



CONSCIOUS COAL MILLING

Derek Stuart, AMETEK Land, USA, looks at why early detection of potential spontaneous heating and combustion locations in coal milling is essential to plant safety.

All coals oxidise during storage, but sub-bituminous coals (such as those from the Powder River Basin), due to their friability and porosity, are especially prone to spontaneous combustion. The increasing use of sub-bituminous coals throughout the world has therefore increased the risks of grinding mill incidents. Avoiding spontaneous combustion in the milling process is essential for personnel safety and asset protection.

The greatest risk of spontaneous heating and subsequent 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 and the high temperature inside the mill can lead to the rapid oxidation of the coal. This results in further heat build-up and the potential for a fire.

If the mill is restarted without removing the hot coal first, an explosion can occur when particles are suspended and exposed to the in-rushing combustion air. Even in routine mill shutdowns, there is a danger that any residual coal left within the mill will oxidise and may explode as the mill is restarted.

Good operating procedures, such as inventory turnover, nitrogen inerting or using chemicals to reduce the risk of auto-ignition, can help to reduce the risks. However, mill fires may still occur. With many baseload plants now being frequently dispatched, the risk of a catastrophic event mounts.

Why oxidation happens

Oxidation is a critically important problem. When coal is exposed to the air, the volatile components may combine with oxygen in an exothermic reaction, leading to spontaneous

heating. The Arrhenius equation tells us that the rate of oxidation approximately doubles with every 10°C increase in temperature, so a runaway condition can occur in which the coal self-ignites in a process of spontaneous combustion.

There are several techniques of monitoring for the effects of spontaneous heating and giving early warning that a dangerous condition may occur. Those techniques mainly work by detecting one of the tell-tale signs of oxidation: either heat build-up or the emission of carbon monoxide gas.

Choosing the most appropriate monitoring technique depends on both the measurement location and the degree of risk. More sophisticated, and therefore more expensive, monitors are appropriate where low rank coals pose an increased likelihood of spontaneous combustion.

Options

Thermocouples are widely used to detect the heat build-up from oxidation or early stage fire, but they have limited sensitivity and cannot monitor the whole volume of the mill. It also takes time for sufficient heat to build up within vessels to generate a detectable increase in temperature, at which point tackling the issue becomes much more challenging.

Carbon monoxide gas detection offers a fast, sensitive means to detect the presence of oxidising coal, as the oxidation process inevitably produces large amounts of carbon monoxide and is a precursor to an actual fire. Large amounts of carbon monoxide are produced by the inefficient oxidation associated with spontaneous combustion. Ambient air contains a very low concentration of this gas – usually well below 10 ppm by volume – so a significantly higher

concentration provides a fast and highly accurate early indication that unwanted oxidation is occurring. Carbon monoxide measurement has the advantages of very sensitive carbon monoxide sensors with detection limits around 2 ppm. Carbon monoxide monitoring is fast, specific and sensitive, and can be calibrated to determine alarm levels that reliably identify a hazardous condition, while minimising the occurrence of false alarms.

Electrochemical sensors are widely used because they are compact and sensitive. A significant drawback is that they give zero output when they fail. That means a faulty sensor will indicate a low carbon monoxide concentration, so it is important to verify correct operation of the sensor. Otherwise, a negative indication can give a false sense of security. Automatic calibration verification, using a calibration gas mixture, can be used to assure correct and reliable operation.

The sample probe for a carbon monoxide measurement system, such as AMETEK Land's Millwatch, should be installed at the classifier outlet so it receives a sample of well-mixed gases from within the mill. AMETEK Land has developed an innovative sample system which does not penetrate into the gas flow. It comprises a large area filter mounted in a side-arm outside the main pulverised coal pipe.

This has advantages over older designs. The sampler is not directly exposed to the flow of pulverised fuel, so there is little abrasion and the lifetime of the sampler is increased. A blowback system uses compressed air to clean the filter periodically, increasing the time between manual cleaning operations. The sampler also can be isolated from the coal flow, allowing the filter to be cleaned or replaced while the mill is online.

Consideration also must be given to the gas path between the mill and the analyser. For indoor locations, a simple stainless steel or Teflon tube can be used. For outdoor runs in cool climates, a heat-traced sample line is usually needed to prevent moisture in the sample from freezing and causing a blockage. A sample probe also can become plugged with coal dust so that it is no longer exposed to the atmosphere. A well-designed analyser can detect a blocked sample probe by sensing a reduction in sample flow.

Alarm

One of the biggest challenges in configuring a carbon monoxide measurement system is the determination of suitable alarm levels. A low alarm threshold gives the earliest warning of a problem, but it can result in an excessive number of nuisance alarms, which may indicate an unusual condition but may not cause any problems. An excessively high threshold can allow spontaneous heating to progress to the point of being hazardous.

The exact value is specific to the fuel type and the storage location. For example, a carbon monoxide concentration greater than 250 ppm can be seen during mill start-up, but in normal operation the carbon monoxide concentration is in the region of 10 ppm.

Millwatch analysers offer two independent alarm points, so an alarm level can be set at 300 ppm during start-up and at 50 ppm for normal operation. Each plant's operating

parameters will eventually determine the proper levels of the dual alarms to provide the proper notifications while minimising nuisance alarms. This is achieved with a simple change of alarm levels on the Millwatch system.

An alternative to a level alarm is a rate-of-change alarm. This type of alarm ignores the background level of carbon monoxide but responds to the rapid increase that is associated with the early stage of spontaneous combustion.

Case study


The Houshi power plant is a 4200 MW electricity generating plant in China's Fujian province. It supplies electricity to the city of Zhangzhou and the surrounding area. There are seven electricity generating units at the site, each of which is rated for 600 MW.

In 2011, the plant operators decided to add Millwatch carbon monoxide monitors to the five coal mills in Unit 1, supplementing their existing temperature and fire sensors. Millwatch provides continuous measurement with no multiplexing. The fast response (T90 is typically less than 50 sec.) to increases in carbon monoxide levels provides early warning to the operator, enabling prevention of plant damage and personnel injury.

The system was chosen because it enables the rapid measurement of carbon monoxide, which would not be possible with a multiplexed system that samples a number of different measurement points every 10 - 15 min., and it has proven extremely effective for this power plant. In 2013, one of the plant's mills showed a rapid rise in carbon monoxide levels, and the analysers allowed corrective action to be taken significantly earlier than would otherwise have been possible, therefore preventing a fire breaking out.

Conclusion

Millwatch is specifically designed for the early detection of potential fire risk in coal pulverising mills. It monitors and quickly responds to sudden carbon monoxide build-up, allowing preventative action to be taken before a hazardous condition develops. By providing continuous, accurate monitoring of carbon monoxide levels, Millwatch improves process safety, protects expensive mill equipment and, therefore, prevents costly downtime from unnecessary shutdowns.

Whilst spontaneous combustion will always carry some risk in coal milling, when continuous monitoring of carbon monoxide is employed, the risks are significantly reduced and a plant can operate in a much safer manner. There are many options available for monitoring spontaneous combustion, but carbon monoxide monitoring has proved to be one of the most effective and is helping many plants across the globe to reduce their risks. 

Bibliography

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