Maintaining large inventories of thermal coal for power generation can create a hazard management issue in regard to spontaneous combustion. The risk involved is assessable and various strategies are available to manage the issue in terms of handling and storage. From a simplistic viewpoint, the lower rank thermal coals, particularly sub-bituminous coals, have an increased propensity for spontaneous combustion, due to their reactive nature and ability to self-heat. GE Power & Water has developed a suite of anti-oxidant products that provide effective inhibition of the self-heating process and have been successfully applied to sub-bituminous coals from the Powder River Basin (PRB). The effectiveness of the anti-oxidants has also been benchmarked against site experience at a laboratory scale at the University of Queensland in Australia.

**Benchmarking Effectiveness**

There are numerous laboratory tests available to assess the propensity of coal to spontaneously combust. These generally provide a relative rating classification of the coal, but do not provide information on the time taken to reach thermal runaway or the behaviour of the coal during the self-heating process. Consequently, a new testing approach has been adopted in order to benchmark results obtained in the laboratory against case study results from applying anti-oxidants onsite. This allows any coal to then be assessed in the laboratory to determine the possible effectiveness of the anti-oxidant and relevant application dosage rates for that coal.
particular coal to achieve a desired outcome (a safe storage time).

The laboratory test was performed in an adiabatic oven, which minimises heat loss from the coal to the surrounding environment. Crushed, fine coal was used in the test with its as-mined moisture content and the test was started from the ambient mine temperature. A low oxygen flow rate was used and all of these conditions helped to optimise the worst case scenario for developing a spontaneous combustion event.

Standard spontaneous combustion index testing of the untreated and treated coal indicated that the intrinsic reactivity of the treated coal was reduced by 23.6%. Figure 1 shows the self-heating results for untreated and treated sub-bituminous coal from the PRB, using the new testing method to evaluate the time taken to reach thermal runaway. The untreated coal rapidly self-heats and, based on the site day’s timescale, the minimum timeframe to thermal runaway is 13 – 20 days. Actual site experience with this coal indicates that heating events at the mine can take place in 15 days. Hence, there is close agreement between the laboratory results and the actual minesite performance of the coal.

The treated coal was tested with a dosage rate that replicates the site application. The shape of the self-heating curve is altered significantly, as the initial self-heating rate is suppressed and, at one stage, there was some heat loss before the coal eventually resumed self-heating at a much slower rate than the untreated coal. As such, the time taken to reach thermal runaway is substantially prolonged by around three times that of the untreated coal. This result is consistent with the site experience from using the anti-oxidant.

Figure 2 shows the results of field trial temperature measurements for treated and untreated sub-bituminous coal from a 40,000 t stockpile. The untreated coal rapidly self-heats, whereas the treated coal is stable for at least 60 days in this case. Further field experience with the use of the anti-oxidant is shown in Figure 3.
which highlights a dramatic reduction in bunker fire events over an extended period of application.

**Additional benefits**

Maintaining a coal stockpile in a low temperature state by applying an anti-oxidant provides a quantifiable safety margin for spontaneous combustion mitigation. This is because the coal self-heating is managed in a controlled manner, which can be demonstrated at a laboratory scale before application.

In extreme cases, where hot spots develop, the coal can rapidly proceed to open flame. This creates both a safety and environmental hazard from the toxic gases that are produced. Treating coal at this stage of spontaneous combustion development is much more difficult and can result in significant economic loss, both in terms of income from lost product and additional resources required to combat the problem. Therefore, the longer the coal stockpile remains at a low temperature, the lower the risk of a spontaneous combustion event.

An additional benefit of the coal remaining at low temperatures is that it retains moisture content, which lessens the amount of coal degradation to produce coal fines. As such, the anti-oxidant also acts in a way that lessens dust generation. Field experience with stockpile building indicates significant reduction in dust emissions for coal that has been body treated with the anti-oxidant. This is demonstrated in Figure 4. There is a substantial dust cloud billowing out from beneath the stacker at the drop point for untreated coal. However, when the coal is treated, this dust cloud virtually disappears. Dust emission readings for the untreated coal can reach in excess of 4 mg/m³, whereas the treated coal barely exceeds 1 mg/m³. A similar experience is recorded at transport load out points. This is illustrated in Figure 5. In this example, dust emission readings of untreated coal are as high as 10 mg/m³ and reduced to lower than 2 mg/m³ for the treated coal.

Areas of a coal stockpile that undergo self-heating will be rapidly oxidised and, subsequently, may suffer calorific value loss. This will be particularly true in the vicinity of any hot spot development, especially if it is allowed to reach open flame and begin to spread throughout the stockpile. Research has shown that calorific value losses generally remain below 1%/year in long-term stockpiles, as long as temperatures remain low (ideally below 50°C). Figures 1 and 2 illustrate that application of the anti-oxidant is able to achieve this criterion for a considerable period of time, even for a reactive coal. In the field trial, illustrated in Figure 2, the treated coal pile remains below 35°C.

**Conclusion**

The effectiveness of applying an anti-oxidant to PRB coal to delay self-heating has been demonstrated both onsite and in the laboratory. For the dosage rates applied, there is an approximate three-fold increase in the time taken to reach thermal runaway. In addition, the coal remains at lower temperatures for a considerably longer period of time, thus reducing the effects of coal degradation and potential calorific value loss.

**Note**

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