December 2010
PF 10-14

Profiles

Propensity of coal to self-heat

'Self-heating of coal is a naturally occurring process caused by the oxidation of coal'

'Natural oxidation is uncontrolled and can lead to emissions and spontaneous combustion'

'Unless handled correctly, the results can be catastrophic in damage to power plant equipment'

Coal, the most abundant fossil fuel in the world, accounts for ~40% of the electricity produced throughout the world. Coal-fired power plants release SO_2 and NOx to the environment, as well as CO_2 and N_2O, particulate matter, mercury and other hazardous air pollutants such as cadmium, arsenic, vanadium and various other acid gases. However, prior to firing in the plant boiler, the coal is stored on site either in stockpiles or silos/bunkers.

Spontaneous combustion, or self-heating, of coal is a naturally-occurring process caused by the oxidation of coal. The self-heating of coal is dependent on a number of controllable and uncontrollable factors. Controllable factors include close management in the power plant, of coal storage in stockpiles, silos/bunkers and mills and management during coal transport. Uncontrollable factors include the coal itself and ambient conditions.

The increasing international trade in both metallurgical and steam coal has led to renewed interest in the potential for spontaneous combustion to occur during transport, particularly by bulk carrier. This problem is becoming greater as the tonnage of lower-rank (subbituminous) coals transported by both rail and sea is increasing. This tendency exhibited by some coals to self-heat and result in spontaneous combustion, can preclude their widespread utilisation.

Properties that influence the propensity of coal to self-heat/combust

The self-heating of coal is due to a number of complex exothermic reactions. Coal will continue to self-heat provided that there is a continuous air supply and the heat produced is not dissipated. The property of coal to self-heat is determined by many factors, which can be divided into two main types, properties of the coal (intrinsic factors) and environment/storage conditions (extrinsic factors). Self-heating results in degradation of the coal by changing its physical and chemical characteristics, factors that can seriously affect boiler performance. The risk of spontaneous combustion during final preparation such as in silos/bunkers and mills also presents concerns in some cases. Properties which influence the propensity of coal to self-heat include volatile content, coal particle size, rank, heat capacity, heat of reaction, the oxygen content of coal and pyrite content. The propensity of coal to self-heat and spontaneously combust tends to increase with decreasing rank. Thus, lignites and subbituminous coals are more prone to spontaneous combustion than bituminous coals and anthracites.

The temperature of coal increases due to self-heating until a plateau is reached, at which the temperature is temporarily stabilised. At this point, heat generated by oxidation is used to vaporise the moisture in the coal. Once all the moisture has been vaporised, the temperature increases rapidly. On the other hand, dry material can readily ignite following the sorption of water. Thus, dry coal in storage should not be kept in a damp place because this can promote self-heating. Therefore, it is recommended that dry and wet coal be stored separately.

Self-heating during transport

The International Maritime Organization (IMO) is a specialised agency of the United Nations with 169 Member States and three Associate Members. The IMO is based in the United Kingdom with around 300 international staff. The Convention establishing the IMO was adopted in Geneva in 1948 and the IMO first met in 1959. The IMO's main task has been to develop and maintain a comprehensive regulatory framework for shipping and its remit today includes safety, environmental concerns, legal matters, technical co-operation, maritime security and the efficiency of shipping. The IMO requires all coal carriers to provide suitable equipment for the early detection of cargo heating. Shipboard fires due to spontaneous combustion have been reported when coals from the USA were exported to the Far East. Measures introduced to prevent the loading of coal with temperatures greater than 40°C and compacting the coal in the cargo hold could be used successfully in stopping a fire. For more information about the IMO visit www.imo.org.

Self-heating in stockpiles

Coal stockpiles are prone to spontaneous combustion especially where large quantities are stored for extended periods. Coals that exhibit the greatest tendency to self-heat (that is lignites, subbituminous and brown coals) are rarely stored for any length of time at the power station. Self-heating occurs more commonly at

power plants than transfer points or ports. This is a reflection on the relative length of storage time involved at each stage. Spontaneous combustion in stockpiles poses significant safety, environmental, economic and handling problems. As well as the economic loss of coal due to fires, the heat-affected coal may become partially or totally unsuitable for its intended use. Thus prevention and early detection of spontaneous combustion is of paramount importance. It is not always clear how frequently fires occur as there is a lack of information published on this topic.

Self-heating in silos/bins/bunkers

Coal silos/bunkers present a particular problem in relation to self-heating. Coal is usually stored only temporarily – perhaps a matter of a few hours or less – in silos used in rail load-outs, so there is little chance for self-heating unless the design of the structure allows coal to build up inside. Long-term silo/bunker storage can provide the possibility of air movement thus providing ideal conditions for accelerated self-heating. Therefore, ventilation is essential at the top of the silo or bunker to remove gas emitted from the coal; sealing the silo/bunker will help prevent self-heating. An alternative prevention method is flooding the upper parts of the silo with inert gas.

Self-heating in pulverisers/mills

Coal pulveriser/mill fires and explosions can be a chronic problem at coal-fired power stations. A pulveriser system may be defined as the section from the coal silo feeding the pulveriser, the burners fed from that pulveriser and the points at which the hot air and cold air ducts leave their respective main supply ducts. The pulveriser system incorporates grinding to reduce coal particle size to allow its circulation within the pulveriser, drying using hot air (primary air input and residence time in the mill) and classification to produce coal so that 70% will pass through a 200 mesh screen (the term is known as coal fineness. Usually, the first step taken in the pulveriser system is inerting by steam. This removes any hot deposits of coal inside the pulveriser system which can cause spontaneous combustion.

Greenhouse gas emissions

There are numerous studies on greenhouse gas emissions (CO_2 and CH_4) from low temperature oxidation and spontaneous combustion in coal mines. These are not discussed in the review. Few studies have been carried out on emission of greenhouse gases from coal stockpiles kept in a coal-fired power generating station. Investigations have been undertaken to evaluate and assess the risk of transporting coal from the mine to a power station. However, in general, the work involves the greenhouse gases emitted due to the use of vehicles, trains, ships or barges to transport the coal. Studies have also investigated the impact of reduced heat value of the coal on final emissions (that is, after firing the coal in a boiler).

Conclusions

The results of spontaneous combustion are serious and negative – damaging economic effects, detrimental environmental consequences and unwanted costs in health problems and, in some cases, human life. To prevent these outcomes, the processes that lead to coal self-heat must be understood and precautions must be taken to avoid fires caused by spontaneous combustion. Heat build-up in stored coal can degrade the quality of coal, cause it to smoulder, and lead to a fire. According to some, throughout the coal-based power generating industry, insufficient information and inadequate education have created serious misconceptions regarding how best to address coal-plant fires.

Each issue of *Profiles* is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of *Profiles* is based on the report:

Propensity of coal to self-heat
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CCC/172, ISBN 978-92-9029-492-4,
47 pp, August 2010,
£255*/£85†/£42.50‡

* non-member countries
† member countries
‡ educational establishments within member countries

IEA Clean Coal Centre is a collaborative project of member countries of the International Energy Agency (IEA) to provide information about and analysis of coal technology, supply and use. IEA Clean Coal Centre has contracting parties and sponsors from: Australia, Austria, Brazil, Canada, China, Denmark, the European Commission, Germany India, Italy, Japan, Republic of South Korea, the Netherlands, New Zealand, Poland, Russia, South Africa, Sweden, Spain, Thailand, the UK and the USA.

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