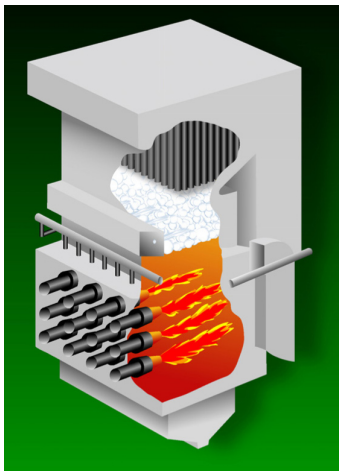
the ENERGY lab

R&D FACTS

Materials Science

Sensors to Detect Corrosion

Ash deposition occurs in the waterwall and superheater sections of coal combustors, as well as in the gasification and syngas cooler sections of coal gasifiers. This ash contains not only the unburned or unreacted portions of the coal but also sulfur- and chlorine-containing compounds formed in the energy conversion process. These deposits are usually solid but very often become molten, causing significant corrosion degradation of metallic materials used in power production facilities. At the present time the only way to detect corrosion problems is by cleaning during scheduled or unscheduled downtime periods.

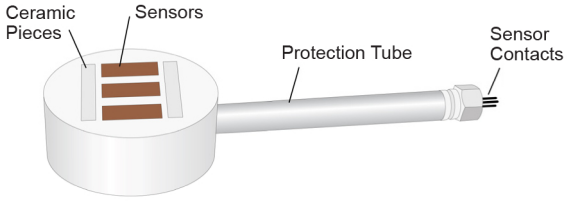


Schematic of a coal-fired boiler showing the burners (lower section) and the waterwall area above the burners.

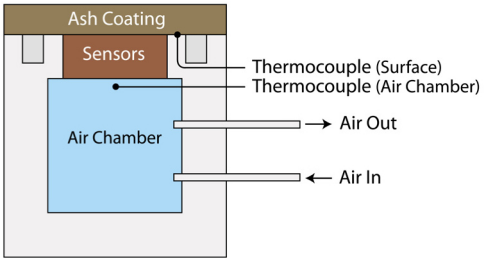
Corrosion sensors that are able to operate at the elevated temperatures in energy conversion processes will give the power plant operator the ability to "see" corrosion as it occurs. With this ability, the operator will then have the choice to:

- Make process changes to reduce corrosion rates or
- Measure the accumulated corrosion damage to better schedule downtime maintenance events.

Researchers at NETL have been studying the use of corrosion sensors based on electrochemical methods. Such sensors typically have three metallic elements (also called electrodes) and use the ash deposits as the electrolyte. The use of techniques such as linear polarization resistance, electrochemical noise, and harmonic distortion analysis provides measurement of corrosion rates and the probability of localized attack.



Schematic of electrochemical corrosion rate sensor.



Schematic of a thermally-cooled sensor.

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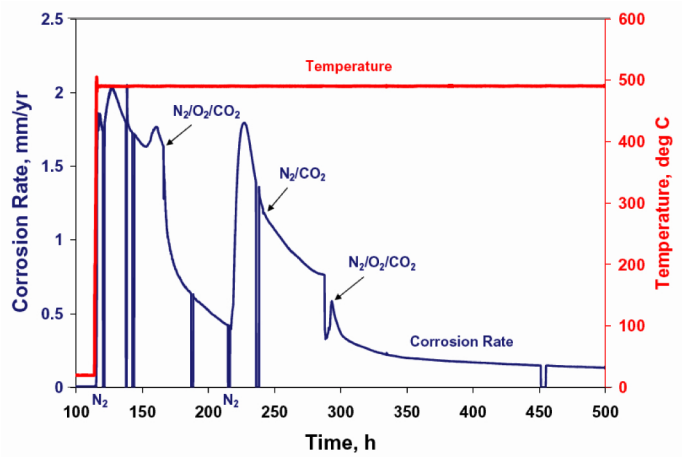
Variations on this sensor design have included:

- Thermally-cooled sensors to impart a thermal gradient and/or to simulate field use.
- Multi-element (9 element) sensors to increase sensitivity in low conductivity electrolytes.
- Multi-sensors containing two or three complete 3-element sensors to allow the study of different materials or different ashes in the same experiment.
- Rugged field sensors for industrial applications.



Effect of changing gas composition on the corrosion rate measured using an electrochemical corrosion rate sensor.

Research on these corrosion sensors shows that they are sensitive to changes in corrosion rate caused by changes in temperature, gas composition, and water vapor.

Corrosion rates measured with the corrosion sensors in laboratory experiments are always calibrated against a corrosion rate determined from mass loss samples exposed in the same experiment. This part of the research has shown that the electrochemical-based sensor typically measures lower corrosion rates than actually occurs. This means that the corrosion rates measured using the corrosion sensors are semi-quantitative. Research is currently underway to attempt to explain this and also to determine calibration factors that will make the measurements quantitative.

Flange corrosion sensors installed in an 8-inch natural gas transmission pipeline.

The same technology used here for high temperature energy conversion applications has been used in the past to detect corrosion problems occurring in natural gas transmission pipelines (see photo above). It is also being used to measure the corrosion rates of rebar and control impressed current cathodic protection of one of the steel-reinforced concrete bridges on the southern Oregon Coast (see photo below).

Patterson Bridge over the Rogue River in Gold Beach, Oregon.