STORAGE OF COAL: PROBLEMS AND PRECAUTIONS

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Contents

Summary

Coal can be stored in large quantities because of some necessities. Although stacking is generally done in open areas, there are also covered stack areas or completely closed coal silos.

Produced coal is generally loaded in trucks or wagons by excavators and loaders to be transported to the storage areas. In many countries various stacking techniques are applied by taking some factors into account such as climate conditions, dimensions and

design of storage and machinery used for this purpose. Widely used methods like Windrow, Chevron and Cone Shell type are explained with their main characteristics.

The problems faced in coal stacks and factors affecting the spontaneous combustion of coal like coalification degree, petrographic composition, moisture content, mineral content, particle size, pyrite content are discussed independently.

1. Introduction

Like gas and liquid fuel, coal is a material which can be stored in large quantities because of some necessities. Although stacking is generally done in open areas, there are also covered stack areas or completely closed coal silos.

Some reasons for coal storage are given below:

- Decrease of demand for coal in the market,
- To be ready for the bottlenecks caused by the halts which may occur in production,
- To meet the consumers' demand without interruption,
- To produce in mild climate conditions and market it in winter,
- To decrease the moisture content of coal,
- The defects which may occur in thermal power stations and washing plants,
- To feed the thermal power stations continuously with coal of specified properties.

However, some negative developments are observed in various characteristics of coal and important problems may emerge because of its long time storing in open areas. Consequently, stocking of coal has to be done consciously and by respecting basing rules.

2. Methods of Coal Stacking

Produced coal is generally loaded in trucks or wagons by excavators and loaders to be transported then to the storage areas. Belt conveyor is another transportation alternative. In recent years, the increased transportation capacities of trucks, their ability to function in topographic irregularities, and their easy adaptation to the changes in working areas are the reasons for preference of transportation by trucks.

In the enterprises where bucket wheel excavators are used, the transportation of coal to the storage area by means of conveyor belt bridges becomes possible. Same operations are relevant for the transportation of the coal carried by ships from the harbor to the storage area. The coal transported to the storage area is spread by movable or fixed belt systems and according to desired stacking geometry. Mobile belt systems generally move on railway or caterpillar (Yu, 1973).

In many countries various stacking techniques are applied by taking some factors into account such as the climate conditions, dimensions and design of storage area and the machinery used for this purpose. Three methods that are widely used will be explained here with their main characteristics.

2.1 Windrow Method

In this method, the stacker moving on rails spills the coal in parallel rows along the silo's length by changing the boom angle from the ground level. As shown in Figure 1-a, the stacker performs the operation by traveling forth and back along the stacking area and beginning to spill the first rows then the second, third rows and so on.

A very good blend can be obtained when the coal is taken by a reclaimer from the stack formed with this method. Disadvantage of this method is collection of rain water between the coal rows and penetration in the stack as a result of long lasting and continuous rainfall (Wöhlbier, 1975).

2.2 Chevron Method

In Chevron Method, the stacker moves along the storage area on an axis which divides the area in equal parcels and spills the coal in triangular prism-shaped stacks. As shown in Figure 1-b, the stacking operation is first performed along the first prism.

The machine spills the second layer on its way back and continues the same operation until the desired final stack height is reached.

When this method is used, the rain water flows down on the slopes of the stacked coal. In summer time, since the surface area exposed to the hot air is larger, drying effect becomes more significant.

In addition, the rock particles not picked out in the production process, roll down on the slopes during stacking and consequently separated from the coal (Wöhlbier, 1975).

2.3 Cone Shell Type Method

In Cone Shell Type Method, the stacker spills the coal in cone shape until the final stack height is reached. As shown in Figure 1-c, the stacker begins to spill the first cone, then moves one step forward to spill the second cone until the stack height and continues the operation step by step.

This method can be applied in areas where long and rigorous winter conditions prevail in order to ensure that stacked coal is affected by rain water at minimum level.

In case Windrow and/or Chevron methods among the ones briefly explained above are used for storage, a very good blend is obtained when the coal is taken from the stack by a reclaimer.

For an optimum blend, the reclaimer has to work perpendicularly to the long axis of the stack. To adjust the calorific value of the blend, high calorific valued coal can be added during the stacking operation (Wöhlbier, 1975).

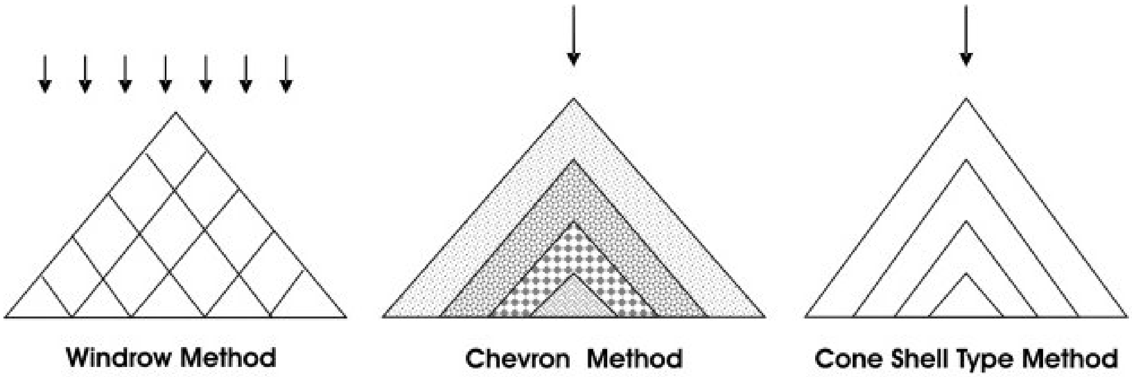

Figure 1: Different Methods of Stacking (Wöhlbier, 1975)

The coal stacks formed in open areas can be generally in cone, prism, cut cone/prism, etc. shaped. Geometric shapes frequently used in coal stacking are shown in Figure 2.

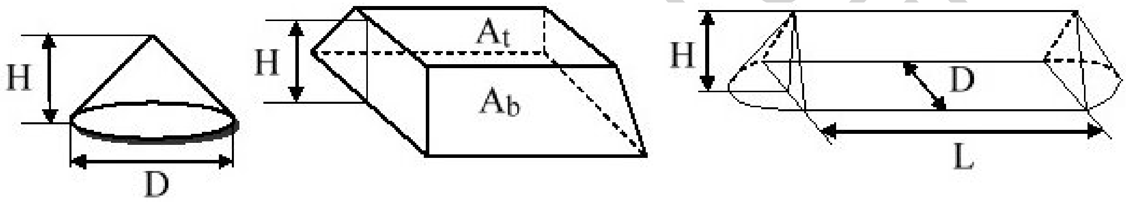

Figure 2: Examples about Stacking Geometry of Coal (Mine Storage, 1959)

3. Problems Faced in Coal Stacks

Besides various advantages, stacking presents also some disadvantages. Some of these are listed below:

- Stacked coal is a unprofitable investment and needs supplementary expenses,
- As a result of oxidation, coking property and calorific value of the coal are decreased,
- Oxidation of coal causes an increase in ignition temperature,
- If the coal is fragile, it will be fragmented so the percentage of small particle size material is increased,
- Oxidized coal decreases the performance of washing plants,
- As a result of storage of the coals containing high percentage of methane in closed silos which are not ventilated as required, explosive gas compositions can be formed.

However, the most important of these are the fires caused by self-oxidation of coal. The fires cause the loss of natural wealth and money. The gasses formed during the fire and the wastes as a result have harmful effects on environment (Duzy and Land, 1985, Ökten et al., 1998).

4. Low Temperature Oxidation of Coal and Spontaneous Combustion

The mechanism of reactions between oxygen and coal is quite complicated. These reactions occur in four steps as explained below:

1st Step : Formation of coal-oxygen complexes and heat generation.

2nd Step : Decomposition of these complexes, yielding of CO_2 and H_2O molecules and formation of more sensible groups [carboxyl (COOH), carbonyl (C=O) and phenolic (OH)] and heat generation.

3rd Step : Decomposition of these groups, too (at temperatures higher than 100°C), production of CO, CO_2, H_2, H_2O and high degree hydrocarbons (ethane, ethylene, propylene) and heat generation.

4th Step : Decomposition of aliphatic structure, production of CO, CO_2 and H_2O (Bhowmick et al., 1959, Swann and Evans, 1979).

In low temperatures, the first step is developed faster than others. Oxygen molecules get connected to the coal surface physically (adsorption) and reaches to the passing pores by diffusion. In this stage, since the oxide layer formed with the exposure of coal surface to the air prevents the diffusion of oxygen partially, oxidation rate is decreased in time (Münzner and Peters, 1965, 1966).

Researches proved that the physical adsorption of oxygen by coal starts at -80°C, it decreases rapidly with increasing temperature and becomes insignificant after 50°C. The chemical reaction of oxygen with coal becomes important after -5°C and physical adsorption is left behind when the temperature increases over 0°C (Sevenster, 1961).

As indicated above, the reactions between oxygen and coal are exothermic. According to the findings obtained at the end of various researches, a heat of 2 to 4 calories emerges for 1 ml oxygen adsorbed to the coal under normal conditions. The heat produced as a result of reactions is generally carried by airflow and there is not any significant change in ambient temperature. However, in some cases formed heat cannot be carried away from the environment and the temperature begins to increase. The reaction gets accelerated and spread over with the increasing temperature; produced heat takes the coal to ignition temperature (around 175°C) in suitable conditions and open flamed fire begins. The time passed from the beginning of oxidation to reaching out to ignition temperature is called Incubation Period (Jones and Towned, 1949; Chakravorty, 1960).

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Biographical Sketches

Ökten was born in Istanbul in 1951. He finished Kabataş Boys High School in 1969 and graduated as a Mining Engineer from the Mining Engineering Department of Istanbul Technical University in 1973. He obtained the Scholarship of DAAD and carried out research studies between 1978 and 1979 in Germany in Bergbau-Forschung GmbH (Essen) and Westfaelische Berggewerkschaftskasse (Bochum). He received his PhD. in 1983 with his thesis titled "Instantaneous Gas Bursting and the Determination of Liability Zones in the Zonguldak Coal Field". He was appointed as Associate Professor in 1990 and Professor in 1997. Dr. Ökten's areas of specialization are Underground Coal Mining, Safety in Mines Mine Ventilation and Ergonomics in Mining.

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