problem has been with high-resistivity contaminants, such as low-sulfur coal ash. Beltran WESP system configurations and designs overcome this challenge using multistage ionizing rods, star-shaped discharge points, and space-saving hexagonal tube designs. This unique geometry generates a corona field 4-5 times more intense than other WESPs, achieving superior collection efficiency on resistant materials. This feature also allows higher velocity gas streams, resulting in faster through-put. Beltran WESPs impose a significantly lower pressure drop compared to scrubbers and fabric filters, and thus also contribute to increased production speeds. Furthermore, these gains in efficiency enable the use of smaller-scale, less-expensive equipment for a given set of operating parameters.

Beltran WESP systems are designed with advanced electronic controls, which can optimize operating parameters such as gas flow, saturation, temperature, corona intensity, etc., to achieve maximum efficiency.

Since the WESP operates at cooler temperatures—usually at the process gas saturation temperature between 100-170° F—the WESP is uniquely adept at capturing condensable organic materials and acid mists, making this technology an invaluable component for sulfuric acid production plants, petrochemical refineries, and spent acid recovery plants.

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