Keep Chimneys In Step with Plant Changes

Operational variations have an impact on the stack, often increasing corrosion and deterioration

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Chimneys and stacks appear to be relatively stable components in an industrial plant. However, they are not immune to the impacts of changing plant operations.

During their lifespans, chimneys may be exposed to a variety of changes, including variations in plant production, energy requirements, and environmental regulations. For instance, in some cases, new environmental regulations may require an extension in chimney height, a modification that alters the stress conditions of an existing structure.

Other problems have developed from the sulfur reduction requirements outlined in the Clean Air Act. To comply with the regulations, some plants may change to low-sulfur coal or may install scrubbers, which affect flue gas characteristics and chimneys. Boiler modifications also alter chimney conditions. Even production slowdowns change the conditions within the chimney, often contributing to increased corrosion and deterioration.

Role of the Stack

Regardless of the operation, chimneys and stacks serve to disperse flue gas into the atmosphere. For the most part, reinforced concrete, brick, steel, and fiber glass reinforced plastic (FRP) are the common choices for chimneys, stacks, and liners. Function establishes the basic stack form.

Whether the structure is a 1250-ft super-stack or a short stack on top of a boiler, round radial-brick, or square and concrete, every stack is unique, designed to perform in a certain environment under specified operating conditions.

Maintenance procedures also must be tailored to each chimney. Those procedures are defined by the chimney design, wear patterns of the stack's construction materials, characteristics of the flue gas, and impact of the environment.

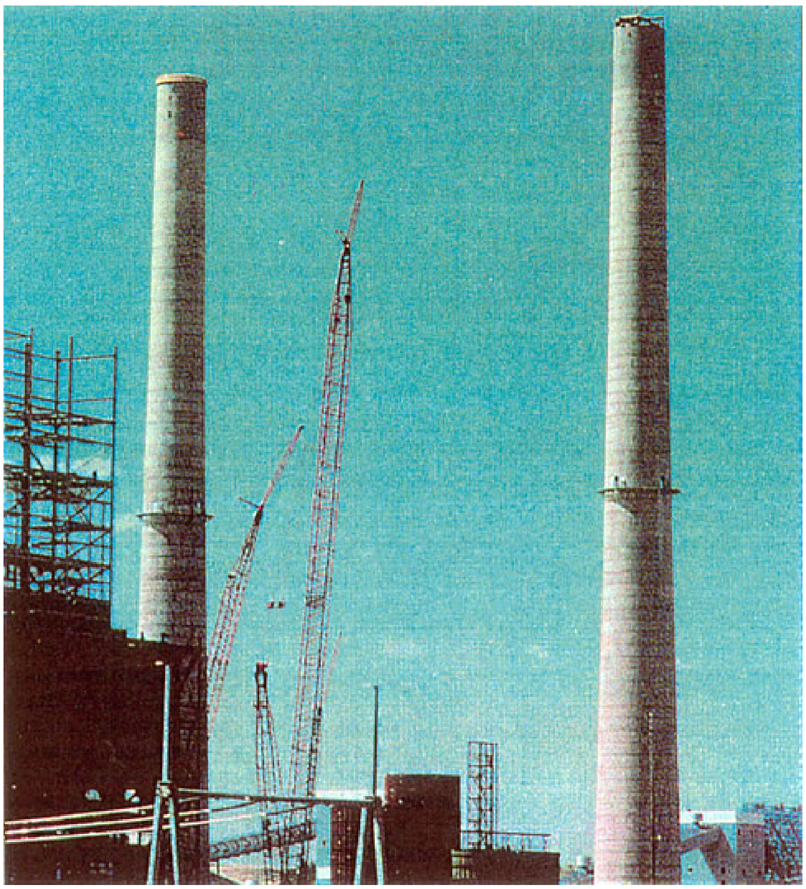
Chimneys and stacks are expected to operate throughout a typical plant life of 30 to 50 years. During that time, plant operations are unlikely to remain static. The impact of changing conditions on chimneys and stacks must be recognized. Maintenance procedures need to be developed and upgraded in response to those changing conditions to help ensure performance, extend chimney life, and minimize the potential for dangerous deterioration and expensive repairs.

Production Level Reductions

A drop in plant production leads to reduced fuel use, lower flue gas volume, and reduced flue gas exit velocity. A very low exit velocity promotes quick cooling, wash-down, and scattering of particulate in the vicinity of the chimney. Each condition poses problems, especially near the top of the chimney, that increase deterioration and discoloration. Low velocity also contributes to particulate buildup on the liner. As a result, more frequent cleaning is required.

A velocity cone is often used to combat the effects of low flue gas volume. Properly designed and installed on top of an existing chimney, a cone increases flue gas exit velocity. The increase raises the effective height of the stack and improves particulate dispersion.

Velocity cones must be properly sized for the system's capacity. If an induced draft fan is part of the system, the cone must be compatible with fan capacity. A velocity cone creates pressure drop. Draft calculations are required to verify adequate draft in the chimney after all losses. The structure must be carefully evaluated to ensure that it can withstand the additional wind exposure created by the cone.



“A significant change in a plant's operating conditions may require a chimney height extension”

Although they appear to be stable components*, chimneys and stacks are not immune to variations in plant operations. The impact of changes in plant production, energy requirements, and environmental regulations must be recognized and maintenance procedures developed and upgraded to ensure proper performance.*

New Boiler Additions

If growing energy requirements require adding more boilers to existing smoke-stacks, new openings may be needed in the outer shell and liner. The openings, coupled with expected changes in flue gas volume and temperature brought about by the new boilers, may significantly change critical stresses and draft conditions.

No new openings should be cut until the stress conditions created by the proposed modifications are evaluated for both the chimney and the liner. Generally, a new opening that is smaller than the existing ones, and installed at the same elevation but 180 deg from them, does not cause excess stress. However, even under these conditions, the edges of the new opening should be properly stiffened. If the size and location of the openings suggest overstress conditions, a reinforced sheath should be installed to mitigate the stress.

Increased flue gas volume and possible temperature changes caused by additional boilers may exceed the chimney's capacity and significantly change the draft. If the flue gas volume is too high, an induced draft fan may be required. If the chimney experiences positive pressure, annulus pressurization should be considered for brick liners. For a chimney that undergoes changes in flue gas characteristics and draft conditions, a more frequent inspection program should be considered to evaluate the impact of those changes on construction materials.

Adding new flues to existing steel liners poses other potential problems. In most cases, a temperature differential occurs inside the liner and promotes liner plate buckling. Evaluations should focus on liner plate stresses caused by nonuniform gas temperatures, bumper reactions, and anchor capacities. A temperature differential of more than 25-deg F makes a study of possible liner reinforcement vital.

Reinforcing any steel liner must be done within the constraints of geometric properties, flue gas temperature, existing restraints, and temperature differential. In one common method, horizontal and vertical stiffeners are installed and the existing number of bumpers and stayrods modified. A typical chimney liner moves vertically, and laterally. Stayrods and bumpers restrain the free thermal movement of the liner and induce thermal stresses. Removing stayrods near the bottom of the liner may reduce liner plate stresses and eliminate the need to anchor the stayrods onto the concrete column.

Surface preparation or partial removal *is often needed before a chimney is extended. Any height extension affects the stress conditions on the structure by increasing the moments caused by wind and seismic loads on the extension.*

Extending Chimney Height

Chimney height is determined primarily by Environmental Protection Agency (EPA) ground level concentration limits on such contaminants as SO_2 and NOx. A significant change in a plant's operating conditions may require a chimney height extension to allow dispersal of flue gas at a higher elevation to satisfy EPA requirements and enable the plant to secure its air quality permit.

Most newer concrete chimneys and steel stacks do not have excessive structural strength safety margins. Any height extension affects the stress conditions on the structure by increasing the moments caused by wind and seismic loads on the extension. The existing chimney may need reinforcement to counteract these loads. In addition, the revised height must not produce excessive friction losses or change the original draft conditions of the chimney.

Extension materials must be selected and the construction completed with care. Special attention should be paid to the top of the chimney. It often deteriorates and may require surface preparation or partial removal before any extension is installed.

Environmental Protection Measures

The $S0_2$ reduction provisions of the Clean Air Act virtually mandate emissions control equipment for plants using coal as a fuel. Two methods commonly used to reduce $S0_2$ levels are switching from high-sulfur to low-sulfur coal and installing scrubbers. Both methods have an impact on chimney performance and longevity. In addition, provisions of the Clean Air Act that focus on volatile organic compounds (VOC) control suggest other technologies and equipment that affect the chimney.

Integrating a wet scrubber into an industrial process changes the characteristics of the flue gas, increasing moisture content and lowering the temperature. Lower temperatures cause a loss of static draft. When combined with higher moisture content, the condition stimulates condensation and leads to acid attack on the liner interior.

Combating the loss of static draft requires a calculation of the draft to determine if the chimney is operating under positive pressure. Positive pressure tends to cause flue gas to penetrate the cracks in brick liners and damage the metal components in the air space.

The problem is solved by pressurizing the space, thereby minimizing flue gas penetration. The modification is accomplished by increasing the air pressure in the annulus to a level higher than the flue gas pressure inside the liner. Such a response requires that new seals be installed to maintain the air space and the air pressure.

Changing flue gas characteristics can also harm steel liners by increasing condensation and enhancing corrosion. Solutions include applying an interior membrane-type coating. Other applications include Gunite lining for brick liners or cladding with alloy steel for carbon-steel liners. When severe deterioration has already occurred, the liner must be replaced with one suitable for corrosive operating conditions.

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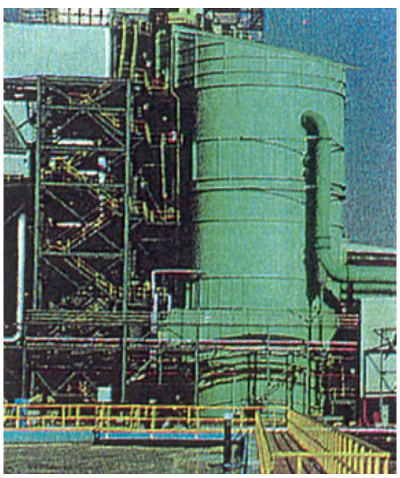
Switching to low-sulfur coal affects the entire combustion system, which has an impact on the volume and characteristics of the flue gas. Although each low-sulfur coal type is unique, certain characteristics are common to most: low caloric value and high moisture and ash content. More fuel is needed to produce the required energy. The added fuel volume leads to an increased flue gas volume, and frequently, a higher moisture content. Both conditions place pressure on the stack and liner.

When operating conditions are below the dewpoint, the increased potential for corrosion exists in the ductwork, lining, and accessories. These areas should be inspected with frequency to determine how effectively the materials are resisting chemical attack. Liners particularly vulnerable to corrosive flue gas should be protected with an acid-resistant coating, Gunite, or steel cladding. In some cases, it may be cost effective to replace the liner with one more suitable to the new operating conditions.

Increased flue gas volume and velocity may scour the liner surface, allowing flakes of deposited material to escape. This potential suggests thorough cleaning of the liner's inside surface prior to any switch in operating condition that promotes significantly higher exit velocities. Higher moisture levels also demand adequate housekeeping at the base of the chimney or stack.

Chimneys and stacks fulfill a critical function at any industrial facility. Because they fall at the end of the process cycle, they are affected by any operational change made in the process. Anticipating the impact of those changes and developing appropriate responses ensure long chimney life and performance.



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