COAL SCIENCE & TECHNOLOGY

Compendium

OF COMPLETED PROJECTS

Department of Coal
(Ministry of Energy)
Govt. of India

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INTRODUCTION

Historically, Indian coal mining industry is almost as old as the European, but its technology status in general remained near-primitive with concurrent equipment obsolescence upto the time of nationalisation. There was hardly any organised or concerted research effort. Perhaps the traditional needs of this labour-intensive, privately owned industry did not warrant any significant research and development work. The coal scenario was depressing, production stagnated and funding for research was scarce.

The commendable exceptions were found in several British-owned coal companies, and the captive mines of the private sector steel plants in adoption of special mining methods including the longwall system, roof control, mine fire control, hydraulic stowing etc., and in the state sector Singareni Collieries Co. Ltd. (functioning from 1945) and National Coal Development Corporation (set up in 1956) in coal exploration and mechanisation. Even these were isolated instances with individual operational problem-solving approach.

Nevertheless, as early as during the first decades of the century the major hazards of mine subsidence, coal fires and explosions attracted serious attention of mining engineers and geo-scientists, and a number of pioneering studies were made. Possibly the first scientific investigations were undertaken by the Mining, Geological and Metallurgical Institute of India. The comprehensively researched Subsidence Committee Reports (1913 and 1927) should be mentioned in this connection.

Other studies of note during the early decades were instituted in the Bengal Engineering College and Indian School of Mines on coal dust explosion, mine ventilation and coal washing. Some outstanding work was also done in research areas involving roof control, sand stowing, low temperature carbonisation, desulphurisation of Assam coal etc.

The Coal Mines Stowing Board created in 1939, undertook important studies on hydraulic stowing, and later assessment of drainage coursing in the coalfields. Several major collapses and subsequent devastating fires and explosions initiated stronger government control over mining methods.

After strong recommendations of the Coal Mining Committee (1937) and Indian Coalfields Committee (1946) for establishment of a government-sponsored national organisation, the Central Fuel Research Institute was set up near Dhanbad in 1947. This institute has been doing pioneering work in the field of coal beneficiation and utilisation, coal combustion, production of smokeless domestic fuel, and in compilation of coal resources data in India, among others.

The Advisory Board for Mining Research constituted with the Council of Scientific & Industrial Research and Coal Board recommended setting up of a mining research organisation, and the Central Mining Research Station was established at Dhanbad in 1955. This establishment gave a much needed direction and incentive to indigenous scientific research activity related to the mining industry. The CMRS has been involved in wide ranging investigative work, both in the field and laboratory, particularly in geo-mechanics, roof support, methods of mining, mine environment, mine safety and health hazards etc.

Research activities connected with industrial development in mining academies and research

institutions took shape in exact and precise terms during the early 1970s, coinciding with the nationalisation of coal industry, and a thorough change of ethos. R & D in coal mining had become a compelling necessity.

The Indian coal industry had been all along lacking the resources, organisation and initiative in applied research in the different areas of coal mining, from exploration, exploitation through beneficiation and utilisation. This lacuna was realised by the government of India and the 'Science and Technology Plan' was formulated in 1975 simultaneously with the then newly established Central Mine Planning & Design Institute Ltd. at Ranchi, as a subsidiary of the Coal India Ltd. The industry-research institution interface started growing rapidly to a significant scale from 1976. The Standing Committee on Science & Technology was set up in 1978, under the aegis of the Department of Coal to guide and coordinate the S & T programme for coal.

This committee was renamed Standing Scientific Research Committee (SSRC) in 1984 with the Secretary (Coal), Ministry of Energy as Chairman, other constituent members being from the CMPDI, the coal producing companies, CSIR, academic and research institutions, Dept. of Environment, Dept. of S & T, Planning Commission, and also eminent scientists.

The SSRC was assigned the task of programming, budgeting and overseeing the implementation of research projects in the hard coal and lignite sectors. The CMPDI was identified as the nodal agency by the SSRC to evaluate the project proposals and coordinate and monitor them regularly. Four sub-committees assist the SSRC, each concerned with one of the selected and critically important areas of applied research, viz,

- Production, Productivity and Safety
- Coal Beneficiation
- Coal Utilisation
- Environment and Ecology.

The CMPDI has been regularly publishing annual reports on S & T projects as an assessment of the Research, Development and Demonstration activities in the continuing programme undertaken under the S & T funding, on behalf of the SSRC. These abstracts of the status of the projects, meant as an information guide had been appreciated both by application engineers and research scientists. It should be mentioned in this connection that a well equipped and suitably manned laboratory has already been established at the CMPDI itself, some of the sophisticated equipment having been received under the United Nations Development Programme.

The present compendium gives abstracts of the completed research and development projects in more detail.

The compilers have painstakingly prepared the summaries with appropriate condensation of the reports with proper indexing. Relevant illustrations and photographs have also been included.

It is sincerely hoped that this volume will be found useful by the readers, and the compilers would welcome their comments on the publication.

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CONTENTS

NAMES OF PROJECTS COMPLETED

ABBREVIATIONS USED

1. Academic/Research Institutions :

ADDA	Asansol Durgapur Development Authority
BHU	Benaras Hindu University
BIT	Birla Institute of Technology, Mesra; Ranchi
CFRI	Central Fuel Research Institute, Digwadih; Dhanbad
CMERI	Central Mechanical Engineering Research Institute
CMRS	Central Mining Research Station, Dhanbad
CMPDIL	Central Mine Planning and Design Institute Ltd, Ranchi
CPEI	Coal Preparation Engineering Institute
IIT (K)	Indian Institute of Technology, Kharagpur
ISM	Indian School of Mines, Dhanbad
KSM	Kothagudem School of Mines, Andhra Pradesh
NGRI	National Geophysical Research Institute, Hyderabad
NML	National Metallurgical Laboratory, Jamshedpur
NPC	National Producitivity Council

2. Industrial Establishments :

BCCL	Bharat Coking Coal Ltd.
BHEL	Bharat Heavy Electricals Ltd.
CCL	Central Coalfields Ltd.
CIL	Coal India Ltd.
IEL	Indian Explosives Ltd.
MPEB	Madhya Pradesh Electricity Board
NCL	Northern Coalfields Ltd.
NEC	North Eastern Coalfield
SAIL	Steel Authority of India Ltd.
SCCL	Singareni Colliery Company Ltd.
SECL	South Eastern Coalfields Ltd.
TISCO	Tata Iron and Steel Company
WCL	Western Coalfield Ltd.

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PROJECT : Scientific Investigation at a Longwall Shearer Face

PERIOD OF INVESTIGATION : December 1976 to September 1981

EXPENDITURE INCURRED : Rs. 3.54 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

CMPDIL undertook a scientific investigation at a longwall shearer face in Borachak seam (2.9 m), Dhemomain Colliery (ECL) as an S & T project. The investigation included strata control and airborne dust studies underground, and size analysis of shear-cut coal.

The objective was to ascertain the adequacy of support system adopted, predict adverse strata movements and ensure corrective measures, whenever necessary. Dust level monitoring was also carried out to evaluate the effectiveness of dust suppression measures. The size analyses were carried out to determine the actual steam-slack distribution of the coal cut and loaded by a shearer.

Salient Features of the Experimental Set-up

Equipment : Cutting/loading machine : Anderton Mavor shearer, 150 BHP, drum diameter, 1.57 m.

Support System : Open circuit hydraulic prop of 40 t capacity.

Field Trial : Longwall caving system of mining was practised in the W2 panel of Borachak seam in Dhemomain colliery on trial. Since past records regarding the strata behaviour at longwall faces were not available for this mine, investigations were undertaken to study the behaviour of the superincumbent strata. Load cells, convergence indicators and strain gauges were used to measure strata movement on the longwall face and the gate roads. Suspension type convergence indicators were used for measuring convergence in the gate roads, and rigid rod type convergence indicators at the longwall face. Load cells used to obtain a fair estimate of load carrying characteristics of the face props. Strain bars were set in the gate roads and fixed in the solid coal at intervals of 5 m adjacent to convergence indicators.

The airborne dust concentrations were determined during the shearer cutting operation using an MSA Midget Impinger at the following places :

along the face

at the inbye end of the face

at the outbye end of the face

in the return air way.

Cooling effect, which is a joint effect of temperature, air velocity and relative humidity at

the working place was measured by Kata thermometer. Relative humidity was also determined by using whirling hygrometer. Air velocity was determined and circulating air quantity was calculated for the face.

Conclusion

The longwall face under study was successfully worked with 40 t open circuit hydraulic props and link bars. Some operational difficulties were experienced during periodic weightings to the prop height, being more than a normal extraction thickness of 2.1 m.

The maximum face convergence observed was 16.5% of the extraction height. To obviate the problem of prop-locking (props getting locked due to covergence), the size of the props selected for use on such face should have a provision to accommodate roof convergence to the extent of 18-20% of the extraction height.

The maximum load on props was found to be 44 t which was 10% higher than their rated capacity. This indicated that the support system was inadequate. In such cases, the interval between props may be reduced to increase the support density.

It was found that the base plates of 25 cm diameter attached to the props, eliminated floor penetration. Thus, in areas where the bearing load on the floor is upto 106 kg/cm^2, such base plates are recommended to be used to prevent floor penetration.

Since strata movement could be found only upto 10 m ahead of the face, careful supporting of the gate roads may be restricted to 15 m against the present practice of supporting them for 26 m.

The maximum level of airborne dust concentration was 4560 ppcc at the coal face during cutting/loading operation, and the average dust concentration was 3376 ppcc. This test was conducted by CMRS.

Results of size analysis of shearer-cut coal shows on an average 55.34% slack (–25 mm) and 44.66% steam coal (+25 mm). Comparing the figures with earlier investigations, coal won by coal cutting machine (under cut) and blasted, as well as coal blasted off-the-solid in bord and pillar system of mining, it was found that mechanised winning by shearer reduces the production of steam coal by about 19 to 20%.

Scope of Application

The strata control investigations had given valuable information about roof behaviour, and helped in designing of longwall faces and selection of equipment.

The data on size analysis and dustiness were useful for appropriate corrective action on the problems faced in mechanised longwall mining.

PROJECT : Methane Drainage at Amlabad Colliery

PERIOD OF INVESTIGATION : December 1976 to December 1978

EXPENDITURE INCURRED : Rs. 16.56 lakhs

IMPLEMENTING AGENCY : BCCL

Introduction

Sofremines with assistance of CERCHAR (Centre d' Etudes et de Recherche des Charbonnages de France) Laboratory (France), based on studies with the help of computer drawn isotherm curves, has evolved methane drainage requirement of Amlabad mine under S & T scheme.

Amlabad (BCCL) is a highly gassy mine with contiguous seams and having CH_4 content upto 94%, which makes the mine workings extremely difficult. The desired rate of production of 2000 t/day could not be achieved with such constraints. To maintain the statutory limit of CH_4 content in the main air return to only 0.75% the requirement of fresh air entering into the galleries would be very high (upto 193 m^3/sec in the return shaft for the XII seam). In this situation methane drainage was considered essential. Methane drainage was also considered necessary for the workings of XIII, XIV and XV seams.

Salient Features of the Experiment

The characteristics of concentration in-situ and rate of emission of methane as a function of time have been established by Sofremines with the assistance of CERCHAR utilising :

- the available results of measurements (gas flow and pressure) previously carried out by CMRS.
- the results of an extensive campaign of drilling/sampling/analyzing (gas flow, methane concentration in coal and in ventilation currents) conducted under the direction of the consultants.
- the results of French experience obtained from the seam of Honi Ueresdu 13 bassin de Lorraine.

The permeability characteristics of the French seam after destressing were found to be similar to those of Amlabad seam in virgin area.

However, before implementation of the methane drainage system and before placing orders for equipment, it was desired to carry out direct measurements in a gallery driven in a virgin area of XIV seam. The outcome of the degasification study shows that :

- the content of methane in gas is 94%.
- desorbable concentration of gas in the virgin area is 6.3 m^3/t of ROM coal in XV, XIV and XIII seam.

- residual desorbable concentration in the developed areas of XIV seam is 1 to 1.5 m^3/t after 6 to 8 months in 20 m wide pillars and 2.5 m^3/t after 6 to 8 months in 100 m wide pillars.

Measurement of gas flows through boreholes drilled from XIV seam towards XV and XIII seams has shown that Amlabad seam can be pre-drained by boreholes, even before de-stressing. The isotherm curve of Amlabad seam is the same as that of F seam, Marienan. Amlabad coal was also analyzed at CERCHAR for gas concentration. Characteristics of methane emission as a function of time were determined using computer programs at CERCHAR. The measurement of porosity of the sandstone beds capable of storing fire-damp was also carried out.

Based on the study, schemes for extraction of XIV seam in virgin areas, extraction of XV seam, development and extraction of XIII seam were drawn up. Ventilation requirement for the three seams, mining programme, access gallery details, mining method in cavable area and in the area to be stowed, gallery supports, etc, have been drawn.

Scheme for methane drainage has also been formulated. In the scheme it is proposed to drill boreholes at 60 m intervals along the galleries in XII seam : 2 boreholes, inclined at 50°/60° at each junction of one out of the two galleries and one crosscut. Boreholes will be drilled upward to XIV seam in the virgin area of the latter and upward to XIII seam underneath the developed areas of XIV seam. Gas will be collected in a pipe network along the galleries in XII seam. Length of collecting pipes will be around 2800 metres at year 5, additional 1300 metres at year 9 and then more or less stabilised. All these gallery pipes will merge into a main installed in the return air shaft and connected at the surface to the extraction plant providing the required depression. Broad characteristics of the plant are :

- diameter of pipes : 200/250 mm in galleries and 300/350 mm in return air shaft.
- average approximate output of gas : 2500/3500 m^3/hour
- depression at the extraction plant : around 2.0 m W.G.

Conclusion

1. Each drivage in XII seam should be ventilated by at least 16 m^3/sec of fresh air in order to limit the peaks of CH_4 content within the statutory limit.
2. XIV and XIII seams need to be pre-drained for making development feasible. Pre-drainage could theoretically come from anywhere, preferably from below the seams, and not from the seam itself, as indicated by worldwide research.
3. Drivage in the overlying seam (XIII or XIV seam) should only take place after a minimum of one year of pre-drainage from XII seam.
4. The surface plant will consist of :

- a water drain with hydraulic packing,
- a flame arrester and a volumetric gas flowmeter,
- a methane content indicator and recorder having switching off arrangement when the CH_4 content comes under 30%,

- 3 exhausters 1000 to 1500 m^3/h, 3 m WG, each coupled to FLP electric motors,
- a bypass with valve to ensure the minimum output compatible with the operation of an exhauster of the natural draught and an over-pressure delivery valve.

5. The exhausted methane will be released either to atmosphere or to a gasometer in the case of use for industrial purposes (eg. nitrogen generation, ovens/boiler heating, etc.)
6. A surface exhaust plant will be installed in a building located 200/300 m from the shafts.

Scope of Application

Based on the investigations carried out and mining methodology developed equipment have been procured for trial of the degasification system. The degasification plant has also been commissioned at Amlabad. The study will help in planning for methane drainage from underground mines having high methane percentage.

PROJECT : Swang Degasification

PERIOD OF INVESTIGATION : December 1976 to March 1983

EXPENDITURE INCURRED : Rs. 8.52 lakhs

IMPLEMENTING AGENCY : CMPDIL/CCL

Introduction

On 10th August, 1967, while crossing a set of dykes during drivage of 9 and 10 dips beyond 21 level in Kargali top seam, high gas emission (8 m^3/minute) was encountered, and all machinery had to be withdrawn and the dips were filled with water as it was not possible to cope with the high emission of gas with available ventilation. Even attempts to drive other dips were not successful due to the occurrence of frequent blowers.

Maximum desorbable gas concentration of the Kargali top seam was estimated by CMRS by direct method to be 0.93 m^3/tonne of coal. Normally such low gas content does not require degasification. On the other hand high emission of gas upto 10 m^3/min had been met while crossing dykes or drilling boreholes. It was obvious that the gas was contained in free state pockets and emitted whenever such pockets of gas were penetrated.

Salient Features of the Experiment

Field Trial : To meet the situation CMPDIL purchased the design of an equipment from CMRS which was used in a pilot scheme of degasification at Amlabad colliery. The equipment was fabricated by Indeconci of Dhanbad under supervision of CMRS, and modified by inserting high capacity water traps in view of high flow of water encountered from the borehole.

The equipment consisted of (a) a grout mixer for sending cement: stone dust slurry in thick viscous form under pressure to fill up the annular space between sand pipe and borehole wall, (b) drilling equipment for boreholes, (c) stuffing box which permits 52 mm drilling rod to drill holes in a manner such that the coal cuttings, gas and water are transported to a separator tank, (d) seperator tank to minimise hazard due to sudden gas influx during drilling in regions where gas emission rates are high, (e) drainage pipes, (f) valves, (g) orifice plates and (h) ventury ejectors to draw gas from the borehole, etc.

Conclusion

With the use of methane drainage system, the methane which used to exceed 0.8% in the general body of air and formed explosive mixtures in pockets, came down to 0.1% and gas pockets disappeared. This permitted uninterrupted drivage of dip galleries even with blasting, which was so long prohibited.

Scope of Application

The degasification system with venturi blower was successfully commissioned. This led to drivage of headings abandoned since 1976. The expertise developed can be utilised in similar situations elsewhere.

PROJECT : Degasification of Coal at Ghusick, ECL

PERIOD OF INVESTIGATION : December 1976 to March 1985

EXPENDITURE INCURRED : Rs. 77 05 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

High gas emissions (upto 28 m^3/min for a production of 250 tonnes per day) had been recorded from Ghusick seam of Muslia colliery (ECL). The adjoining mine called Old Muslia was abondoned in 1958 after a methane ignition and subsequent fire. Development work even in the present Muslia colliery was stopped in January 1973 and were not resumed until 1983 (except for a brief period in 1977) because adequate ventilation could not be provided to the faces to dilute the excessive emission of gas. Complete data on gassiness of Ghusick seam was also not available at the time on request of the Chief Technical Adviser, ECL, CMPDI prepared a draft report which was placed before ECL, CMRS, ISM and DGMS. It was agreed to undertake on determination of the gassiness of the seams at Ghusick and to establish a modern gas drainage system.

Salient Features of the Experiment

Field Trial : Gas content of coal seams was determined from the coal cores obtained from exploratory boreholes in 1976-77. The gassiness was determined by the 'Direct method developed by the USBM. It was for the first time that the method was used for determination of gassiness of coal seams in the country. It was also for the first time that a scientific attempt was made to find out gassiness of coal seams at the time of prospecting itself.

Gas content of Ghusick seam was further determined by experts from FRG in Jan-Feb 1979. Based on these studies, a detailed engineering report for gas drainage system was prepared by them. A gas drainage system was designed, installed and commissioned in July 1983.

Conclusion

Gas content of Ghusick seam was determined successfully by the direct method. An advanced and sophisticated gas drainage system was installed for the first time in the country and persons were trained in its operation. As sufficient gas has not be encountered so far, very little gas could be drained; the system remains on standby to deal with any high methane emission in future.

Scope of Application

The expertise gained in determining gas content of virgin seams by 'Direct method' is a useful tool which may be employed for ventilation planning. The know-how acquired on drainage of methane can be used in seams which have high gas content. A plant for methane drainage is already under erection at Amlabad colliery of BCCL.

PROJECT : Strata Control Studies at Longwall Faces

PERIOD OF INVESTIGATION : December 1976 to March 1985

EXPENDITURE INCURRED : Rs. 18.93 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

Mechanised longwall system of mining has brought out substantial improvement in productivity and safety in the advanced countries of the world. Success of the longwall mining system, to a large extent, depends upon the efficiency of roof control at the face. Indian coal measure strata, which are well known for their generally hard and massive nature, pose a great problem for the success of the longwall technology in Indian conditions. The project was, therefore, undertaken to investigate the behaviour of roof over longwall faces and ascertain the adequacy of support systems under various geo-mining conditions.

Salient Features of the Experiments Set-up

Field Trial : A total of five longwall faces of varying mining conditions of different collieries, namely, Bijuri colliery (WCL), Saunda 'D' colliery (CCL), Dhemomain colliery (ECL), Banki colliery (WCL) and Dhemomain colliery powered support panel (ECL) were studied. These panels represented both manual and mechanised forms of extraction with both individual support and powered support face conditions. The panels also reflected the widely varying geological conditions associated with Indian mines and provided information on strata behaviour under depths varying from very shallow to medium.

Conclusion

It was noted that in case of the faces at shallow depths the problem of strata control was very prominent resulting in either frequent failures and collapse of the face, or the strata acting as a massive composite beam without any yield and accumulating large stresses and thereby creating a potential danger of sudden roof collapse. It may be therefore desirable that the longwall mining is adopted for faces deeper than 100 m.

Strata movement in the gate roads was found confined to a distance of 10 m from the face.

It was noted that the British concept of having the setting load at 25% of the yield load of the support did not generally provide an efficient roof control system. For the Indian strata high setting loads to the extent of 75-80% of the yield load was recommended.

In cases where the bearing capacity of the floor rocks was less than 100 kg/cm^2, floor penetration by 40-tonne hydraulic props was noticed when the load on these support units exceeds 25 tonnes.

It was noted that in case of individual prop support faces average support density of 40 t/m^2 was adequate for satisfactory roof control.

It was found that the maximum roof covergence over the individual support longwall faces was 11 to 12%, while in the case of powered support faces it was less than 5%.

Scope of Application

The investigations led to development of design criteria for longwall faces and related support system. The expertise developed is being used for design of longwall faces and selection of suitable face support equipment.

PROJECT : Study of Corrosion and Its Control in Coal Mines of North Eastern Coalfield (NEC), Assam

PERIOD OF INVESTIGATION : April 1982 to January 1988

EXPENDITURE INCURRED : Rs. 13.67 lakhs

IMPLEMENTING AGENCY : Indian School of Mines

Introduction

In coal production operations of NEC, Margherita, materials worth lakhs of rupees are destroyed due to corrosion every year. Cast iron pumps, mild steel pipe works used at Ledo and Jaipur collieries of NEC for pumping acid mine water out of the mines suffer very rapid corrosion and their working life is sometimes reduced to a few hours only. Acid mine water arises from the chemical leaching of sulphate salt, atmospheric and bacterial oxidation of pyrites and organic sulphur present in the coal seams and the strata above and below the coal seams. Thiobacillus thiooxidans and thiobacillus ferrooxdanes present in acid mine water were found to accelerate the pyrite oxidation.

In view of the importance of investigations on corrosion control of mining equipment the objective set was to analyse the various causes of corrosive mine atmosphere and mine waters at NEC and to find out suitable control measures to abate the corrosion of mining equipment.

Salient Features of the Experiment

Based on earlier research on chemistry of corrosion, and also on data from CMRS on physico-mechanical characteristics of mine waters of NEC, ISM scientists classified mine waters in five categories. To carry out analytical studies of mine water, 180 mine water samples from 36 locations in different mines of NEC were collected and analysed. pH and specific conductivity values were determined using EC digital pH-meter and Systronics digital conductivity meter respectively. Chlorides and sulphates were estimated by titration. Total hardness and calcium hardness were estimated by EDTA method using eriochrome block T and murexide indicator respectively. Tests for calcium and magnesium contents were also done. Ferric and ferrous ions were volumetrically estimated using a DPA indicator. Copper and zinc were estimated by perkinelmer-atomic absorption spectrophotometer. Total dissolved solids were also estimated. It was observed that apart from general corrosion, erosion-corrosion is much severe in the case of CI pumps and pipes at Ledo colliery of NEC. Pump impellers, stage rings and diffusers were found to be the worst hit parts. The cause of corrosion was found to be the high acidity in mine waters coupled with high amounts of ferric, sulphate and other agressive ions present in the water. High humidity and temperature of the mines also favoured rapid deterioration of the equipment.

The first trial to control corrosion was done by using potasium oxalate as an inhibitor. A corrosion inhibitor is a substance which, when added to a corrosive environment in small concentrations, reduces by a reaction at the metal-to-solution interface the agressive nature of the environment. The CI pump trials with mine water containing potasium oxalate inhibitor at 1×10^{-4}M and 5×10^{-4}M concentration levels showed 21.8% and 45.2% protection respectively. Increase in the concentration of the inhibitor from 1×10^{-4}M to 5×10^{-4}M raised the life of the pump by 23.5%. In view of the relatively weak coating provided by the oxalate inhibitor at 5×10^{-4}M concentration level in the dynamic system and low economic feasibility of the overall

process of the synthesis of oxalic acid from saw dust, it was thought to try a better and more economic method, i. e. anti-corrosive electroplating.

The parts made of CI and MS could be made rust-resistant by alloying the steel with nickel and chromium, but due to its high cost more economically feasible approaches were applied.

Multi-layer metal electroplatings applied over the worst hit parts of CI centrifugal pumps proved satisfactory in pumping out acid mine waters at New Mine/Quarry of Ledo colliery. Different types of nickel platings, viz., bright nickel (25 m), semi-bright nickel (50 m) and hard nickel (75 m) applied over the CI pump fittings afforded considerable protection to the pumps.

Investigations on the electroplated (Cu-BNi-Cr) a CI pump of model 99D6, carried out at main dip of the New Mine of Ledo colliery, indicated almost a four-fold (90 hours) increment in the service life of the pump. The service life of the pump in natural mine water without any treatment was found to be about 22 hours. With another combination of multi-layer electroplatings (Cu-Hni-Cr) over CI pump tested at the same main dip, having all identical conditions, the service life of the pump was found to be 103 hours (five-fold), i. e., percentage improvement in the life expectancy of the pump with the electroplating treatment was 368%.

In the investigation on 99D4 pump with multi-layer electroplating (Cu-SBNi-BNi-Cr) treatment, the service life of the pump was found to be about 134 hours. Thus, a six-fold increment in the service life of the pump was achieved. Improvement in the life expectancy of the protected pump in this case was almost 500%. The service life of a CI pump tested in natural quarry water of Ledo colliery without any protective treatment was found to be about 23 hours.

For comparison, a stainless steel pump was tested in natural mine water without any protective treatment at the main dip of New Mine of Ledo colliery under almost identical conditions as those of other CI pump trials. The pump could work for about 511 hours with minor repairs after which the shaft of the pump was found to be mechanically damaged. This stainless steel pump showed good resistance to the acid mine water but the capital cost is considerably high when compared to that of either a CI pump or electroplated CI pump.

The protection afforded by the electroplating treatment may be mainly due to hard-nickel and duplex-nickel platings. The under coating copper may serve to firmly adhere both to the substrate and the layer of the nickel plating. Chromium plating could protect the under-coating of nickel which would otherwise tend to tarnish in mine atmosphere.

In the case of the bright nickel plating system, any corrosion at a defect in the chromium layer, rapidly attack the underlying bright-nickel owing to the high corrosion current density (small anode/large cathode), causing undercutting and attack on the substrate when the nickel layer is penetrated. In the duplex nickel system, since bright nickel corrodes more rapidly than semi-bright nickel, the penetration is delayed with consequent enhanced protection of the substrate.

Conclusion

Corrosion control by multi-layer metal electroplating was found to be economically feasible. The percentage improvement in the life expectancy of the pumps with electroplating treatment was about 370%.

Scope of Application

Multi-layer metal electroplating treatment was found applicable in controlling acid mine water corrosion on pumps and may also be applied on other mining equipment, such, as dewatering pipes, conveyor idlers, coal tubs, etc.

PROJECT : A State-of-the-Art Report on Pipeline Transport of Coal and Sand

PERIOD OF INVESTIGATION : December 1976 to December 1978

EXPENDITURE INCURRED : Rs. 1.50 lakhs

IMPLEMENTING AGENCY : CMPDIL/BCCL

Introduction

As desired by the Ministry of Energy the CMPDIL brought out a report on the subject under the S & T scheme.

The first commercial installation of pipeline transport system was made in 1957 by Consolidation Coal Co. in the USA for transporting 1.25 million tonnes of coal per annum. On August 14, 1970, the world's largest and longest coal slurry pipeline of 436 km length started operating across the state of Arizona (USA). In India, transporting of iron ore at Kudremukh by pipeline is worth mentioning in this context.

When the material transporting medium is a liquid, the system is known as a slurry pipeline, and when the conveying fluid is air it is called a pneumatic pipeline, and when the transported solid material is encapsulated for reasons of its protection, the systems are called hydro-capsule pipeline or pneumo-capsule pipeline. Coal is generally transported by slurry pipeline systems.

Field Trial : Based on the study of field trial reports, it was noted that there are two basic conditions for slurry pipeline transport, the first that the flow must be turbulent in nature, and the second that any excessive sediment deposit must not be allowed to take place on the bottom of the pipeline. Coal is to be crushed to 14 mesh size in crushing plant and then the water-solid mixture with average coal to water ratio of 50% to 60% is prepared. For boosting the mixture positive desplacement pump of plunger type for 2500-3000 psi pressure, or centrifugal slurry pump of upto 700 psi pressure requirement is used. The pumping stations are to be kept at about 100 to 150 km intervals, and at the recovery end dewatering and drying facilities are to be provided for drying coal down to 25 to 30% moisture by centrifuges.

Conclusion

The following are the favourable conditions for and advantages of pipeline transport of coal.

1. The pipeline costs are cheaper than unit rail for throughputs of over 10 million tonnes per year, and for distances over 800 km in flat terrain. However, for short distances, only in difficult terrain, pipeline transport may be economical.
2. As the terminal costs remain the same, longer the distance the more economical is the transport by pipeline.

3. The slurry pipeline is an efficient mode of transportation in respect of energy conservation. A pipeline of over 1600 km consumes between 2.5% to 3.25% of energy transported as compared to 4% by rail and 20% by EHV (132 KV and above).
4. Effect of operating cost escalation is less in a pipeline transport because about 70% of pipeline tariff is capital related charges, once the capital investment is made, these charges are fixed.
5. Slurry transport is feasible upto distance of 10,000 km.
6. Drying of coal below 8% to 10% moisture appears to be uneconomical, and thus pipeline transport is feasible where the consumer is able to use high moisture coal.
7. Slurry transport has a definite edge over other modes of tranport where the terrain is difficult, eg. hills and valleys.
8. It is capable of transporting very high quantities, say 25 million tonnes per annum with a single pipeline.
9. Loss of coal in transit is minimised.
10. Dust problem is minimised.
11. Reduction in noise, traffic congestion and environmental disturbances is significant.
12. Manpower requirement is low.
13. Maintenance charges are low.
14. It is a continuous process unaffected by vagaries of climate and weather.

Transport of Sand

Transport of sand by pipelines is costlier than an alternative mode of transport, such as, unit train etc. The high cost of pipeline transport of sand is mainly due to heavy wear of pipes. Unless the wear of pipes is reduced either by decreasing the velocity of flow by addition of fine material, or wear resistant pipelines are developed at reasonable prices, the pipeline transport of sand may not be economically feasible.

Scope of Application

Slurry transport of coal is a feasible and economical mode of transport in difficult terrains and also in flat terrain where the transport distance is over 800 km and the quantum of required transport is over 10 million tonnes per year.

PROJECT : Development of Instruments for Continuous Recording of Methane

PERIOD OF INVESTIGATION : December 1976 to December 1980

EXPENDITURE INCURRED : Rs. 0.50 lakh

IMPLEMENTING AGENCY : BCCL/CMRS

Introduction

Methane gas has been responsible for a large number of explosions in the mines. Currently used methanometers in India are for spot detection only (detection at particular place and particular time), not to check and record the presence of methane continuously. With the objective to monitor methane concentration in the mine atmosphere continuously by an indigenous instrument the CMRS developed a system which was fabricated by Bharat Bijlee Ltd, Bombay, and was installed for trial at Sudamdih and at Moonidih (BCCL).

Salient Features of the Experiment

Field Trial : This single point telemonitoring system (SPTS) developed by CMRS had a sensor positioned underground which worked on the principle of wheatstone bridge with the indicator and recorder at the surface.

Conclusion

It was found that the system could work only for six months satisfactorily, and had the following drawbacks which could not be solved. Hence the SPTS instrument was not used further.

i. The installation frequently broke down due to low life of the indigenous sensor which was only about 6 months against 5 years of an imported one.

ii. The system was found to be affected by power cables lying by the side of the SPTS system, which should have been immune to external interference, such as, AC pick up.

PROJECT : Heat Flow Studies and Problems of Heat and Humidity in Coal Mines

PERIOD OF INVESTIGATION : January 1977 to February 1982

EXPENDITURE INCURRED : Rs. 2.26 lakhs

IMPLEMENTING AGENCY : Indian School of Mines

Introduction

Deep coal mines of the future will have serious problems of heat and humidity, particularly due to the steep geothermal gradient existing in Indian coalfields. The objective of the study was to carry out laboratory and field investigations on heat flow, climatic conditions and ventilation systems for deep mine, and to suggest remedial measures for control of the mine climate. In this project studies were conducted in mine airways of Moonidih (BCCL), Chinakuri 1 & 2 pits (ECL) and Sudamdih (BCCL) mines.

Salient Features of the Experimental Set-up

Field Trial : The temperature and humidity conditions in three deep mines were studied in detail. Thermal gradients of airways and virgin strata temperature (VST) were also determined and analysed. Based on the study, prediction equations for wet bulb temperature rise were formulated. The VST was measured using maximum thermometers in the drilled holes. The holes were generally left for one day to allow dissipation of drilling heat before introducing the rods with thermometers in the holes. Wet bulb temperatures were measured at the beginning and end of the airways with a whirling hygrometer having 0.2°C least count.

Velocity of the air was measured by using vane type anemometers by the traversing method at least at two stations in each airway. The number of air measurement stations in an airway increased depending upon its length and variations in the cross-section. For age correction the formulae used by Lambrecht were used. Corrections for airway size, air velocity were taken into account, and an attempt was made in this study to derive some empirical equations on thermal gradients for various types of mine airways based on climatic observations conducted in the three mines mentioned above.

Conclusion

Thermal gradient of dry and damp, moderately wet and wet airways can be calculated by considering the difference between virgin rock temperature (virgin strata temperature) and the air wet bulb temperature as the driving force for heat flow. Good correlation was obtained between these two parameters in case of individual mines but the correlation coefficient was low when the results from different mines were pooled together.

Scope of Application

For predicting the climatic conditions a more comprehensive study covering a large number of mines is needed. The study, however, gives a methodology for future work.

PROJECT : Evaluation of Strength and Workability of Coal Seams and Coal Measure Rocks

PERIOD OF INVESTIGATION : January 1977 to June 1983

EXPENDITURE INCURRED : Rs. 2.87 lakhs

IMPLEMENTING AGENCY : Indian School of Mines

Introduction

The project was essentially designed to mount a major effort on the quantification of the strength characteristics of Indian coal measure rocks for which a data base was lacking, and secondarily, to establish and examine the applicability of face mechanisation systems through laboratory and field studies.

Salient Features of the Experimental Set-up

Laboratory/Field Trial : Studies on the strength and abrasivity of coal measure rocks vis-a-vis application of road beading and tunnelling machines were made. Performance of road heading machines in Jharia, Raniganj and Singareni coalfields were monitored, and various workability indices such as, protodyakono V index, friability index, the Polish V index, cone indentor and point load strength index were investigated. In-situ studies were also carried out with the help of schmidt rebound hammer.

The study on 'workability' of coal measure rocks was enlarged and extended to comprehend their cavability characteristics, as in India normally the roof consists of massive strata. For the first time in India the height of immediate roof unit was delineated using the Polish borehole penetrometer.

Determination of strength-size relationships of different Indian coals, triaxial and post-failure characteristics, estimation of strength from index tests and coal constituents also formed a part of the project.

Conclusion

Achievements of the project can be enumerated as follows :

1. Evaluation of workability of selected Indian coal seams.
2. Development of a classification model of coal measure rocks vis-s-vis application of road heading machines.
3. Development of a data bank on physico-mechanical properties of rocks and abrasivity characteristics.
4. Evaluation of cavability characteristics of longwall roofs.

Scope of Application

Since the data being generated is a continuing process, the norms for use of the strength indices have not been submitted in the present report. The implementing agency has planned to publish the cataloque at some later date, which is expected to be useful to the coal industry.

PROJECT : Investigation in Different Parameters in and around Longwall workings

PERIOD OF INVESTIGATION : December 1976 to September 1982

EXPENDITURE INCURRED : Rs. 6.94 lakhs

IMPLEMENTING AGENCY : CMRS

Introduction

The most accepted techniques used abroad for investigations into different parameters of strata behaviour at and around a longwall mining face are : equivalent material mine modelling and in situ observations.

The modelling technique was developed as an indirect tool to deal with strata control problems, and plan remedial measures before longwall panels were opened underground. This involved :

- development and selection of artificial materials to simulate the strata conditions
- development of a simulation modelling technique
- precise observation of displacement and strain in the strata
- measurement of stress in and around workings.

The following study was proposed to be carried out as field/in situ observations.

Geo-mechanical studies of rock mass, i. e. (a) jointing behaviour of the roof rock (b) caving sequence of longwall roof (c) behaviour and bearing capacity of floor (d) roof core studies for the support resistance (e) strength and stability of floor under different conditions.

Salient Features of the Experimental Set-up

Field/Laboratory Trial : Study with equivalent material model : Experimental studies were taken up under the guidance of Mr V T Gerokhov of VNIMI, USSR, to develop artificial materials for model study. Plaster-based artificial materials were jointed to get desirable brittleness and bonding strength. Gypsum-based artificial materials (gypsum, portland cement and plaster of paris) were found to be satisfactory in respect of strength, brittleness and ease of handling. A stereo-comparator and universal camera were procured and used for model observation of strain. The following model investigations were undertaken :

1. Investigation of the cavability of Dishergarh seam : study conducted with association of Mr Gerokhov,
2. Cross-slicing of thick seams : developed as an alternative to Kazimierz and Yankowice methods (of Polish origin) to extract thick seams underneath surface features,

3. Oblique slicing of Argada seam (CCL) : study conducted in collaboration with Dr L N Gapanovich of Skochinsky Institute, USSR,

4. Biaxial model studies : a biaxial model constructed to study the effect of lateral stress over the stability of bord and pillar workings,

5. Triaxial model study : investigations conducted on three-dimension models. The problem of extraction with three or four-side barriers solved, and surface subsidence observations taken.

Field Studies

1. Rock Mass Study : Tests conducted in laboratory furnished the sample properties which could presumably be 2 to 10 times higher than the rock property. This difference was mainly due to the geological discontinuities in the strata. A factor - weakening co-efficient was developed on the basis of the field observation of the exposed roof. The co-efficient is defined as follows :

weakening co-efficient = 0.01 x K1 x K2 x R

where K1 is the joint spacing
K2 is the joint fitting
R is the RQD

2. Support Design : A system was developed to delineate roof stability and the support resistance on the basis of the following :

- weakening co-efficient of the roof,
- thickness of the immediate and main roof,
- bending strength of the beds.

On the basis of these factors, a stability index 'N' was developed and support resistance for poor, moderate and roofs defined.

3. Studies at Chinakuri (ECL) : Dishergarh seam workings : The following studies were conducted with association of the Soviet experts :

- bump proneness of the seam,
- seam floor bearing capacity,
- caving characteristics of the roof.

The study enabled to appreciate the behaviour of roof rock mass and make an analysis of geo-mechanical parameters.

4. Powered Support Studies : The suitability and the performance of Dowty 4 x 280 tonne chock support was studied at Moonidih (BCCL) at two different longwall faces, PS-1 and PS-2.

5. Floor study of coal seams : The stability of mine workings depends upon the caving sequence or stability of the roof, the resistance necessary for roof support and the bearing capacity of the

floor under varying conditions. In this programme of investigations, the bearing capacity was determined for sandstone floor, shale floor, sand pack and coal in floor.

Conclusion

The model studies conducted for Dishergarh seam workings of Chinakuri mine revealed the support requirement could be as high as 120 tonnes/m^2, which was practically not possible by individual props. The rock mass studies should be conducted in mine models and in situ conditions until a suitable powered support system under each geo-mining condition is designed.

Scope of Application

The mine modelling technique can be used to solve strata control problems under any mining condition. The basic informations have already been collected for Jharia and Raniganj coalfields. The generalised findings could be adopted in these areas for designing suitable support systems. The study has given a concept of understanding the behaviour of rock mass under stress conditions.

Such model studies will help the practising mining engineer to understand strata behaviour and design an appropriately safe method of working.

It is expected that the methods of working evolved will improve conservation by enhancing the percentage recovery commensurate with safety, to the extent of 50% to 80%. It is estimated that the large reserves along the boundary fault of Jharia coalfield could be extracted by cross slicing (upto 80% recovery), and seams underlying built-up areas, townships and water bodies could be extracted upto a 50% recovery by wide stall method.

The model study should open up a new method for the exploitation of coal from pillars standing in multi-section development of thick seams. Over a thousand million tonnes of coal is sterilised in such conditions, and efforts must be undertaken for recovery of this coal.

PROJECT : Optimisation of Design of Mine Pillar Parameters and Feasibility of Extraction of Locked-up Coal below Built-up Structures, Water-logged Areas and Hard Covers

PERIOD OF INVESTIGATION : August 1980 to February 1986

EXPENDITURE INCURRED : Rs. 3.48 lakhs

IMPLEMENTING AGENCY : CMRS

Introduction

Design of pillars is probably the single most important problem in bord and pillar mining, which has been the primary method of underground coal extraction, and has consequently attracted the attention of researchers for several decades. Existing formulae for determination of pillar strength were critically examined in the project report against actual case studies and a suitable empirical model has been proposed.

The report submitted by the CMRS consists of three parts, the first one containing pillar design with all associated basic studies. The second and third parts include geo-mechanical design of the 'knife-edge' method and stability of partings between contiguous pillar workings.

Salient Features of the Experiment

Field Study : Studies on triaxial aspects for pillar design and post-failure behaviour of several Indian coals were conducted and an empirical formula for triaxial behaviour was formulated. From the data obtained of 20 seams correlation between schmidt hammer rebound and in situ strength was formulated. A nomogram based on nine longwall and six depillaring case studies was drawn to estimate the area of main roof fall. The 'equivalent face advance', i. e. advance required to cause the main roof fall was found to be related to RQD and Barton's roof quality. Based on studies of 23 failed pillar and 20 stable pillar cases a procedure for pillar design/stability problem in bord and pillar workings was developed including design of chain-pillars and stowed and unstowed pillar arrays. A computer procedure for pillar load estimation was also developed.

The Russian 'knife edge' method of depillaring which was successfully used for about eight years but was subsequently abandoned due to several safety considerations were reconsidered with geo-mechanical design. RQD for roof strata was considered for design and the method is recommended only if RQD of roof strata upto five times the working height is between 25 and 60% only. An equation was developed for rib design. A primary design condition was that the span between two consecutive ribs should not cave immediately upon support withdrawal, but should cave after the back rib (immediately preceding the one protecting the face) is either blasted or collapses of its own accord.

Stability and design norms for parting between contiguous pillar workings were developed to avoid accident due to failure of parting of contiguous seams. The study was based on

two-dimensional finite element modelling and analysis of finding the maximum possible developed stress in the parting. It included modelling some case studies and development of norms for design purposes.

Based on various test data, e. g. compressive strength, joint parameters, maximum tensile stress in parting was calculated and then stress reduction factors in Barton's rock quality Q were determined, and the average junction span was computed.

Conclusion

With increase in width/height ratio of a sample beyond 4 to 6, the post-failure strength starts ascending after an initial fall, i. e. regaining strength presumably due to reconsolidation of the broken coal mass.

Using the type N schmidt hammer, a reasonable correlation between in situ crushing strength of 0.3 m^3 coal samples and the lower mean of rebound values was obtained.

A safety factor nomogram has been developed for design of stowed voids, pillar arrays and chain pillars.

In longwall and depillaring panels the maximum equivalent face advance at which the nether roof collapses, has been found to have a direct relationship with RQD. The area of roof fall, which increases with increase in rectangularity of the panel, can be effectively reduced by adopting a face length of 1.55 times the equivalent face advance where the latter is calculated by the given equation.

The 'knife-edge' method can suitably be designed when the RQD is between 25 and 60%.

Using the Barton's rock quality formula and calculating stress reduction factor as per CMRS equation, average junction span can be calculated.

Scope of Application

With help of the various logical equivalance developed, the width of a gallery, including junction span, partings and pillar width can be estimated for mine safety and conservation.

Measurement of pillar stress, strain and deformation deep depillaring **(MT/9.3)**

Junction support at GDK-9 with steel girders set on steel props, at cross channels with roof bolting **(MT/9.3)**

Roof convergence study along the goaf edge of conventional depillaring face.
(MT/9.3)

Vibrating wire stress capsule and borehole extensometer in pillar for stress & deformation study
(MT/9.3)

PROJECT : Application of CO_2 for Combating Mine Fires

PERIOD OF INVESTIGATION : December 1976 to June 1987

EXPENDITURE INCURRED : Rs. 2.59 lakhs

IMPLEMENTING AGENCY : CMRS

Introduction

The project was undertaken to examine the applicability of carbon dioxide (CO_2) infusion during sealing operations for controlling and extinguishing coal mine fires and in stopping the progress of fire in underground mines.

Fires in coal mines remain an imposing and serious problem was estimated by the erstwhile Coal Board that more than 22 million tonnes of coal had been lost by fire by 1969. Mostly, the measures adopted so far to control fire reaching the surface have been by the air exclusion method of surface sealing and trenching.

Experience in Foreign Countries

Application of inert gas has been widely attempted abroad for combating large scale mine fires. Infusion of liquid CO_2 and liquid NH_4 was successfully made in Australia. In China, flue gas generated by burning slack coal (CO_2 16%, O_2 3%, N_2 80%), and then cooling the combustion product through pipes immersed in open tanks of water was successfully employed for combating underground fires. In the Federal Republic of Germany infusion of nitrogen for dealing with fire gave satisfactory results. The amount of nitrogen required to be infused was 8.6 times the void volume of the fire affected area. In Poland inert gas infusion during sealing-off operations of fire areas was used as a preventive practice. The inert flue gas was generated by burning oil in a jet aircraft engines. In the UK, nitrogen pumping through dispensing units at the surface via shaft and inbye galleries for effective dealing with fire was practised. In the USA, reportedly CO_2 infusion was effectively tried under different situations of fires. Also, remote sealing of abandoned areas by inert gas (CO_2 + N_2) mixture infusion along with fly ash is being experimented with.

Besides CO_2, N_2 or a (CO_2 + N_2) mixture, other inert gases which have been employed to combat coal mine fires with varied degree of success are halons (halogens, Cl_2, Br_2, F_2 methane or ethane) and steam-water (steam used to flush the air out before the subsequent operation of quenching the fire by water jets).

Field Trial: CO_2 has an endothermic effect at the reduction stage of producer gas reaction (CO_2 + C = 200) and also help to cool down the temperatures rapidly. One kilogram of inert CO_2 occupies about 500 litres at NTP and, being heavier than air, fills up a closed space from the floor upward. Heat dispersion from the hot zone to other parts of the mine for subsequent dissipation is poorer than with N_2 or flue gas.

There are a number of major fire areas in the BCCL, several of which have been controlled by inert gas infusion.

Sudamdih Mine Fire : For CO_2 infusion at Bhulanbararee colliery (BCCL) while a scheme was under preparation, emergent situation arose at Sudamdih shaft mine and thus the CO_2 infusion arrangement was used to assist in sealing the freshly occurring fire. The main objective of CO_2 injection was to minimise possibilities of methane explosion. A total of 42 tonnes of CO_2 was introduced from 16/18 kg cylinders over 14 days. The role of CO_2 as inert gas taking out heat from the hot zone could be only marginal. As the inert gas was being flushed in, the amount of CH_4 in the mine environment increased at a much faster rate (730,000 m^3 of CH_4 from different horizons/day of 24 hours).

Bhulanbararee fire : In this case the fire was in a sealed off caved goaf. The total quantity of CO_2 infused was 35.7 tonnes at the rate of 125 m^3/hr. Adequate warning arrangement for the manifold and connector from cylinders was made to facilitate a smooth and steady supply of CO_2 and prevent clogging. The fire was partially controlled.

South Tisra fire : The shaft pillars of a pit were engulfed by fire advancing from three sides. It was essential to save the pit till the second pit was put into commission. Further, the advance of fire had to be halted to save surface railway tracks.

CO_2 infusion from surface to the fire area was carried out and monitoring of the progress of the fire was undertaken to study the efficacy of the method. Other fire combat measures used were consolidating the cracks and crevices of the shaft pillar with liquid cement-sodium silicate infusion, bulldozing at surface, and filling the underground voids by stowing with sand-dolomite-water slurry.

Lowering of temperature was faster with the sodium silicate infusion and effective control of the fire was achieved.

Conclusion

Infusion of CO_2 is a useful method while sealing a fire area where high emission of methane may pose a serious explosion hazard during the sealing-off operation, and where sufficient amount of CO_2 can be reached near the seat of the fire.

If the fire occurs in a lower section in a thick seam working or a lower level in an incline mine, CO_2 may be effectively employed to control fire by preventing air leakage through dip-rise stoppings. CO_2 being heavier than air fills the voids of the lower section and acts as an air seal.

Temperature can be rapidly lowered by sodium-silicate infusion.

Scope of Application

Trials were carried out with varied degrees of success at Sudamdih, Bhulanbararee and South Tisra mines.

With the encouraging results obtained, the CMPDI installed an inert gas plant at Laikdih Deep mine (ECL). This was highly effective in checking the spread of fire, which would have otherwise consumed the main transport level causing a total disruption of production for a considerable period. Similar installation of fire fighting plants may be undertaken in fire affected mines.

PROJECT : Development of Water Spray and Fog nozzles and Dust Suppression System (semi-automatic and automatic) for Suppression of Dust and Blasting Fumes in Mines.

PERIOD OF INVESTIGATION : December 1976 to February 1987

EXPENDITURE INCURRED : Rs. 0.56 lakh

IMPLEMENTING AGENCY : I I T, Kharagpur

Introduction

The project was sponsored by the Department of Coal, Ministry of Energy, Govt. of India, in 1976 with the objective of developing an effective suppression system for the dust raised during various mining and its allied operations.

The common suppresing agent is readily available is water, which is an effective means of preventing dust from getting airborne as well as its suppression after it becomes airborne. Water sprays are currently the main means of dust control in mining operations and reportedly reduce the respirable dust level by 30%. Micron size dust particles behave like gas molecules and remain suspended in air and carried over long distances in the airways. These particles when covered with water films by spraying, become heavier and tend to settle on the floor. Water droplets should be large enough to act through their weight. The distance between larger droplets increases and the statistical probability of the dust particles and water droplets colliding becomes low. The micron droplet sizes are not desirable as they do not adhere to the dust particles, and often do not wet them. Optimum droplet size is a significant requirement for dust suppression. Further, high relative velocity between water droplets and dust particles is required for good efficiency.

Salient Features of the Experimental Set-up

Fabrication of several nozzles and valves was done, but the quality of finishing and casting was unsatisfactory, and therefore, rejected as detailed nozzle specifications were available from manufacturers of water spray systems, attention was focussed on the development of quick-acting valves from automatic spraying at loaded belt conveyors and mine cars. Dust suppression system in coal winning with shearer loaders and coal ploughs, in transport and in drivages were highlighted in the report.

The theoretical aspects for the development of the spray design were studied. Performance of different types of nozzles, e. g., pressure nozzles and air atomizing nozzles with spray charateristics such as, different spray patterns, flow rates, etc., were evaluated. Water spray nozzles were further classified depending upon the spray patterns and their application.

A detailed study was done on a strainer developed in the USA for trapping dirt to have a non-clogging water system. Investigations were also made on spray-fan ventilation system in which conventional water sprays suitably positioned on the intake side of continuous miners (continuous coal winning machines) e. g., shearer-loader, coal plough, to move fresh air to the

face. Dust control measures at coal plough and shearer loader faces and coal haulages were also studied. In drivages using auxiliary ventilation, coal dust and blasting fumes could be suppressed by creating a fog zone at the face over a length of 20 m outbye with water sprays.

Based on the study, the following designs were suggested.

A quick-acting valve for use in an automatic spray system for materials on moving belt conveyors, and for manually operated system of spraying loaded mine cars single or in train.

A quick-acting valve for automatic spraying of full or empty cars in a train

An automatic pressure relief valve

Line strainers

Spray nozzle test setup

Scope of Application

The designs prepared for several automatic and semi-automatic water spray devices can be used in dust and fume suppression systems. These are likely to provide an effective solution for prevention of dust hazards in mining activities.

PROJECT : Evaluation of Stability of Pillars and Barriers

PERIOD OF INVESTIGATION : January 1977 to September 1982

EXPENDITURE INCURRED : Rs. 0.42 lakh

IMPLEMENTING AGENCY : Dept of Mining Engineering, BHU

Introduction

The purpose of the project was to study the stability of coal pillars and barriers, and to develop formulae for their design in a coal mine.

Investigations were carried out for delineating fracture characteristics around mine openings, stability of parting pillars, and the effect of rectangularity and cubic length ratio on pillar strength and establish a reference for design of coal pillars and barriers.

The report consisted of three main parts - Stability analysis of mine openings, Stability analysis of mine pillars, and Stability analysis of barrier pillars.

To evolve a relationship the approach followed was to analyse the available information developed by researchers in the USA, South Africa, etc., for conditions in their coalfields. After laboratory studies with Indian coals and coal bearing strata, several formulae were developed for Indian conditions with suitable modifications.

Salient Features of the Experiment

Laboratory Test : To investigate the fracture characteristics around mine opening, equivalent material model studies using sand, wax and plaster of paris were carried out. Fracture mechanics was studied by loading the prismatic model specimens with single and twin circular and square openings. Studies were also carried out on cylindrical specimens. The load-deformation curves were recorded for each specimen, and fracture initiation and propagation were photographed.

For pillar design purposes, experiments on specimens of coal, sandstone and plaster of paris were carried out under servo-controlled loading conditions to observe the effect of pillar size on crushing strength of coal, effect of rectangularity on crushing strength and effect of rectangularity and cubic length ratio on crushing strength.

For the barrier pillar design, consideration of length, width and height at a panel, inclination of the seam, physico-mechanical properties and elastic constants of the rock, horizontal primitive stress and pressure as a result of hydraulic head were taken into account. Based on the above parameters investigations were carried out to determine the load coming on coal pillars, and for prediction of average pillar stress by the analytical expression developed by Coats (1965, 1971), strength of a barrier and a suitable factor of safety.

Conclusion

The major findings of the study are the following.

The spacing between two mine openings should not be less than three times the diameter of the openings and for the best stability the openings should be preferably located vertically one above the other.

The Salamon's formula and its modification for application in Indian mines have been found adequate for calculation of strength of pillars.

Equations have been given for the design and strength of barrier pillars and the relationships obtained from computer analysis are claimed to fit with studies made by other investigators in this field.

Determination of size and design of pillars and barriers based on the investigations is reportedly more realistic for commensurate rock characteristics and mine depths.

Scope of Application

Design formulae can be used for planning suitable dimensions of pillars and barriers. Computer aided design (CAD) guidelines for barrier pillars and panel widths at different depths with factors of safety of 1 to 1.25 and optimum percentage of extraction have been provided for one case. Similar design curves can be developed for mining conditions in other cases and can be used for planning and design.

PROJECT : Study of Parameters Effecting the Flow of Air in Mines and Development of Measuring Equipment

PERIOD OF INVESTIGATION : January 1977 to September 1982

EXPENDITURE INCURRED : Rs. 0.63 lakh

IMPLEMENTING AGENCY : Dept of Mining Engineering, BHU

Introduction

The objectives of the project were to find out the effects of various structures/installations in mine roadways like, supports, conveyors, etc., on ventilation and develop instruments, gauges, etc., to enable measurement of various parameters in an experimental set-up. To meet the objectives devices were developed for installation at observation points in ducts to measure velocity variation across the cross section and to provide arrangements for the measurement of pressure. The work of design, fabrication and experimental observations involving model support systems was carried out for rectangular ducts and partly for arched ducts.

Salient Features of the Experiment

Laboratory Study : For the study of resistance offered by supports of different spacing in the ducts an experimental set up was installed, which comprised a manometer designed, developed and fabricated for measuring pressure losses, static pressure, velocity pressure and the total pressure of air in the experimental ducts. The manometer was developed with a provision to control the inclination of the measuring arms. Wooden three-piece supports, 1 cm, 1.25 cm and 1.5 cm round and square sections having two vertical members and one crossbar, were also fabricated. These sets were connected with each other with the help of aluminium strips with holes at a spacing of 2.5 cm. The sets were screwed to the aluminium strips so as to enable variation of spacing between the sets in multiples of 2.5 cm. Aluminium arches of 1 cm, 1.25 cm and 1.5 cm round and square sections were also fabricated and connected with the aluminium strips. Wooden three-piece supports were designed for rectangular ducts and arches were made for arched ducts.

Experimental observations were made for the study of resistance offered by the supports at different spacings in the rectangular as well as arched ducts.

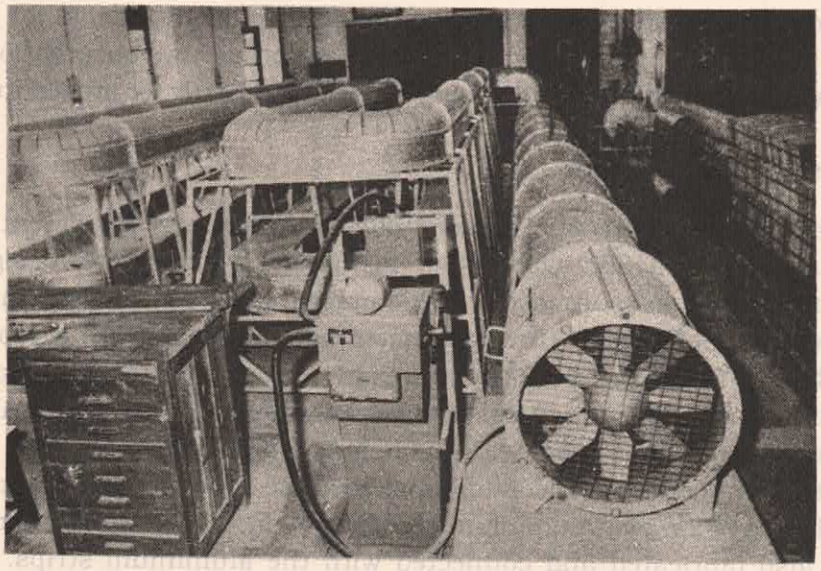
Conclusion

The nature of curves plotted confirms that pressure loss across the supported length of an airway increases with increase in spacing of supports upto a value when spacing diameter ratio is 10 and then decreases continuously.

From the observations a relation was achieved to predict the length to which boundary separation extends about the set for different shape and size of support sets.

Scope of Application

The results obtained in the laboratory experiments can be used for underground support design with a view to minimise the resistance caused by supports to mine ventilation. Before using the results of the experiments it is essential to compare the results with observations in actual underground roadways.



General View of the Assembly at the Various Ducts, - to study factors of aerodynamic resistance
[(MT/10.2 (b)]

PROJECT : Stability of Slope in Openpit Mines

PERIOD OF INVESTIGATION : January 1977 to December 1981

EXPENDITURE INCURRED : Rs. 1.34 lakhs

IMPLEMENTING AGENCY : Indian School of Mines

Introduction

The project sought to establish appropriate methodology and design norms for determining an ultimate pit slope with a fairly high degree of confidence. The study became necessary as it was realised that 'slope stability' will play an important role in the safe and economic exploitation of open pit mines.

After detailed consultation with the concerned coal companies and CMPDI, Jhingurda opencast project of CCL was selected for the study. The major points in favour of the selection were the maximum depth of working (300 m) and presence of a high hill on the dipside. It was realised that the steeper final pit slope will effect a lot of saving in rock excavation. Furthermore, this mine is the biggest opencast coal mine working the thickest coal seam (130 m) in India at this time.

Salient Features of the Experimental Set-up

Laboratory/Field Study : For the assessment of stability of a slope or for its design a large amount of information is required. Some of these can be obtained at little or no extra cost during the exploration stage. Requirement of input data are given below :

I. Preliminary information (Exploration stage)

I.1 Geological map for information about broad geological features, surface topography, drainage areas and surface flows.

I.2 Information within the mine area and some distance beyond pit boundary would include.

- Surface topography
- Surface geology
- Mapping of rock exposure and outcrop
- Indication of any structural discontinuities giving location, orientation, spacing, dip, in-fillings, etc.
- Geological cross-sections
- Drill hole data - Borehole log, RQD of cores, core recovery ratio, depth of ground water table
- Physico-mechanical parameters, such as, compressive strength, shear strength, angle of internal and density

- Cross-sections drawn perpendicular to the final face alignments
- Rainfall records

II. Secondary information (Design and initial operation stage)

Analysis of primary information will determine the likely mode of failure - circular, planer, wedge or topping failure, flow of liquefied mass (mud flow etc.) or a combination thereof.

For circular failure shear strength and angle of internal friction should be determined for each of soft rock and subsoil formations. Laboratory shear test may be supplemented by in situ shear test. Effect of water on these parameters is also to be determined. For planer and wedge failure detailed information of structural discontinuities is to be collected. Laboratory tests for shear and angle of internal friction should be performed along discontinuity plane.

Swelling index for soft material is also to be determined. Ground water pressure along the main discontinuties is to be measured by piezometric installations. Intensity of blast vibration and its effect on slope stability are to be determined.

III. Information from failed slope will provide considerable amount of relevant informations. In case of failure numbers of photographs at different angles should be taken apart from collecting other details, e. g. presence of cracks, water seepage, cross-section across the slope.

To design the slope a microcomputer package was developed for the analysis of wedge failure in open pit slope and for the analysis of circular (rotational) failure in open pit slope.

Conclusion

The slope stability analysis for the Jhingurdah opencast project was carried out in two stages, the intermediate and final stages.

The slope instability at the final pit may be caused due to wedge failure. The joint sets in rock may play an important role. It was observed that a slope limited to 55°, wedge failure should be unlikely.

The intermediate slope may fail in a circular mode since the overburden rock at this stage is generally weaker. A slope of 35° in overburden rock should be adequate, unless there is a heavy rain water recharge. Coal appears to be more competent and a slope of 45° is found to be in order. Hence for a composite slope of coal and overburden, a steeper angle of 45° for coal strata and flatter angle of 35° for coal measure rock are recommended.

In case of a rising terrain (uphill side), the chance of slope failure is higher. For coal measure rocks, the pit slope should be flatter at about 32 .

Scope of Application

With the help of the basic approach used in this particular case study, slope design may be carried out for other cases. A slope only one degree steeper may effect saving to the tune of lakhs of rupees on overburden excavation cost alone. Slope stability has an important role in the safe and economic exploitation of opencast mines.

PROJECT : Methane Emission and Control in Mines

PERIOD OF INVESTIGATION : April 1976 to May 1981

EXPENDITURE INCURRED : Rs. 1.35 lakhs

IMPLEMENTING AGENCY : Indian School of Mines

Introduction

The objective of the project was to study the emission and migration characteristics of methane gas under Indian coal seam conditions and to develop control measures. The project objective could only be partly fulfilled. Due to non-availability of research personnel and suitable equipment a few identified jobs such as, development of core barrel to hermatically seal coal cores to determine gas content in virgin coal seam, study of migration characteristics of gas through coal seam and coal measure strata could not be undertaken. The jobs carried out are desorption characteristics of coal seam, measurement of porosity and permeability of a few coal seams and trial with silicagel infusion to control methane emisson.

Salient Features of the Experiment

Laboratory Study : Firedamp given out from a number of seams, e. g. Chinakuri 1 & 2 pits Dishergarh, Amlabad XIV seam, Moonidih XVII T seam were tested by gas chromotography. For desorption characteristics of coal seams, a adsorption isotherms of fine coals, e. g. Amlabad (XIV seam), Moonidih (XVII T seam), Dishergarh seam of Chinakuri, Argada seam of Bhurkunda, Koithi seam of Girmint, were determined in the laboratory. For obtaining the isotherm coal was powdered first to 1/2 mm size, the fraction between 120 and 500 micron size was then selected and kept in a steel cylinder from which air was drawn out by a vacuum pump. The coal was thereafter saturated with methane under pressure of approximately 50 atm for a period of 3 to 6 days. It was then allowed to desorb methane by release of pressure in steps. The volume of desorbed gas was measured and the adsorption isotherm of coal drawn.

Measurements of porosity and permeability were carried out by an apparatus developed by NGRI Hyderabad, but results obtained from this apparatus did not tally with those obtained from a Ruska permeameter available with Petroleum Engineering Department of the ISM. Further coal cores could not be tested on the Ruska permeameter due to technical difficulties arising from contamination of the mercury used.

To control gas emission by infusion laboratory trials with different gelling chemicals, alkalies and acids were conducted to select suitable concentrations for proper setting characteristics. A borehole packer seal was also developed to permit injection of the gel into coal.

Field Trial : Field trial to control gas emission was undertaken at XIV seam workings of Amlabad colliery. The trial was conducted with sodium silicate, hydrochloric acid and hydroxide solution. Silicagel was infused at a pressure of 20 kg/cm^2. At a higher injection pressure of 30 kg/cm^2 infusion of the gel occurred. The infusion trial showed a reduction in methane emission in development headings by about 43%.

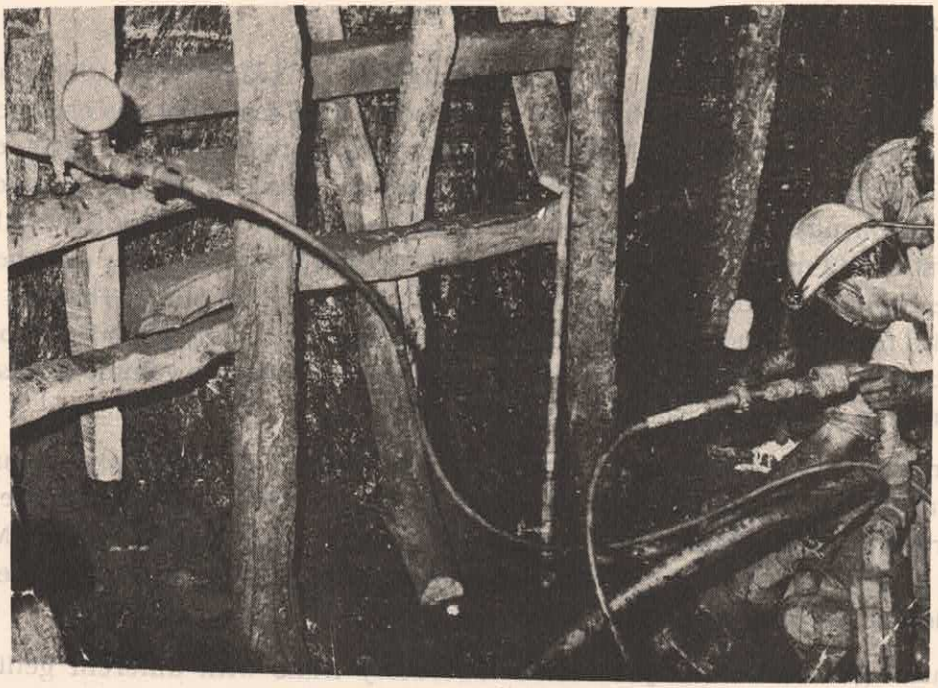
Conclusion

The objectives identified for the project could be partially fulfilled. However the field trial carried out with silica gel meets the important requirement of the project.

Scope of Application

The gas content of coals can be determined by the indirect method based on the adsorption isotherm technique if reservoir gas pressure in a coal seam is known. The method was first applied by Soviet engineers while planning Chinakuri 1 & 2 pits in 1978. Reservoir gas pressure has to be determined in the field.

The technique of silica gel infusion has been successfully demonstrated. Though a high cost method, it can be used where both methane emission control as well as increase in strength of coal are desired.



Gel Infusion in Progress,
- For Control of Methane Emission

[(MT/10.3 (b)]

PROJECT : Assessment of Surface Movement and Structural Damages due to Mineral Extraction

PERIOD OF INVESTIGATION : January 1977 to April 1981

EXPENDITURE INCURRED : Rs. 0.65 lakh

IMPLEMENTING AGENCY : Indian School of Mines

Introduction

The project was undertaken to investigate subsidence phenomienon in Indian coal mines, and its prediction with a special reference to the Jharia coalfield (BCCL). To assess the parameters of mining subsidence during extraction of thick seams, and identification of the nature and extent of subsidence damage was done to confirm the results using equivalent material modelling.

The need to study subsidence was mentioned in the first and second Subsidence Committee Reports (1922 and 1935) but until the 1960's subsidence investigation in India was almost primitive. The Report on the Dangers from Subsidence in Mines of Bharat Coking Coal Limited (May 1977) makes evident that there were abandoned coal panels standing either on pillars at a critical stage of stability, and sudden subsidence, without much of a warning, could take place around heavily congested surface areas. Sudden collapses with ground movement at East Kendwadih in 1976 and at Bararee colliery in 1977 were examples, which resulted in damage of surface and other structures including railway siding and hospital/school buildings. It has been estimated that some 150 million tonnes of coal are locked up below Jharia town and its precincts upto 0 seam to a depth of 380 m from the surface.

Salient Features of the Experiment

Field Trial : A subsidence survey was conducted at Pootkee and East Katras collieries (BCCL). Measurements were also started at Chapapur colliery but later abandoned as the entire survey network on the surface was wantonly damaged. Some limited measurements at Ningah colliery (ECL) were also carried out. A equivalent material model of East Katras was also completed. Literature survey of the state-of-the-art control of mining subsidence in Indian coalfields and the rest of the world was also undertaken, including enquiry into sudden collapse of East Kendwadih and Bararee collieries (BCCL).

Based on the field observation at Pootkee colliery over bord and pillar panel of XV seam (5.4 m) overlying previously extracted seams XVI & XVI A, and at a depth of about 140 m, the subsidence factor was found to be 28%. The limit angle was between 22° and 27°, and the angle of fracture was between 2° and 6°. Some uplift of ground in the tension zone was also noted.

In East Katras, subsidence observation over longwall panel of XI sp. (1.4 m) at a cover depth of 45 m with overlying goaved seams of XI & XII seams, the limit angle was found to be 47° along the longitudinal axis and 32° transversely. The subsidence factor was 50% and the maximum

tensile strain was 4.4 mm/m. With equivalent material model the data was verified. In the model the limit angle was obtained at 38° while the subsidence factor was of the order of 46.6%.

Conclusion

Due to lack of a fulltime staff, sufficient data could not be generated for predicting magnitude of ground movements and subsidence, and to recommend remedial measures. It was also found that there were only about 25 available case histories which could be examined. Much of the subsidence information available lacked precision, and inaccuracies in correlation of surface and underground workings did not warrant investigation.

The subsidence under shallow cover situation in the Indian coalfields are of discontinuous or sink hole type subsidence, for which no predictive equations have yet been established.

Scope of Application

Based on the study carried out during the project, it is noticed that most of the subsidence is discontinuous and sink type, and hence least predictable and potentially most hazardous. Therefore further detailed study is required to be taken up.

For working at depths where continuous troughed subsidence are expected, harmonic extraction in single seam as concept of 'stepped face' layout devised by Beevens and Wardel can be used for surface protection. To work below surface structures the principle drawn by Polish workers, W. Budryk and St Knothe can also be used, i. e. the principle of super-imposition of positive and negative travelling strains for seam extracted with hydraulic stowing so that the subsidence factor does not increase beyond 0.12; horizontal stain does not exceed 3 mm/m; and to minimise the strain two seams are worked concurrently with distance between the working fronts given by expression,

$$d = \frac{H_1 + H_2}{\text{Tan } B}$$

where H_1, H_2 are depths of seams being worked and B, the angle of fractures, measured from horizontal.

PROJECT : Assessment and Control of Ground Movement around Extraction Perimeter in Longwall and Bord and Pillar Workings

PERIOD OF INVESTIGATION : January 1977 to February 1988

EXPENDITURE INCURRED : Rs. 1.60 lakhs

IMPLEMENTING AGENCY : Indian School of Mines

Introduction

The project was sponsored by the Ministry of Energy, Govt. of India, and executed by the ISM, Dhanbad. The investigation was planned for predicting behaviour of strata around underground workings to design adequate strata control measures.

The investigation included; Measurement of convergence and prop loads both in bord and pillar and longwall workings; Assessment of effect of mining a lower seam by longwall caving on the workings of the top seam developed by bord and pillar system; Simulation of workings of a longwall face by equivalent material models; Determination of strength of timber props, 3 to 5 m long, which are commonly used in Indian mines.

Salient Features of the Experiment

Field Study : The investigations were made at Pootkee, Godhur, Busseria and East Katras collieries (BCCL) and Ningha colliery (ECL).

At Pootkee colliery the strata behaviour was studied in bord and pillar extraction of a 5 m thick seam at 145 m depth. The maximum convergence recorded was 4.98 cm at the extraction height of 4.8 m, i. e. only 1.04% of the seam thickness. The convergence developed at uniform rate indicating bending of wide span of superincumbent strata which could rupture with an impact when the span had become extensive.

The study was also conducted at Godhur colliery in the X seam, (16.7 m) in which pillar extraction in the bottom section (3 m) was done with stowing, leaving coal stooks, (5 m x 5 m). The original galleries were heightend to 4.8 m. The heightening of galleries resulted in a cumulative convergence of 1.6 mm in 3 months' time, and convergence was also noted at intervals. In the coal pillar splitting area a convergence of 6.3 mm was recorded. The stooks underwent a compression of 0.001 to 0.0036 cm over a length of 25.16 cm, and in the roof heightening area a compression of 0.006 to 0.014 cm was recorded over a face length of 25.15 cm. The study indicated that the coal stooks left were rather large, and there was a scope for increasing the extraction percentage.

At the Busseria colliery, the site of investigation was the X seam (8.1 m) at an average depth of about 60 m, and developed in two sections. The measurements showed that both convergence and divergence occurred in the top and bottom section workings. In the top section, initially, there was divergence and subsequently a convergence. The maximum convergence noted was 0.16 cm. In the bottom section initially, there was a convergence (upto 0.71 m), but when the face advance was within 35 m of the measuring station, a divergence started and attained its maximum value when the top section registered the maximum convergence.

A study was also conducted at the longwall plough face of XI special (1.4 m) seam at 40 m depth of East Katras colliery. The peak convergence at the face was measured at 220.50 mm/m of face advance, i. e. 11% of the total seam height. The rate of convergence was associated with loud reports of rock fracture followed by the main roof fall. The maximum convergence was recorded at the middle of the face, and lesser convergence were recorded towards drive and tail ends. The maximum convergence took place during, before and after the main roof fall, as well as during the local fall. The convergence along the face was not uniform indicating that the support system at the caving face was not well planned.

Inter-strata movement was studied at Ningha colliery to evaluate the effect of mining the Dishergarh seam on the overlying workings of Rana seam developed on bord and pillar system, the parting being about 175 m. Working in a lower seam results in subsidence in the workings of overlying seam, after a certain area has been extracted in lower seam; the non-effective area in this case was found to be about 50 m^2/m depth. The subsidence factor was 22.7%. The development of subsidence in the top seam was erratic as frequent lowering and heaving of the floor was observed. The final magnitude of the floor heaving was as much as 556.3 mm. The workings underwent both tensile and compressive strains of a magnitude of 0.91 mm/m and 0.88 mm/m when the face was about 103.6 m and 206 m respectively from the barrier.

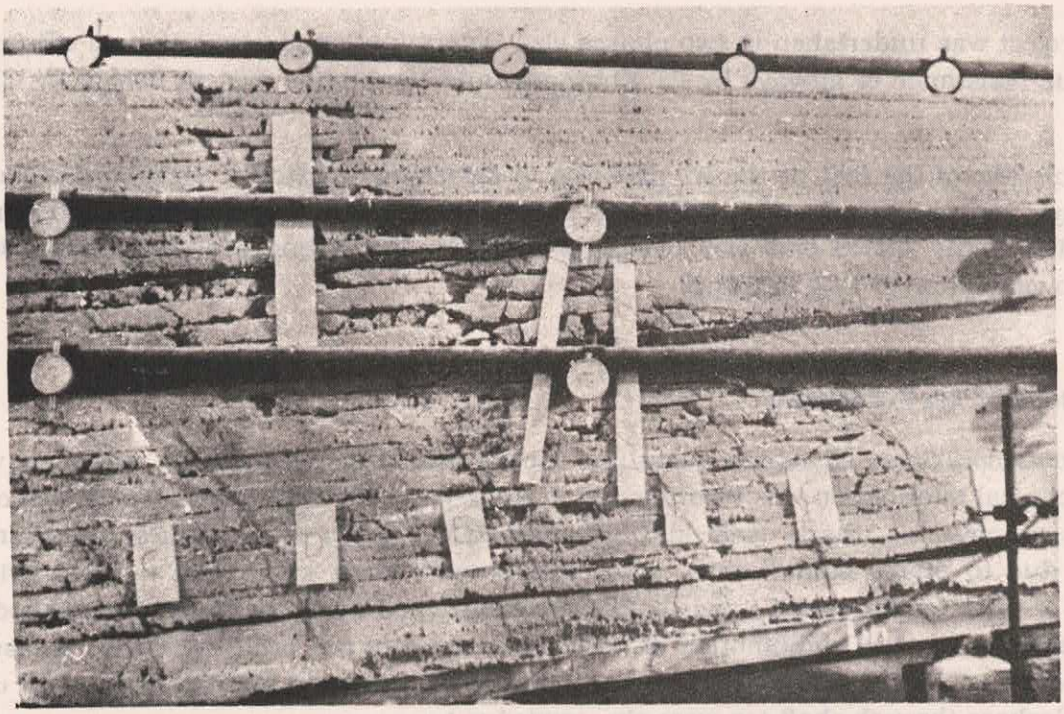
Load bearing capacity of timber props was also investigated. The strength of props falls down considerably with increases in the length to diameter ratio. An approximate equation relating the strength of props is formulated as, P in tonnes = 32 – 0.8 L/D, where L and D are the length and dia of prop. There was a marked reduction in the strength of timber prop having eccentricity in excess of 2.5%. Some erratic results were also noted, for instance, the load sharing capcity of a 1.9 m long prop was 40 tonnes, which is very high and load bearing capacity of 3.6 m long prop was only 5.4 tonnes which is too low. This indicated that timber is not a very reliable roof support.

Equivalent material model studies were done to estimate the behaviour of strata in (i) horizontal slicing of XI/X seam (21 m) of Sudamdih colliery (BCCL) and (ii) longwall mining of XIA special seam of East Katras colliery. The models were simulated on a scale of 1 : 1000. Equivalent material for the Sudamdih model was a mixture of sand, gypsum and lime, and mixture of sand, gypsum and mica. Materials were mixed in suitable proportion to simulate the particular strata. Observations for fracture cracks, convergence between roof and floor with help of travelling microscope were taken. The model studies although qualitative, did establish the behaviour pattern of strata, and could be used as a useful tool to predict strata behaviour in different method of extraction in Indian coalfields.

Conclusion

Since the convergence in depillaring areas of bord and pillar working were observed to be little, in depillaring districts light props of smaller load bearing capacity would in general, be adequate. Timber props can not be relied upon for designing systematic support.

Equivalent materials model studies provide a powerful tool to visualise the behaviour of strata in a particular situation, and should prove invaluable for evolving new and innovative techniques of coal extraction.



Development of Fractures in the Roof and Overlying Strata at a Longwall Face - Model Study
[(MT/10.3 (d)]

PROJECT : Determination of Ventilation Coefficients and Ventilation System Design

PERIOD OF INVESTIGATION : October 1979 to March 1986

EXPENDITURE INCURRED : Rs. 8.19 lakhs

IMPLEMENTING AGENCY : IIT, Kharagpur, and CMRS

Introduction

The project was undertaken in two phases viz., Determination of ventilation co-efficient on aerodynamic resistance of airways by IIT Khargpur, and Ventilation system design by CMRS, Dhanbad.

The objective of the first or the IIT part was to determine resistance coefficient of various mine airways, including shafts and drifts, and optimisation of design of fan drifts and evasses. The objective of the CMRS part was design of auxiliary ventilation system with particular reference to ventilation of long headings.

Salient Features of the Experiment

Field and Laboratory Study : Extensive literature survey was conducted by IIT, based on which relevant technical information was incorporated in the report. The field study was carried out in TISCO group of collieries, Jharia coalfield (BCCL) and WCL. Studies were conducted to determine resistance due to pipes, ladder ways, shaft conveyance, shaft inlets and outlets. Friction coefficients of mine roadways and mine shafts were determined using the barometer method and trailing hose method, and combination of both. Resistance of fan drifts were also measured. Based on data so collected in the field, model studies of fandrift bend at shaft connection under varying air leakage through shaft top were also carried out.

With a view to provide guidelines for successful installation and execution of ventilation system for blind heading drivage, CMRS carried out the following studies :

Layout of various auxiliary ventilation system and analysing merits and demerits of each system.

Leakage rates for various conditions of fittings (clampings) in laboratory.

Resistance of right angle bend and coefficient of friction for new ducts in laboratory.

Characteristics curves for three types of auxiliary fan experimentally.

A total of 36 studies in 26 auxiliary fan installations were carried out in the field. Based on laboratory and field data, equations were developed for calculation of various ducts, and assemblies. Design criteria and procedure for designing simple and multiple fan systems were evolved and outlined. A nomogram to aid in designing simple system, was prepared. Operating procedures for multiple fan and precautions for reduction of leakage and recirculation were outlined in the report.

Conclusion

At IIT, a good literature survey has been done and provided in the report which may not be of much use for field application. The CMRS study on ventilation system design meets the objective of the project.

Scope of Application

Mining engineers responsible for successful installation and execution of ventilation system for blind heading drivage will get a guideline for proper selection, installation and operation of simple and multistage auxiliary fans.

PROJECT : Chemical Eradiction of Green Growth

PERIOD OF INVESTIGATION : April 1978 to December 1979

EXPENDITURE INCURRED : Rs. 0.07 lakh

IMPLEMENTING AGENCY : ECL/CMPDIL

Introduction

A large number of surface fires, particularly in the Jharia and Raniganj coalfields were initiated from burning of the widely growing variety of weeds such as, 'bontulsi' and 'phutus' (lantana) which have a prolific growth in the areas on waste coal heaps and carboniferous shale debris to be found in most old collieries. In fact at one time, the dry bontulsi weed was regularly used as a charcoal ingredient in manufacture of country gunpowder.

The project proposal was submitted by ECL to the CMPDI and a committee was constituted headed by the RD, RI-I Asansol, to examine the proposal. The committee submitted the following observations with recommendations :

2, 4-D mixed with 'Dalapon' as suggested by Dr Mukherjee of Indian Agricultural Research Institute, New Delhi, could be tried on an experimental basis to observe the efffectiveness of the chemicals on eradication of the weeds.

Imkemex, India Ltd., were to be requested to give a demonstration to prove the effectiveness of their 'Gramoxone' weedicide for eradication of the wild bushy and weedy growths.

Salient Features of the Experiment

Field Trial : Trials for eradication of weed growths were conducted between November 1977 and February, 1978, at Sounda 'D' and Central Saunda colliery (CCL) by Hamsons Pest Control Service, Bokaro Steel City, and in May/June 1978, at Barkakhana workshop (CCL) and Sanctoria mine (ECL) by Imkemex India Ltd. The trials were successful.

Type of chemicals used : Two patented chemicals namely, Fernoxons and Gramoxone manufactured by Imkemex India Ltd. were applied in the trials. Both chemicals were found suitable to eradicate leafy bushes and plants, but not very effective against grassy weeds unless used in large doses. After discussion on the subject the Imkemex suggested that another chemical, 'Dalapon' (2-2 type Dichloro-propionic Acid) available with them, is very effective to eradicate grassy weeds (monocots). Field trial with Dalapon was not conducted as the scope of the experiment did not include removal of grassy weeds.

All these chemicals are post-emergent type. There are pre-emergence herbicides too, which are normally used in agriculture.

The dosage rates of chemicals depend on the type and density of growth of vegetation. The

typical dosage rate used in the experiments was 150 to 250 cc of chemicals in 10 litres of water with non-ionic soap solution like, Gental for a 500 m^2 of land area. The solution was applied by a manually operated sprayer. In case of sturdy and hard growths, the solution should also be painted on the stumps. The treatment is most effective if it is done during May to July, after the first showers when the seeds germinate. However, any rainfall within 48 hours of the treatment will tend to wash the chemicals away. In winter, weeds are in full bloom, and have a natural strength to withstand chemical treatment. If chemicals are used in this season, larger quantities should be used. It is desirable that mechanical cleaning is done first, and after removing the cut weeds, the chemicals are sprayed before the weeds grow upto an inch in height.

Conclusion

The softer growth may require 3 to 4 sprays and harder growths 6 to 7 sprays at internals depending on the reappearance of the growth. The land so treated will remain free of growth for about 3 years.

Scope of Application

Removal of the wild green growth surrounding a mine surface is necessary for the following reasons :

It obviates surface fire hazards. There are a number of instances in Jharia coalfield, where fire reached in coal seams as a result of burning weed growth at surface.

Surface drains built in the mine intake to conduct water to nearby 'jore' or 'nallah' (waterways) which often get blocked by wild plant growths. Due to such obstructions to the flow, large quantities of water find its way to underground workings. The eradication of the wild plant growth impeding the natural drainage will substantially reduce cost of underground pumping, and possibly, even save mines from flooding in the mansoon season. It may be mentioned in this context that regular subsidence surveys and surface water drainage monitoring should be carried out on a regular basis.

The chemical eradication is quicker and cheaper than manual removal of wild growth.

PROJECT : Study to Evolve Norms for the Safe Stacking of Coal

PERIOD OF INVESTIGATION : April 1978 to September 1982

EXPENDITURE INCURRED : Rs. 0.22 lakh

IMPLEMENTING AGENCY : CMPDIL/CMRS (Working Group)

Introduction

A seminar held in May 1976, deliberated on evolving practical method for prevention of surface fires, mainly coal stack fires. The assigned Working Group examined the deliberations and gave several recommendations with regard to research work on coal stack fires. One of the recommendations was to find out the safe height of coal stacks of different ranks, and the effectiveness of consolidation of the stacks. The related project work was started in April, 1978 and field trials were conducted in two stages with Jhingurda (CCL) coal fires, during February to July 1980, and again during July 1980 to Feb. 1981.

Salient Features of the Experiment

Coal stack heating mostly originates from spontaneous combustion, though the contribution from other extraneous sources, like contact fires, radiation heat from an adjacent hot source are also known. When the critical temperature of combustion is exceeded the coal undergoes a self-propellant oxidation, and at this stage it becomes very difficult to control the heating which eventually breaks into a coal fire. In a coal stack on fire there remains a mantle of heat build-up zone neither too near the stack surface, nor in deeper layers. The heat generated is normally dissipated with the air flowing over the surface of the stack, but with the ingress of air in deeper layers, the heat liberated is mostly retained, leading to a rise in temperature, and consequently enhance the oxidation rate. The depletion of oxygen in air thus caused, creates a suction, and further air entry is followed by further rise in temperature. The heat thus builtup would progressively move towards the interior of the stack, till an optimum distance is reached beyond which oxygen depletion occurs, and progressive heating is controlled. This results in a mantle of heat build-up zone. The German experience for ROM coking coal in unconsolidated stages is that the heat built-up zone lies between 1 to 3 m depths from the surface. From the CMRS studies with Bisrampur and Jambad coals (ECL), it is observed that the heat build-up zone for unconsolidated stacks with ROM sub-bituminous coals lies within about 1.2 m depth from the surface. In fact, the magnitude and depth of the mantle of heat build-up zone would depend on stacking parameters like the state of consolidation, size fraction, oxygen avidity of the coal concerned, ambient air velocity, ambient temperature and humidity, storing period, and also the dimension of the stack, particularly its height.

Field Trials Undertaken in India : Field investigations, making experimental coal stacks of different dimensions, were made with Jhingurda coal, at Singrauli (NCL). It was observed that a loose stack of coal, a little over 1 m high catches fire normally within one month's exposure. As size segregation was difficult, trials were conducted on ROM coal. In the first phase, spontaneous

heating on four stacks of coal with different dimensions and heights, and in the second phase, three stacks with different stacking parameters were studied.

From the experimental stacks of coal the following data were recorded and analysed.

Thermal surveys at 1 to 2 m depths from surface (within the heat built-up zone) were conducted through probes using mercury thermometers. The change in thermal profile of stacks were drawn and analysed.

Gas samples through perforated pipes inserted in the stacks were collected from 1 to 2 m depth from surface. Analysis of O_2 depletion and CO_2 formation in the heat built-up zone were carried out.

Conclusion

1. The safe stacking practice recommended to be followed are :

Keep the stacking ground level firm and well rolled and well drained. Plan stacking in a manner that the average direction of wind is along the length of the stack,

Keep away all sources of heat from the stacking ground,

Do not stack coals from different sources together,

Avoid stacking old coals with the freshly mined in the same stack,

Avoid stacking wet coal together with the dry coal,

Do not allow foreign materials like cloth, wood and organic waste etc., thrown on stacks,

Consolidate in stages of 0.5 m heights at a time after the coal is uniformly distributed on the stacking ground which would help avoiding segregation of different sizes in the stack,

Level the top surface of the stacks and close the multiple air channels as far as practicable to increase resistance to air currents,

Maintain the edges and the perimeters of the stack and prevent coal slides, or rolled out large coal to stay for long periods.

2. Consolidation by dozing and shaping a proper slope angle of the stack would appreciably remove the spontaneous risk even with ROM coal. The recommended processes are given in the following :

Normal consolidation by pressing with a 8-tonne dozer would suffice for a month's storage; semi-consolidation can be achieved by dozing with a dozer, and also pressing the side slopes for a 3 to 4 month-storage; for longer storage periods, full consolidation of stack is to be done by dozing with 13-tonne dozer at different stages and also pressing the size slopes. The shape of the stacks will also change according to the degree of consolidation desired.

The stack slopes recommended are :

	loading	*unloading*
normal consolidated stacks	$\tan^{-1}$ 0.2	$\tan^{-1}$ 0.7
semi-consolidated stacks	$\tan^{-1}$ 0.2	$\tan^{-1}$ 0.5
fully consolidated stacks	$\tan^{-1}$ 0.2	$\tan^{-1}$ 0.3

PROJECT : Study of Spontaneous Heating of Coal by CO-detector UNOR-1

PERIOD OF INVESTIGATION : April 1978 to March 1985

EXPENDITURE INCURRED : Rs. 4.09 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

Possibly, the most important parameter to detect spontaneous heating of coal underground during mining operations, is detection of CO (carbon monoxide) in the ambient atmosphere. The objective of the project was to study the spontaneous heating characteristics of coal seams. It was proposed to use a sensitive instrument (UNOR-1) to measure/monitor very low concentration of CO in the return airways of mines. The mines selected for study were Kottadih and Seetalpur (ECL). The Samla seam of Kottadih colliery, apparently highly succeptible to spontaneous heating, had been worked out in bord and pillar system, where the first installation of the instrument was made. The other study was conducted at the Hatnal seam of Seetalpur colliery being extracted by longwall advancing with caving.

Salient Features of the Experimental Set-up

Field Trial : The UNOR-1 apparatus works on the principle of absorption of infrared radiation by molecular gases within certain ranges of wave length. The instrument was tested, calibrated, and then installed underground at Kottadih colliery where the top slice of 2.4 m of Samla seam was being worked with blasting and manual loading at a retreating caving face with an average progress of 0.16 m per day (3-shift). The distance between the instrument and sampling point varied from 10 to 30 m. The position of instrument remained fixed but the sampling point was moved as the face retreated.

Conclusion

The UNOR-1 is a useful instrument for early detection of heating.

There is little likelihood of spontaneous heating occurring at a retreating longwall face worked in single slice without leaving coal in the roof.

Scope of Application

CO-detection equipment system and related methodology was established as a result of the experimental observations. Subsequently, with a follow-up procedure, the present requirement of the instrument was estimated, and purchase orders placed with the suppliers. Two such apparatus have been already installed.

PROJECT : Optimisation of Blasting Parameters in Coal Mines

PERIOD OF INVESTIGATION : July 1979 to September 1982

EXPENDITURE INCURRED : Rs. 5.55 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

Rock penetration and fragmentation in large opencast/surface miners have been a subject of assessment to optimise a cost-efficient system. To develop blasting efficiency, reduce the cost of blasting and evolve a scientific basis for determining blasting parameters in coal mines the CMPDI and IEL were engaged for a continuous joint programme of work in selected high-cost mines of the CIL. This resulted in substantial saving in the blasting cost and increased output per round of blasting.

Salient Features of the Experiment

Blasting Method and Technical Approach : Most of the underground mines use blasting off the coal face without any previous cut by coal cutting machine (solid blasting system) it required a precise layout of blast holes, sequence of initiation and estimation of the explosive charge in each hole. The complete system has to be properly designed for obtaining satisfactory results.

The basic principle of optimum blasting is to improve the blasting efficiency by adopting a suitable drilling pattern, and using the correct sequence of delay action detonators. It may be used to safeguard the deterioration of immediate roof under weak roof conditions, and to reduce the consumption of explosives.

Field Trials Undertaken : Experiments were conducted at Patherdih and Goluckdih (BCCL), and Walni (WCL) collieries. A wedge cut pattern for face blasting was followed in which the holes were drilled to form a wedge with also a central hole. Blasting of the central hole provided a free face for the adjacent holes put in line drawings plan and X-section.

Both wedge and fan cuts were initially tried, but the wedge cut was finally adopted in view of the convenience in drilling the pattern and obtaining higher output as compared to the fan cut.

Conclusion

The optimised blasting practice introduced during the trial showed considerable improvements in efficiency and cost reduction of the blasting over the existing practice.

The design of blast parameters is based on systematic analysis of each case keeping in view the geological conditions and mining parameters. A universally applicable design may not be possible to obtain.

Scope of Application

The optimisation of blasting parameters has a wide scope of application in the high-cost collieries of CIL of reduce the explosive costs.

PROJECT : Investigation on Spontaneous Fire Hazard and its Prevention (Jhingurda Colliery)

PERIOD OF INVESTIGATION : June 1979

EXPENDITURE INCURRED :

IMPLEMENTING AGENCY : CFRI

Introduction

The major constraints in coal extraction and project development in the Jhingurda area (NCL) are proneness of the low rank coal, high moisture, high volatile coals to oxygen adsorption, auto-oxidation and spontaneous heating. It had been reported that Jhingurda top seam coal very often caught fire within six to ten days of its mining and exposure to the inclemencies of weather. Even some of the coal faces in the working benches in the opencast mine were reported to be on fire. To investigate the reasons and suggest remedial measures to deal with mine fire, the CFRI undertook the project sponsored by CCL (at present NCL).

Salient Features of the Experiment

Field Trial : To collect relevant data, preparatory investigations based on a series of laboratory studies were made vis-a-vis auto-oxidation including crossing point and ignition temperature of the coal. The layout of the experiment was worked out based on a number of concepts earlier developed at CFRI on the basis of laboratory studies. The series of experiments were started from early June, and continued till late June 1979, when the rains had set in. The measurement of temperature at all the points of the five experimental faces was systematically taken as per schedule, right from the 'zero' day till the 18th day of experiment. One of the faces (face no. 4) was regularly drenched with water every fifth day as scheduled. Moisture samples were suitably drawn from the seven blank coal faces every third day commencing from the 'zero' day when all the experiments were set in motion.

Conclusion

The summary of findings is as follows :

(a) Virtually no significant rise in temperature was observed in any of the five experimental coal faces, despite their exposure for a period of 18 days to extreme conditions of the prevalent atmosphere, e. g., high temperature around 40°-50°C and low humidity ranging from 15% to 20% R.H.

(b) It was also observed that though the ambient conditions were most favourable for rapid desorption and loss of moisture from the coal faces, there was virtually no significant drop in the original level of bed moisture (about 18% to 20%) of the Jhingurda top seam in any of the coal faces.

(c) Interpolation studies on the variation of temperature with maintenance of moisture level in the coal face as measured upto a depth of 9" suggested that the immunity of the coal faces to occurrence of any active auto-oxidation and self-heating was perhaps, due to the protection conferred on the coal by high level moisture maintained in situ by the seam throughout the period of exposure and investigation. The concept and contention seem to be plausible in view of a similar finding earlier established in laboratory model studies on the role of moisture in controlling auto-exidation reaction.

(d) It was advanced that the apparently continuous loss of moisture from the exposed coal faces at Jhingurda, or for the matter in any coal seam, was perhaps replenished by the mass migration of water from the inner depths of the coal seam through capillary action, actuated by the unsteady equilibrium arising out of continuous desorption from the exposed faces. A low rank coal seam, like, the Jhingurda top, having as it does about 20% bed moisture can well be deemed as a vast water reservoir, which may be a perennial source of replenishing the moisture loss, because of usual percolation of ground water through rock strata overlying a coal seam.

(e) In view of the above-mentioned experiments, observations and interpretations, it was not perhaps unreasonable to conclude that a coal face, retaining as it does, a high level moisture, very often to its saturation level, if not to the level of its visible wet conditions by itself, could not undergo active auto-oxidation, and therefore be a primary site for the onset of spontaneous fire, unless of course some extraneous and unforseen situations were brought to bear on the faces.

(f) The above contention was lent support by the result obtained from the studies on isolated, small stacks of the same Jhingurda top seam coal, where significant rise in temperature by as much as 10° - 11°C had occurred in course of hardly three weeks on the peripheral core of the conical stacks. Such occurrence of incipient auto-oxidation was ascribed to the fall in moisture content in the outer layers of the stack. The loss of moisture from coal stacks was irredeemable and not replenished in situ as occurred at coal faces.

(g) The effect of boric acid, calcium chloride or oil-water emulsion which had been sprayed on three of the five experimental coal faces, was not discernible. Perhaps this was masked by the natural protection offered by the persistently high moisutre level maintained at the coal faces by capillary action from inside the depths of the coal seam.

The CFRI scientists concluded that coal faces of a seam in situ (e.g. Jhingurda top seam) retaining as it does, characteristic bed moisture can not spontaneously catch fire due to auto-oxidation reaction. Obviously the incidence of such fires at the quarry and the coal faces must be due to some other reasons.

Scope of Application

The conclusion drawn should be deemed as a prelude to a more detailed investigation which may be taken up in further extension of preliminary findings.

The investigations have provided some significant information about the features of coal–air interaction, hitherto unknown in Indian conditions, as are likely to occur at coal faces of a seam in situ, vis-a-vis what usually happens to an isolated stack of coal.

PROJECT : Investigation of Creep Properties of Indian Coals

PERIOD OF INVESTIGATION : July 1979 to October 1983

EXPENDITURE INCURRED : Rs. 0.82 lakh

IMPLEMENTING AGENCY : Department of Mining Engineering, BHU

Introduction

The objective of the investigation was to determine time-dependent and long term strength of a number of Indian coal measure rocks by direct long term method, and to find out stability of some short term methods for prediction of long term strength.

The study was necessitated because it has been observed that the strength and deformation of rocks are time-dependent. A rock may fail at a stress considerably below its usual compressive or tensile strength determined by conventional short term laboratory test, if this stress is maintained over a long period of time. Therefore, in designing structures which have to stand for a long time in such rocks, considerations of time-dependent effects become important.

Salient Features of the Experiment

Field/Laboratory trial : To study the creep properties, BHU had taken considerable effort in designing and fabrication of one double lever type loading rig and two hydraulic loading rigs. Time-dependent tests were carried out on Karanpura shale, Jharia coal and Singrauli coal. Coal and coal measure rock specimens were prepared and tested for apparent density, hardness, longitudinal wave velocity, triaxial strength, uniaxial compressive strength, modulus of elasticity, poisson's ratio, stress and strain behaviour and time-dependent test. Different test specimen were loaded in special creep testing rig at different percentage of their uniaxial compressive strength. The tests were terminated when no failure took place for about 100 hours though one speciment was loaded upto 1800 hours.

As the data found from time-dependent test is of considerable scatter, no meaningful conclusion could be drawn.

Conclusion

(i) Indian coal and shale show a good creep (i.e. deformation with time at constant stress) which can not be neglected while designing a structure in such rock.

(ii) Creep studies may be utilised in preparation of slope failure if original joint system interlock has not disappeared.

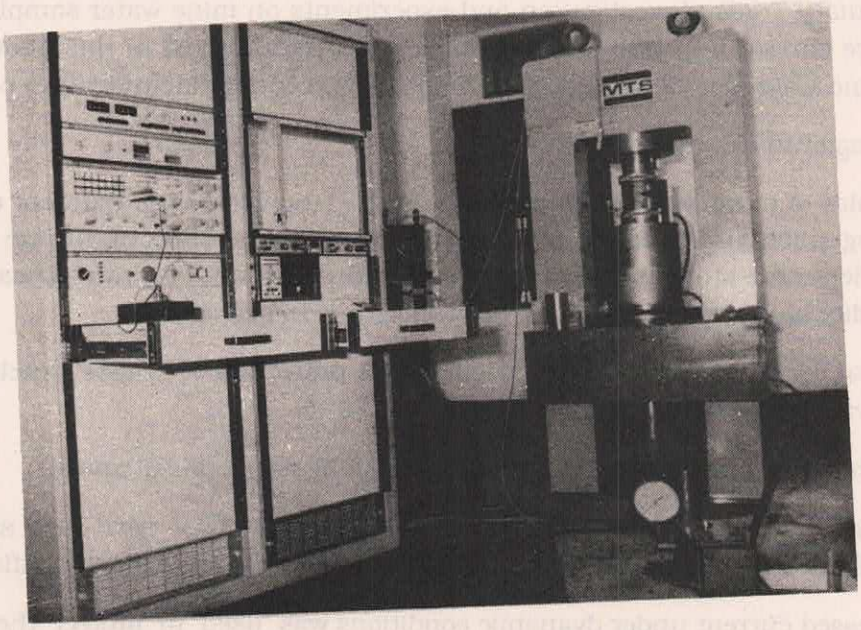
(iii) Based on short term strength, it is possible to predict long term strength.

(iv) Though Dilatancy method is more accurate, log stress - log strain or simply stress-strain method may be employed for quick determination of long term strength values.

(v) It was finally concluded that time-dependent strength by direct method is quite tedious and time consuming and it is not worthwhile to spend labour and time needed to determine it.

Scope of Application

Due to scatter data obtained, the project ended with a negative finding. For application of creep properties further study on more samples are required.



Triaxial Test Set-up to Study Creep Properties
(MT/28)

PROJECT : Corrosion Problem due to Mine Water its Cause and Prevention

PERIOD OF INVESTIGATION : July 1979 to December 1983

EXPENDITURE INCURRED : Rs. 0.80 lakh

IMPLEMENTING AGENCY : Department of Mining Engineering, BHU

Introduction

Problems of corrosion due to mine water in three opencast mines (Bina, Jhingurda and Gorbi) in Singrauli coalfield (CCL) were studied with the aim to find a proper remedy against corrosion of pump-impellers and other components in the dewatering machinery.

Salient Features of the Experiment

Field and Laboratory Trials : Investigation and experiments on mine water samples and corroded pump parts were carried and also artificial mine water synthesized in the laboratory was used representing mine water for determining methods of prevention/identification of corrosion.

The following studies were made :

i. Samples of mine water were prepared in the laboratory with different concentration of hydrogen ion and variation of SPM, and the corrosion effect on bronze panels and impellers were studied. The effect of suspended particle, hardness of water and turbidity on corrosion could not be studied due to lack of time.

ii. Several sacrificial anodes were tried for the protection of bronze panels in stationary artificial mine water.

iii. Further zinc plates were tried very successfully as sacrificial anodes.

iv. Scraped steel (annealed as well as unannealed) was used as sacrificial anode for the protection of bronze panels (static as well as dynamic) in artificial mine water.

v. Impressed current under dyanamic conditions was used to protect the impellers of the pump.

Conclusion

i. All abundant loose coal through which mine water passes should be removed from the vicinity.

ii. Cathodic protection to the pump using sacrificial anode and impressed current is a feasible remedy to prevent corrosion of pumps.

iii. Corrosion resistant material in the construction of pumps should be used more.

iv. The water treated with suitable chemical inhibitors and absorbents to get neutral or alkaline water having much less corrosivity, i.e. increasing the pH of water to approximately 7 (neutral water). This is only suitable for closed circulatory system. Inhibitors HPO_4^{-2} with concentration range of 0.1 to 1.0 was found suitable to arrest corrosion.

Scope of Application

The corrosion rate of impellers in a particular mine condition and corresponding impressed current to be applied between impeller and inert graphide electrode for maximum protection may be ascertained using the experimental set up installed at Department of Mining, BHU.

Since the pH of the water passing through exposed coal face and stack coal area is low (approx 3), an attempt to reduce acidity and hence corrosivity of mine water, all loose coal lying in the dumping area should be removed.

PROJECT : Establishment of Cavability Parameters of Coal Measure Strata with a view to Investigate the Feasibility of Applying Longwall caving

PERIOD OF INVESTIGATION : April 1981 to March 1985

EXPENDITURE INCURRED : Rs. 1.67 lakhs

IMPLEMENTING AGENCY : KSM, Kothagudem

Introduction

Before introducing longwall mining in large scale in Godavari Valley coalfield of SCCL it was found appropriate to know the caving characteristic of rock, which is an influencing factor for success of the longwall technology. With the above in view, the project was taken up to develop and establish laboratory and in situ facilities for determining physico-mechanical properties of coal measure rocks, and to analyse the results obtained from simulated model studies for establishment of cavability indices.

Salient Features of the Experiment

Laboratory Test : Based on a literature survey of Indian and international approaches of classification for cavability, laboratory tests were conducted. Facilities for physico-mechanical properties for in situ and lab specimens were established. Coal measure rocks were tested and equivalent material models with sand, lime and gypsum were simulated. In the model studies undertaken the simulation could not be made perfect.

Conclusion

The technique of laying the simulated rock from the prepared EQM mix needs perfection. There was a variation in properties of the samples of the mix prepared for model when compared with calculated values. Thus the project failed to achieve its ultimate objective.

Scope of Application

As the objective of the project could not be fulfilled, KSM was requested to contact CMRS to develop proper equivalent material before equivalent material model restudied and results applied in the field.

PROJECT : Development of Roof Supports for Mechanised Bord and Pillar Workings and Fast Drivages and their Field Evaluation

PERIOD OF INVESTIGATION : April 1981 to March 1986

EXPENDITURE INCURRED : Rs. 15.26 lakhs

IMPLEMENTING AGENCY : CMRS

Introduction

The major objectives of the study were the development of suitable supports for fast mechanised drivages and mechanised depillaring workings, supports for freshly exposed roofs and longwall gate roads, economical supports to replace wooden supports, drilling and bolting equipment for quick installation of roof bolts, and the development of reinforcement techniques for disturbed ground conditions, and keeping in view the need for mechanisation and the need to replace timber supports in underground coal mines, develop various support systems.

Salient Features of the Experiment

Field Study : In pursuit of objectives set in this project, strata movement investigations were conducted in various coalfields and suitable support designs were developed.

Strata movement investigations in freshly exposed roof in roadways with varying strata conditions were conducted at Lachipur colliery (ECL), Mithapur colliery (ECL), VK-7 Incline (SCCL), Bahula colliery (ECL). Based on the study of these four mines it was observed that the rate of movement became high within a few days after roof exposure. In poor roof conditions the movement was as high as 300 mm even within 24 hrs, and therefore, immediate support was required to arrest the bed separation.

The quick setting supports developed for freshly exposed roof included triangular steel chock with screw system, modified screw prop and recoverable bolt. The triangular chock (with screw jack) was found to withstand blasting effect at 1.2 m from working face. It was portable and could be used to support upto 3 m working height. The recoverable type bolt was designed for temporary support under freshly exposed roofs, and it was found to have an anchorage strength of 5 to 9 t.

For conservation of timber as well as to improve the effectiveness of supports, economical steel props and chocks were developed replacing wooden supports. A quick setting and economical pit prop as an alternative to wooden prop was also developed and field tested in over ten mines. Tubular chocks were developed for heights upto 2.5 m and they were found to have load bearing capacity of 40 t with 60 mm yield. They could be used in the junctions and at the goaf edge in mechanised depillaring. To replace timber chocks two types of square steel chocks were designed, one for 2.6 to 3.0 m working height, and another for 3 to 4.5 m height having bearing capacity of 40 t with yield values of 80 mm.

For difficult ground conditions such as, fault zone in Mithapur colliery, cement injection and subsequent reinforcement by grouting long ropes were found to be effective.

To keep pace with the fast development of mechanised drivages rectangular steel supports and resin bolts with W-strap were developed. Resin bolts with wire netting was experimented with a Jamadoba (TISCO, Jharia coalfield). In bad roof condition such as Venkatesh Khani (SCCL), resin anchored or inorganic cement grouted bolts along with steel channel, wire netting and steel props were successfully tried.

In mechanised depillaring these supports were tried successfully at Godavari Khani (SCCL), and Pathekhera mines (WCL).

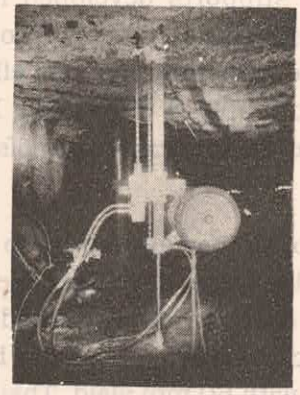
Roof stiching were tried successfully in longwall gate roads of Chinakuri 1 & 2 pits (ECL). Roof bolting equipment was also developed by CMRS.

Conclusion

The above developments fulfill the major objectives of the projects. Based on these studies guidelines for application of the various support measures under different geo-mining conditions have been evolved in the report.

Scope of Application

The recommendation made in the report will be useful for the practising mining engineers in the selection of suitable support systems. The use of the steel supports developed by CMRS is expected to achieve large scale reduction in timber consumption. Quick setting support system will go a long way in the mechanisation of coal mines in the country.



Pit props designed by CMRS in use to support harlage roads and depillaring areas
(MT/33)

Pegasus light-weight roof bolting drill
(MT/33)

PROJECT : Geomechanical Classification of Coal Measure Roof Rocks

PERIOD OF INVESTIGATION : April 1981 to March 1986

EXPENDITURE INCURRED : Rs. 2.23 lakhs

IMPLEMENTING AGENCY : CMRS

Introduction

To prevent roof fall accidents, proper support design is essential. A study made in this project to develop an empirical approach for roof characterisation to formulate support design criteria for rational selection of roof support.

A number of rock mass classification system such as, Rock Structure Rating (RSR) of Wickham, Tiedemann and Skinner, Rock Mass Quality (RMQ) of Barton, Lien and Lunde and Rock Mass Rating (RMR) of Bieniawski, are available. When their application was attempted in Indian coal mine conditions it was found that most of these approaches have certain limitations, and therefore unsatisfactory. Keeping Bieniawski RMR as base, a modified RMR design was formulated for Indian conditions.

Salient Features of the Experiment

Laboratory Study/Field Study : Extensive literature survey and field investigation in over 50 mines were carried out to collect data on the factors responsible for roof deterioration. On analysis of the data, five most significant parameters were selected for classfications. 1. layer thickness, 2. structural features, 3. rock weatherability, 4. strength of rock and 5. ground water seepage. Field and laboratory studies were undertaken to determine geotechnical properties of roof rock under different strata conditions. Borehole stratascope was used to measure layer thicknesses. In case of structural features the qualitative description of each discontinuous or anomalous features was designated an index number, and the combination of these numbers would give the total index for the structural features. Measurement of rock weatherability was done by slake durability index. Point load indices (S) were determined, and strength of rocks were taken to be fourteen times of the point index. Ground water seepage rate was determined by collecting water dripping through 1.5 m long hole drilled in the roof.

The weightages assigned for the above-mentioned five parameters were 30, 25, 20, 15 and 10 per cent respectively in order of importance. Based on further statistical analyses, appropriate ratings division was made for the index values/index numbers of the five parameters. Accordingly, after determining the geotechnical properties at each location, ratings were assigned for the parameters. Sum of these ratings gave the rating for the whole roof, called the rock mass rating (RMR). When there were two or more rock types in the roof, the RMRs of the different beds were combined by weighted average method as follows :

$$\text{Combined RMR} = \frac{\text{(RMR of each bed x bed thickness)}}{\text{(thickness of each bed)}}$$

The RMR (or combined RMR) of the roof may be adjusted, if necessary, to account for some special situations like depth, stresses and method of work. The final RMR obtained in this way is classified as below :

RMR	Class	Description
0 - 20	V	Very poor
20 - 40	IV	Poor
40 - 60	III	Fair
60 - 80	II	Good
80 - 100	I	Very good

Correlations were developed between RMR and the likely rock pressure. The empirical relation obtained between RMR and rock loads is :

Rock load = span x mean rock density x (1.7 - 0.037 x RMR + 0.0002 x RMR)

In addition, support systems were also correlated with the RMR, and support design guidelines were developed for each class of roof :

Class	General Support Systems
Very poor	Steel arches
Poor	Resin bolting with props and wirenetting
Fair	Roof stitching supplemented with bolting
Good	Regular bolting with full-column cement grouted bolts
Very good	Supports only in disturbed areas.

Elaborate guidelines for both temporary and permanent workings have been given in this report. Depending on these guidelines, proper support measures can be selected for any type of roof rock.

Conclusion

This study has provided a sound base for support selection, thus fulfilling a long felt need for a scientific approach to roof support interaction.

Scope of Application

The support design based on the classification has already been used in over 50 mines in all major coalfields of India, and its effectiveness shows its applicability.

Its main application is in bord and pillar development workings of coal mines, but it can also be successfully applied to depillaring areas and longwall gate roads with some refinement.

PROJECT : Pilot Study Project to Stabilise Water-filled Voids at Ramjibanpur Colliery

PERIOD OF INVESTIGATION : April 1982 to June 1988

EXPENDITURE INCURRED : Rs. 25.14 lakhs

IMPLEMENTING AGENCY : ECL/CMPDIL/ADDA

Introduction

Coal mining in Raniganj coalfield was first started in and around present township of Raniganj. Two coal seams had been worked at shallow depths and the whole area is now standing on pillars, galleries being mostly water logged. Percentage of extraction is roughly estimated to be 70% or more. A number of surface subsidence had been reported in the area and the Director General of Mines Safety declared the surface area unsafe. As cost of rehabilation of the inhabitants may be very high, there was a thinking of stablising unsafe mine workings beneath the township. The conventional stowing method of first getting access into water logged working to be stablised was considered unsuitable for the purpose. Mr H B Ghosh, formerly Chairman, ADDA tried a method in a laboratory model at Kunustoria Area office, ECL, and he could establish that water-logged underground voids could be stablised by sending sandwater slurry alongwith compressed air from surface. Based on this experiment, a scheme for stablising a part of Burra Dhemo seam working at Ramjibanpur colliery, (ECL) was submitted and approved. The objective of the project was (i) to find out a suitable method to stablise inaccessible water-filled underground voids from surface, and (ii) to find out a geophysical method to detect underground voids from surface.

Salient Features of the Experiment

A pilot study was undertaken in Burra Dhemo seam (R V) of reconsituted Ramjibanpur colliery having area of 232 m x 146 m. The seam thickness is 2.9 m having a gradient of 1 in 5.5, the depth of cover is 17 m to 41 m, pillar size 22 m x 22 m, and gallery size approx 4.5 m x 2.1 m. Total volume of void was estimated to be 2400 m^3.

A 250 mm dia borehole was drilled to a depth of 34.3 m and the hole was cased (ID, 200 mm) upto the roof of the seam. A stowing pipe (ID 125 mm) was installed inside the casing pipe in such a manner that the bottom end of the stowing pipe was 100 mm above the bottom end of casting pipe and the top end of the stowing pipe was 0.45 m above the top end of the casing pipe. The annular space at the bottom was kept open but at the top it was closed by an iron plate. Just below the top end, the casing pipe had a nozzle attached with it for sending compressed air to the bottom of the borehole through the annular space between the casing and stowing pipes.

A mixing vat (5.5 m x 3 m) made of cement concrete was made having a slanting base lined with iron plate. A screen was fitted across the width of the vat to prevent pebbles, weeds etc. from entering the stowing pipes.

Another borehole having 375 m dia was drilled to a depth of 37.35 m on the dip side, and was cased all through upto the roof of the seam. A submersible pump having 150 m head and 1362

1/min discharge capacity was installed in this borehole to dewater the seam. The discharged water was recirculated to the vat for slurry formation. For storage of water a 8 m^3 capacity overhead tank was constructed about 5 m off the vat. An air compressor having a working pressure of 8.62 bar was also installed about 5 m off the vat. Two tappings were taken from the compressed air receiver. One of the tappings was connected to the inside stowing pipe and another to the nozzle of casing with help of 25 mm ID hose pipe. The purpose was to send compressed air to the bottom of the borehole, either through the annular space or through central pipe or through both.

Two boreholes having 300 mm dia/250 mm dia were drilled on the rise side for outlets of air sent to the water logged workings through the stowing borehole.

The principle of hydro-pneumatic stowing may be briefly described as follows. First, sand will be thoroughly mixed with water in mixing vat and the sand water slurry will have a free fall through the stowing range. Compressed air will simultaneously be fed to the bottom of the borehole to mingle with sand slurry emerging out in the water logged gallery. Initially sand particle will be deposited at the bottom of the stowing borehole in a conical shape. The tip of the sand pile will get continuously broken by compressed air and sand particles will be carried outward of the pile aided by air bubbles on their way ultimately towards the air release boreholes located on the rise side. Air bubbles create intricate pathways above the partially deposited fill and the sand will ultimately fill the galleries upto the roof.

During the operation the stowing rate was recorded to vary from 14 t/hr to 55 t/hr with the compresse air pressure at compressor varying from 2.5 kg/cm^2 to 5 kg/cm^2. Thus through one borehole 17580 m^3 of sand could be stowed. To locate the unapproachable voids geo-physical studies were conducted. The first study by DC resistivity method using various electrode configurations were conducted when the galleries were not filled with water and the method was found unsuitable for the purpose. The second study in two stages was carried out by ISM and CMPDI using 'Gravity tower vertical gradient survey' method. The studies so conducted, though not claimed a success, were neither entirely discouraging. Further study is needed for obtaining more positive results.

To check the sand filling, six small diameter (75 mm) boreholes were put in the project area and heights of fillings were measured.

Conclusion

During the execution of the pilot project about 17580 m^3 of sand could be stowed by one borehole using hydro-pneumatic method. About 893 m^3 of sand was also stowed with help of small slurry pump (60 HP) through one borehole situated in the rise side. Thus out of 24000 m^3 of void in pilot project, 77% of void were stowed by both hydro-pneumatic and pumped slurry back filling method.

Scope of Application

Hydro-pneumatic stowing can confidently be used for stablising inaccessible and water logged workings underlying residential area and other larger built up localities, e. g., Raniganj and Barakar townships in W. Bengal.

A View of Surface Installation at Ramjibanpur P. S. Project - ECL
(MT/36)

PROJECT : Remote Sensing of Damodar Flood Level

PERIOD OF INVESTIGATION : March 1977 to February 1985

EXPENDITURE INCURRED : Rs. 1.65 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

Most of the coalfields under CCL, BCCL and ECL management are associated with one or more major river systems of which Damodar is one. So, it is an essential requirement to keep a close watch on the level of water in Damodar as well as the rate of its rise, i. e. the river water which is likely to threaten the nearby mines, particularly during the rainy season. This project concerned flood level warning of Damodar river.

A system was developed by BIT, Mesra, in co-ordination with PSE Cell of CMPDI, which could be used to continuously monitor the water level of the Damodar river, at remote catchment areas by radio telemetering the data to a central console station, so that precautionary measures could be initiated successfully in advance to protect the personnel and machinery underground.

Salient Features of the Experiment

Field Trials and Laboratory Work : The system comprised one central station and four remote stations. The central station consisted of an electronic console with display printer, transreceiver. A transducer immersed in water at a remote station gave out a proportional signal corresponding to the depth of water. The signal was processed and telemonitored by the electronic console and the transreceiver. All data received and processed by the central console were displayed and printed out. Sensing of the water level and telemetry of the data corresponding to the water level was done on a command signal from the central station.

The telemetry portion of the system was tested with the central station at BIT, Mesra, and the remote stations at SIRTDO complex and CMPDI which are approximately 15 kms away. This part was found to be working satisfactorily in the simulated conditions of water level.

The field trials at AK colliery of CCL could not be completed because of faults in the level sensor installed to detect the level of water in the Damodar river.

Conclusion

The total system worked satisfactorily except the sensor. It is suggested to obtain a proper sensor to monitor the actual level of water in the river.

Scope of Application

Because of floods in the rainy season, water in the Damodar river is mostly muddy with silt. Therefore, it has been difficult to identify a proper sensor which will give the actual depth of water in the river. It is suggested that an enquiry be made at likely sources for a suitable transducer to monitor the depth of water under these conditions. After such a transducer is obtained the total system can be made fully operational and indigenised to meet the requirements of mines which are being inundated in the monsoon.

PROJECT : Goaf Temperature Monitoring System

PERIOD OF INVESTIGATION : March 1977 to February 1985

EXPENDITURE INCURRED : Rs. 0.28 lakh

IMPLEMENTING AGENCY : CMPDIL

Introduction

Detection and assessment of spontaneous heating in a coal mine, and specially in goaves are very important from the safety point of view. Investigations have established that a rise in temperature in old working and goaves is a pointer to the heating in the area. Generally heating is accompanied by a progressive phenomena viz, appearance of haze, sweating of strata, gob stink, fire stink and ultimately smoke and fire. These phenomena can be observed and detected by human sensory organs. For effective and timely detection of heating, instrumental measurements should be made over a large area with a number of measuring points in a goaf with a continuous monitoring arrangement.

In view of the utility of measurement of temperature, a project on goaf temperature monitoring system was conceived by the PSE Cell of CMPDI.

The main objectives of the project were :

- Indigenous development of an efficient temperature monitoring system for goaf areas.
- Installation, field trial, performance evaluation of the system.

Salient Features of the Experiment

Field Trial/Laboratory Work : The system developed basically consisted of the following units :

Central console unit

Sensors with cable connections to the central console

The *Central console* unit was housed in a dust proof enclosure. The system worked on the property of the change in silicon semi-conductor junction parameter (PN) with temperature to detect the changes in temperature. Any small change in PN junction parameter due to change in temperature was detected as an unbalance of a balanced bridge. This change was amplified and directly displayed in a meter located at the central console station provided to monitor eight probes. Any of the probes could be selected by a manual switch at the central console.

Sensor : The PN junction was housed in metal casing which was installed inside the goaf. The construction of the metal housing was such that it could withstand the impact load of any local fall in the goaf. The sensor was connected to the central monitor by a cable, properly protected against the hazards in the mine.

Calibrating and Lab Testing : The total system was developed by SIRTDO at BIT, Mesra (Ranchi), and it had undergone rigorous testing in SIRTDO laboratory. The calibration of the system carried out by the developing agency was later inspected by PSE Cell of CMPDI.

The system was again tested in the PSE Cell lab and after stisfactory performance was put into field trials.

The system was installed in the following mines :

Saunda 'D' colliery (CCL) R & D longwall face

Dhemomain colliery (ECL)

Seetalpur colliery (ECL)

Conclusion

The conclusion was based upon the observations of field officials as well as the PSE Cell team.

- As a temperature measuring device, the system worked satisfactorily.
- During the field trial, it was found that the protection of the sensor and cable posed the major problem. Laying of steel pipes for protection of the cable was difficult.

It was felt that the existing sensing cables should be replaced by armoured cables for protection against roof falls.

Scope of Application

The maximum length of the probe from the central console was only 100 m. Hence it was felt that the present goaf temperature monitor was inadequate as the system provided for the assessment of goaf temperature of limited areas, and it is difficult to detect heating in more distant parts of the goaf. It was suggested that the aspect be examined in depth and modifications made to ensure its practical utility by improving its capability to cover the entire panel length. Also, the system should be further developed for onward transmission of goaf temperature data automatically to a central station at the surface with a display and printout facility.

PROJECT : Run-away Coal Tub Alarm System

PERIOD OF INVESTIGATION : March 1977 to February 1985

EXPENDITURE INCURRED : Rs. 0.80 lakh

IMPLEMENTING AGENCY : CMPDIL

Introduction

In most of the Indian mines coal tub trains are hauled up an inclined road by haulage. Accidental decoupling tubs in a train are likely to occur while they are hauled up the incline causing a run-away at high speed. To prevent such accidents a system was designed, known as 'Run-away Coal Tub Alarm System' for the safety of the workmen underground.

Salient Features of the Experiment

Field Trial/Laboratory Work : The system aimed at electronic detection of coal tub (s) when decoupled due to a mechanical failure while being hauled up the incline, with the provision of an audio-visual alarm being initiated under such circumstances. The electronic console of the system was put in an FLP enclosure.

The system consisted of the following :

FLP Electronic System

Transducer

FLP Lamp (110 V)

FLP Hooters (110 V)

Intrinsically Safe Track Change System (Optional)

The inductive type transducer was embodied between the haulage tracks and formed a part of the bridge along with the electronic system. The electronic system supplied an A. C. signal to excite the bridge. Whenever tubs are moved over the transducer, an unbalanced signal is produced in the initially balanced bridge. This signal was processed to D. C. output. Whenever the tubs decoupled due to any mechanical failure, the unbalance produced was more than the usual unbalanced signal when the tubs are normally hauled up. This unbalanced signal was processed to excite the FLP lamp and hooter to give audio visual alarms.

An optional feature was an intrinsically safe track change system. The unbalanced signal processed the tub decoupling was also utilised to change the track so that the decoupled tub would hit against the wall instead of running away underground.

Field Trial : After a successful test in the laboratory in simulated conditions the system was put

under field trials at Saunda 'D' mine (CCL). It was found to be working satisfactorily at various haul speeds.

Conclusion

Though the prototype was found to be successfully working in the mine when the transducer was kept at six inches from the bottom of a runway tub, it is suggested to improve the sensitivity of the system so that detection can take place at a distance of 12 inches which will be more suitable in the existing mine situation. It is also suggested that the enclosure for the transducer be made more rugged. The system was tested and developed only for tub run-away conditions. It is suggested that an intrinsically safe track changing system to be integrated with the system so that the run-away tub is automatically diverted from the main haulage tracks.

PROJECT : Automatic Coal Tub Weighing System

PERIOD OF INVESTIGATION : March 1977 to February 1985

EXPENDITURE INCURRED : Rs. 1.24 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

A large number of mines in CIL are incline mines. The coal from underground is transported to the surface by tubs by a haulage installed at the surface. The present method of measuring the mined coal is by counting the number of tubs assuming they are loaded to the full capacity. In order to determine the actual tonnage of coal produced, it is essential to weigh the coal in the loaded tubs. In view of this, a coal tub weigher and counter system was to be developed. The project aimed at accurately supervising the coal production by automatically counting the number of loaded tubs and weighing their payload.

Salient Features of the Experiment

The automatic coal tub weigher and counting system consisted of a weighing platform installed under the rail track near the incline mouth just before entering tippler. The platform supported on a group of load cells weigh automatically, with a manual back-up, when the tubs were passing over the platform. Four load-cells located at the four corners of the platform sensed the weight of the coal tub as it passed through the weighing platform. The signals from load cells were processed in the system for display and printout after adjustment of the weight.

Field Trial : The system developed by BIT, Mesra was successfully tested in laboratory for display and printout condition of the simulated weight. Subsequently the system was put into field trial in Bhurkunda mine (CCL). The transducer could not function properly as they were not able to withstand the actual mining condition. Further development was entrusted to Encardio-rite, Lucknow, a reputed manufacturing unit of load cell transducers.

The modified system was successfully tested in the laboratory and was put into field trials where it worked satisfactorily without print facility, even though there were some problems due to transducer not being able to withstand actual mining conditions. The firm was procuring a suitable printer for the above purpose.

Conclusion

The major problem faced during field trial was of a sensor that can withstand mining conditions of dust, heat, humidity, etc. Further attempts have to be made to improve the transducer performance to meet the rigourous conditions so that better accuracy can be achieved.

Further Scope

It is suggested this system be further developed using a microprocessor having a VDU (Video Display Unit) and printer so that statistical data regarding production on shiftwise, dailywise and weeklywise basis are available for the management to take appropriate decisions. A direction of logic may be also incorporated in the system to avoid mishandling by operators.

PROJECT : Development, Trial and Performance Evaluation of Auger-cum-Drill Machine

PERIOD OF INVESTIGATION : May 1983 to September 1987

EXPENDITURE INCURRED : Rs. 31.48 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

In the conventional method of gallery development in bord and pillar mining the coal faces are first cut by a coal cutting machine (under, middle or over cut), followed by hand held drilling and blasting. Coal cutting and sequential drilling operations are carried out by different sets of workmen. These two activities and delay in either operation in any form affects the total cycle time. In case of blasting off the solid coal face when the cutting machine is eliminated, there is some gain in productive time, but the pull obtained per blast is not very attractive. To overcome these problems the concept of auger-cum-drill machine was investigated for application with the following objectives :

- ensure directional drilling to achieve a better pull
- provide a free face by augering
- reduce manning and manual effort at the face.

In order to develop a machine to suit Indian conditions, CMPDI initiated discussions with a number of machine manufacturers, and ultimately selected Eimco Elecon (I) made machine.

Salient Features of the Experiment

The CMPDI with technical assistance of Eimco Elecon (I) Ltd developed a prototype crawler mounted auger drill. The technical parameters were formulated by CMPDI. An auger of 280 mm dia was designed to be mounted on a chassis of Eimco 625 B model side discharge loader which was selected for its heavy duty crawler. A Secoma drill rig, capable of drilling 45 mm dia holes to a depth of 2 m in any desired direction, was also mounted on the chassis. The drill was powered by a 48 kW FLP motor provided with hydraulic transmission. There was provision for reversing the direction of rotation of the auger in order to retrieve it in case of jamming. The auger had a two start helical design which helped in removing the cut coal and acted as a screw conveyor. The machine was equipped with a number of safety features, such as, low-fluid-level cutoff switch and high-fluid-temperature cutoff switch to protect the hydraulic system, pilot-operated push button station for remote start/stop of the gate end box, automatic grade retardation system on inlet part of traction motors to stop machine instantly in case of breakage in hose, etc. The machine also incorported a dust suppression arrangement for the auger as well as for the drill. All electricals used in the machine were approved by the DGMS for use in gassy coal mines in India. The machine was capable of cutting hard coal having a compressive strength of around 450 to 500 kg/cm^2.

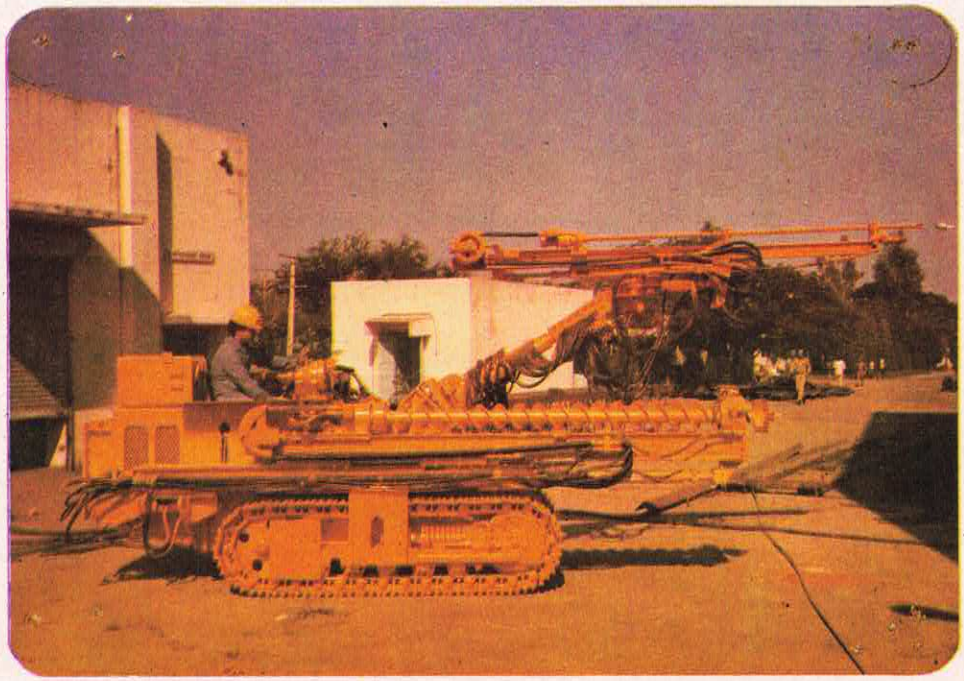
Field Trial : The first prototype machine was delivered at Churcha colliery (CCL) in February 1986. It was taken underground and commissioned in April 1986. On an average the machine gave 9 to 10 cuts per day which could be increased if sufficient number of faces were available. It is successfully working in Churcha giving an average pull of about 1.7 m per cut.

Conclusion

Project officials and the project coordinators at CMPDI were satisfied with the performance so far achieved by the auger-cum-drill machine. It should prove to be a satisfactory substitute for coal cutting machines and hand held drills.

Scope of Application

The machine requires a clear working height of 2.5 m for its operation in gallery development. It can be well manoeuvered within a gallery size of 4.5 m wide x 2.5 m high as it can take a spin turn within a gallery width of 4.5 m. A study done by an industrial engineering team reveals that the auger-cum-drill machine can be fully utilised if four shuttle cars and two mechanical loaders are deployed for a single auger-cum-drill machine.



Auger-cum-drill
(AE/27)

PROJECT : Hydrogeological Investigation

PERIOD OF INVESTIGATION : January 1977 to March 1985

EXPENDITURE INCURRED : Rs. 24.97 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

Hydrogeological conditions in the earth strata are always considerably disturbed during any mining operation, both underground and surface. Moreover, such hydrogeological disturbances along with the mining activity are likely to impose extremely grave situations, where caved or goaved (underground void) areas are formed. These may be in the form of sudden inflow of water into the mine workings and may consequently result in flooding of the mines, endangering safety of workmen and suspending production. Though extensive investigations on this aspect have been made abroad, only recently such scientific studies have been taken up in India.

Hydrogeological studies in coal mine undertaken by the CMPDI to predict water inflows were a pioneering effort in this regard. Investigation and subsequent analysis of the geological and aquifer hydraulics which are closely associated with mining parameters likely to affect operations, were made both in proposed virgin mining blocks as well as where actual mining was in progress. A mine drainage concept was developed and several models on inflow prediction expounded. As a result of the studies it should be possible to predict and interpret different mine conditions in the entire hydrogeological aspect.

PROJECT : Carbolite Coke Oven

PERIOD OF INVESTIGATION : December 1976 to March 1986

EXPENDITURE INCURRED : Rs. 4.35 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

The project was taken up to study the coke making properties of coal during the prospecting stage, under simulated coke oven conditions in laboratory using a 15 lb carbolite coke oven, and to assess the strength of coke from core samples in terms of micum indices, which determine the utilisation potentiality of the coal.

Borehole coal cores, five from the Jharia coalfield and six from West Bokaro coalfield were evaluated.

Salient Features of the Experiment

Each coal sample of 7 kg was crushed to a fineness of 75 to 80% through 3 mm seive. The gross moisture being maintained between 7% to 8% by adding water and keeping the bulk density to about 820 kg/m^3 required by standard coke oven charge. The sample coal charge was tamped down in a cardboard box (320 mm x 110 mm x 280 mm) and was introduced in the oven. The temperature was gradually increased in 2.5 to 3 hours to 900°C after which the charge was kept for further 15 mins at the same temperature. After coking was completed the coke was discharged, quenched, dried and taken up for different tests, viz : proximate analysis, phosphorus content and micum indices.

Since only 4 to 5 kg of coke could be obtained from each charge, micum test by standard micum apparatus, requiring 50 kg of coke could not be made. A micum apparatus was used for this purpose which was standardised with reference to tested coke samples collected from R & D Centre, SAIL, Ranchi.

The m 40 and m 10 indices of the coals from the Jharia coalfield were found to be 70 to 77.5 and 10.2 to 16.0 respectively. The ash percentage of the coke was found to be 21.2 to 27.2.

The borehole coal cores from seams VA and V of Jharkhand block of West Bokaro coalfield showed suitable micum indices for metallurgical industries. The ash percentage of the cokes ranged from 28.2 to 31.3. Results of these tests were found to be in conformity with the pilot plant analysis of the same seams from nearby areas.

Scope of Application

The 15lb coke oven is a useful tool to predict the strength of the ultimate metallurgical coke from borehole core samples, which helps in proper utilisation of coal in the metallurgical industry.

The potential coking coal areas in the coalfields can be identified in advance for exploration/exploitation and will expedite investment and planning decisions for future coal production programmes.

Discharge of coke from the Carbolite Coke Oven
(CE/2)

PROJECT : Introduction of Geophysical Logging for Coal Exploration

PERIOD OF INVESTIGATION : 1978 to 1983

EXPENDITURE INCURRED : Rs. 27.35 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

Coal exploration is heavily dependent on core drilling which is a time consuming operation. In some cases the core recovery is not optimum, and also some additional testing of borehole cores is required to be done for rock property estimations. The geophysical logging of boreholes has been found to be useful for accurately demarcating litho boundaries in boreholes and also for providing additional information on rock properties helpful for mine planning needs.

Salient Features of the Work

Two mobile geophysical loggers were imported under the scheme. The geophysical logging parameters like, self-potential, resistance, resistivity, natural gamma ray, density, etc, were recorded in a total of 216 boreholes including 47 non-coring boreholes in different coal exploration blocks. An improvement in the accuracy of the delineation of litho boundaries could be achieved by the experiment.

Conclusion

It could be demonstrated that geophysical logging is an important tool for achieving high accuracy in coal exploration. Identification of a coal seam and demarcation of its boundaries, lithological correlation etc. within a short time could be facilitated by this technique. The zones with poor core recovery could be adequately assessed with this methodology without recourse to re-drilling.

Scope of Application

This indicated enlarged application of the technique in exploration programmes. Five more geophysical loggers have since been procured for use in coal exploration work and geophysical logging has been integrated into the overall exploration plan in CMPDI.

PROJECT : Electrical Resistivity Survey for Sub-Surface Geological Mapping for Location of Coal Seam Incrops and Faults

PERIOD OF INVESTIGATION : 1978 to 1982

EXPENDITURE INCURRED : Rs. 2.24 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

The project was undertaken to test and establish a methodology to provide additional data for achieving greater accuracy in detailed exploration for coal. The Sonepur Bazari block (ECL) was selected as it was already explored by core drilling and could thus provide a base for assessing the efficacy of the methodology.

Salient Features of the Experiment

A low power (4 Watt) AC resistivity meter was used for electrical resistivity profiling over 8 profiles totalling to 15.5 like kms in an area with seam incrops and faults, with 12 to 45 m thick detrital cover. Various electrode configurations, namely, Wenner, Schlumberger, Half-Schlumberger and Two-Electrode were used for profiling.

Conclusion

All the coal seam incrops could be detected and some of the faults could also be inferred. It was established that the resistivity surveys could be of help in providing greater accuracy with possibly reduced drilling for delineation of coal seam incrops.

Scope of Application

The electrical resistivity method could, therefore, be employed in various coal exploration blocks where incrops of sufficiently thick coal seams are available below moderately thick detrital cover. The methodology has been integrated into the routine exploration practice in CMPDI.

PROJECT : Electrical Resistivity Survey for Sand Thickness in Part of Damodar River near Sudamdih, (BCCL)

PERIOD OF INVESTIGATION : 1978 to 1982

EXPENDITURE INCURRED : Rs. 0.53 lakh

IMPLEMENTING AGENCY : CMPDIL

Introduction

The objective of this project was to study the feasibility and efficacy of the electrical resistivity survey in estimating the reserves of sand occurring in river beds which are employed for sand stowing in underground coal mines.

Salient Features of the Experiment

In the Damodar river channel near Sudamdih (BCCL) boreholes were available giving the thickness of river sand available at each borehole point. 60 vertical electrical soundings (VES) were undertaken in an area of 0.3 km^2 with station intervals of 50-100 m. The sounding results were then compared with the available borehole data. The comparison indicated that direct correlation was not possible with sand thickness available from the boreholes and that indicated by VES.

Conclusion

Because of the leakage of electrical current through various random directions the VES method was not found suitable for estimating loose sand thickness in river channels.

Scope of Application

No further scope of application of VES for estimating sand thickness and reserves in river channels was therefore, indicated.

PROJECT : Seismic Refraction Survey for Sub-Surface Geological Mapping

PERIOD OF INVESTIGATION : 1978 to 1982

EXPENDITURE INCURRED : Rs. 3.20 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

The project aimed at exploring the efficacy and feasibility of seismic refraction survey methodology for locating coal seam incrops and faults to aid in making coal exploration more accurate.

Salient Features of the Experiment

The Sonepur-Bazari block (ECL) was selected for experimentation since drilling data was available to compare the results of the survey. 11 profiles totalling to 13.86 like km with spread lengths of 110 m to 220 m with geophone group intervals of 10 m and 20 m respectively, were employed for the experiment. A total of 5 shots were fired for each spread, two each at both the ends and one at the centre. The two end-on shots were taken with different off-sets. A 12-channel seismograph (Nimbus ES-1210F) was used with 14 Hz geophone and high voltage capacitance discharge blaster.

Conclusion

Adopting the interpretation techniques of Redpath (1973) the results were found encouraging. About 90% of all the incrop locations and faults could be detected by the survey.

Scope of Application

The methodology thus could be employed for areas with coal seam incrops under moderate detrital cover. The methodology has been integrated into the routine exploration activities of CMPDI. The survey could in addition help deduce the rippability characteristic of near-surface rocks to help opencast mine planners.

PROJECT : Geophysical Strategy to Solve Coal Exploration Problems in Jhanjra Area (ECL) Raniganj Coalfield

PERIOD OF INVESTIGATION : 1978 to 1982

EXPENDITURE INCURRED : Rs. 1.55 lakhs

IMPLEMENTING AGENCY : Centre of Exploration Geophysics, Osmania University in collaboration with CMPDIL

Introduction

The scheme was taken up to develop a multi-dimensional approach of geophysical surveys for rendering the coal exploration programme more accurate. No geophysical techniques were identified earlier for exclusive and specific use for coal exploration. The scheme, therefore, aimed at evaluation of the package of geophysical techniques and parameters that could be used for coal exploration.

Salient Features of the Experiment

The detailed geophysical surveys namely, gravity, magnetic, electrical resistivity profiling, electrical resistivity sounding and seismic refraction surveys were undertaken in Jhanjra block (ECL). The block had earlier been explored in detail by drilling and could thus provide the base for comparison of geophysical results.

Conclusion

It could be seen that the discontinuities of the shallow and deep basement depths could be inferred satisfactorily with the suite of geophysical techniques employed. The surveys could provide information on profile lines in addition to the point data available from borehole drilling.

Scope of Application

The experiment indicated that a large scope for application of all these methodologies exists in coal exploration depending upon the needs of exploration in a particular block. The methodologies have been integrated into the routine exploration techniques for coal in CMPDI.

PROJECT : Shear-wave Refraction Survey for Location of Sub-surface Voids

PERIOD OF INVESTIGATION : 1978 to 1986

EXPENDITURE INCURRED : Rs. 3.83 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

India has an old coal mining history and there are some old underground mine workings for which maps and details are not available which could pose a grave hazard for reconstruction or new mine development activities. The present project was taken up to explore the delineation of such unknown underground voids through seismic refraction surveys from surface.

Salient Features of the Experiment

The available ES-1210F Nimbus 12-channel seismograph used for experimentation in a shallow cover pit mine along with horizontal and vertical component geophones of 14 Hz capacity with spread length and initial offset of 20 m and 3 m respectively. Sledge hammer blows on a bar were used as the source of seismic energy. It was found that the seismic energy source was not strong enough to generate waves strong enough to penetrate sufficiently in depth. Enquiries from outside indicated that a suitable source will be too costly and the results not guaranteed.

Conclusion

The experiment of shear wave refraction survey for the location of unknown sub-surface voids could not succeed because of the weak strength of the seismic source deployed.

Scope of Application

Although it is theoretically possible to detect sub-surface voids with this methodology enquiries with International experts and manufacturers have failed to promise guaranteeable results. It would thus be necessary to explore possibilities of further experiments with allied survey methodologies.

PROJECT : Physico-Mechanical Properties of Rock and Coal from Exploration Data

PERIOD OF INVESTIGATION : 1978 to 1984

EXPENDITURE INCURRED : Rs. 4.42 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

All coal mining projects whether opencast or underground face difficulties arising out of heterogeneous behaviour of ground. To guard against such situations, geo-engineering investigations are necessary to evaluate the ground conditions.

This scheme was taken up to formulate a methodology and an instrumentation system, which would be simple and capable of generating geo-engineering data during exploration rapidly and economically. The work programme included (i) formulation of statistical models for estimating important geo-technical parameters, (ii) design of an instrument for rapid estimation of rock strength.

Salient Features of the Experiment

The angle of internal friction and cohesion are the two important rock properties required for a mine design. Under this scheme statistical models were evolved for estimation of these rock properties from uniaxial compressive and tensile data on which quicker and cheaper methods than the present practice of estimating these parameters from triaxial tests may be evolved.

A portable rock penetration tester was developed indigenously for rapid estimation of rock strength from chip samples of irregular shapes.

Scope of Application

The equations developed for the estimation of angle of internal friction and cohesion of rocks enable estimation of these properties from uniaxial strength data alone. These properties, therefore, can also be determined for thin beds which do not produce sufficient number of core samples required for triaxial testing.

The portability and the manual loading system of the rock testing instrument, make it suitable for field use. The cost and time required for these tests being very low, sufficient quantity of reliable rock strength index data can be generated quickly.

PROJECT : Development of Computer Based Geodata Bank for Coal and Lignite Deposits of India

PERIOD OF INVESTIGATION : April 1978 to June 1988

EXPENDITURE INCURRED : Rs. 23.00 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

The objective of the project was to create a computer based national geodata bank for coal and lignite deposits of India.

Salient Features of the Experiment

An overall system for computerisation of coal exploration data was conceived. The necessary codification and system design were made keeping in view the current and anticipated requirements. The prime-coking coal reserves, on a regional basis, of the Jharia coalfield (BCCL) were stored on magnetic tape. The methodology for capture, entry and validation of the archival borehole log data and current borehole log, and quality data was finalised. In the process, the system was tested with the data of three archival geological blocks and seven current geological blocks. These data were validated and stored on magnetic tapes. A system for drill machine utilisation and cost was implemented for MIS.

System analysis of the data from Singareni coalfield (CCL) was done to ascertain the suitability of the computerised system to those data.

The suitability of the designed systems for end use was established by testing them with the application software developed by CMPDI. The systems also stand tested for broad compatibility with MINEX, the software for coal exploration recently imported separately by CMPDI from Australia.

Conclusion

Systematic data capture is the first and the most essential step for an integrated computerisation of large systems. This helps easy and efficient storage and retrieval and more effective handling of voluminous basic geological data. This also results in greater uniformity in data reporting and quicker and better report generation. The system, if implemented routinely as designed, will immensely help the exploration geologists, though initially there may be some difficulty during transition from the manual to computer based system, when parallel maintenance of both the systems will be required.

Efforts made in this project will not only be beneficial for the geologists but will also provide a sound base for computerisation in mine planning for which prior computerisation of basic geological data is essential.

Scope of Application

The present data bank creation is on the basis of flat files. The same can be used to design a Data Base Management System in future. Establishing complete compatibility with the MINEX has to be tried after the MINEX software is fully commissioned at CMPDI.

Development of a data bank is a continuing process. No system, especially a large system, can be absolutely foolproof unless it is timetested on a routine basis. Future modifications/updating, if any, are to be taken care of as and when required.

PROJECT : Computer Software Package for Plotting Geological Contours and Cross-sections, and Estimation of Overburden Volume and Coal Reserves.

PERIOD OF INVESTIGATION : April 1978 to January 1983

EXPENDITURE INCURRED : Rs. 2.31 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

The main objective of the project was to develop a computer software for interactive interpretation of borehole data, plotting of contour maps and geological cross-sections, and to estimate reserves of coal and volume of overburden.

The project was carried out in collaboration with the Computer Science Dept. of Indian Statistical Institute, Calcutta.

Salient Features of the Experiment

The research work package was developed in the following seven modules :

1. Creation of a set of non-overlapping triangles with borehole location points as vertices, using the shortest distance method.
2. Location of missing seams in boreholes and entering the information in a tentative fault file.
3. Analysis of change in thickness of parting between seams and indications of faults, if any, to be entered in the tentative fault file.
4. Matching the fault information available in the master file with that of the tentative fault file as created in modules 2 and 3 and creation of a new fault file.

   Modules 2, 3 and 4 above may not need any interaction with the geologists, except for supplying certain input data as and when required by the system.
5. Drawing of contour plans (graphics) on the basis of the master borehole data for the concerned seam and type of contours. A geologist can breake input traces of possible faults, and the system redraws the maps incorporating these inputs. Such interaction is carried on with repeats till the interpretation is satisfactory.
6. Drawing of desired geological cross-sections of the basis of the master borehole data and fault file with display of possible fault locations. The geologist can interactively input/modify the faults and can supply the points of pinching/splits etc.
7. Modules 5 and 6 are highly interactive and the modifications by the geologist can be supplied through a thumb wheel cursor available on the keyboard of the graphic terminal.

The above package was developed and tested with small sets of test data.

Scope of Application

The package was developed on Dec. 10/90 system at IIT, Kanpur, but it can be implemented easily on VAX-11/780, which has been procurred by CMPDI, for routine processing of coal exploration data. Besides the advantage of a manyfold increase in speed and accuracy of data processing, this would enable geo-scientists to experiment with numerous interpretation models and thereby, improve the quality of interpretation of data. Application of the package would also bring in uniformity in documentation.

PROJECT : Computerisation of Geophysical Logs

PERIOD OF INVESTIGATION : 1978 to 1985

EXPENDITURE INCURRED : Rs. 1.82 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

Two geophysical loggers (Logmaster) were procurred by CMPDI under S & T project 'Geophysical logging for coal exploration (CE-3)'. These were equipped only with analog chart recording facility. It was proposed to design and fabricate a data logger attachment to the analog recording geophysical logger for coverting analog signals to digital form during geophysical logging, in the field itself. Recording the data in digital form on a computer-acceptable formated cassette tape recorder for subsequent computer processing and quantitative interpretation was to be incorporated. This project was carried out in collaboration with the Calcutta University.

Salient Features of the Experiment

An on-line digital recorder of analog signals was designed, consisting of a data logger system, which would sample and multiplex upto seven channels at a time from the analog data channels. The multiplexed data signals were digitized and fed to the micro-processor memory. The stored digits were loaded on to the tape in a format using Kansas City standard so that these could be subsequently processed in a computer.

A switch gain buffer amplifer stage was incorporated between the analog output unit and the data logger input unit to eliminate the background noise. The digital recorder system was tested at several stages and found to be satisfactory.

Scope of Application

The data logger attachment can record the signals in digital form on an audio cassette, and can be processed by the computer. This will facilitate rapid quantitative interpretation.

PROJECT : Installation of 5 tph Batac Jig at Patherdih Coal Washery (BCCL)

PERIOD OF INVESTIGATION : April 1978 to July 1986

EXPENDITURE INCURRED : Rs. 65.59 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

The present situation of expensive beneficiation of high ash coal demands that new techniques should be examined for their suitability for obtaining optimum recovery of clean coal on an acceptable techno-economic basis.

One of the oldest methods for mineral beneficiation is jigging. The jigging process consists of re-arrangement of particles having different specific gravities into stratified layers resulting from an alternate expansion and compaction of a bed of particles by a pulsating fluid flow followed by removal of stratified layers of clean coal and rejects.

The air-pulsated Baum jigs have been in wide use since the inception of mineral beneficiation, but have certain limitations of performance and efficiency. To improve these characteristics several radical modifications have been incorporated in the basic design, and the Batac jig was developed in the Federal Republic of Germany, and very successfully used in beneficiation of coal.

It was felt worthwhile to instal a pilot scale Batac jig plant to study its performance for Indian coals and generate data which may substantiate its incorporation in the proposed coal preparation plants. An experimental Batac jig plant was, therefore, installed at Patherdih Coal Washery (BCCL), in 1984.

Slient Features of the Experiment

The first performance test was carried out on the pilot Batac jig at Patherdih coal washery in Sept. 1984. The next four tests runs were conducted in Nov. 1984. Approximately 125 tonnes of a coal sample from the Jharia coalfield (BCCL) was washed in the pilot plant (Patherdih washery feed coal with approx. 30% ash) and the laboratory investigations were conducted at Patherdih coal washery Laboratory for the evaluation of Imperfection (Im). The average imperfection value of the pilot Batac jig obtained worked out to be 0.15 which entirely conformed to the guaranteed 0.15. The pilot plant also achieved its rated capacity of 5 tph.

Follow up Action

1. Based on its satisfactory performance, a Batac jig was installed at Rajrappa washery (CCL) and another two arranged to be installed at Madhuband (BCCL) and Kedla (CCL) washeries.
2. It was proposed to renovate the existing 3-tph heavy medium cyclone pilot plant installed at Patherdih coal washery. Therefore, testing of R O M coal in both these washing equipment, namely, Batac jog and H. M. cyclones would be conducted to generate data to be utilised while planning future washeries and modifying the existing ones.

Project Code : CP/10

PROJECT : Flocculation of Coal Fines and Clarification of Washery Water

PERIOD OF INVESTIGATION : July 1983 to December 1986

EXPENDITURE INCURRED : Rs. 10.36 lakhs

IMPLEMENTING AGENCY : Indian School of Mines, and CMPDIL

Introduction

The increasing percentage of fines in raw coal feed to washeries (present level is approximately 10%) have adversely affected the material balance in washing circuits in the currently operating plants, and create operational problems and jamming of thickeners which may result in complete shut-down of the plants for several days. Frequent bleeding of thickeners have become essential to avoid jamming. Recirculation of (suspended) fines laden thickener overflow water creates further problems in the processing circuit.

All these practical problems demanded comprehensive studies on flocculation of coal fines. It was felt necessary to take up an S & T project on the subject. The project was carried out in the Dept. of Fuel & Mineral Engineering of Indian School of Mines, Dhanbad, with assistance of CMPDI, Ranchi.

Slient Features of the Experiment

Bench scale tests were carried out, and later on pilot plant trials were conducted to confirm behaviour of coal samples when subjected to continuous operation. A pilot plant was setup in the Mineral Engineering laboratory of the ISM for this purpose.

Settling tests were carried out on the samples from the Barora, Bhojudih, Moonidih, Patherdih and Sudamdih washeries of BCCL to estimate the effect of various flocculents, flocculent dosage and pulp density.

It was observed by the project investigaitons that the settling rate increased by 10 to 25 times with increase in flocculent dosage upto 2 mg/1 at all pulp densities and with all the three flocculents used, viz., Magnafloc 1011, BASF 400 and Superfloc 127. It was also observed that the solid content in the overflow of pilot plant thickener decreases and at the same time the solid content in the underflow increases with the addition of flocculents till the optimum level is reached. However, indiscriminate addition of flocculents either remains non-beneficial or produces adverse effects.

Conclusion

In general, pilot plant results were found in close conformity with the bench scale test results which was quite encouraging. Magnafloc 1011 was found to be the best suited for all the samples collected for pilot plant tests.

Recommendations

Based on the overall findings of the investigations, the following were recommended :

i. All the washeries must incorporate a flocculent addition system in their dewatering circuits, with the arrangements to provide real time particle size analysis, pulp density of feed to thickener and automatic adjustment of flocculent dosing system. On line monitoring of these parameters alongwith overflow turbidity should be arranged.

ii. The choice of flocculent, its dosages level etc. are to be carefully made depending on the existing operating condition of the plants (tonnage being treated, pulp density of the feed slurry, feed size distribution etc.), and also on the objectives to be achieved (higher settling rate at maximum tonnage or optimal tonnage at minimum turbidity of recirculated thickener overflow water).

PROJECT : Testing of Coal Samples at the Photometric Sorter Installation in Canada

PERIOD OF INVESTIGATION : June 1985 to July 1986

EXPENDITURE INCURRED : Rs. 0.46 lakh

IMPLEMENTING AGENCY : CMPDIL

Introduction

In several advanced technology countries, like, Canada, Australia, Finland, Italy, South Africa etc. photometric ore sorters are being used for separation of various ores such as gold, chromite, limestone, feldspar, magnetite etc. from stone and gangue materials, on the basis of their different light reflectance characteristics.

It was felt that such an equipment might be suitable for separating stone and shale pieces from R. O. M. coals, especially, the non-coking coals, as a deshaler (a dry mechanical method of separation of coal from the associated shales material in the coal seam). At the 11th meeting of the erstwhile Standing Committee on Science and Technology (SCOST) held in October 1982 it was suggested that a team could be sent to test R. O. M. coal from several mines in the ore sorter installation in Canada.

Accordingly, representative samples of R. O. M. coal from Bina, Jhingurdah and Jagannath opencast mines (NCL, formerly CCL) were sent to RTZ Ore Sorter Ltd., Canada in September, 1984.

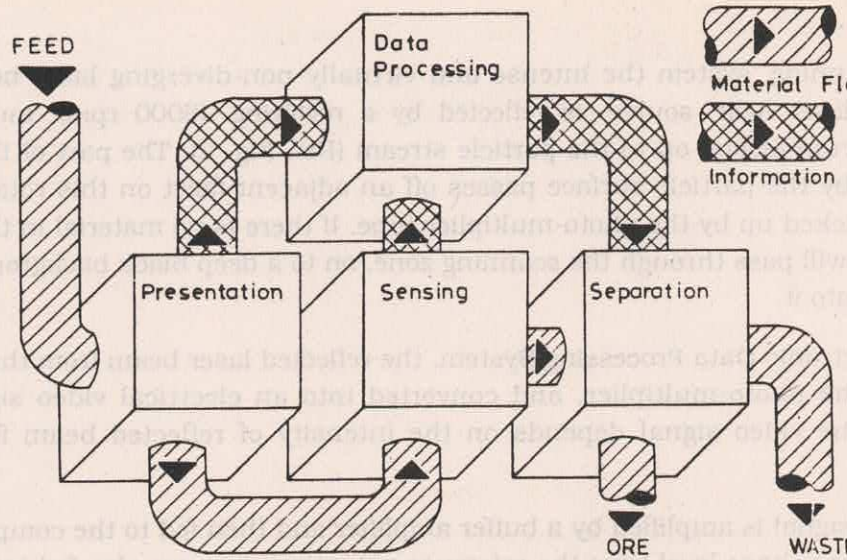
At the 4th meeting of the Standing Scientific Research Committee (SSRC) held in May, 1985, the committee approved of deputation of a team of two officials to Canada to attend the testing of coal samples so that the team could examine the adaptability of the photometric ore sorter for separation of extraneous material, i. e. shale and other impurities from R. O. M. coal. Coal samples which had already reached Canada were tested in the photometric ore sorter installation of RTZ Ore Sorter Ltd., Canada in presence of a two-member team from CMPDI.

Description of Photometric Ore Sorter : The Photometric Ore Sorter consists of four basic sub-systems, namely :

i. Feed presentation system
ii. Scanning/Sensing system
iii. Electronic data processing system
iv. Separation system

A schematic diagram of these sub-system is given in Fig. 1.

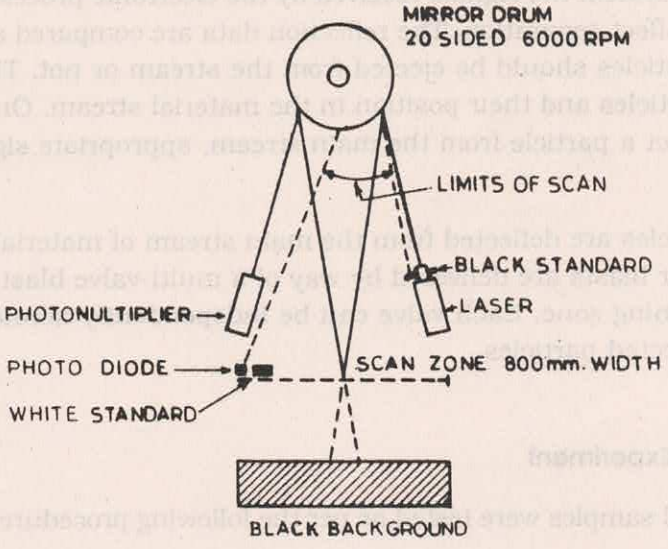
The feed presentation system presents the particle stream from a surge bin to the sorter by vibro-feeders as a mono-layer in random order, in such a way that no two particles touch each other. Each particle in the steam is kept in stable equilibrium while passing through the scanning zone.



PHOTOMETRIC ORE SORTER
(SUB - SYSTEMS)

Fig 1.

OPTICAL SCANNING SYSTEM



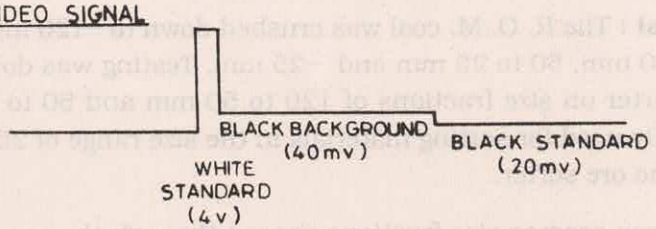


Fig 2.

In the scanning system the intense and virtually non-diverging laser beam emitted by a Helium/Neon laser light source is reflected by a revolving (6000 rpm) multi-faceted mirror (20 mirrored drum facets) on to the particle stream (Ref. Fig. 2). The part of the beam which is reflected back by the particle surface passes off an adjacent facet on this rotating mirror drum and is finally picked up by the photo-multiplier tube. If there is no material in the scanning zone, the laser beam will pass through the scanning zone, on to a deep black background roller and will be dissipated onto it.

In the Electronic Data Processing System, the reflected laser beam from the material surface is sensed by the photo-multiplier, and converted into an electrical video signal. The voltage amplitude of the video signal depends on the intensity of reflected beam from the material surface.

The video signal is amplified by a buffer amplifier and then fed to the comparator board. The pre-set reference voltage level from the reference potentiometers are also fed into the comparator where the video signal is compared with the reference voltage level from the potentiometers. The signal produced by the video rack when the reflectance levels are below a pre-set level, is defined as 'black level data' and when the reflectance levels are above the pre-set level, it is defined as 'white level data'.

All white and black level data for each material are fed to and accumulated in the Analyser board for programmable logical operation on these signals to provide an ACCEPT and REJECT decision.

In the Separation system the signals received by the electronic processor are used to compute the necessary data to affect separation. The reflection data are compared against pre-set values to determine whether particles should be ejected from the stream or not. The other data computed are the sizes of the particles and their position in the material stream. Once the decision is made by the processor to eject a particle from the main stream, appropriate signals are transmitted to the separation system.

The selected particles are deflected from the main stream of materials by means of blasts of compressed air. The air blasts are delivered by way of a multi-valve blast manifold located above and ahead of the scanning zone. Each valve can be independently actuated by the processor to clearly deflect only selected particles.

Salient Features of the Experiment

Three R. O. M. coal samples were tested as per the following procedure :

(a) Jagannath Coal : The R. O. M. coal was crushed down to −120 mm and screened into three size fractions, 120 to 50 mm, 50 to 25 mm and −25 mm. Testing was done with a 16/40 model of the photometric ore sorter on size fractions of 120 to 50 mm and 50 to 25 mm only because the model 16/40 is generally used for sorting materials in the size range of 25 to 100 mm. The −25 mm was not processed in the ore sorter.

60% of each of these coarser size fractions passed through the ore sorter and the remaining 40% was kept as reserve sample. The ore sorter was set to get 'accept' deshaled coal with 33-35% ash.

(b) Jhingurdah Coal : The tests on Jhingurdah coal were also conducted on similar lines of Jagannath coal.

(c) Bina Coal : Crushing and screening of Bina coal was also done as above. In order to test the flexibility of the ore sorter for producing the 'accept' product with lesser ash content setting of the sorter was done to get the accept fraction with 21.0% ash content of the coal.

Observations

i. From the 120 to 25 mm fraction of R. O. M. coal with ash content of 47.5% from Jagannath mine, 68.0% of deshaled coal with 35.0% ash could be obtained. The ore sorter could sort out 32.0% of reject with 66.0% ash.
ii. From the 120 to 25 mm fraction of R. O. M. coal from Jhingurdah mine with an ash content of 40.0%, 82.5% of deshaled coal with 33.5% ash could be obtained. The yield of rejects was 17.5% with 73.5% ash.
iii. From the 120 to 25 mm fraction of R. O. M. coal from Bina mine with ash content of 41.0% about 44.0% of clean coal with 21.0% ash could be obtained. The yield of reject was 56.0% with 57.5% ash.

Recommendations

The following were recommended :

i. Since the performance of photometric ore sorter as a dry deshaler, with a very high ash content non-coking R. O. M. coal has been found to be satisfactory, it is suggested the one photometric ore sorter may be imported in the first phase for installation at one of the mines in CCL/WCL which produce high ash non-coking coals.
ii. The plant will be available for testing of samples from different mines and may be taken as a project under the S & T programme for coal.

Follow up Action

In view of the above recommendations a proposal for installation of a photometric ore sorter, under the S & T programme, was put upto the SSRC for its consideration and approval.

The SSRC at its 7th meeting held on October 1986 observed the following :

As the coal were already been tested and results found satisfactory, it is not desirable to fund the project out of S & T grants as funds seem to be required essentially for procurement of equipment and trials. The procurement of the photometric ore sorter may be taken up as a coal company project and not out of S & T funds.

PROJECT : Trials of Beneficiated Non- coking Coal from Nandan Washery (WCL) at Satpura Thermal Power Station

PERIOD OF INVESTIGATION : October 1985 to December 1987

EXPENDITURE INCURRED : Rs. 215.12 lakhs

IMPLEMENTING AGENCY : CPEI, CMPDIL

Introduction

The continuous efforts by the thermal power plants during the last 12 years or so in reaching the optimum level of power generation while using untreated R. O. M. high ash coals were unsuccessful. This resulted in the realisation that high ash coals besides being low in heat value had other deleterious effects attending, which would always be a constraint to efficient operation of a thermal power plant. The main concern was erosion caused by the ash directly affecting the boiler performance. The equipment most affected were grinding elements of pulverisers, fuel piping, boiler convection heat transfer, induced draft fans and ash handling system etc. The continuous interaction between BHEL, CEA and CIL during the last five years or so, has resulted in the growing realisation of the urgent need to lower the ash content in the non-coking coals to help the power houses to improve the plant load factor.

It has been well established that coal washing offers multifold advantages to operation and maintenance of the major consumers, power sector and which have been time and again brought out by various study groups. But the power sector has not appreciated fully the benefits that will accrue from use of beneficiated/deshaled non-coking coal in thermal power stations and has been reluctant to bear the cost of deshaling/beneficiation. In order to establish, on actual basis, the economic advantages of using beneficiated non-coking coal for the power sector the project titled "Trial of beneficiated non-coking coal from Nandan Washery at Satpura Thermal Power Station" was taken up by Coal Preparation Engg. Institute CPEI/CMPDI under Science and Technology Scheme in 1985.

Silient Features of Experimental Set-up

Field Trials/Laboratory Experiments : Under this scheme, raw non-coking coals of Ambara Sasti, Sukri and Mohan collieries of WCL were identified for beneficiation in the Nandan Coal Washery. The Nandan Coal Washery primarily constructed as a coking coal washery, was selected for the beneficiation of non-coking coal as the washery had adequate spare capacity which could be utilised for this purpose. The non-coking coal from the sources mentioned were beneficiated in Nandan Coal Washery using coarse coal and fine coal jigs for 75 to 10 mm and 10 to 0.5 mm fractions of coal respectively, obtaining two products, viz. cleans and rejects. Slimes (-0.5 mm) was not beneficiated and was collected in slime ponds.

Coking and non-coking coals were washed in alternate fortnights of the month. While the one was being washed the other was being received and stacked.

The deshaled coal produced in Nandan Washery (NCW) was despatched to Satpura Thermal Power Station (STPS) where it was stacked separately for the trial. The trial with deshaled coal was conducted on Unit No. 8 of 210 MW capacity, installed in 1983, where the problem of less generation, greater mill erosion, and oil consumption existed resulting in frequent tripping of the unit. The trial was carried out continuously for one month with deshaled coal consuming approx. 85,000 tonnes during the trial period.

The problems relating to the plant utilisation factor, plant load factor, generation, coal consumption, support fuel oil requirement, number of coal mills required, auxiliary power consumption, coal mill rejects, boiler efficiency, functioning of CHP, smoke and dust emissions, ESP performance, maintenance of boiler and its auxiliary units, furnace wall slagging/boiler tube leakage/clinker formation/abnormal erosion etc. problems with raw coal feeders, scraper chain conveyor, clinker grinder and ash disposal system and alpha quartz, content were identified for the study and observation at the STPS end during the trial period.

The NPC prepared formats for monitoring the trial both at washery and thermal power plant end in consultation with NCW/WCL, STPS/MPEB, CPEI/CMPDI and BHEL.

The daily log sheets of STPS Unit No. 8 were suitably modified to cover all the information required in the desired format. On the basis of daily reports, weekly and monthly reports were made.

In accordance with the format, data were collected both at the washery and power plant ends. The monitoring of the trial at STPS and was done by CPEI alongwith representatives of STPS, WCL and NPC.

For proper evaluation of the data collected samples of coal collected at the washery end were analysed at the CPRI, Banglore, and CFRI, Nagpur, in addition to normal routine testing done at washery laboratory. The samples collected at the STPS and were sent to the CPRI, Banglore, CFRI, Bilaspur in addition to routine testing done at the STPS. Environmental Engineers Inc., Nagpur were engaged for carrying out measurement of the particulate emission from the boiler flue exit while using deshaled non-coking coal and raw non-coking coal. The final evaluation report was prepared by the NPC.

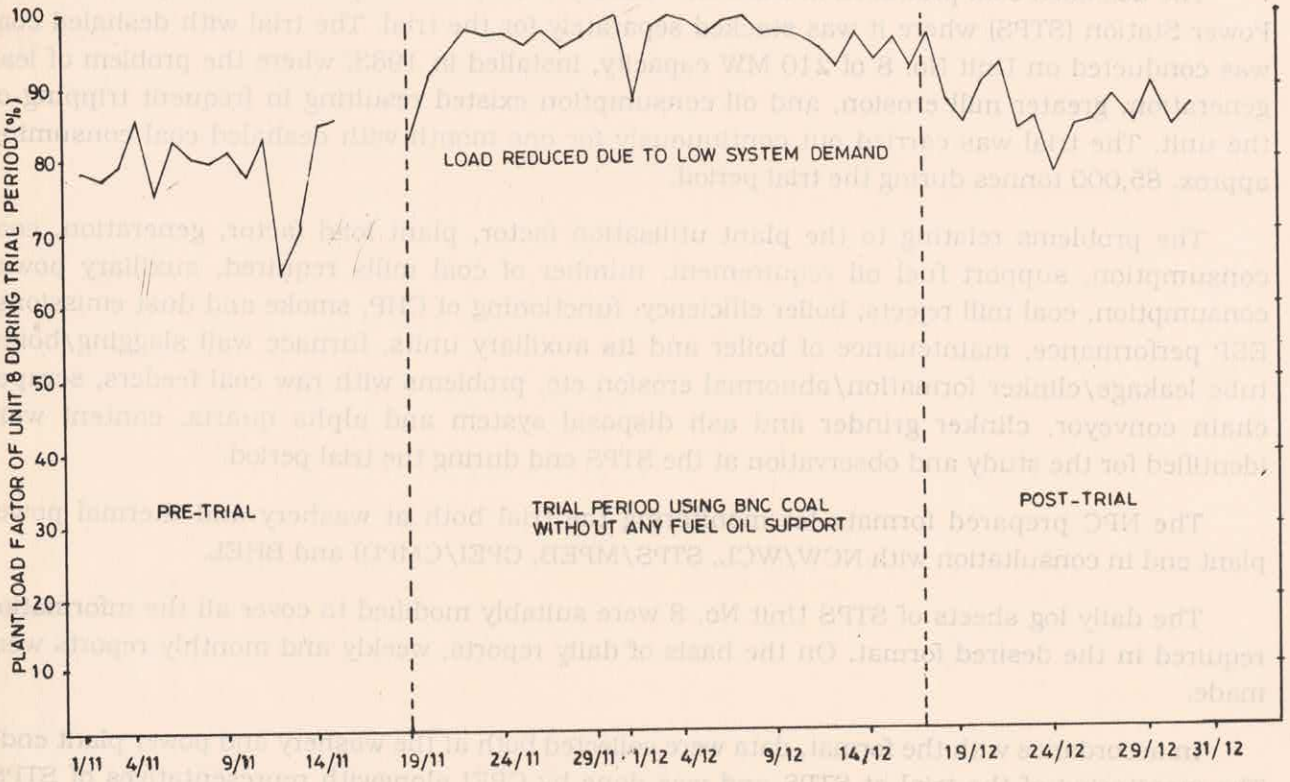
Coal Characteristics

The average ash and moisture content of R. O. M. non-coking coal deshaled at Nandan Washery was 43.4% and 3.7% respectively. The average ash content of the deshaled coal produced during the trial period was 31.69% and moisture 3.57% under air dried condition.

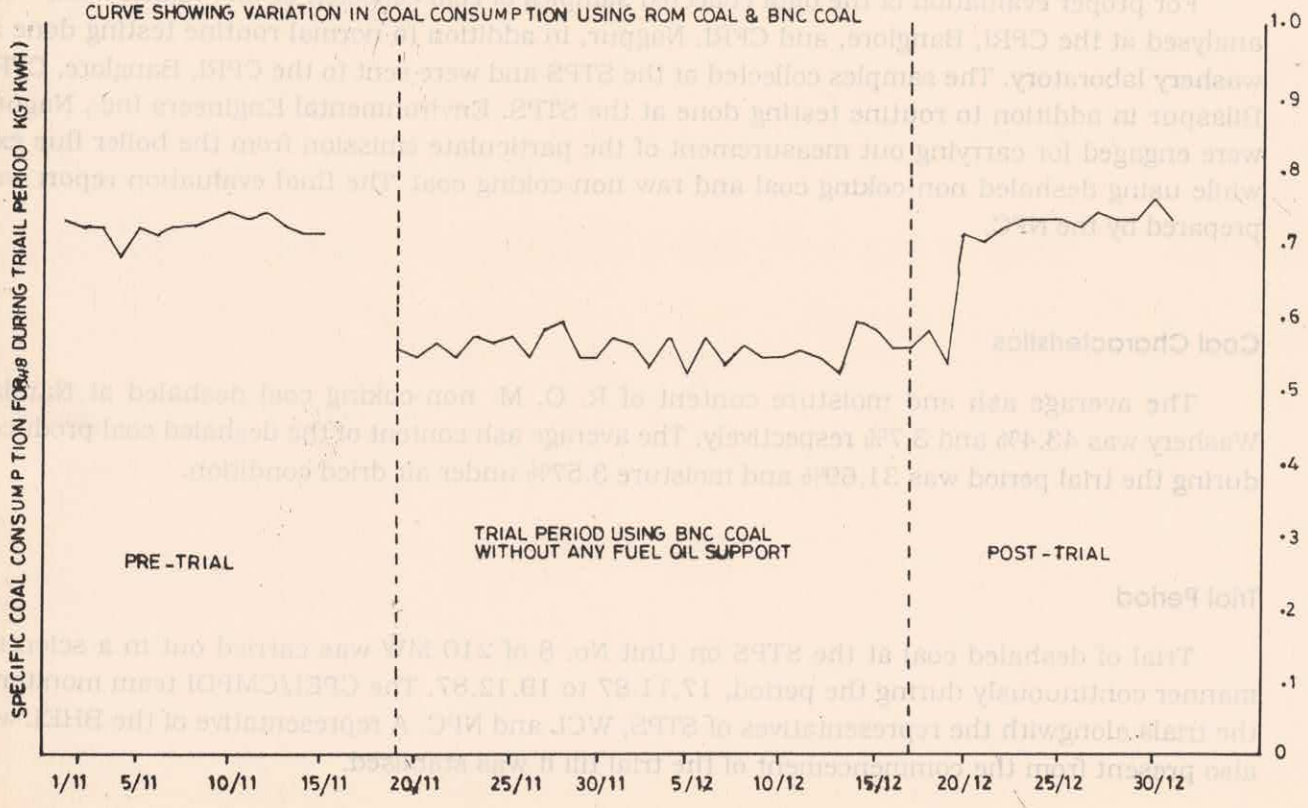
Trial Period

Trial of deshaled coal at the STPS on Unit No. 8 of 210 MW was carried out in a scientific manner continuously during the period, 17.11.87 to 19.12.87. The CPEI/CMPDI team monitored the trials alongwith the representatives of STPS, WCL and NPC. A representative of the BHEL was also present from the commencement of the trial till it was stablised.

DAILY PLANT UTILISATION FACTOR CURVE FOR UNIT 8 DURING PRE-TRIAL, TRIAL PERIOD & POST TRIAL PERIOD



CURVE SHOWING VARIATION IN COAL CONSUMPTION USING ROM COAL & BNC COAL



Conclusion

The performance of Unit No. 8 of STPS while using deshaled coal during trial period in comparison with that the same unit using R. O. M. coal during the period, 22.9.87 to 15.11.87, just prior to the trial, proved that the use of deshaled coal in thermal power station is highly favourable on the basis of the advantages established as given below :

1. Improvement in plant utilisation factor from 73% to 96%.
2. Improvement in generation from 3.71 MU/day to 4.83 MU/day.
3. Reduction of coal consumption from 0.77 kg/kWh to 0.553 kg/kWh.
4. Elimination of support fuel oil (from 5 ml per unit generated to nil).
5. Saving in the operation of coal mills, from 5 coal mills/day to 4 coal mills/day.
6. Saving in auxiliary power consumption from 0.088 kWh/kWh generated to 0.075 kWh/kWh generated.
7. Reduction in coal mills rejects from 0.35% to 0.031%.
8. Improvement in boiler efficiency by 2%.
9. Smooth functioning of the coal handling plant due to low ash content, uniform size and absence of stones and foreign materials.
10. Reduction in smoke and dust emissions from 29.78 g/m^3 to 17.23% g/m^3.
11. Saving in running maintenance of the boiler and its auxiliary units.
12. No furnace wall slagging/boiler tube leakages/clinker formation/abnormal erosion etc.
13. No problem with raw coal feeders, scraper conveyor chain and clinker grinder and ash disposal system.
14. Reduction of alpha quartz from 14.5% to 11.0%.

The most important realisation of the trial was the achievement of almost full load operation continuously on this unit with four coal mills in service, reduction in coal consumption, elimination of support fuel oil, practically no difficulty in ash disposal system and other auxiliary units with reduced ash/dust burden and smooth functioning of coal handling plant.

Techno-economics

The estimated annual savings due to the use of deshaled coal was Rs. 426.0 lakhs, as result of the benefits mentioned above. The calculations were based on the actual cost of deshaling at the Nandan Washery which was running at 45% capacity utilisation.

PROJECT : Studies on Beneficiation Characteristics of Non-coking Coal from Talcher Coalfield (viz., reduction in alpha quartz and ash content)

PERIOD OF INVESTIGATION : October 1986 to December1986

EXPENDITURE INCURRED : Rs. 0.82 lakh

IMPLEMENTING AGENCY : National Metallurgical Laboratory (NML) with CMPDIL

Introduction

Talcher coal has very high abrasive characteristics and consequently adverse effects on the operation of thermal power plants. This investigation was sponsored by the CMPDI to be conducted at NML at the instance of Adviser (Projects), Deptt. of Coal, Govt. of India and was directed primarily to see if beneficiation of such coal in terms of its ash content could simultaneously cause a reduction in the amount of alpha quartz content.

Salient Features of the Experiment

The beneficiation studies were conducted at the NML Jamshedpur on R. O. M. non-coking Talcher coal from Seam-II of Jagannath colliery (SECL) on the following two routes :

i. Laboratory float and sink tests on 100 to 0.5 mm 75 to 0.5 mm, 25 to 6 mm and -5 mm size fraction by heavy liquid separation.
ii. -10 mesh R. O. M. coal crushed to grinds confirming progressive levels of -200 mesh coal and treated in a floatation cell.

The alpha quartz in coal ash was determined by standard X-ray diffraction technique with the help of Philips X-ray diffractometer (PW 1130) and using Co-K alpha radiation.

Conclusion

The analysis of the results showed that alpha quartz particles are very much interwoven and closely associated with the other inorganic material. Beneficiation of the R. O. M. coal reduces the overall ash content with also a corresponding reduction in the alpha quartz content in the beneficiated coal.

PROJECT : Application of Indian Coals in Hot Briquetting (BFL Technology)

PERIOD OF INVESTIGATION : April 1978 to December1979

EXPENDITURE INCURRED : Rs. 6.11 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

Reserves of good quality coking coal in India as an input of metallurgical grade coke for conventional steel making process are scarce. This has directed developmental efforts towards its conservation through adoption of improved techniques of carbonisation or alternative technologies like 'Formed coke' where coking coal can be partially or fully replaced by non-coking coal to prepare a 'synthetic' sized coke for metallurgical purpose. One of the proved technologies for formed-coke making is Bergbau-Forschung-Lurgi (BFL), developed in West Germany. In this process, the plastic stage of coking coal (on heating) is utilised in making briquettes with non-coking coal in hot conditions. To assess the suitability of Indian coals for the hot briquetting process for the production of metallurgical grade formed coke, two coal samples from Gidi (CCL) and Girimint (ECL) were sent to Lurgi, West Germany for testing, and if found suitable, to prepare a Feasibility Study Report of installation of a 600 tpd formed coke demonstration plant (adopting BFL process). The report was submitted to CMPDI in July 1978. On examination of the report, it was decided that the final decision for setting up a plant would be taken after observing satisfactory performance of a similar plant set up by the British Steel Corporation. But due to some technical difficulty British Steel Corporation had to close down the plant and in view of this, the proposal was not pursued.

Salienf Features

The study report describes the individual process stages with reference to flow sheets, and includes technical data and a specification of the equipment. The process basically aims at production of metallurgical grade formed coke from non-coking coals in admixture with coking coals. The process is carried out in three stages. In the first stage, fine grained coal 0 to 10 mm, which is to provide the char component for hot briquetting, is dried, and carbonised. In the second stage, the hot char is blended with dried and crushed coking coal along with tar pitch (65% char, 25% coking coal and 10% tar pitch). The mixture is briquetted at a temperature of 500°C. In the third stage, the hot briquettes are cooled in a shaft cooler with circulating inert gases. The gas handling and tar separation are done in parallel streams. The design of the system adopted in this report is based on the high-volatile Gidi coal with 34.3% VM 9% (m.f.) to provide char component and on the Girimint coal with 37.5% VM (m.f.) as the coking coal component.

Scope of Application

Application of the process will help utilisation of coals, normally unsuitable for conventional coke ovens, for production of metallurgical grade coke, for conservation of high grade coking coals. The techno-economic viability of the system has to be evaluated before a commercial plant is installed.

PROJECT : Domestic Briquettes from Non-coking Coal Fines

PERIOD OF INVESTIGATION : April 1978 to August 1980

EXPENDITURE INCURRED : Rs. 0.96 lakh

IMPLEMENTING AGENCY : CMPDIL

Introduction

A scheme was evolved to explore the possibilities to develop a cheap domestic fuel utilising non-coking coal slacks, specially in terms of a reference made by ECL on the difficulties experienced for disposal of the slack coal from the ECL collieries, J K Nagar (Bogra seam) and Kenda (Dobrana seam). Samples from these sources were tested in CFRI to assess their acceptability for briquette making. After encouraging results of laboratory scale tests, detailed investigation on 5 t of slack coal from Bogra seam of J K Nagar colliery was made at CFRI. A feasibility report based on this technology was approved as an S & T project with a total budget of Re. 1 lakh for the 1978-79. As desired by ECL, this FR for setting up an experimental domestic briquette plant in J K Nagar industrial complex, for utilising the Bogra seam slack coal for a production capacity of 100 tpd finished product, was prepared.

Salient Features

The FR recommended setting up an experimental domestic briquette plant with the following features :

Capacity of the plant : 100 tpd smokeless domestic briquettes

Process : Briquetting of prepared coal mixed with bentonite binder, followed by drying and carbonisation of the briquettes

Coal input : −25 mm 145 tpd

Bentonite : 14.86 tpd

Estimated capital investment : Rs. 112.41 Lakhs (1980)

Working days/year : 330

Estimated requirement of power (per day) : 5000 kWh

Estimated requirement of water : 200 m^3 per day

Manpower : 119

Cost of production/tonne : Rs. 315.29 (1980)

Scope of Application

This technology merits two counts, viz :

Utilisation of non-coking coal slack having little outlet at that point of time and domestic fuel demand - may be met from non-coking coals available and obviate dependence on the supply of solid domestic fuel from West Bengal-Bihar regions.

Project Code : CU/5

PROJECT : Conversion of Lancashire Boiler to Fluid bed Combustion System

PERIOD OF INVESTIGATION : April 1978 to June 1981

EXPENDITURE INCURRED : Rs. 2.57 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

A collaboration project between Central Mine Planning & Design Institute Ltd (CMPDI) and Central Mechanical Engineering Research Institute (CMERI) was taken up to develop a system capable of using low grade slack coals to replace high grade sized coals in the existing Lancashire boiler of Mithani colliery (ECL) having a steam raising capacity of about 6000 lbs/hr at and from 100°C, which was identified for the conversion purpose. The ECL agreed to spare the boiler for experiment and share the expenditure of the project. It was arranged to be taken up under the S & T grant. Accordingly the FR on the project was prepared by CMPDI in April 1978 with assistance of CMERI and the approved by the CMD, CMPDI, and the Executive Committee of CMERI prior to taking up the project work from sept. 1978.

Salient Features

The boiler identified for conversion was of commercial size, and it was decided that a suitable retrofit combustor will be designed to keep the modifications to a minimum. The retrofit was to be designed, fabricated and tried as an adjunct to the existing boiler for the optimisation of the various parameters to attain a steam generation capacity from the boiler at least an equivalent. The design of the retrofit was finalised from laboratory investigation of CMERI and other supporting data available from published literature. The main emphasis was laid on

Fluidisation characteristics and feed point spacing

Bed material size and heat transfer characteristics

Carbon loss and combustion efficiency

Bed stability.

Scope of Application

This project assumed importance from the point of view of utilisation of inferior grade slack coals. On successful development of this system good quality sized coal which is being used for Lancashire boilers of conventional design could be made available to other industries which require higher grade coal. Techno-economic analysis based on the laboratory investigation data did not justify the investment and as such, the project was dropped.

PROJECT : Development of Coal-fixed Domestic 'Chullah' (oven)

PERIOD OF INVESTIGATION : 1979 to 1984

EXPENDITURE INCURRED : Rs. 2.35 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

With the objective of developing a suitable design of domestic 'chullah' which can use raw coal directly (in substitution of soft-coke), work on this project was taken up by CMPDI on its own at the beginning, whereafter the Indian Institute of Petroleum (IIP), Dehradun was also associated to participate as a sponsored project when the deveolpment work continued in parallel in both the organisations.

Salient Features

The design finally submitted by IIP, Dehradun could be assessed to be more suitable for the burning of low volatile (VM 18%) low grade coal directly. However, some modifications were done by CMPDI to suit the specific domestic needs. On the other hand, the design developed by CMPDI was considered suitable for the burning of medium volatile (VM around 25%) coals, both coking and non-coking.

Scope of Application

Considering the status of development achieved in terms of the scope of work outlined in the original proposal, further studies relating to the assessment of consumer's acceptance of the units was undertaken followed by mass fabrication of the chullahs and their distribution among consumers of different income groups. On examining the feed back information received from different users, it appears that potentiality did exist for both the designs subject of availability of sized raw coal at a reasonable price and the chullahs being available within the purchasing power of the consumers. In the context of present price structure of raw coal and soft-coke as well as the problems of making sized coal available to the domestic consumers, there is little prospect for its popularisation.

PROJECT : Coal-based Lighting Aid for Solid Domestic Fuels.

PERIOD OF INVESTIGATION : July 1979 to December 1980

EXPENDITURE INCURRED : Rs. 0.34 lakh

IMPLEMENTING AGENCY : CMPDIL

Introduction

With a view to avoid use of conventional domestic lighting aid like cowdung cake, wood etc which are responsible for the initial smoke formation during the lighting of solid domestic fuels, an R & D programme of producing a smokeless coal-based lighting aid was initiated under approval from the Ministry of Energy. Keeping in view the high reactivity of the low rank coals, two sources viz. Turra seam coal from Gorbi colliery of Singrauli coalfield and Hutar seam coal from Hutar colliery of North Karanpura coalfield were identified for conducting laboratory investigation at CFRI based on earlier work carried out by them. With the test data generated through laboratory and bench scale investigations at CFRI, an FR on this project was prepared by CMPDI in Nov. 1980.

Salient Features

Preliminary tests at CFRI with the two coals indicated technical potentiality in favour of Hutar coal, and as such, further tests were done with Hutar coal as the feedstock. The process steps considered in laboratory, were crushing the coal to 2 mm, preparation of smokeless high VM reactive char at the lowest possible temperature, grinding of char to −0.42 mm, mixing of char with oxidising agent and non-smoking binder followed by agglomeration of the mixture without application of pressure. The agglomerates thus prepared were dried before testing their suitability as smokeless lighting aid. Different oxidising agents like $MnCL_2$, NH_4NO_3, $NaNO_3$ and $KMnO_4$ were used with bentonite and starch binders. In the bench scale investigation different alternatives of carbonisation procedure were tested. Out of which the fluid-bed carbonisation (carbonisation with external heating and self-heating) was found to be the most suitable. Based on the laboratory test results, the char produced was crushed and agglomerated with 10% coal fine, 5% bentonite, 2% cooked starch and 0.25% $KMnO_4$ which was found to be the optimum composition.

Scope of Application

The laboratory and bench scale studies revealed that it was possible to produce a lighting aid with smokeless ignition characteristics utilising Hutar coal with additives. But installation of an experimental small scale plant was not recommended owing to the following reasons.

Sufficient technical data could not be generated in the bench scale at CFRI ;

the mechanical strength of the product was very low ;

the product was likely to be cost intensive due to expensive additives and a large number of process steps.

PROJECT : Feasibility Study of DKS Formed Coke Technology

PERIOD OF INVESTIGATION : July 1979 to October 1983

EXPENDITURE INCURRED : Rs. 0.85 lakh

IMPLEMENTING AGENCY : CMPDIL

Introduction

In May 1977, the CMPDI prepared a booklet entitled Basic Information and Data on Coals, for application possibilities of different technologies in formed coke making for metallurgical uses in India. In terms of this booklet, Sumitomo Metal Industries (SMI) of Japan showed interest in use of Indian coals for formed coke technology. Nine different coal samples from ECL and WCL along with coal tar-pitch (from Bhilai Steel Plant) were despatched to Japan in July 1978 for laboratory scale tests. The SMI furnished a mid-term report in Oct. 1978 followed by a final report in Nov. 1979. Later on after discussion with the SMI team of engineers and with encouraging the test results, the CMPDI intended to get a medium scale laboratory test and box coming tests done. The formal proposal to this effect for Rs. 2.0 lakhs was approved.

Salient Features

DKS (Didier Keihan Sumitomo) i technology for formed coke making uses a certain percentage of coking coal as a binder coal along with the base non-coking coal. In this process, both the base coal and binder coal are crushed to –3 mm blended, mixed with coal tar pitch at 100°C, briquetted and carbonised in sloped-bottom ovens.

After experimenting with coals from various sources in the laboratory scale, the SMI preferred to have prime coking coal of Dugda type as binder coal with non-coking coal of Chirimiri (WCL) as base coal for DKS formed coke making. The most suitable combination was found to be Chirimiri coal (un-washed) 50%, Dugda coal (washed) 40% and binder 10%.

For medium scale testing, an agreement was signed on the 30th July 1981 between the CMPDI and SMI, at a total fee of Yen 3.55 (equivalent to Rs. 1.25 lakhs) for testing with WCL coals as the base coal along with the binder coals from Dugda and Bhojudih washeries coal tar pitch. The report of the experimental results with recommendation was submitted in May 1982.

Scope of Application

The objective of formed coke making is to use non-coking coal for metallurgical purpose in replacement of coking coal. The test results revealed that only upto 50% non-coking coal can be used in the process. In the meantime, other technologies aiming at maximised use of non-coking coal in steel plant practice had went much ahead in the commercial application stage. In this context it was decided not to prusue with this project. If a future situation favours, this technology can be adopted for conservation of coking coal.

PROJECT : Development of Smokeless Coal-block

PERIOD OF INVESTIGATION : 1979 to 1984

EXPENDITURE INCURRED : Rs. 11.55 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

The coal-block is a shaped solid fuel prepared from inferior grade raw coal and coal washery by-products as feed-stock for meeting the fuel needs of various types of consumers both industrial and domestic. The blocks are easily ignitable, clean and easy to handle.

Salient Features

The feed-stock was crushed below 30 mesh, mixed with binder and oxidisers and charged in a hydraulic press to make coal blocks of 150 mm dia, 75 mm height with 19 vertical holes (15 mm dia each). The formation pressure was 300-500 kg/cm^2. This was done first at laboratory then at bench scale. The product was subjected to consumer's reaction trial at the Army establishment at Delhi with encouraging results.

Scope of Application

Those blocks produced on large scale can supplement the rising domestic fuel demand. In view of relatively better thermal efficiency, this may help conservation of low grade coking coal which forms the feed stock for the soft-coke making. This study justified the installation of a Demonstration Scale Plant, and in fact on being insisted by Army Authority one such unit has been set-up by CMPDI at the 48 AD Regiment New Delhi for demonstrating the working of the process to the Army trial team.

PROJECT : Carbonisation of Middlings from Bhojudih and Dugda-II washeries in Salem Hearth

PERIOD OF INVESTIGATION : July 1979 to July 1981

EXPENDITURE INCURRED : Not Claimed by Implementing Agency

IMPLEMENTING AGENCY : BCCL

Introduction

A technology for devolatilising coal was developed by Salem Corporation, USA and is being marketed by Lurgi, West Germany. This process has been applied abroad, mostly for the production of low VM coke for metallurgical industries and for the production of domestic coke. Two Indian coal samples were sent to Lurgi for tests with a view to establish their suitability in domestic coke making through this technology. Though it was possible to produce domestic coke out of Indian coal samples, the cost of production and capital investment was found to be unfavourable.

Salient Features

This process basically consists of carbonisation of coal in rotary shallow-bed hearth. Fresh feed supplied near the external edge of the hearth passes though the furnace in concentric circles, the residence time being around one hour. The volatile matter burns above the fuel bed maintaining a reducing atmosphere just above the bed preventing loss of the fixed carbon. The stack gas is made pollution-free through a post combustor. The temperature of operation is 1000-1450°C depending on requirement, and coking time is comparatively low than other standard processes.

Scope of Application

Although this technology has found wide application abroad mainly for metallurgical coke making and also for domestic coke making, it was not found to be an attractive proposition for domestic coke making due to high capital investment requirement and low market price for domestic coke in India.

Project Code : CU/12

PROJECT : Preliminary Survey for Potential of Desulphurisation of High Sulphur Assam Coals

PERIOD OF INVESTIGATION : April 1976 to March 1982

EXPENDITURE INCURRED : Rs. 0.23 lakh (April 76 to April 82 from CMPDIL funds)

IMPLEMENTING AGENCY : Indian School of Mines

Introduction

For removing sulphur from Assam coals, an attempt was made to desulphurise the coal by bacterial means and a three-year research project (April 1976 - March 1979) was undertaken by the ISM with the fund provided by the CMPDI. In this investigation, it was found that the bacteria ferrobacillus ferroxidans were very effective in removing both pyritic and sulfate sulphur in laboratory scale experiments under controlled conditions. Indication was also obtained that organic sulphur could be removed by bacteria capable of growing in Dibenzothiophene (DBT). For further investigation a two-year project (April 1979 - March 1981) was taken up by the ISM as an S & T project.

Salient Features

The experimental procedure consisted of :

Isolation of bacteria capable of growing in DBT.

Treatment of coal samples by the bacteria under controlled conditions.

It was found that the bacteria isolated from DBT culture are capable of removing not only organic sulphur, but also pyritic and sulfate sulphurs from coal. When a sample of coal from the 60 ft seam Baragolai colliery (NEC) Assam was treated with the bacteria isolated from DBT, 45% of the total sulphur of the original coal was reduced.

Scope of Application

Although preliminary test results were encouraging, some useful inference can be drawn only when tested in a large scale. Moreover economic viability of the process has also to be established before recommending any scope of the application. Further study on this subject is being planned.

PROJECT : Preparation of FR for Recovery of Tar from Bee-hive Coke Ovens

PERIOD OF INVESTIGATION : April 1983 to March 1984

EXPENDITURE INCURRED : Rs. 1.37 lakhs

IMPLEMENTING AGENCY : CMPDIL

Introduction

The 'bee-hive' coke oven has been named after the typical shape of a bee-hive. Unlike bye-product ovens, the bee-hive ovens are internally heated type where the heat of carbonisation is derived by combustion of the VM and to some extent fixed carbon of the coal charge in the oven itself. No bye-product is recovered from such ovens. However, capital cost of such ovens is much less compared to bye-product ovens.

In the existing bee-hive coke ovens, the tar coming out with the gas is wasted causing air pollution as well as loss of valuable bye-product. This situation prompted consideration for a developmental programme for an economic tar recovery system incorporated in bee-hive ovens to help improving the overall economics and minimise air pollution. A proposal for preparation of a feasibility report for setting up an experimental improved bee-hive coke oven plant with tar recovery arrangement was approved and the FR was submitted by CMPDI in March 1984.

Salient Features of the Experiment

The plant was proposed to be located in Bhowra colliery (BCCL) with a capacity of 30 tpd coal throughout (-3 mm size). The estimated daily production of hard coke, tar and fine coke are 21.375 t, 0.6 t and 1.125 t respectively. The total capital requirement was Rs 75.34 lakhs and Rs. 3.85 lakhs was the working capital (early 1984 estimate). The estimated production cost of coke, after credit for bye-product was Rs. 1040.20 (based on 200 working days/year) and Rs. 808.35 (based on 350 working days/year).

Scope of Application

The FR was examined in depth by the experts on the subject and doubts were expressed about the working of the system, particularly, with inferior quality coal use for beehive coke making. In the meantime CFRI claimed to have developed a faster type of beehive oven for carbonisation of substandard coking coals. In the opinion of the CFRI existing ovens can be improved for reducing air pollution. In view of above, experimental oven was not setup as planned.

PROJECT : Drying of Lignite and Extraction of Humic Acid

PERIOD OF INVESTIGATION : 1984 to 1985

EXPENDITURE INCURRED : Rs. 15.50 lakhs

IMPLEMENTING AGENCY : Centre for Applied Research & Development, NLC Ltd

Introduction

Lignite with around 50% moisture (as mined), if dried, yields a better fuel in terms of CV and reduces the transportation cost to the consumers. Moreover, the humatic material present in lignite, if extracted, may be used as a plant growth stimulator. In view of these advantages the Centre for Applied Research & Development (CARD), NLC Ltd, Neyveli initiated a project study of drying of lignite and extraction of humic acid with the Mining Research Institution of Belgrade, Yugoslavia. The report was submitted to NLC in April 1985.

Salient Features of the Experiment

The drying technique adopted was Fleissner process where sized lignite is first backed with hot water, and treated with high pressure steam and then with hot air. In this method, the size degradation was restricted.

In the other part of the study, investigation was made on the extraction of humic matters from lignite through alkali leaching at varying temperatures and pressures.

Scope of Application

The Yugoslav study revealed that for the Neyveli lignite, the Fleissner process was not applicable due to its friable nature.

It has been concluded that humic matter in lignite can be extracted using NaOH at ambient pressure in a simple mixing autoclave. But the humates thus obtained cannot meet the requirements of a fertiliser; they can atleast be used as soil conditioner. Further R & D work may be taken up to produce low cost fertilisers starting from these humates.

PROJECT : Noise Problem Arising out of Coal Mining Activities and its Abatement

PERIOD OF INVESTIGATION : April 1980 to March 1985

EXPENDITURE INCURRED : Rs. 0.90 lakh

IMPLEMENTING AGENCY : CMRS, Dhanbad

Introduction

Noise production is a part of industrial activity. The effect of noise on human being can result in loss in hearing capacity and other physiological and biochemical adverse effects. In coal mining industry, especially in the large opencast projects, the noise generated in the work place environment and that due to the frequent movement of heavy vehicles pervades the community life and may, in some cases, exceed the accepted community noise level for healthy living. The objective of the study consisted mainly of estimating the noise level to which the different categories of workers were exposed during their work and to identify the noise sources (machine/operation). Abatement measures of equipment could not be properly studied for lack of cooperation from manufacturers, which is very much necessary.

Salient Features of the Experiment

The study of noise problem was carried out in the following situations, viz,

i. in coal washeries and coal preparation plants,

ii. in opencast mining

iii. in underground coal mining

For assessing the noise level exposures of the workers the measurements were carried out near the worker's ear using a precision sound level meter coupled with a 1/3rd ocatve hand analyser. The measurements were taken with 'A' weighting mainly, though 'B' and 'C' weightings were also recorded for comparison.

i. Coal Washeries & Coal Preparation Plants

Noise level measurements were undertaken in four coal washeries viz, Kathara, Kargali, Patherdih and Sudamdih and also in four coal preparation plants viz, Dhemomain, Bankola, Jitpur and Girmint. The noise levels as recorded were as follows :

	Noise levels in dB		
Place	A weighting	B weighting	C weighting
Washeries	76 to 110	80 to 112	84 to 114
Coal Preparation Plants	76 to 108	79 to 98	81 to 102

ii. Opencast Coal Mines

Noise level measurements were recorded during operations of different machines, both during idling and operating. The observations were recorded inside and also

Noise Level Measurements in Drilling Operation
in an Opencast Coal Mine
(SE/2)

outside the operator's cabin. The study was conducted at Dhori, Parasia, Damagoria, Bonjamehari, Junkunder, Kusunda, Charnala, Kumarkhela, Purushottampur, Ghanashyam, Dalurband and Gopinathpur opencast project of ECL and BCCL. The noise levels recorded were as follows :

	Noise levels in dB		
Place	A weighting	B weighting	C weighting
Opencast Mines	73 to 104	82 to 108	82 to 120

iii. Underground Coal Mines

While recording noise level measurements in underground coal mines both Longwall and bord & pillar workings were covered. Wherever practicable, noise level measurements were recorded both near the machines as well as near the operator/attendant of such machines. The study was conducted at Chinakuri, Bankola, Kunustoria, Chemomain, Jitpur, East Katras, Sudamdih and Girmint collieries. The following table gives a picture of the noise level as recorded :

	Noise levels in dB		
Place	A weighting	B weighting	C weighting
Underground Mines	70 to 106	82 to 105	80 to 109

Conclusion

It was found that noise levels emitted by most of the machines exceeded the TLV of 90 dB (A) and the noise dosage exceeded the limit. The study revealed that it was not the maintenance or installation but the basic design of the equipment and machineries which are responsible for high noise levels. In some cases, a new machine was found to emit more noise than an old one.

The suggested abatement measures are :

i. proper insulation of the operators cabin,

ii. proper administrative control by way of reducing exposure time of individual workers to reduce dosage,

iii. improved design of machines,

iv. use of ear muffs and ear plugs by persons likely to be exposed at high noise level areas.

Scope of Application

The data generated during the study period leaves considerable scope for the coal producing companies to closely interact with the heavy earth moving machinery manufacturers to improve the design of the machines for reduction in noise levels.

PROJECT : Study of Effluents of Coal Washeries to Evolve Efficient Treatment Progress

PERIOD OF INVESTIGATION : December 1979 to December 1985

EXPENDITURE INCURRED : Rs. 1.96 lakhs

IMPLEMENTING AGENCY : CMRS

Introduction

The objectives of the study were the following :

i. Prevention of water pollution by effluents from coal washeries,

ii. Development of efficient and economic treatment processes for the effluents,

iii. Recovery of coal fines being wasted at present with the effluents.

Coal washery effluents discharged to inland surface waters constitute a serious threat to the quality of the receiving water, and reduces the potentiality of their immediate and subsequent beneficial uses. The Damodar river, which is the main source of water supply in the Dhanbad-Jharia coal belt needs special attention as it has already become one of the most polluted rivers in the country because of the discharge of untreated coal washery effluents.

Thus there is an urgent need for investigation of the extent of pollutant load with the effluents, identification of hindrances, if any, to the efficiency of the present treatment method to evolve modifications necessary to overcome such hindrances and also to evolve some more efficient treatment processes to prevent water pollution, and recover the large amount of coal fines now being lost with the effluents.

Salient Features of Experimental Set-up

The investigational work was carried out at Dugda, Patherdih (BCCL) and Kargali and Kathara (CCL) washeries. The study involved investigation in each washery mainly on

i. effluent formation and its treatment methods,
ii. physico-chemical characteristics of the washery effluents,
iii. evaluation of the efficiencies of the present treatment method,
iv. evaluation of effluent flow rate,
v. evaluation of amount of loss by the washeries in terms of coal fines,
vi. evaluation of pollutant load run-off,
vii. identification of hindrances responsible for improper functioning of the present treatment method and necessary modifications for improvement, and,
viii. development of a more efficient and economical treatment process.

Conclusion

The investigation revealed that a large amount of coal fines ranging from 10 to 200 tonnes/day is lost by each washery with its effluent and the amount of suspended solids going to river as pollutant with the final discharge of any washery ranges from 1 to 2.5 tonnes/day. The main hindrance for improper functioning of present treatment system seems to be the unscientific method of settling pond operation. No clarification area is allowed in the ponds. The effluent is sometimes allowed to flow through ponds already filled up with deposited solids.

The investigation led to the following recommendations for improvement of coal washery effluent treatment

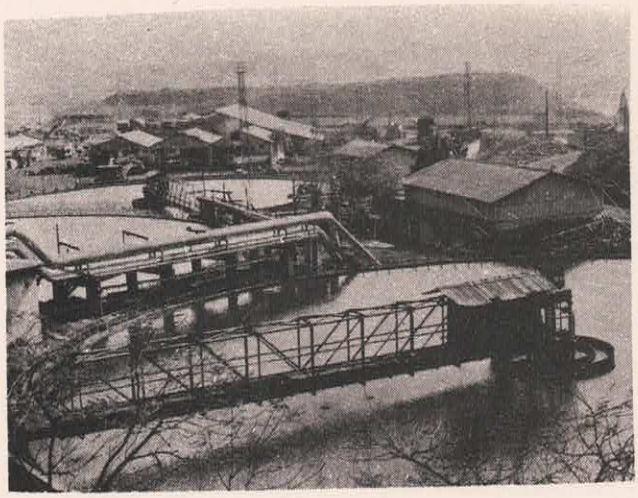
(a) Modification of existing treatment system,

(b) Modification of working system of ponds,

(c) Modification/reconstruction of settling ponds.

Scope of Application

The implementation of the recommendations arising out of the study will enable the washery operators to operate their units in an environmentally acceptable manner.



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