# RE-Konnect

Risk Engineering Bulletin

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**In Focus:**

# Spontaneous Combustion of Coal


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# Editor's Note

The outbreak of fire without application of heat from external source is a great concern for industries. Across India 75% of coal fires have been caused by spontaneous combustion of coal. Prevention of spontaneous combustion is a key issue for both in economic and environmental terms. There are various technologies available in different parts of world to prevent and control spontaneous heating. In this issue of RE-Konnect, we discuss the mechanism of spontaneous combustion of coal and its causes and prevention.

# Did You Know?

- The chemical reaction between coal and oxygen at low temperature is extremely complex and remains not well understood despite many years of research.
- Sprinkler water/rain over the stockpile is more prone to fire as wetting is exothermic process and can accelerate spontaneous heating of coal.
- In India, the earliest recorded incident due to spontaneous combustion of coal was in 1865.
- In Planitz, now a part of the city of Zwickau, a coal seam that had been burning since 1476 could only be extinguished in 1860.
- There are presently more than 100 active coal fires in China, and it's estimated that as many as 200 million tons of coal is needlessly burned in the country every year.

# Disasters

## Jharia Coalfield fires burn for a century

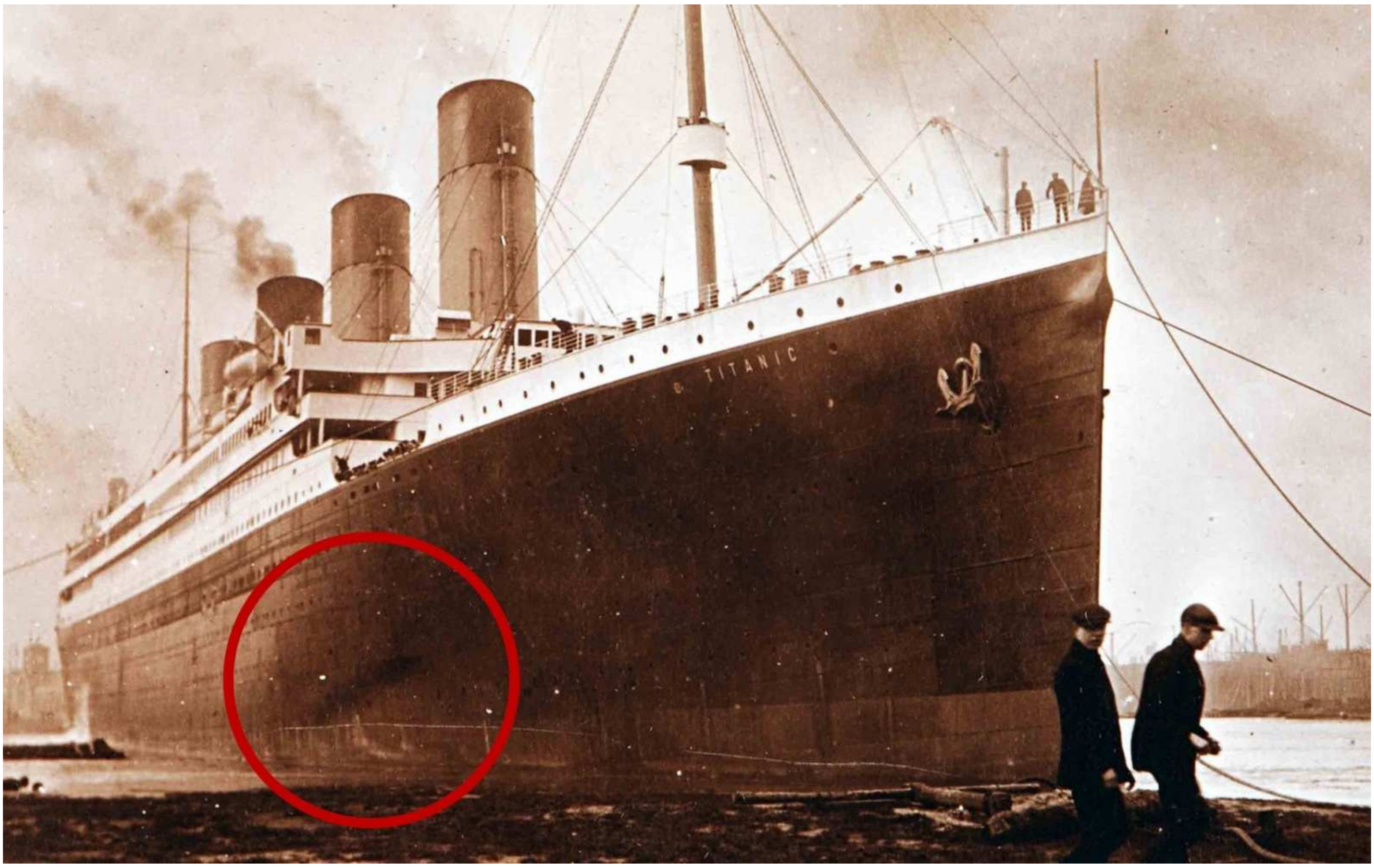
Indian coal mines have a long history of extensive fires and are as old as the history of mining itself. Mine fires gained wide spread attention in India in 1930 with the occurrence of major fires in the Jharia Coalfield. In 1937, the number of fires reported in Jharia and Raniganj Coalfield by the Coal Mining Committee was 28. In the year 1994, CMRI (Presently CIMFR), Dhanbad collected the data on fires reported to exist in different coalfields of India was about 196. In JCF alone, about 1864 million tonnes of coal is lying blocked in about 65 fires spread over an area of more than 17 sq. km. (The fire area includes not only the area actually under fire but also the area which has been sealed off due to heating and since then has not been reopened) affecting the prime coking coal reserve. This constitutes a staggering 12% of the total coal reserves. They endanger not only lives of men in mines but also induce considerable economic losses. An open fire in these fields induces environmental pollution by emission of vast quantities of steam, smoke and deadly gases posing serious health hazards.

## A Lesson Learned from the Titanic

Spontaneous combustion of coal had caused a stubborn fire in Titanic's starboard bunker in the aft corner of Boiler Room No. 6. About 12 men were assigned to fight this coal bunker fire. The coal on top of the bunker was wet, but the bottom of the pile was dry. The coal pile began to smolder. The fire was detected by its sulfurous odor during the ship's departure from Southampton on her maiden voyage. It is uncertain how long this fire had burned, but from testimony of surviving stokers at the inquiries, it appears that it burned for at least 72 hours. The 12-man crew made every effort to put it out. Those fighting the fire were alarmed at their inability to extinguish it. The engineering officers instructed these men not to converse with the passengers so as not to alarm them.

As a precautionary measure to prevent a coal pile fire in the forward starboard bunker of Boiler Room No. 5 through heat transfer, the coal there was also fed into the furnaces. It is believed that the fire was extinguished during the evening watch on Saturday, April 13, by a combination of wetting down the coal pile with a fire hose and ultimately feeding the burning coal into the furnaces.

During the period the fire burned, steel in the lower corner of the transverse watertight bulkhead between Boiler Room Nos. 5 and 6 ultimately became red hot. Some have theorized that this fire ultimately resulted in the weakening of ship's structure during the collisoin with iceberg and lead to it's deadly fate, at least in part.



# Flavour of the Month

Coal stored in a sealed storage dome at a thermoelectric coal-fired power station in Italy.

A monster bucket wheel excavator at a coal mine in Kazakhstan, weighing 45000 tons. It can scoop out coal at the rate of 4500 tons per hour and requires 27 miners to operate it at any one time.

# Mechanism and Causes

Standard requirements for fire are Heat, Oxygen and Fuel (Fire Triangle). All three elements are required to initiate and maintain fire. Therefore, removal of one of these elements can extinguish the fire. In spontaneous combustion, coal is a fuel. The interaction of oxygen on the surface of coal leads to oxidation reaction which results in heat and, eventually causes fire.

The oxidation of coal, alike all oxidation reactions, is exothermic. The exact mechanism of the reaction is still not well understood. However, scientists believe that the nature of the interaction between coal and oxygen at very low temperatures is fully physical (adsorption) and changes into a chemisorptions form subsequently. The coal-oxygen-water complex made during initial stage (peroxycomplexes) breaks down above 70-85 deg C, producing CO, CO2 and H2O molecules. The rates of chemical reaction and exothermicity change with the rise in temperature. Radical changes take place, beginning at about 100 deg C majorly due to loss of moisture. This leads to rise in temperature, producing more stable coal-oxygen complexes until critical temperature is reached. Critical temperature for bituminous coal is 160-170 deg C and for anthracite coal is about 185 deg C. Carbon Monoxide liberation increases rapidly until a temperature of about 230 deg C is reached. At this temperature spontaneous combustion may take place. At about 350 deg C coal ignites and combusts.

Following factors can affect the propensity of coal to combust spontaneously:

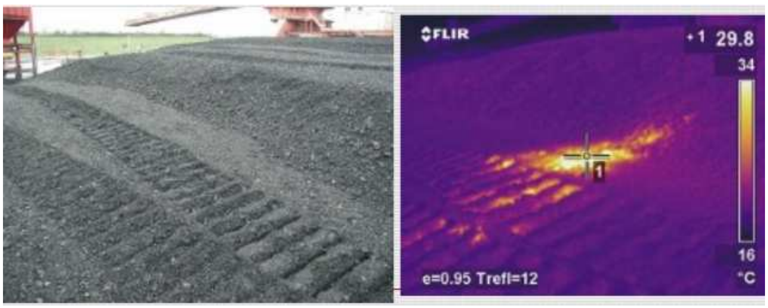
- **Intrinsic factors** affecting oxidation of coal are:
  - Low rank of coal, low ash, weak caking properties.
  - High friability, high reactivity and high heat capacity.
  - High coefficient of oxygen absorption.
  - Low thermal conductivity, high volatile matter and bacteria.
  - Pyrites, moisture content, particle size and surface area of coal.
- **Extrinsic factors** affecting oxidation of coal are:
  - Faults, folds, dykes, weak and disturbed strata conditions, seam thickness.
  - Steepness of seam, shallow cover, multi-seam in close proximity.
  - Porous petro-graphic structure, increasing time of exposure of broken coal.
  - Mine ambient temperature, barometric pressure, oxygen concentration and caving characteristics.
- **Coal handling procedures** – long time retention of coal, which increases the possibility of heating. New coal added on top of old coal creates segregation of particle size, which is a major cause of heating.

# Loss Prevention

Huge quantities of coal are typically stored in bunkers, silos, hoppers and open air stockpiles. Best prevention technique is to know your coal. Following considerations can dramatically reduce loss experience:

- Storing coal with low sulphur content (less than 1%) is helpful. Sulphur compounds in coal liberate considerable heat as they are oxidized.

- Air circulating within a coal pile should be restricted as it contributes to heating. Making low incline plane and compacting of stock by bulldozer and vibrating roller is helpful.
- Moisture in coal contributes to spontaneous heating because it assists the oxidation process. Moisture content should be limited to 3%.
- Following the 'First-In', 'First-out' rule of using stock reduces the chances of hot spots by helping preclude heat build-up for proportion of stocks remaining undisturbed for long term. Use coal as quickly as practicable.
- The shape and composition of open stockpiles can help prevent fires. Coal should be packed in horizontal layers (range from 1½' to 3' high) which are then levelled by scraping and compacted by rolling. Segregation of coal particles by size should be avoided, as it may allow more air to enter the pile and subsequently oxidize and heat finer sized coal.
- The height of coal pile is important. Limit un-layered, un-compacted high grade coal to a height of 15' (10' for low grade coal); maximum height is 26' for layered and packed coal.
- Inert covering material such as tarpaulin sheets with sufficient heat resistivity can be used to cover the openly kept stockpile to reduce the loss of calorific value and further oxidation of coal. It helps in cutting off oxygen to come in contact with coal.
- Monitoring is essential for controlling spontaneous combustion of coal. Where storage facility is large and difficult to access, a continuous and fully automatic thermographic monitoring device can be employed. Properly install and maintain fire fighting equipments and encourage regular visits to the coal storage facility.




- Even the most universal firefighting substance, water, cannot be used indiscriminately because of the remote possibility of a steam explosion. The use of water should be carried out sensibly as there is always a risk of production of water gas by the mixture of carbon monoxide and hydrogen. Water should not be used in thick jets. Sprinklers are suggested instead of water jets.

# Guidelines

Following codes and standards should be referred for coal stockpiling, handing and loss prevention:

- **The coal mines regulations, 1957**
- **NFPA 120:** Standard for fire prevention and control in coal mines.
- **FM Data Sheet 8-10:** Coal and charcoal storage
- **IS 3595-2002:** Code of Practice for fire safety of industrial buildings: coal pulverisers and associated equipments

# Engage

Answer the following questions and win Amazon coupons worth Rs 500 each. Send the answers to *editor.bulletin@tata-aig.com*

Five winners for this quiz will be announced in the next issue.

**Q1.** Which of the following stacking arrangement is most susceptible to fire as per the guidelines discussed?

A) 9 feet high: un-layered and un-compacted, low grade coal
B) 25 feet high: layered and Packed, high grade coal
C) 16 feet high: un-layered and un-compacted, high grade coal

**Q2.** What physical phenomenon is involved in the slow oxidation of coal?

A) Adsorption B) Absorption C) Desorption

**Q3.** Which method should be employed for prevention of spontaneous combustion of coal?

A) Segregation by Size B) Circulation of air C) Compaction

**Winners of the previous issue are as follows:**

- **Shikha Agarwal** – Placement, Marsh India Insurance Brokers, Ahmedabad
- **Alok Patel** – RI-Engg & Large Risk, GIC of India, Mumbai
- **Kalpana Balaji** – Reinsurance, UIB Insurance Brokers, Chennai
- **Gourisankar Sesetti** – Projects, Acciona Energy, Bangalore
- **V V Srinivasarao** – NFCL, Kakinada

**Answers to previous questions**: 1. DGA 2. Corona Discharge 3. Hydrogen and Methane

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*A rapidly spreading fire in a coal storage facility. Polymeric materials in the belt further worsen the situation*



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