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Controlling spontaneous combustion of coal by pyro-seizure method using brine freezing process and low temperature CO_2 injection

Shankar Dodamani
National Institute Of Technology Karnataka, Surathkal, India

ABSTRACT :*Energy is the primary need of the world and coal is the major source of energy. Thermal power is the mostpreferredenergy over decades and coalplays an important role. Coal losses are very high in India due to mine firescaused by spontaneous combustion in more than 200 coal mines in India. High efficiency coal extraction should be given more importance and further coallosses due to spontaneous combustion should be controlled. In this paper, it is discussed how spontaneous combustion canbebroughtunder control by Pyro-seizure method using freezing process by circulating cold brine solution in the drilled holes around the fire area by which heat can be transferred out of the fire area. Injection of low temperature CO_2 in the seam cuts off the Oxygen supply and its low temperature reduces the risk of CO imission.*

Keywords –*Brine solution, Freezing method, Spontaneous combustion.*

I. INTRODUCTION

Spontaneous combustion of coal is the process of self heating resulting eventually in its ignition without the application of external heat. Coal when exposed to air absorbs Oxygen at the uncovered surface. Some fraction of the exposed coal substance absorbs Oxygen at a faster rate than others and the oxidation results in the formation of gases. Mainly CO_2, CO and water vapour along with the evolution of heat during chemical reaction. If the rate of dissipation of heat is slow with respect to the evolution of heat by oxidation there is a gradual build up of heat and temperature reaches the ignition points of coal thereby causing fire.

The Freezing method is mainly used in construction of shafts in heavily water bearing strata. This method can also be used to control heat flow in coal seam and thus control spontaneous combustion of coal. By this method heat from the seam and do not allow temperatures to reach ignition points. In this paper mechanism and methodology is discussed.

II. MECHANISM OF SPONTANEOUS COMBUSTION OF COAL

Although many factors affect heat producing actions, the oxidation of carbonaceous matter in coal at ambient temperatures is the major cause for the initiation of spontaneous combustion.

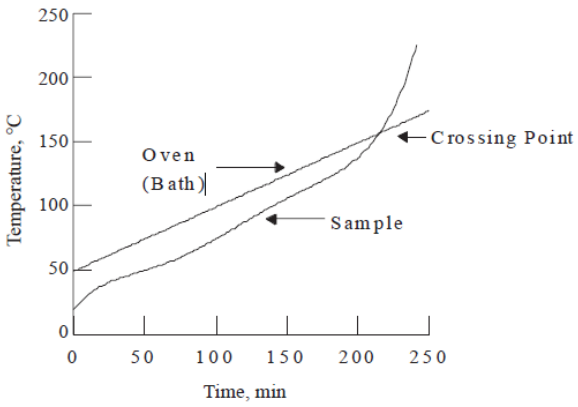

Fig.1: Time-temperature curve.

The oxidation of coal, like all oxidation reactions, is exothermic in nature. The exact mechanism of the reaction is still not well understood. However, the nature of interaction between coal and oxygen at very low temperatures is fully physical (adsorption) and changesinto a chemisorption form starting from an ambienttemperature. The rate of oxygenconsumption is extremely high during the first few days (particularly the first few hours) following theexposure of a fresh coal surface to the atmosphere. It then decreases very slowly without causing problemsunless generated heat is allowed to accumulatein the environment. Under certain conditions, theaccumulation of heat cannot be prevented, and with sufficient oxygen (air) supply, the process may reachhigher stages.The loose coal-oxygen-water complex formedduring the initial stage (peroxy complexes) decomposesabove 70-85^0 C, yielding CO, CO_2 and H_2Omolecules. The rate of chemical reactions andexothermicity change with the rise in temperature,and radical changes take place, starting at about100^{0}C, mainly due to loss of moisture. This processcontinues with the rise in temperature, yielding morestable coal-oxygen complexes until the critical temperatureis reached. From then on, it is fairly safe to assume that an actual fire incident will result.

III. METHODOLOGY

The necessary factors for combustion are combustible material, sufficient supply of oxygen and ignition temperature. In this method oxygen supply is cut off and temperature is lowered down. Thus not satisfying the factors for combustion of coal.

After detecting the site of spontaneous combustion, and confirmed its location, drilling plan around the location of spontaneous combustion is prepared. A series of equally spaced boreholes that are drilled around the site of spontaneous combustion.

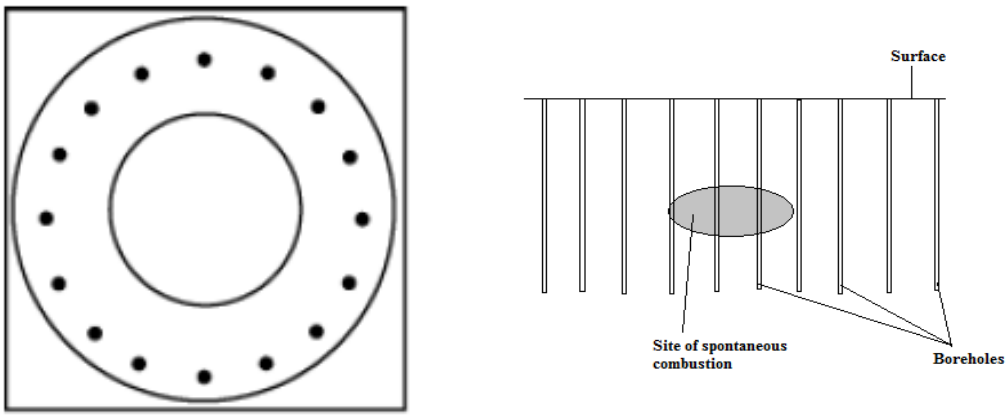

Fig.2: Top view of tube (left) cross section of strata (right).

By inserting heat sensors in the boreholes, a sketch of radial bands based on the temperature in the seam around the site of spontaneous combustion is made. The holes are first drilled in the outer band which is at a lower temperature as compared to the adjacent inner band.

The freezing pipes installed around the perimeter of the site of burning coal, and extend into sub-surface strata. The pipes contain an external pipe, an open-ended inner tube of slightly shorter length and a pipe in the centre which is used for injection CO_2 and water.

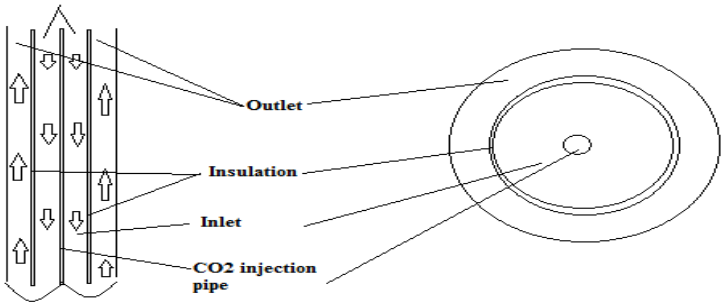

Fig.3: Freezing tube.

In the first stage of operation, the tubes are inserted into boreholes and the initial temperatures are noted. High pressure, low temperature CO_2 is injected into the seam of coal around the site of heating so as to cut off the supply of oxygen. The heat trapping property of CO_2 traps the heat around the burning coal and reaction between coal and oxygen stops.CO_2 at 70^0C breaks its bonds between carbon and oxygen and forms CO and nascent oxygen. This nascent oxygen is chemically very active and can easily react with coal and form CO in enormous amounts. Therefore CO_2 at very low temperature is used in injecting.

Continuous temperatures are noted down at regular intervals. There would be change in the temperatures of the seam with respect to time. Then water is injected into the seam in order to create heat transfer medium between the seam and freezing tubes. Then the circulation of brine solution is started. As the cooling agent, typically chilled brine is circulated through pipes, heat is extracted from the seam. The brine coming out with heat is returned to refrigeration plant where it is again cooled.

This procedure is continued till the adjacent inner band attains a temperature near to 80-85^0C. This radially inward movement of freezing perimeter finally reaches to the innermost band. By that time the temperature is considerably lowered and the oxygen supply is cut off and inerted by CO_2 there will be tendency of coal to extinguish by itself as the basic requirements of combustion, heat and oxygen, are taken out.

IV. CONCLUSION

This method of controlling spontaneous combustion is costly, but by that we can save millions of tons of coal that is being burnt into ashes every year. Especially in a country like India where energy needs are increasing day by day, saving this huge amount of coal may give sufficient energy through thermal power plants. Not only in the area of power but also in terms of extracting clean coal by clean technology without wasting the natural resources

There may be many other technologies which can control spontaneous combustion of coal, but this technology may serve the needs in India especially, where there is heavy coal losses in underground as well as surface coal mines due to spontaneous combustion.

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