Hoosier Energy Merom power plant.

FIRE IN THE COAL MILL

Derek Stuart, AMETEK Land, and Todd Collins PE, Hoosier Energy, US, discuss available techniques for detecting early signs of mill fires and explosions.

Mill fires and explosions can occur at any coal mill, so precautions need to be taken to minimise the risks. Of all the techniques available for early detection of dangerous conditions, carbon monoxide (CO) monitoring is among the most attractive because it is fast, sensitive and very specific. For over 2 years, AMETEK Land CO monitors installed at Hoosier Energy's Merom power plant in the US have operated reliably, with no mill explosions. Successive experience has allowed the site to determine alarm levels that are sensitive, while minimising the occurrence of false alarms.

Hoosier Energy's Merom power plant in Indiana, US, is a coal-fired baseload generator, which comprises two 535 MW generating units. It went into commercial operation in 1982 and provides power to electric distribution cooperatives in southern Indiana and southeastern Illinois. At full load, it uses 10,000 tpd of coal. Coal is supplied by road and rail from mines in southwestern Indiana. Hoosier Energy has a strong commitment to safety and maintains a robust safety programme, endeavouring to operate with the utmost regard for the health and safety of its employees and the public.

Safe coal handling practices are designed to ensure that the fuel remains intact throughout its journey from the mine until the point at which it is ignited in the boiler. Risks of unwanted combustion occur everywhere the coal is handled, processed or stored, including railcars,

AMETEK Land millwatch analysers installed at the Merom power plant.

coal piles, conveyors and silos, as well as in the coal mills. While appropriate precautions differ at the various stages of the process, this article concentrates on appropriate detection methods for coal mills.

Each generating unit at Merom has three Riley Power double-ended ball tube mills. The mills can each provide 65 tph of pulverised coal to the boiler, a total of 195 tph per boiler.

NFPA Annex K.5 Coal Firing General Considerations states: "It takes as little as 1.4 kg of pulverised coal in 28.3 m^3 of air to form an explosive mixture. Since a large boiler burns 45.4 kg/sec of coal, the safe burning of pulverised coal necessitates strict adherence to planned operating sequences". The boilers at Merom burn 54 kg/sec of coal.

The greatest risk of fire occurs when the mill is shut down under load, as this leaves a large amount of pulverised fuel inside a hot mill. The large surface area of the pulverised coal, as well as the high temperature inside the mill, leads to rapid oxidation of the coal. This results in further heat buildup and the potential for a fire. If the mill is restarted without first removing the hot coal, an explosion can occur when particles are suspended and exposed to the air. Even when a mill is shut down routinely, there is a danger that any residual coal left within the mill will oxidise, which can explode as the mill is restarted. To prevent a coal fire, the mills can be inerted with a steam deluge when an unexpected shutdown occurs or when there is a high risk of a coal fire.

Safety methods

Several methods are available to detect the presence of oxidisation within the mill. Temperature monitoring can detect the heat buildup, but it has limited sensitivity and discrete sensors have difficulty monitoring the whole volume of the mill. This method was used at Merom before 2011, but experience showed that it did not provide a reliable indication that a hazardous condition was developing within the mill.

CO gas detection offers a fast and sensitive means to detect the presence of oxidising coal, as the oxidation inevitably produces large amounts of CO. There are a number of reasons for choosing CO measurement for this application, but the most important are the availability of sensitive CO sensors able to detect a few parts-per-million of CO and to sample a large portion of the mill using a probe mounted at the classifier outlet.

Installation

Having decided to monitor CO within the mills, Hoosier Energy and Riley Power determined that AMETEK Land's Millwatch analysers were best suited to the task. The analysers have a long track record, with hundreds of installations worldwide. The main features of the analysers include the following:

- Rugged sample probes with automatic blowback to maintain a good sample flow.
- Automatic calibration verifies correct operation of the analysers, confirming that they respond correctly to CO.
- Twin-stream analysers allow continuous measurement from two sample points, with no multiplexing and no increase in response time. This last feature is especially important as a hazardous condition can develop within a few minutes and a multiplexed system, sampling six measurement points, will typically sample each point only once every 10 – 15 min.

Because the ball-tube mills have outlets at each end, with a classifier on each outlet, two sample points were needed on each mill. For enhanced reliability, a redundant configuration was chosen with two sample points on each classifier, giving four samples per mill. With three mills per generating unit, a total of 12 sample points were needed for each unit or six twin-stream analysers. Redundant measurements reduce the likelihood of a nuisance alarm, as a high CO measurement is unlikely to be detected on one coal pipe, while the others continue to show normal readings.

Even though the inside of the classifier is a hazardous area, the sample probes are simple devices with no electrical connection and so no special precautions were needed. The initial proposal was to mount the sample probes directly on the classifiers. Although this would have provided a representative sample, the probes have an abrasion shield, which prevents the stainless steel filter from being damaged by the high concentration of coal dust. An installation location at the classifier outlet was preferred, since this allowed the abrasion shield to face the flow of coal dust and protect the filter. Blowback controllers were installed close to the classifiers, but outside the hazardous area.

Along with the CO monitors, an in situ oxygen probe was installed on each classifier, to determine the oxygen concentration while the mills are inerted using steam.

The CO analysers were installed at the same level as the classifiers. This meant the sample lines could be kept short and the response time minimised. The chosen location also gave easy access for maintenance. Commissioning took place during an outage in May 2011.

The main practical challenge in configuring the Millwatch analysers was the determination of suitable alarm levels. A CO concentration greater than 250 ppm was seen during mill startup, but in normal operation the CO concentration was in the region of 10 ppm. Millwatch analysers offer two independent alarm points, so alarm levels were set at 300 ppm during startup and 50 ppm in normal operation. Although the startup alarm seemed robust, there were occasional spikes above 50 ppm CO in normal operation, so the alarm level was increased several times with a final figure of 125 ppm. This avoided nuisance alarms, while providing good sensitivity and response to abnormal operating condition when the mill may need to be inerted.

Enhanced safety

In the two years since the Millwatch analysers were installed at Merom, there have been a number of high CO alarms, but there have been no mill explosions. This is an impressive achievement for a baseload power plant. During that time, the Millwatch analysers have proven to be reliable, requiring no more than routine maintenance and providing enhanced safety.

On 8 December 2013, the Millwatch analysers demonstrated their value. With Unit 2 running at full load, one of the mills tripped and the operators observed a rapid increase in the CO readings, even though there was no indication of a temperature rise. Within a few minutes, the CO level was above the alarm threshold and the operators made the decision to activate the deluge system. The boiler continued to operate using coal from the remaining mills, with output dropping to 60% of its rated value. The CO level in the mill started dropping after 15 min and within 45 min the CO level was below 10 ppm. The mill was restarted 2 hours after the high CO alarm was detected and was returned to full operation in 3.5 hours. The Millwatch CO analysers detected a potentially dangerous condition and allowed it to be dealt with quickly with no damage to plant or personnel.

Summary

In conclusion, CO monitoring provides a rapid and reliable method for detection of potentially dangerous coal oxidation within a mill so that action can be taken to reduce the risk of a fire or explosion. At the Hoosier Energy Merom power plant, 12 twin-stream Millwatch analysers from AMETEK Land have provided good reliability and a high level of safety coverage with no explosions in the mill since they were installed more than two years ago. WC