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IMPLEMENTATION OF INTERACTIVE SPONTANEOUS COMBUSTION HAZARD ASSESSMENT AND MANAGEMENT AT MEANDU MINE

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ABSTRACT: Since recording a spontaneous combustion event in-pit at Meandu Mine in 2014 interactive spontaneous combustion hazard assessment and management has been adopted by the mine to eliminate the risk of any future events. This has proved to be very successful due to a diligent and systematic set of management practices that commences with sampling and spontaneous combustion testing of the coal as it is exposed in each new strip at the mine, with feedback of results into the mine planning process through to stockpiling of the coal at the mine and at the Tarong Power Station. The key control in this process is the use of a new test method that quantifies the minimum incubation period for spontaneous combustion to develop under site conditions.

INTRODUCTION

Leading practice in all coalmines requires the implementation of a Principal Mining Hazard Management Plan (PMHMP) for spontaneous combustion. In Australia, sound scientific data is a mandatory requirement for use as a basis to assess the spontaneous combustion hazard. This information is routinely used for developing risk assessments, control measures, standard operating procedures and management strategies in order to provide safer working environments for personnel, reduced potential for lost time and decrease asset losses.

Australian coalmine operations have been using adiabatic oven testing since the early 1980's to rate the propensity of coal to spontaneously combust (Humphrey, Rowlands and Cudmore 1981). The R_{70} initial self-heating rate parameter normally obtained from these tests is rated using a relative scale (Beamish and Beamish 2011). Evaluation of the resulting intrinsic spontaneous combustion propensity rating enables a general appraisal of the possible likelihood of a spontaneous combustion event to be made; however it provides no indication of the timeframe in which an event can occur under the prevailing site conditions. A more advanced method of adiabatic testing is now available that replicates initial site conditions and measures the incubation behaviour of the coal, thus overcoming the major deficiencies of current spontaneous combustion propensity index parameters (Beamish and Theiler, 2017). The results obtained are benchmarked (calibrated) against actual on-site spontaneous combustion events of a range of coals from Australia and overseas covering the full rank spectrum from low to high rank.

Since recording a spontaneous combustion event in-pit in May 2014 (Beamish, Edwards and Theiler, 2015), Meandu Mine has routinely implemented an interactive spontaneous combustion hazard assessment strategy that utilises adiabatic incubation testing to help guide the management of safe coal extraction, handling and stockpiling from the mine face to the Tarong Power station. This paper presents operations for future reference examples of the results obtained from using this strategy, which could be used by other.

MINE LOCATION AND GEOLOGICAL SETTING

Meandu Coal Mine is located in the late Triassic Age (~200-220 Ma) Tarong Basin approximately 200 km north west of Brisbane, Queensland (Figure 1). A thermal product coal is produced from three main seams in the Tarong Beds to supply Stanwell Corporation's Tarong Power Station (TPS) (Simmons, Edwards and Ferdinands, 2013). The Tarong Beds coal measures consist of thick coal seams which are interlayered with fine grained clay,

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quartz-rich or iron-rich stone bands of variable thickness within a sedimentary package of conglomerates, sandstones, siltstones and mudstone. Pegrem (1995) previously classified the coal from the Tarong Beds as high ash, low volatile, low sulphur steaming coal with weak coking properties. There are three main seams being mined at Meandu Mine, namely Ace, King and Queen. The seams increase in ash content with stratigraphic depth (Young, 2013). As the coal at Meandu Mine is not able to be easily "free dug" it is blasted in order for it to be mined.

Figure 1: Tarong Basin Location (Queensland Department of Mines and Energy, 2013)

COAL SAMPLES AND ADIABATIC TESTING

Coal samples were collected from various strips at Meandu Mine as they were uncovered (Figure 2), as well as two samples (C06 King B and Carey's 2 King) from stockpiled coal. The samples were tested in an adiabatic oven to establish their R_{70} values and minimum incubation period. The R_{70} testing procedure is described by Beamish (2005) and essentially involves testing a dried, crushed coal sample under adiabatic conditions from a fixed starting temperature of 40 C. The Incubation test procedure uses the coal in its "as-mined" moisture state and the test commences from a starting temperature that reflects the site-specific conditions. In the case of Meandu Mine a typical summer temperature of 35 C is used. The results obtained provide both an indication of the minimum incubation period (the time taken to reach thermal runaway) and the characteristic behaviour of the coal as self-heating progresses. The results are benchmarked against the heating that occurred in a coal bench (K4E ST12) at Meandu Mine in May 2014.

Figure 2: Sampled coal material from Ramp 5 ST7 for spontaneous combustion testing

The coal quality details of the samples are contained in Table 1 and their similarity in coal rank is demonstrated on a Suggate rank plot (Suggate, 2000) shown in Figure 3. According to the ASTM coal rank classification the coal is high volatile B bituminous. The coal type is predominantly high in inertinite (dull) as most of the samples plot below the New Zealand high vitrinite coal band (Figure 3).

Table 1: Coal quality data and ASTM rank rating for coal samples from Meandu Mine

Sample	Moisture (%, ar)	Ash (%,db)	Volatile Matter (%, dmmf)	Calorific value (Btu/lb, mmmf)	ASTM rank
K4E ST12 AK	7.3	8.7	40.2	13666	hvBb
C06 King B	8.0	15.6	35.7	13906	hvBb
Carey’s 2 King	6.5	17.5	34.8	13837	hvBb
K4S ST3 Q	7.4	10.4	36.9	13868	hvBb
Ramp 5 ST4 Q1	5.4	16.8	34.8	13800	hvBb
Ramp 5 ST4 Q2	7.7	13.0	33.8	13788	hvBb
Ramp 5 ST7 Q1	6.4	26.7	37.6	13461	hvBb
Ramp 5 ST7 Q3	6.8	25.9	34.1	13643	hvBb

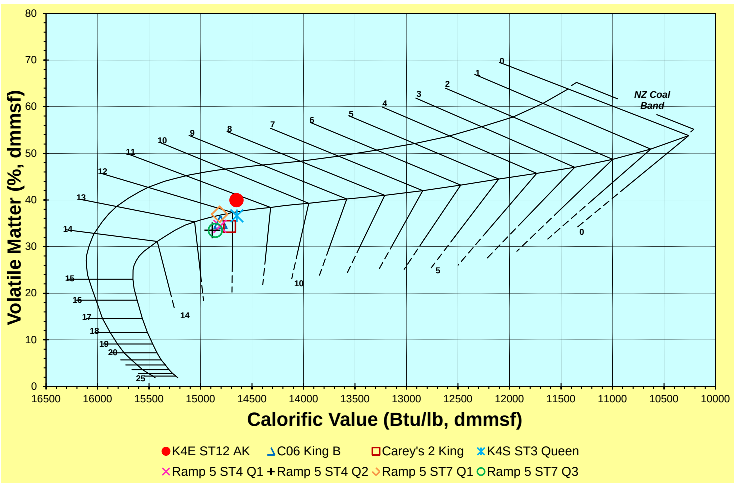

Figure 3: Suggate rank plot of coal samples from Meandu Min

ADIABATIC SELF-HEATING RESULTS AND DISCUSSION

R_{70} values

The R_{70} values for the Meandu coal samples are shown in Figure 4. Generally, as the ash content of the coal increases the R_{70} value decreases. However, the Carey's 2 King sample was from a stockpile that had been formed for some time before being sampled. Consequently, it had undergone some pre-oxidation, which is indicated by the lower R_{70} value for the ash content of the coal. The fresh, low to medium ash content coal would be classified as having a high intrinsic spontaneous combustion propensity, whereas the high ash content and pre-oxidised coal has a medium intrinsic spontaneous combustion propensity rating.

Incubation behaviour

Since the R_{70} test is performed on a dry-basis it does not provide any indication of the moderating influence of moisture in the coal on the low temperature self-heating behaviour. However, the Incubation test results in Figure 5 clearly show the moisture moderating effect. For example, the Meandu samples C06 King B, Ramp 5 ST4 Q1 and Ramp 5 ST4 Q2 all have similar R_{70} values (3.14, 3.37 and 3.39 respectively rating them as having a high intrinsic spontaneous combustion propensity), but it is only the Ramp 5 ST4 Q1 sample that has a short incubation period to thermal runaway. This sample has a moisture content of 5.4%, whereas the other two samples have much higher moisture contents, (C06 King B (8.0%) and Ramp 5 ST4 Q2 (7.7%)). The C06 King B sample reached a maximum temperature of 74 C, before evaporative moisture heat loss overtook the heat being generated from coal oxidation. The Ramp 5 ST4 Q2 sample reached a temperature of 69 C after 63 hours of testing and can be seen to be decreasing in self-heating rate (Figure 5).

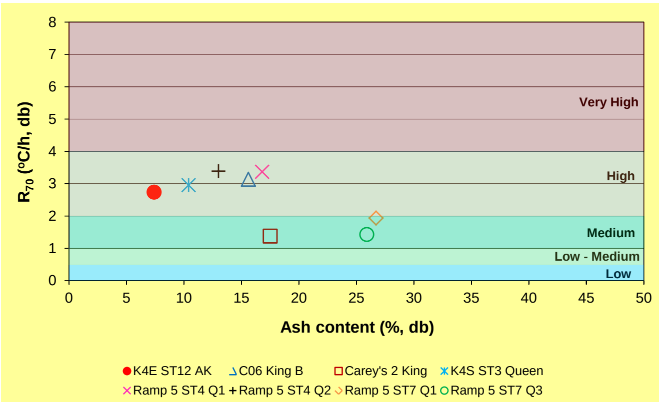

Figure 4: R_{70} self-heating relationship with ash content for coal samples from Meandu Mine, showing intrinsic spontaneous combustion propensity classes based on Queensland conditions

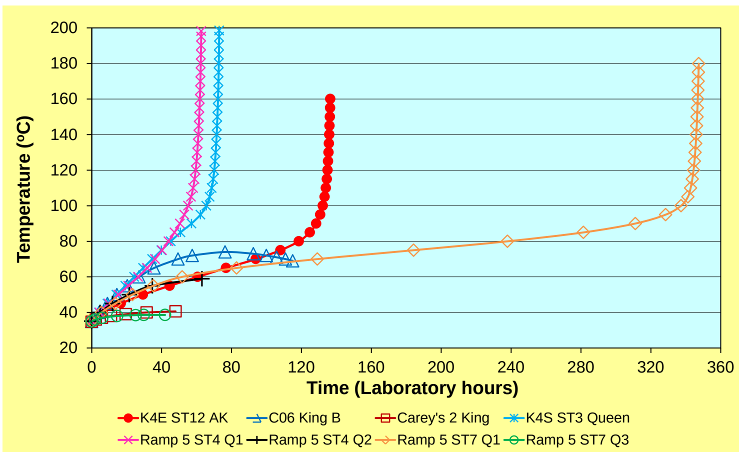

Figure 5: Adiabatic incubation test results for coal samples from Meandu Mine

The pre-oxidation of the Carey's 2 King sample (Figure 5) was sufficient to lower the intrinsic reactivity of the coal and created a very slow self-heating response with moisture present. A similar result was obtained for the Ramp 5 ST7 Q3 sample and as such both of these samples could be classed as having no likelihood of reaching thermal runaway. The Ramp 5 ST7 Q1 sample had a very long incubation period almost three times that of the K4E ST12 AK sample, which developed into a spontaneous combustion event after approximately 4 months of being exposed. This coal could also be considered as having no likelihood of reaching thermal runaway for practical purposes in the timeframe of normal operations at the mine. In contrast however, the K4S ST3 Queen and Ramp 5 ST4 Q1 samples rate as having a high likelihood of developing into a spontaneous combustion event. Consequently, a set of well-defined management practices were used to monitor and handle this coal.

SPONTANEOUS COMBUSTION MANAGEMENT AT MEANDU MINE

As a result of the spontaneous combustion event in Meandu K4E pit ST12 and experience gained from the incubation testing of Meandu coal the following practices have been implemented as part of the PMHMP for the mine:

- All new strips are systematically channel sampled and sent to the laboratory for Incubation testing as soon as possible. When the samples arrive at the laboratory they are given priority to obtain results that can be fed back to the operations to assist with mine planning and decision making for effective and safe spontaneous combustion management.
- Based on the initial laboratory test results for the K4E ST12 AK sample and the corresponding spontaneous combustion event, coal should not to be left exposed in-pit for greater than 70 days where possible, regardless of which pit or coal seam has been exposed. This provides a factor of safety of approximately 1.7. However, more recent interactive testing of coal from newly exposed strips has enabled this value to be modified to a shorter timeframe for coals that record a shorter incubation period.
- Limit coal blast areas to prevent the exposure of coal to the atmosphere for extended periods within pits that have been identified to contain low ash content coal due to its higher intrinsic reactivity.
- For coals that record a short incubation period a reduced residence time is used for the ROM stockpile. Compaction is implemented in several lifts and the batters lowered to reduce air ingress to the pile interior (Figure 6).
- Improved communications between Meandu Mine and the Tarong Power Station regarding coal deliveries to ensure risk of spontaneous combustion is managed effectively. For long term stockpiles a staged compaction process is used, which effectively turns the stockpile into the equivalent of a fractured coal pillar with low porosity and permeability. Under these circumstances the Incubation test results for these Meandu coals indicate a minimum incubation time on site of greater than 2 years. This has been verified from site experience with the Meandu coal.

In addition, a review and update of the previous Spontaneous Combustion Standard Operating Procedures has also been undertaken. The most recent "SOP" review (Document 4868-SE-SOP1027) in 2016 utilised the knowledge gained from the in-pit spontaneous combustion event and minimum incubation periods calculated from laboratory testing of all Meandu Mine coal seams. This document has been developed and implemented to ensure the safety of persons in, or near heated areas or areas with a potential for spontaneous combustion at Meandu Mine, in accordance with the Coal Mining Safety and Health Regulation 2001 Section 138.

Figure 6: Carey's low ash "Enviro" coal stockpile, track rolled in several lifts and batters reduced to limit ingress of air in line with SOP 4868-SE-SOP1027 ("Spon Com") guidelines

CONCLUSIONS

Coal self-heating performance for hazard assessment can be characterised using adiabatic oven Incubation testing to establish the minimum incubation period (time to thermal runaway if it occurs). This practice has been applied to coal samples from Meandu Mine and the results obtained have been compared against an actual in-pit spontaneous combustion event at the mine. The closeness of the match between the laboratory result and the site performance at Meandu provides confidence in adding Meandu to a benchmarking database for future mine planning. This new benchmark result can also be used to compare coals from other mining operations for input to hazard assessment and P MHM P.

The use of interactive laboratory testing as coal is exposed in-pit to obtain sound scientific data for hazard assessment planning and matching against mine site performance should be used as leading practice for industry. In view of the event at Meandu it is clear that if optimum conditions prevail spontaneous combustion can readily occur. These circumstances can be identified in advance of mining by testing the coal to evaluate the likelihood of a spontaneous combustion event under the prevailing site conditions. The data obtained can also be used as input to the auditing and improvement of current management practices.

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