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New emission control system debuts at Wisconsin Public Service

The acid plant at WPS' new ReACT™ emission control system features ZeCor® equipment, including cooler, piping, and pump tanks.

When Wisconsin Public Service (WPS) considered the challenge of how to capture multiple pollutants from its electric generating operation, it turned to a relative newcomer in emission control technology, a system called ReACT™ (Regenerative Activated Coke Technology). Though ReACT has been used for years in power plants in Japan, it had not been applied commercially in the United States until its debut at Weston Unit 3 in Wausau, WI. WPS installed the system at Weston 3 to control emissions of sulfur dioxide, nitrogen oxide, and mercury.

Weston 3 is a 350-megawatt plant that burns Powder River Basin (low-sulfur) coal and is one of five electricity generating units at the company's Weston Power Plant, just south of Wausau. Of the four other units, one is coal-fired and three are gas-fired.

The impetus behind the new emission control installation was to ensure compliance with current, pending, and anticipated environmental regulations while keeping costs for consumers in check. "What really appealed to us," said Corey Houn, principal engineer at WPS, "was ReACT's combination of an emission-reduction system that also would be the most cost-effective for all of our customers." Part of the cost-effectiveness is the creation and sale of sulfuric acid, the by-product of the gas-cleaning process.

The new system at WPS was designed, built, and installed by Hamon Research-Cottrell (HR-C), part of the worldwide Hamon Group and a major provider of air pollution control technology. HR-C serves the North American market from its offices in Somerville, NJ, and offers the ReACT technology under a license agreement from J-Power Entech.

Construction at WPS began in 2013 and was commissioned in November 2016. The total estimated cost for the installation is $345 million.

About WPS

Wisconsin Public Service (WPS) began operation in 1883 as the Oshkosh Gas Light Company. It was incorporated as Wisconsin Public Service Corporation in 1922. WPS started its Weston Power Plant in 1954 and it was during those years that the company began installing electrostatic precipitators on the stacks of its coal plants to remove coal fly ash. In 1970, WPS established its headquarters in Green Bay, combining offices there with offices in Milwaukee and Oshkosh.

Through a sequence of acquisitions and mergers, WPS became part of a larger corporation in 2015 called WEC Energy Group, Inc., which includes natural gas operations in Wisconsin, Michigan, Minnesota, and Illinois.

WPS produces electricity using a mixture of fuels and generation methods, including coal, natural gas, wind, and hydroelectric. WPS also purchases power generated by solar and biogas facilities. The majority of electricity that customers use, however, comes from coal-fired power plants. Weston 4, the newest unit, is one of the cleanest coal-fired power plants in the country. Currently WPS serves more than 441,000 electric customers and more than 325,000 natural gas customers in northeast and central Wisconsin and an adjacent portion of Michigan.

Multi-emission control system, ReACT™, installed at WPS' Weston power plant with acid plant in lower left.

About ReACT

ReACT is a dry scrubbing system that removes sulfur dioxide, nitrogen oxide, mercury, and particulates from the emissions of coal-fired plants. The technology is based on the adsorption of these pollutants into activated coke pellets.

Besides emission control, ReACT uses no water, generates virtually no waste, and does not affect the quality of the coal fly ash, features that were very attractive to WPS. "It was part of their consent decree to reduce emissions for each of these pollutants while being sensitive to both water and solid waste issues," explained H. James Peters from HR-C's EVP Technology Business Development team.

ReACT consists of three stages:

—Adsorption Stage: Exhaust flue gas comes into cross-flow contact with a slowly moving bed of activated coke pellets. SO_2, NOx, and mercury are adsorbed into the activated coke carbon matrix. At the same time, the activated coke surface acts as a catalyst for the reduction of NOx to elemental nitrogen and water. Both the SOx adsorption and the NOx reduction use ammonia as a reagent or as a reducing agent.

—Regeneration Stage: The activated coke pellets containing adsorbed SO_2 and mercury are transferred to a thermal regenerator that pre-heats, heats, and then cools the pellets. Thermal desorption reactions take place and the pollutants are released as a sulfur rich gas stream. The pellets are returned to the adsorption stage. The adsorbed mercury is retained in the regenerator.

—By-Product Recovery Stage: The sulfur-rich gas containing the SO_2 flows to an adjacent acid recovery plant where sulfuric acid is produced, stored, and prepared for re-sale.

Because ReACT is based on adsorption (rather than absorption like in a wet flue-gas desulfurization process) no water is added to the flue gas stream. After ReACT, flue gas is directed to the stack at the same temperature and humidity levels as the inlet flue gas, but with SO_2 and SO_3 reduced to very low levels. Water vapor plumes are minimal, even in winter.

Though commercial application of ReACT in the United States is new, the original concept for SO_2 adsorption on activated coke started in Germany in the 1960s. Then, Japan-based Mitsui continued developing the idea in the 1970s. Beginning in the 1980s, the Electric Power Development Company (which became J-Power) purchased the technology, refined its multipollutant control aspects, and began commercializing it in Japan. ReACT is now recognized as an advanced multi-pollutant control technology alternative to wet flue-gas desulfurization.

The DynaWave® gas scrubber pretreats flu gas to remove dust and containments prior to entering the acid plant.

Besides the WPS Weston 3 plant, ReACT has been applied to a number of Japanese coal-fired utility boilers. One of these power plants, Isogo, which runs two 600 MW plants, has the lowest emissions of any coal-fired power plant worldwide. The technology has also been utilized in several large sinter plants in the steel industry, and in a variety of industrial applications in refining, mining, and incineration.

The ReACT system installed at WPS includes these major components:

- ReACT process adsorption and thermal regeneration equipment.
- Activated Coke (AC) and reagent (ammonia) material handling and preparation facilities.
- Auxiliary equipment to support adsorption, regeneration, and material handling.
- Sulfuric acid plant with pre- and post-treatment facilities, plus bulk storage and offloading systems for product acid export and neutralized effluent from the gas cleaning system.

Wisconsin Public Service's new ReACT™ emission control system is the first of its kind to be built in the United States. The system captures sulfur dioxide, nitrogen oxide, and mercury from a coal-fired electric power plant in Wausau, WI.

The acid plant

The sulfuric acid plant portion of the ReACT system is a 50 MTPD, single-absorption unit where the gas leaving the absorbing tower is recycled to the front end of the ReACT. "This is an interesting feature of the acid plant," said John Horne, sales director at MECS, Inc., DuPont Clean Technologies. "Because the tail gas is returned, there is no stack to the atmosphere, so an additional emission source is eliminated, along with the need for double absorption or a tail gas scrubber."

MECS, Inc. (MECS) provided the basic engineering and products for the acid plant including catalyst, Brink® mist eliminators, DynaWave® scrubber, and ZeCor® equipment. ZeCor® was used throughout the plant including piping, absorbing and drying towers, pump tanks, and acid coolers.

The extensive use of ZeCor® was also notable. "Even the strong acid coolers are alloy and do not use anodic protection," said Daniel Freeman of SNC-Lavalin. "The overall effect is a remarkably tidy plant with excellent low iron acid." SNC-Lavalin provided engineering, procurement, and mechanical commissioning services to the project.

Piecing the acid plant together with converter, gas to gas heat exchangers, ZeCor® pump tanks, and startup acid storage tank.

ReACT™ system includes a sulfuric acid plant with gas preheater (foreground), ZeCor® absorbing and drying towers, and converter.

ZeCor® material was used to fabricate many pipes and vessels throughout the acid plant plant.

The DynaWave® gas scrubber was necessary to pretreat incoming gas to the acid plant. The incoming gas contains a number of contaminants, heavy metals, hydrogen chloride, hydrogen fluoride, dust, and steam, which must be removed before the gas can enter the contact section of the acid plant.

"Many of the heavy metals, the dust, and steam are easily removed through the MECS® DynaWave® scrubber," explained Steven Patterson, MECS® process engineer. "But scrubbing alone cannot fully capture mercury." To deal with the mercury, the team identified a targeted mercury removal solution to be engineered in tandem with the acid plant.

The Weston power plant in Wausau, WI, is a multi-unit electricity generating facility operated by Wisconsin Public Service.

Portions of the acid plant are housed indoors, providing protection for equipment and workers, while other equipment, such as the converter and acid towers, are just outside the building.

The steam turbine and generator at Weston 3.

WPS principal engineer, Corey Houn, in front of the new acid plant's drying and absorbing towers.

Efficiencies

Several aspects of the acid plant's design helped manage capital costs and will continue to reap benefits for operational costs going forward. For example, the entire gas cleaning system is indoors. "This provides protection from the elements for equipment and operators, which serves both well," said Patterson. "An elevator serving 10 floors provides numerous levels of easy access to the equipment. No ladders or platforming required." A separate building houses the acid pump tanks, a startup acid storage tank, and acid coolers, while the converter, acid towers, gas heat exchangers, and product acid storage tanks are outdoors adjacent to the building.

Within the DynaWave® scrubber, a single vessel serves the dual purpose of scrubbing the incoming gas and condensing the steam. "The compact footprint saves on capital because there are fewer pipes and one less set of pumps," said Patterson, "and running one less set of pumps also reduces operating expenses."

The team also installed a process air preheater to manage fluctuations in the power plant's operation. Changes in the power production rate can impact the strength of SO_2 gas fed to the acid plant and hence the acid plant's ability to remain hot. However, a necessary feature of the acid plant is that it continuously remain "hot and ready," Patterson explained, "even when the SO_2 concentrations are low, because a production increase can occur anytime."

To keep the plant online and ready to receive gas, the team installed a process air preheater and a number of gas valves that isolate the acid plant from the upstream portions of ReACT. "Having an acid plant that can respond quickly to increased power production yet be optimized for heat retention even during decreased production times has been a valuable asset to us and to our customers," said Houn.

Throughout the entire ReACT system, the benefits widen, especially concerning water. Compared to a wet flue gas desulfurization (WFGD) installation, the savings are substantial. Considering only the evaporation requirements for WFGD," said Peters, "the use of ReACT avoids consumption of more than 100 million gallons of water per year."

The ability to minimize the amount of byproducts is another great advantage of the ReACT system. Instead of producing gypsum as in a wet flue gas desulfurization system, ReACT produces marketable sulfuric acid and virtually no additional byproducts. The ability to maximize revenue adds to the environmental benefits of the installation of the ReACT system.

The results

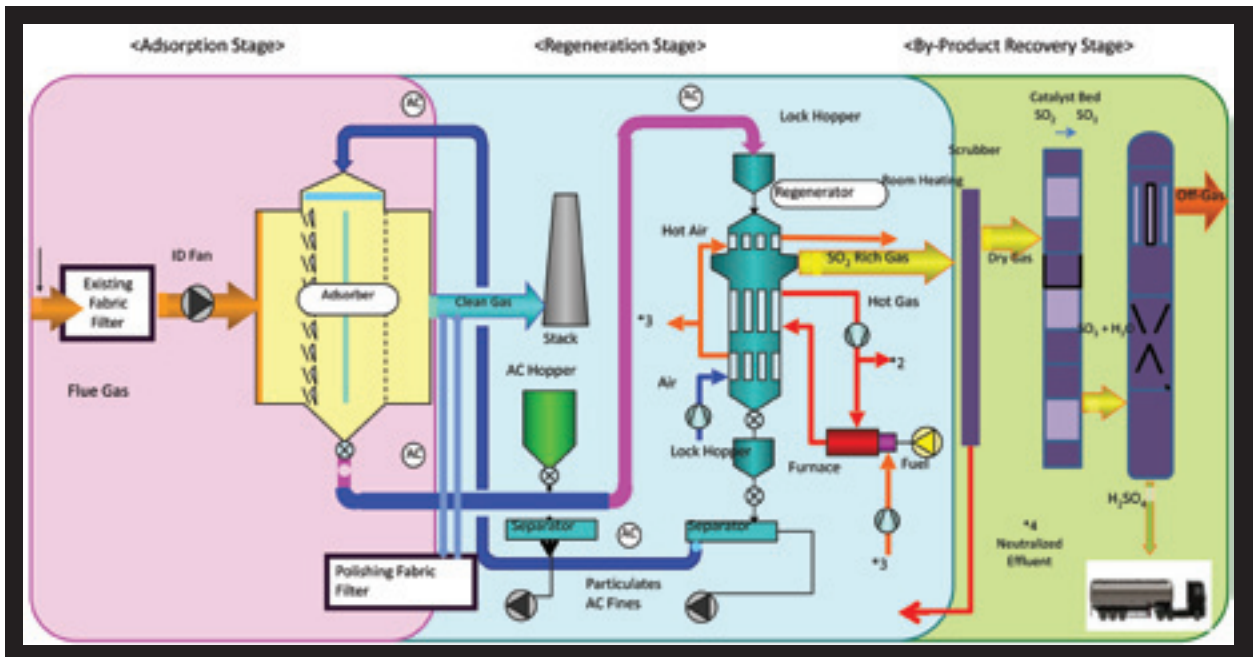
ReACT is designed to capture greater than 90 percent SO_2 and mercury each, as well as better than 20 percent NOx. So, how's the plant doing? "We are achieving those numbers," said Houn, "and we are now in compliance with all environmental regulations and permits."

Moreover, as of February 2017, WPS has sold greater than 2,500 tons of sulfuric acid generated at Weston 3. "The revenue we've received from the sale of the acid has lowered the plant's operational costs—savings that have been passed along to our customers," Houn said.

The system's performance has been an endorsement of the ReACT implementation. "We and our project partners are proud to see the ReACT technology and the acid plant working as designed," said Houn. "And choosing the ReACT system showcases our commitment to reduce emissions while serving our customers through the most cost-effective methods."

However, the idea of producing sulfuric acid was a new concept that took some adjustment on the part of plant staff. "The introduction of an acid plant to a power generation site was eye opening for the site operators," said Freeman. But staff participated in pre-training on a simulator as well as onsite training after the installation. "The post-commissioning support we provided at the request of WPS," said Freeman, "helped give the best possible experience to the company's multiple shifts and ultimately became part of a successful outcome overall."

At this point in the project, with the system fully operational, WPS expects to perform some fine-tuning. "We understand we will need to refine our use of the ReACT system and acid plant as they continue to operate in the future," Houn said. "However, we are confident that with the input of our partners, the ReACT system and acid plant will continue to operate as efficiently as possible for years to come." ❑



ReACT™ Process