A STUDY ON HYDRAULIC STOWING

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Abstract – Mining is the process of extract the ore\minerals from the ore\mineral deposits. Mining operation can done in two ways either opencast or underground process. In underground mining the extracted areas are to be back filled with incombustible materials like sand or fly ash for ensuring the safe conditions of mined area. The process of back filling the mined out aera with different filling materials is known as stowing. Stowing is practiced in depillaring stage to fill the voids with incombustible material formed during extraction of pillars. Stowing process is essential for underground working areas to avoid the subsidence, roof collapsing. In mines the stowing method can be carried out with different methods. Generally hydraulic stowing practice is widely used. In this paper an extensive study was carried on various hydraulic stowing methods and result shown that the use of pond ash as stowing material is having more benefits when compared to other materials.

Index Terms **- Underground mining, Hydraulic stowing, Sand, Pond ash , Overburden.**

I. INTRODUCTION

When mineral is extracted from an underground mine the void or goaf is packed with sand or other packing material wherever it is conveniently and cheaply available in sufficient quantities. The process is known as "**goaf stowing**" or "**goaf packing**" and often simply as "stowing". The material employed for goaf packing may be stone or shale obtained from bands of stone or sand if they are present in the coal seam under extraction. They may be used for erecting pack walls or for stowing in the mined out goaf, in the crushed form. Other material which is sent down the mine for goaf stowing may be sand, earth, boiler ash, crushed material available from quarry overburden, shale pickings at the screening plant, washery refuse, mill tailings, or slag from blast furnace for iron ore smelting.

Types of stowing

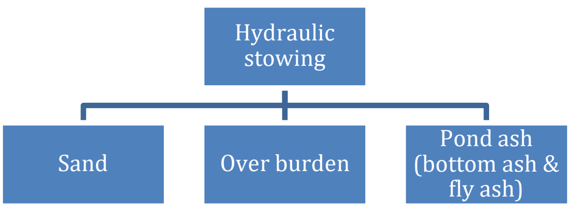
1) Dumping it with baskets with the help of human labour as in "**Hand packing".**
2) Transporting the material with water in pipes and allowing the water to percolate through bamboo matting or similar perforated barricade erected at site. This process is known as "**Hydraulic stowing".**
3) Throwing it with the help of a high-speed belt conveyor as in "**Mechanical stowing".**
4) Introducing the material in a stream of compressed air as in "**Pneumatic stowing**". Sand packing is adopted to stabilize and workings where pillars and galleries are high. It is adapted sometimes to from a barrier underground against fire area.

Surface manifestation of underground coal extraction occurs in two forms, pothole and trough subsidence. Pothole subsidence is a sudden depression of ground surface of small area due to sudden collapse of overburden into the underground void. Trough subsidence is a large area depression of the surface terrain, which is common at greater depth. Pothole subsidence is hazardous to life, as it does not impart any prior indication before its occurrence. Ground movements produce various forms of damage to different surface features and structures. Stowing in underground mine ensures the safety and productivity of the mine, as enumerated below;

High percentage of extraction is attained and therefore wastage of coal underground is reduced. Extraction of thick seams, a seam below fire area, water bearing strata and below railways, national highways, towns, etc, can only be extracted with stowing.

Ⅱ. METHDOLOGY

Mostly hydraulic stowing done with sand used in underground mines. Due to insufficient of sand material it can replaced by over burden or pond ash (fly ash & bottom ash) or any other incombustible material.



Flow chart 1: Hydraulic stowing with different filling material

2.1 Hydraulic stowing with sand; Hydraulic sand stowing is most popular method used in underground mines. The process of back filling in mined out area with sand material is known as sand stowing. The sand is transported to site by trucks aerial ropeways, and dredgers discharging sand into bunkers.

Specific gravity of sand – 2.65

Table 1: Concentration of sand and water as follows

Sand	Water(by vol)
1	1.5
1	2

The average ratio of sand: water may be 1:1.5 by volume.
One tonne of coal extracted needs theoretically nearly 1.3 tonne of sand in a virgin area. Where in old working the ratio may extend to 2.5 tonne of sand for every tonne of coal extracted.

- In Bord and pillar method nearly 1.5 tonne of sand per tonne of coal extracted.
- In longwall method advancing working nearly 1.4 tonne of sand per tonne of coal extracted.

2.2 Hydraulic stowing with overburden: In this method the mined out area will be stowed with overburden material. Due to the insufficient sand the stowed material is replaced by overburden material. In opencast mining, the soil is removed and heaped in the form of overburden dumps. Opencast mines face several problems of handling and disposal of overburden from mine as storage area is required more. Hence attempts are made to utilize the overburden in stowing rather than dumping it. For using overburden in stowing it should undergo processing plant. The processing is carried to meet the properties such as specific gravity, particle size distribution, porosity, permeability have been determined and compared to accordance to river sand.
Specific gravity

Table 2: Specific gravity of river sand and processed overburden

Sample	Specific gravity
River sand	2.65
Processed OB	2.67

Specific gravity of OB changes at various depths.
Particle size distribution;
The material used for stowing as to go through particle size distribution. Wet sieve analysis is used for estimating the fine percentage for each sample and dry sieve analysis is used for estimating of gradation properties.
Permeability is an most important characteristics in hydraulic stowing. The permeability of processed overburden is higher than composite materials.
Porosity of overburden sample is less than river sand.

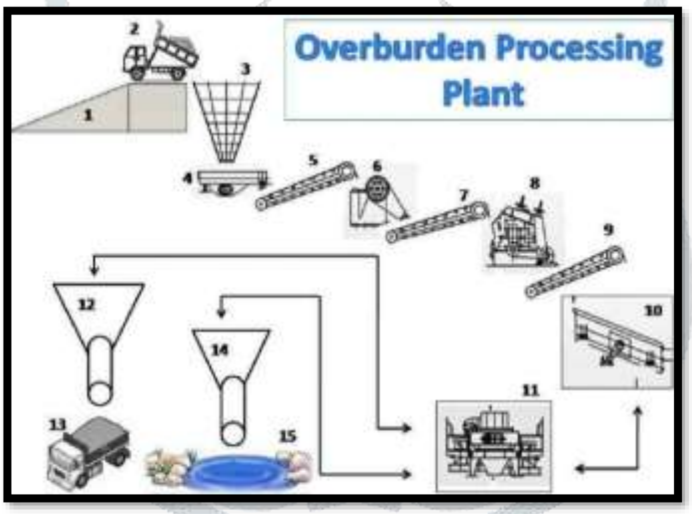


Figure 1: Overburden processing plant

1. Ramp
2. Lorry
3. Hopper
4. Vibro feeder
5. Belt conveyor-1
6. Primary jaw crusher
7. Belt conveyor-2
8. Secondary roller crusher
9. Belt conveyor-3
10. Scrubber
11. FBC
12. Sand cyclone
13. Sand loaded lorry
14. Clay cyclone
15. Clay pond

2.3 Hydraulic stowing with pond ash:

Typically two types of ashes, namely fly ash and bottom ash are produced in thermal power plant. The ash locked in the ash ponds which known as pond ash. They are also called as fly ash. Pond ash is sufficiently available at a lower cost and utilized in bulk in various geo technical applications. For effective stowing it is desirable that the stowing material should be chemically inert and devoid of carbonaceous matter. Presence of organic carbonaceous matter causes auto oxidation which is responsible for spontaneous heating. Therefore pond ash is essential to assess its suitable for stowing in underground mines.

Table 3: Specific gravities

Sample	Specific gravity
River sand	2.65
Fly ash	2.1 to 3.0
Bottom ash	2.1 to 2.7
Pond ash	2.03 to 2.27

Bottom ash specific gravity values changes as low as 1.9 to high as 2.3.
The ratio of water: ash mixture is 1: 1.
Stowing rate is about 105m^3 per hour.
Sieve size is about 150 to 600 microns.
Due to less sieve size less chances of pipe blockage.
The void percentage in bottom ash stowing is about 41%.
Bottom ash and fly ash is lighter than sand so its requires less energy for stowing.

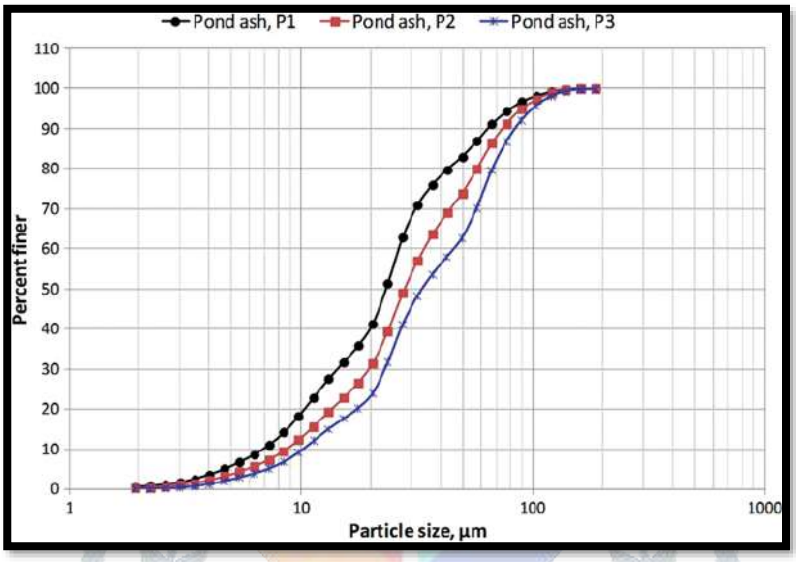


Figure 2: Particle size distribution curves of pond ash samples

2.4 METHOD OF WORKING:
2.4.1 SURFACE ARRANGEMENT:
a. Sand bunkers
b. Water bunkers
c. Mixing chamber

2.4.2 UNDER GROUND ARRANGEMENT:
a. Pipe layouts

Sand bunker capacity:
The minimum capacity of stowing bunkers not be less than a day requirement.
CMR has provided design of ground level with elevating conveyors. Sand will be transported into an elevated surge bunker.

Calculations:
1.25$m^3$of sand is required to fill 1$m^3$of void. (25% extra for filling development galleries). Considering 15% extra for wider galleries due to long exposure, cavities, etc.,1.4m^3 of sand required for 1m^3 of coal produced, (i.e.,1.4m^3 of sand is Required of 1.3 te of coal produced, where the sp.gr. Is 1:3.

Hence, for 1te of coal produced 1.4/1.3m^3 of sand required. Generally, the volume of sand to be stowed/tone of coal produced is taken as to 1.1 to 1.2m^3.

Ex: - production from two stowing district = 2 × 250 tonne
Quantity of sand to be stowed/day = 550 – 600m^3
Sand bunker capacity = 600m^3

Figure 3: Sand bunker

Water tank capacity :

As a rough guide, for a 150mm. diameter stowing range, the minimum rate of Water supply should not be less than 3.5 to 4.5m^3 /min. To maintain theoretical velocity. Flow of water can be measured using flow meter. We should have Water tanks of adequate capacity on the surface. The capacity of the existing Water tanks can be increased by either heightening and strengthening (wherever possible) the walls or an additional one be constructed so that. Their capacities are raised to at least a day's requirement.

Figure 4: Water bunker

There should be to pipe ranges coming out from the water tanks so that in case of one getting clogged, the other can be made operative and sudden distribution of water supply to mixing chamber is prevented.

For 200 to 300 meters depth, the average ratio of sand to water is around 1: 1.5 however, it varies with the individual installation. But for deeper mines it is nearly 1: 1.3

Taking and: water ratio as 1: 1.5.

The quantity of water for 600m^3 of sand is = 600 × 1.5 = 900m = 9,00,000 litres = 1.98 lakh gallons.

Capacity to be calculated after considering the above points.

Mixing Chamber

The place where the mixing cone is located is called mixing chamber. The size of the chamber should be sufficient to accommodate the desired number of mixing cones and pipe ranges. On the mixing cone there is a screen to prevent pebbles or stones larger than 25 mm size from going into the shaft range with the sand-water mixture. These rejects have to be picked up and collected in the chamber from where they are removed to surface. The chamber should have sufficient lighting and as the work goes on in humid conditions all fittings and cables should be moisture proof.

To measure the input of sand and water in the mixing cone with a view to have control on the stowing operations, the mixing chamber is equipped with: -

1) **Water meter**: - Kent 'velocity meter is commonly used on some installations; alternatively, a V notch or a venturi meter may be used: and

2) **Lea Recorder**: - The sand input may be calculated in terms of the area of chute opening which can be recorded by a Lea chute opening recorder.

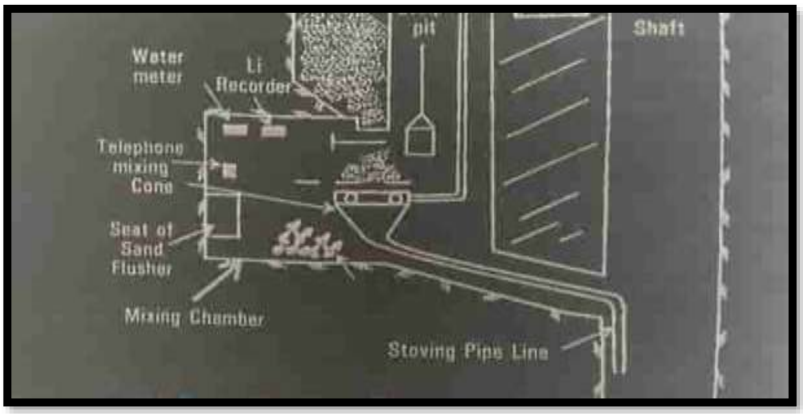


Figure 5: Mixing chamber

Mixing through design

Adequate mixing of sand water can be ensured by using properly designed mixing through. CMRI scientists have standardized the design of throughs for various hydraulic gradient / conditions to suit the limited space available in the mixing chambers. The design and specification of mixing through is given below,

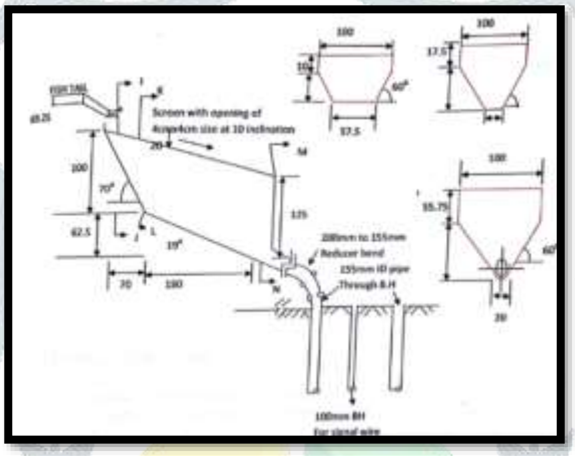


Figure 6: Mixing trough

Fish tail at mixing trough

A properly designed fish tail should be used for better mixing of sand and water . Fish tail should be located below the chute of the surge bunker which discharges sand in to the mixing through . It has to be arranged perpendicular to the discharge of sand so that the jet of water cuts the sand flow for proper mixing . The design and specifications of fish tail is given below,

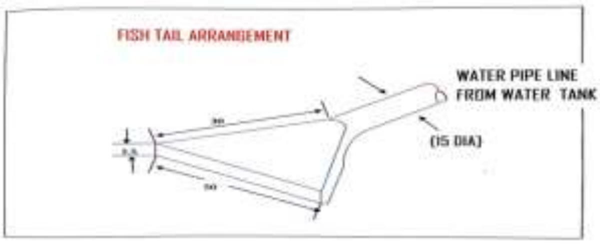


Figure 7: Fish tail

Stowing pipes and their layout

The sand water slurry pipe, from the mixing chamber downwards, may be installed in a borehole, in a steeply dipping stone drift or in a shaft.

The pipes used for sand stowing range are of C. I., mild steel, hot roiled seamless tubes or alkathene. They have flanges for joints (except in boreholes). C.I. pipes are heavy, have a low tensile strength of only 15 kg/mm^2 and are used for more or less permanent installations in drifts, shafts, main cross-cuts, etc. Their use is not favored at the face. Sizes in use are .125 to 150 mm bore, 3 m long, and with 20-25 mm thick walls. The life of C.I. pipe is observed to be 4 lac. te of sand for 20 mm thick walls and nearly 8 lac te for 25 mm thick walls.

M. S. Pipes are lighter than C. I. pipes and have a tensile strength of 45 kg/ mm- . M. S. pipes are preferred to C. I. pipes for face pipe range due to their comparative lightness. M. S. pipes are usually with 12 mm thick walls, and of 5.5 to 6m lengths. Their life is 6 lac te approximately.

Stowing pipe range consists of three main portions:

1) Shaft range, drift range, or borehole range.
2) Underground roadways range.
3) Face pipe range.

At the commencement of stowing the stowing range is extended so as to keep the end of stowing pipe nearly 7.5 m away from the dip side boxing. The velocity of sand: water mixture would depend upon the pressure head available. A nozzle is attached to the pipe end to increase the throw in special cases. Without nozzle the throw in one case was 3 m but with the help of a nozzle it was increased to nearly 7 m. The nozzle is of mild steel and tapers from 125 mm dia. to 85 mm dia. within 1.2 m length. To stop the stowing, the flow of sand into the mixing chamber at the surface should be stopped first and then, after 3-4 minutes, the flow of water should be stopped when the discharge through the nozzle is only of water. This avoids pipe jam.

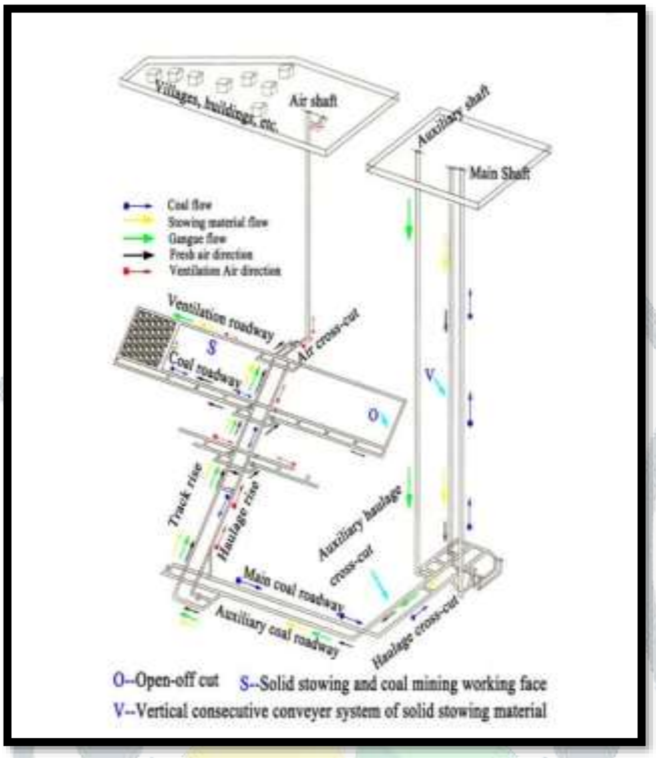


Figure 8: Under ground stowing pipe layout

Supporting system: Before a goaf is packed a boxing (a barricade of bamboo matting) should be constructed as near the face as possible, leaving space for conveyor path, coal cutting machine and roof supports. On a longwall face the width between previous boxing of sand pack and new boxing under construction is generally 4 to 5 m. With smaller widths of packs, cost of boxing becomes high and face work gets disrupted frequently. Materials used for boxings of narrow packs 1.5 m to 1.8 m in width should be stronger than those for packs of larger widths, say 3.5 m to 4.5 m, as the pressure developed on boxing in narrow packs due to sand is more. Bamboo matting or hessian cloth is generally used, and in some installations coir matting has been tried. The latter, though costly, can be used 3 to 4 times and has thus an economic advantage over the bamboo matting or hessian cloth which can be used only once. Wooden props or telescopic rails are erected along the new boxing line and the hessian cloth or bamboo mating is fixed to it by wire nails or strings from the floor to the roof. In some cases props are placed slightly inclined.

Figure 9: Supporting system

Ⅲ CONCLUSION:

Generally the mined out area was back filled with different incombustible filling materials. The process of back filling of the mined out area is known as stowing process. By the stowing process we can avoids the dangers from mining subsidence and roof collapsing in underground mines. Hydraulic stowing is the popular stowing method that can used in mines. In hydraulic stowing different materials (sand, pond ash, overburden) are sent to voids for back filling. The method of working is same for all these filling material. Mostly sand is used in hydraulic stowing process. As sand is used for infrastructures and other major engineering works there was a scarcity for sand.

In present study the following conclusions are drawn

- As there is a scarcity for sand, it can be replaced with other materials like overburden and pond ash
- Sand and pond ash are can be directly used for back filling but in case of overburden it needs some processing in order to use it as filling material
- The cost of sand is more when compared with other filling materials
- Overburden is less cost as it is readily available at nearby pit.
- The rate of stowing is high with pond ash when compared to other materials
- The concentration ratio with water changes with different materials because different materials will have different properties.

Further it is recommended to use pond ash as filling material in hydraulic stowing as it is having low cost, high rate of stowing and it can be used directly without any further processing and also as the pond ash is considered as waste in the thermal power plants the waste management can also be done.

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