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Persons in the News

Shri Bhola Singh presently Director (Technical/P&P), Central Coalfields Ltd, has been selected for the post of Chairman and Managing Director, Northern Coalfields Ltd recommended by Public Enterprises Selection Board. Shri Bhola Singh started his career with Northern Coalfields Limited (NCL) in 1987 as Graduate Engineer Trainee. Working at NCL at early stage of career, benefited him professionally in achieving excellence in production, productivity, safety, environment and overall mine management. Sri Singh introduced Cast Blasting & Eco-friendly Electronic detonation in NCL mines too. He has published many technical papers on blasting and rock fragmentation in journals of national and international repute.

In 2008, Shri Bhola Singh joined AES (USA based MNC) as the Head of Greenfield mining project in Chhattisgarh. Later on, he worked for Manohar Coal Blocks allotted to Odisha Power Generation Corporation (OPGC). Before joining at CCL, Shri Singh has to his credit of working as Project Director at Sasan Power Limited having the distinction of being the country's first Ultra Mega Power Project (6X660MW) catered through a highly mechanized Moher & Moher Amlori Extension coal mining Project at Singrauli, Madhya Pradesh. Being at the helm of the affairs, Sri Singh was responsbile for delivering coal targets both qualitatively and quantitatively to maintain sustainable power generation which culminated in adoring the rare feat of supplying electricity to over 40 million customers across 7 states at the cheapest tariff in the world. During his stint, the coal mine touched new benchmarks and got prestigious National Safety Award from the Hon'ble President of India in 2017.

Indian Mining Industry News

COAL NEWS

INDIA'S COAL IMPORT RISES 50% TO 19 MILLION TONNES IN JUNE

India's coal import increased to 18.77 million tonnes in June, a 50% rise when compared to the same month last year. According to data from mjunction services, India imported 12.51 million tonnes of coal in June 2020. Import of coal through major and non-major ports dropped by 5.76% in June over May this fiscal. The data is compiled by mjunction, which is a B2B eCommerce that publishes reports on coal and steel sectors.

"There was a modest decline in import volumes in June which was on the expected lines. This trend is likely to continue during monsoon as the seaborne prices remain at multi-year high levels. Meanwhile, some buyers shifted preference from imports to domestic coal. It is to be seen if they hold on to it when seaborne prices stabilise," Vinaya Varma, MD & CEO mjunction services said. Out of all the imported coal in June, non-cooking coal increased from 8.28 MT last year to 13.05 MT. Coking coal also rose to 4.06 MT from 2.46 MT YoY. Coal import in April-June this year was 60.97 MT, a 32.13% rise from last year (46.14 MT).

COAL INDIA ARM NCL DISPATCHES 3.87 LAKH TONNES OF HIGHEST-EVER COAL IN SINGLE DAY

Coal India arm Northern Coalfields Ltd dispatched the highest ever coal in a single day on August 27, the coal ministry said on Saturday. "On 27th August, 2021 the company's offtake grew to a whopping 3.87 lakh tonnes," the coal ministry said in a statement. Northern Coalfields Ltd (NCL) also sent the highest ever, 38 coal rakes of Indian Railway to upcountry coal consumers of Rajasthan, Uttar Pradesh, Haryana, Gujarat, Delhi, and other states fulfilling the energy requirements of the country in this pandemic time. NCL dispatches its majority of coal through eco-friendly modes like Indian Railway Rakes, merry-go-round (MGR), and belt pipe conveyor.

In FY'21, NCL dispatched over 87 per cent of its coal through these modes of transportation. In a pro-environmental step, 24 per cent reduction in coal transportation from the road was seen in the last fiscal. Keeping up the pace with the growing demand for energy, NCL has dispatched 46.19 MT of coal till date with Y-o-Y growth of 17 per cent in 2021-22. The company has been entrusted with 119 MT of coal production and 126.5 MT of coal dispatch in this fiscal. In a step towards 'AtmaNirbhar Bharat', the company is also supplying coal as import substitution to Uttar Pradesh, Madhya Pradesh, and other state's coal consumers.

NORTHERN COALFIELDS TO SPEND RS 133 CRORE ON CORPORATE SOCIAL RESPONSIBILITY ACTIVITIES IN FY22

Coal India arm NCL targets to spend Rs 132.75 crore in the current financial year on corporate social responsibility (CSR) activities, the coal ministry said on Saturday. The company had spent around Rs 130 crore on CSR in 2020-21. Northern Coalfields Ltd (NCL), a company under the coal ministry, will impart training in plastic engineering trade to 500 youth living in and around the operational areas of NCL, and ensure their job readiness in the competitive market. The training will be organised with the help of the Central Institute of Petrochemicals Engineering and Technology (CIPET), Chennai, the ministry said in a statement.

NCL will spend Rs 70,000 per trainee under CSR for this residential training programme containing course fee, course material, uniform, training kit, accommodation and other overhead charges. The selected candidates will be imparted training in plastic processing, injection moulding, blow moulding and plastic recycling, by CIPET at its centres located at Bhopal, Gwalior and Lucknow. This training programme has been prepared as per the norms set by the National Skill Qualification Framework (NSQF) and approved by the National Skill Qualification Committee (NSQC). In this regard, a memorandum of understanding has been signed between the holding company of NCL, Coal India and CIPET, Chennai. For selection of candidates, NCL in association with CIPET has organised a two-day screening session at Nigahi and Khadia projects and subsequently, 345 eligible candidates were selected for the skill development programme. The remaining candidates will be selected in upcoming screening rounds. NCL operates with 10 highly mechanised opencast coal mines, and accounts for 15 per cent of national coal production. The company had produced over 115 million tonnes of coal in the last fiscal.

MINING NEWS

HINDALCO HAS $2.5-3 BILLION CAPEX PLANS FOR NEXT 5 YEARS: KM BIRLA

Aditya Birla Group's metal flagship company Hindalco has chalked out a capex allocation plan of $2.5 to $3 billion over the next five years, chairman Kumar Mangalam Birla said. “Hindalco has earmarked approximately $2.5-3 billion of growth capex on a consolidated basis,” Birla said, addressing the shareholders at the company’s annual general meeting. The focus of this framework, Birla said, is on pursuing profitable growth opportunities via organic expansions, strengthening the balance sheet through deleveraging, creating a clear road map for ESG, and overall stakeholder value enhancement.

In Novelis, the announced capex will be invested mainly in auto-finishing line expansions in the US and China and rolling and recycling capacity expansions in Brazil. In India, the company will implement organic growth projects entailing a capital outlay of over $1billion toward Utkal alumina expansion, various aluminium and copper downstream expansions, and speciality alumina projects. Birla said that the company has recommended a 300% dividend of 3 per equity share. “Hindalco reported a consolidated operating profit or EBITDA of ?18,896 crore, an increase of 22% year-on-year. Consolidated PAT on continuing business was ?5,182 Crore, a 38% growth, YoY,” he said.

“Your company announced its Silvassa extrusion facility this year to increase the share of VAP. This plant will service the fast-growing market for extruded aluminium products in the western and southern regions of India,” Birla said, adding that in the copper business, too, the shift toward value-added products continues. During FY 21, Hindalco brought down the consolidated net bebt-to-EBITDA to 2.59 times at the end of the financial year from a peak of 3.83 times at the end of June 2020, after closing the acquisition of Aleris. “The acquisition is a key step toward the diversification of the company’s downstream portfolio into certain premium market segments, particularly aerospace. After the acquisition; this year proved to be remarkable for Novelis (+Aleris) as it delivered its best performance,” Birla said. “We continue to see a strong demand across all our business segments, plants running at capacity, and improving margins, supported by better macros and operating efficiencies,” Birla said.

Hindalco’s ESG commitments for FY22 include achieving net carbon neutrality by 2050. “Net neutrality means for every tonne of carbon dioxide we put into the atmosphere, we take out one tonne from it, thereby achieving a balance,” Birla said.

TATA STEEL TO INVEST RS 3,000 CRORE IN JHARKHAND IN NEXT THREE YEARS TO EXPAND CAPACITIES

Tata Steel NSE expressed commitment to invest Rs 3,000 crore in Jharkhand in the next three years to augment capacities. The commitment was made at the launch of Jharkhand Industrial and Investment Promotion Policy (JIIPP) 2021 here, launched by Chief Minister Hemant Soren. The Jharkhand government aims to facilitate investment to the tune of Rs 1 lakh crore in the state and generate 5 lakh jobs through two days investors meeting that concluded.

"Tata Steel plans to invest Rs 3,000 crore in the next three years in Jharkhand with expansion of capacities of coal and iron ore mines and downstream value added steel portfolio," Chanakya Choudhary, Vice President - Corporate Services, Tata Steel, told PTI. Choudhary said Tata Steel was in Jharkhand for the past 114 years and it was home to the steel company. Soren said: "You all are part of Jharkhand family. And we want our family to grow further so that the rich identity of the state comes in front of the country and the world."

The chief minister said that an upgraded industrial policy has been prepared and it is a matter of pride that Tata Steel has expressed willingness to invest in Jharkhand. Tata Steel is Asia's first integrated private sector steel company dealing with mining to manufacturing and marketing of finished products. It is the flagship company of the Tata group and is among the top-ten global steel companies with an annual crude steel capacity of 34 million tonnes per annum. It has a revenue to the tune of Rs 1,84,191.47 crore.

It is the world's second-most geographically diversified steel producer, having operations in 26 countries and commercial presence in over 50 countries. The larger production facilities are in India, the UK, the Netherlands, Thailand, Singapore, China and Australia. Tata Steel Limited (India), Tata Steel Europe Limited (formerly Corus), NatSteel and Tata Steel Thailand are the operating companies within the Group. The company's raw material operations are spread across India and Canada, the key manufacturing functions are performed by the raw materials and iron-making groups, while the Shared Services provides maintenance support for a smooth production. Eyeing to attract big-ticket investments and make Jharkhand a leading hub for manufacturing of electric vehicles, among others, Jharkhand Chief Minister Hemant Soren had offered sops and facilities to mega industrial players including Tatas, Vedanta, SAIL, NTPC and Maruti Suzuki. "During one on on meeting with Tata Group officials, the Chief Minister asked them why can't they open an electric vehicles manufacturing plant in the state," an official privy to the meeting told PTI.

Tata Motors one of the leading automobile manufacturers, has one of its manufacturing plants already located in

Jamshedpur, Jharkhand. A Tata Group senior official said that the discussions centred around the proposed EV policy of the state and expansion of group activities in the state, and the group would soon come out with suggestions in this regard.

SAIL AIMS AT REDUCING NET DEBT TO RS 15,000-20,000CR IN FY22

Steel Authority of India Ltd is aiming at reducing its net debt to a range of Rs 15,000-20,000 crore in the current fiscal if the prices and demand for the commodity remain stable, a top company official said on Thursday. The Maharatna PSU has around Rs 30,000 crore net debt as of June 30, 2021, down from Rs 35,350 crore by end of the previous fiscal. "We are aiming at reducing the debt drastically from around Rs 30,000 crore now to anywhere between Rs 15,000-20,000 crore, depending on steel prices and demand situation," SAIL chairman Soma Mondal said on the sidelines of the inauguration of MSTC's new headquarters in New Town on the outskirts of the city. She was hopeful that demand will pick up in the coming months. Prices of flat products remain stable, while those of long ones are improving, Mondal said. Domestic steel major had decreased its net debt by Rs 16,131 crore to Rs 35,350 crore during the 2020-21 financial year. The company had announced that it would spend Rs 8,000 crore as capital expenditure during the current financial year. The steelmaker posted a consolidated net profit of Rs 3,897 crore for the April-June quarter of the 2021-22 fiscal, as against a loss of Rs 1,226 crore in the year-ago period.

ARCELORMITTAL TO INVEST RS 1 LAKH CRORE IN GUJARAT

The world's leading steel and mining conglomerate ArcelorMittal would invest Rs 1,00,000 crore in different projects in Gujarat, including its steel plant at Hazira near Surat, a Gujarat government release said. ArcelorMittal Chairman Lakshmi Niwas Mittal along with the CEO of ArcelorMittal Nippon Steel India (AM/NS India), Dilip Oommen, called upon Gujarat Chief Minister Vijay Rupani at Gandhinagar, the release said. During the meeting, Mittal "expressed his commitment to invest Rs 50,000 crore for the expansion of Hazira-based steel plant", said the release. Notably, AM/NS India had taken over the steel plant from Essar in 2019 following an insolvency proceeding initiated by lender banks. According to the release, Mittal is also willing to invest another Rs 50,000 crore in solar energy, wind energy and hydrogen gas production in Gujarat. In all, the group would invest Rs 1,00,000 crore in the near future in Gujarat, it said. Rupani welcomed the decision and assured to provide all necessary help, the release said.

TATA STEEL ANNOUNCES RS 270.28 CRORE ANNUAL BONUS FOR 2020-21

Tata Steel is set to shell out Rs 270 crore in annual bonuses for its employees, a press release from the steel major said. On Wednesday, the Tata Workers' Union and Tata Steel signed a memorandum agreeing on the bonus amount for the accounting year 2020-21. From the total payout of Rs 270.28 crore, various divisions at Jamshedpur including Tubes, an amount of Rs 158.31 crore will be given. The minimum and maximum annual bonuses have been set ar Rs 34,920 and Rs 3,59,029 respectively. T V Narendran, CEO & MD, Atrayee Sanyal, Vice President (HRM) and other senior executives signed on behalf of the management, while Sanjeev Kumar Choudhary, president, Tata Workers Union, Shailesh Kumar Singh, deputy president, Tata Workers' Union, Satish Kumar Singh, general secretary, Tata Workers' Union and other office bearers signed for the Union.

A Memorandum of Agreement has also been signed between the steel company and the Indian National Metal Workers' Federation (INMWF) and Rashtriya Colliery Mazdoor Sangh (RCMS). The total payout in annual bonuses at Coal, Mines and FAMD is Rs 78.04 crore. Another Memorandum of Settlement was signed on Wednesday between Tata Steel and the Tisco Mazdoor Union for Rs 3.24 crore approximately. The agreement was signed by Avneesh Gupta, VP (TQM and E&P), Atrayee Sanyal, VP (HRM), and other senior executives signed on management's behalf and Rakeshwar Pandey, president, Tisco Mazdoor Union, Adityapur, Shio Lakhan Singh, general secretary, Tisco Mazdoor Union and the other office bearers signed on Union's behalf.

INDIAN OIL EXPANDS JV WITH MALAYSIA'S PETRONAS TO FOCUS ON LNG PLANTS

Indian Oil Corp announced it was expanding its joint venture with Malaysia's state-run Petronas to include building liquefied natural gas (LNG) terminals, fuel retailing and gas distribution. IOC, the country's top fuel retailer, imports some liquefied petroleum gas (LPG) through IndianOil Petronas Pvt Ltd, its equal joint venture with the Malaysian firm. The state-run firm is keen to tie up with global firms, as it attempts to strengthen its grip in new cleaner energy areas such as hydrogen. "We are pursuing more such win-win associations with respective segment leaders to explore newer avenues of growth and gain competitive advantage in the future," Chairman S.M. Vaidya said at the annual shareholders meet. IOC is investing Rs 1 lakh crore ($13.49 billion) to raise its refining capacity by 25 million tonnes a year in next 2-5 years, Vaidya said, adding his company aims to maximise yields of chemical products.

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Optimal Capacity Utilization in Rail Transportation of Coal: Operational and Financial Implication for Coal India Limited

S.K. Sadangi*

ABSTRACT

Nearly half of annual dispatch of coal by Coal India Limited to its customers is done through rail mode. Freight charges paid to Railways for carrying coal is a significant part of the landed cost of coal incurred by customers. Rakes provided by Railways comprises of wagons that have a distinct Permissible Carrying Capacity (PCC) signifying the maximum weight of coal that can be loaded onto a wagon. Even if a loaded wagon contains coal lesser than the PCC, thus leaving idle capacity, Railways would still charge freight for load equal to full PCC. Freight charge for this idle capacity, sustained by the consumer, is reimbursed by CIL and its subsidiaries in fully in case of certain type of wagons while partly for others. The amount reimbursed to customers by subsidiaries of CIL every year on account of wagon/rake under loading has tremendous operational and financial implication, rising from a level of Rs. 332 Crores in 2014-15 reaching Rs. 772 Crores in 2018-19. While the real cause(s) behind under loading charge had rarely been understood in its entirety, the recent extraordinary rise was all the more puzzling since it was not associated with very little growth in rail-borne dispatch. Technological and contractual attempts to control under loading losses based on the prevalent hypotheses by some coal companies in past had largely failed to achieve the desired objective.

In the quest to comprehend the age-old phenomena of under loading a major data analytic exercise was undertaken in 2018-19. Prevailing hypotheses were tested on the touchstone of aggregate and granular data for their validity. The analysis enabled new insight, helped isolate the real causes behind it and devise systemic measures to arrest the trend. Revelation from this exercise succeeded in curbing the rising trend leading to substantial saving of Rs 333 Crores in 2019-20 and [1] 512 Crores in 2020-21 from the projected trend line without any investment in infrastructure or technology. The article discusses the dynamics of under loading, its operational financial consequence for CIL and data analytic exercises which can sometime reveal aspects of a problem that could remain untraced despite years of organization experience.

Coal is the most abundant fossil fuel in India accounting for 55% of the India's energy needs. Coal India Limited (CIL) is world's largest coal producing company with an annual production of 602 Million Metric Tons of Coal (FY 19-20) which accounted for 83% of national production of 730.87 MMT that year. In the same year CIL's dispatch was 581.2 MMT out of a national total of 706.77 MMT. CIL's Coal business is handled through seven of its wholly owned coal producing subsidiaries namely; Eastern Coalfields Ltd (ECL), Bharat Coking Coal Ltd (BCCL), Central Coalfields Ltd (CCL), Western Coalfields Ltd (WCL), South Eastern Coalfields Ltd (SECL), Northern Coalfield Ltd (NCL), and Mahanadi Coalfields Ltd (MCL). Its 8th wholly owned subsidiary, Central Mine Planning & Design Institute (CMPDI), functions as the planning and technical arm.

Dispatch: While CIL dispatches coal through 5 different modes i.e *Rail, Road, Belt, MGR and Rope*, the dominant mode is *Rail*. In FY 2019-20, dispatch through rail accounted for 282.4 MMT (48.6%) out of total annual dispatch of 581.2 MMT. The corresponding figures for 2018-19 were 304 MMT (50%) and 608 MMT respectively. Rail dispatch takes place at Railway sidings located near the mine(s) in "rakes" indented from Railway. A typical rake comprises of 59 wagons. Wagons in a rake could be of same or different design. Each wagon has a distinct "Permissible Carrying Capacity" (PCC) defined by Indian Railway depending on its design. The most common wagons designed for coal transportation have PCC ranging from 65 MT – 70 MT making a typical rake carry about 3835 to 4130 MT of Coal. In most mines the job of transporting the coal from mine's stock yard to the siding and then loading it into the wagons of a waiting rake is done through outsourced contractors. Loading of coal into a wagon is invariably done by mechanical "Wheel Loaders" or "Pay loaders" of different bucket capacities (3 /4/5 Tons etc.).

Freight: Freight forms a significant part of the landed cost of coal for a consumer along with royalty and various types of taxes. For some long-distance consumers, freight charge can even be more than the basic price of coal they buy from CIL. After a rake gets loaded and ready for

**CVO, Coal India Limited*

dispatch it is weighed on an Electronic In-Motion-Weigh Bridge (EIMWB) to determine to weight of coal carried in each wagon of the rake which is certified by designated Railway Authority in a document called RR Railway Receipt (RR). Along with various other details, RR stipulates the freight (if any) to be paid to railways for carriage of coal to the destination point. While a customer pays to CIL the price of coal inclusive of taxes, it is Railways, the carrier, to whom he pays the freight charge and penalty (if any).

Loading Variation and Capacity Utilization: Freight charges levied by Railways for coal transportation is calculated on the basis of "*Permissible Carrying Capacity***"** of each wagon and not the actual weight of coal contained inside it as determined from Weighbridge measurement. In other words, even though the weight of coal inside a wagon might be lesser than its Railway designated PCC - by even a single ton - freight billed by Railway will be for the full PCC of the wagon(s). Such situation is known as "**wagon under loading**" or "**rake under loading**. The implicit logic behind such Railway freight policy is that it is up to the coal purchaser to ensure full utilization of PCC in all wagons of the rake which they have provided. If anyone leaves idle capacity in the rake, they (railways) should not be deprived from realizing the full PCC freight. As far the customer is concerned, he contends that the additional freight paid by him for the "idle capacity" [**PCC – actual weight of Coal]** should be reimbursed by CIL since it is they (or their contractor) who has made such deficient or "under" loading. Indeed, the additional freight charge suffered by the customer for the unutilized wagon/ rake capacity is currently reimbursed to them (fully for some type of wagons and partly for others) by Coal India. As opposed to the under-loading scenario, if the weight of Coal determined from the Weighbridge happens to be more than the Permissible weight the customer is charged not only the regular freight for the "overloaded" amount but also an additional penalty which can be a multiple of the regular freight charge. In such cases, all penal freight charge is completely borne by the customer and no reimbursement is made by CIL. Thus, for the same amount of coal the financial consequence of **overloading** is more severe than under loading for the customer. Moreover, there is a limit for overloading a wagon beyond which Railways would not allow rake movement at all. In such cases they "push back" the rake asking CIL to remove the extra coal and bring it within the permissible overload limit. Both under load and overload amounts are calculated wagon-wise. Even if a single wagon is overloaded/under loaded while the rake as a whole might have no variation, the financial consequences as described above will still follow.

Under loading – The Puzzle: Under loading charges paid by CIL had assumed alarming proportion in recent times, rising from ₹ 332 Crores in 2014-15 to ₹ 772 Crores in 2018-19. In just 3 Years (2016-17 to 2018-19) CIL suffered a cumulative loss of ₹ 1899 Cr on this account. These figures do not include Customers' share of under- loading charges which are not reimbursed by CIL in case of certain type of wagons. But more puzzling aspects emerged when the quantum of unloading charges paid by CIL subsidiaries each year were juxtaposed with the quantum of rail loading activity. For instance, under-loading charge rose by an amount of ₹ 110 Cr between 2017-18 & 2018-19 during which CIL's rail off take actually declined marginally (from a level of 294.45 MT in 2017-18 to 290.51 MT in 2018-19). This is peculiar since quantum of under loading and consequent financial loss is expected to largely follow the trend of total rail loading. In any case, it seemed inconceivable that CIL should continue to sustain such massive losses year after year simply because they are unable to load wagons to their permissible capacity at a time when advanced technology and instrumentation are the order of the day.

THE DOMINANT HYPOTHESES

To find a solution to the above problem and arrest the rapidly rising under loading, detailed consultations were made with both field and HQ executives. During these discussions two major hypotheses were advanced about the cause behind under loading:

The Overload Risk Aversion Hypothesis: Financial consequence of overloading (penal freight imposed by Railways) being much more than under loading paved a tendency amongst the pay loader operators to leave the wagon little underloaded. In other words, under-loading was happening as a sequel to risk-aversion strategy against the overloading.

The Technical Challenge Hypothesis: The only way the financial consequence arising out of loading variation can be avoided is to load exactly the same weight of coal as the PCC of the wagon – neither a metric ton more or nor a ton less. This is practically impossible to achieve through mechanical pay loaders with diverse bucket capacities. Loading with pay loader assumes a particular weight (the maximum payload) for a fully loaded bucket. The payload operator counts the number of loaded buckets used for a wagon to reach the PCC. But if the PCC is not perfectly divisible by the bucket payload, he has to partially fill the bucket on a human estimation basis to reach the remainder of PCC. Such eye estimation of the last bucket cannot be perfect which may lead to one or two tons of under load. For instance, a BOXN wagon has a PCC of 68 MT. With a 5MT capacity pay loader, the operator will use 13 full-bucket-lifts to reach 65 MT. Thereafter, for the remaining 3 MT he has to make an eye estimation which can induce under load. In such a case, using a 2 MT Pay loader may seem to solve the issue since 70 is perfectly divisible by 2. But going for a 2 MT pay loader (or 1 MT payload) will increase the number of pay loader to be deployed and also the time to load a rake, resulting into demurrage charges apart from adversely affecting the cycle time of a rake. Moreover, although a full bucket load of a pay loader is said to signify a particular weight, it can vary according to bulk density of coal which prone to wide variation.

For a company which loads a material as heterogeneous as coal into nearly 100,000 rakes (nearly 5.5 million wagons of diverse designs) a year through mechanical pay loader with diverse bucket capacities ensuring such exactitude in loading did appear very challenging. Various technical solutions to ensure accurate loading and contractual solutions to at least shift the risk to the loading contractors had indeed been attempted in past by certain subsidiaries. But as would be seen in subsequent narration success almost always eluded such attempts.

Data Analytics: The entire data set pertaining to rail dispatches of 2017-18 & 2018-19 available in Coal Net database of each subsidiary company was collected for an aggregate-level Exploratory Data Analysis. This was followed by a conducting data analytic exercise of granular data comprising of 47,954 RRs pertaining to the subsidiary that undertakes highest amount of rail loading and seem to contain addition peculiarities suggesting hidden causative factors.

Testing the Overload Risk Aversion Hypothesis:

When subsidiary-wise break up of under-loading charges paid by CIL was collected and juxtaposed with their respective rail off-take, a totally different picture seemed to emerge that was highly inconsistent with overload risk aversion hypothesis. This became evident when underloading quantities and underloading charges suffered by four (4) subsidiaries for FY 17-18 were examined as the following table illustrates.

Table 1: **Under Loading vis-a-vis Rail Offtake in FY 2017-18**

Subsidiary	**Rail Offtake** in MT	**Under loading Charge Paid to customers** in Cr	**Under-loading loss per Million ton of rail – loading** in Cr
E	30.4	54.40	1.79
C	32.7	199.60	6.10
B	24.4	111.50	4.57
M	89.4	35.60	0.39

The table above shows how for almost similar quantitative level of rail dispatch, the financial implication for subsidiary "C" is nearly 3.5 times more than "E". Similarly, "B" loaded lesser quantity of Coal than "E" but its under-loading loss is twice that of "E". Still more surprising is the case of "M" which loaded more coal than "B", "C" & "E" put together and yet suffered nearly 10% lesser financial loss on this account. Obviously, if the inability to load a wagon accurately by pay loaders or an aversion to avoid overloading risk would have been the reason behind underloading then such factors should have been commensurate with the quantum of rail loading by the subsidiaries - at least across the three geographically contiguous subsidiaries (which was the case with subsidiaries "B", "C" and "E". The extreme lack of correlation between quantity dispatched by rail and the under-loading charge suffered by the above subsidiaries were too low to be explained by the two dominant hypotheses. Obviously, some other factors were at play.

The Distance Factor: This was the "distance factor" over which an under loaded rake travels. For the same level of under loaded tonnage in wagon if the distance between originating siding and destination (called the *Chargeable Distance* in Rly. parlance) is more, then obviously freight charged by Railway will be more. Thus, rakes of customers who are taking coal too far away locations like Punjab, Gujrat and Rajasthan are prone to notch up greater under loading charge loss even for little amount of idle capacity per wagon. When the case that generated maximum loss in a subsidiary in 2018-19 was analyzed, the impact of the distance factor manifested itself rather dramatically

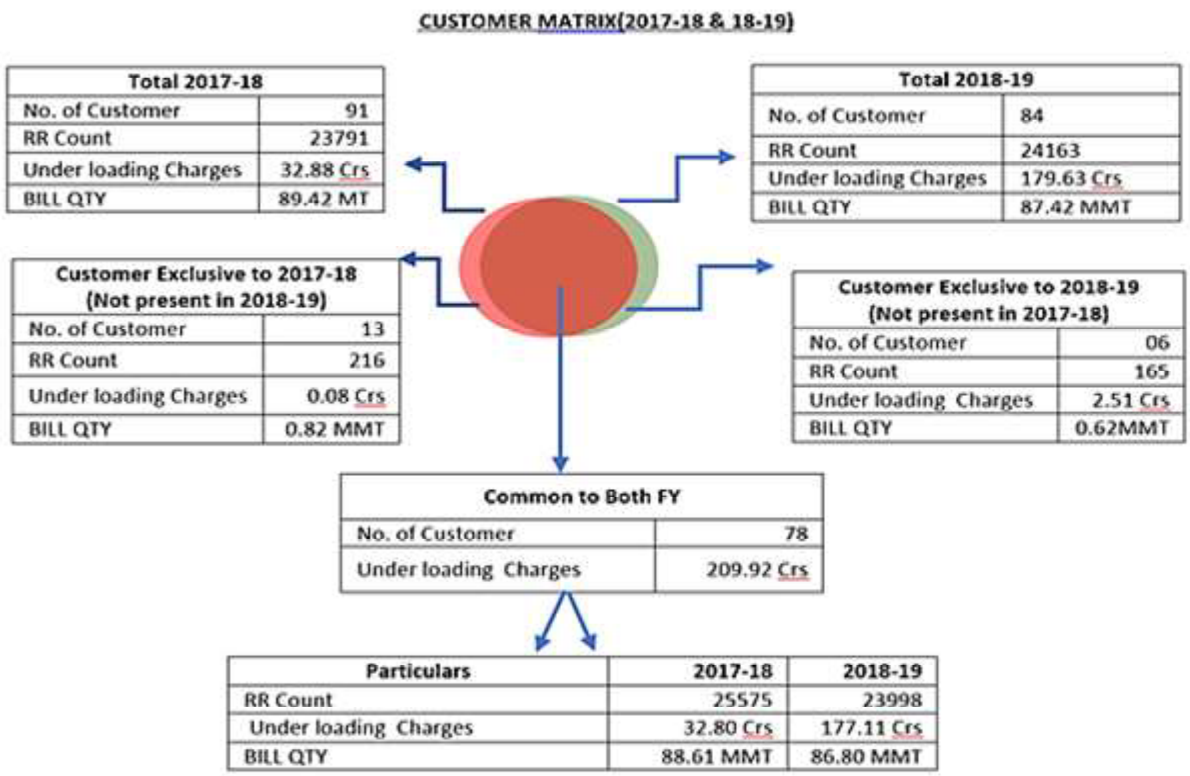
The effect of Distance on Under load Charge : *The Case of M/s "X"*

The maximum under loading charge paid by subsidiary "M" in 2018-19 was for a rake loaded on 31-05-2018 from a siding to a Punjab based thermal power plant. In this case the distance from originating to destination station happened to be 1583 Kms. The total Permissible Carrying Capacity of all the wagons in that rake was 4128 MT but the rake left the loading siding with some "idle capacity". The Railway freight for such distance was ?2680.96/ton while basic price of coal contained in that rake was ? 748.00/ton. The resulting under loading charge reimbursed to this customer for that rake ballooned to ? 24.59 Lakhs which was more than basic sale value of coal contained in the entire rake amounting to ? 23.88 Lakhs!

A question that arises here is whether the observed differences in "under loading charge" among subsidiaries could be because of some serve a larger number of "long distance" customers while others don't? However, a comparison of under loading loss during 2017-18 & 2018-19 within the same subsidiary "M" confounded this conclusion which the table below illustrates:

Table -2: **Under loading Variation within same subsidiary**

Subsi diary Name	Year	Rail Offtake in MT	Under-loading Charge Paid to customers in □ Cr
"M"	2017-18	89.4	35.60
"M"	2018-19	87.4	179.65



CUSTOMER MATRIX(2017-18 & 18-19)

Total 2017-18	
No. of Customer	91
RR Count	23791
Under loading Charges	32.88 Crs
BILL QTY	89.42 MT

Total 2018-19	
No. of Customer	84
RR Count	24163
Under loading Charges	179.63 Crs
BILL QTY	87.42 MMT

Customer Exclusive to 2017-18 (Not present in 2018-19)	
No. of Customer	13
RR Count	216
Under loading Charges	0.08 Crs
BILL QTY	0.82 MMT

Customer Exclusive to 2018-19 (Not present in 2017-18)	
No. of Customer	06
RR Count	165
Under loading Charges	2.51 Crs
BILL QTY	0.62MMT

Common to Both FY	
No. of Customer	78
Under loading Charges	209.92 Crs

Particulars	2017-18	2018-19
RR Count	25575	23998
Under loading Charges	32.80 Crs	177.11 Crs
BILL QTY	88.61 MMT	86.80 MMT

As the table above shows, under loading loss in "M" registered more than 500% increase in 2018-19 while rail dispatch actually *decreased* by 2 million tons! While one might attribute *inter-subsidiary differences* in a given year (like between "C" & "M") to a possible prevalence of larger number of long-distance customers in one subsidiary as compared to the other, it didn't seem to be the reason for explaining the huge *intra-subsidiary difference* in under loading for "M" in just two-year span as customer composition is not known to change radically is such a short time span within a given subsidiary.

Incredulously, a natural question arises as to how such fivefold increase could have happened in the same subsidiary for a lesser rail offtake? When the same question was thrown open to several field executives, the most common view was the possibility of inclusion of a large number of new long-distance customers who might have entered in 2018-19 but were not there in 2017-18. As narrated before, it was possible that even a few rakes of such small number of long-distance customers are loaded with maximum accuracy (i.e. minimum idle capacities) they could still generate substantial underloading charge. But this cannot be ascertained without verifying the actual customer matrix in both these years. It is at this point, the need for a more elaborate study of individual customer, the underloading in their rakes and the distance factor became essential analytic tool to understand the real reason behind the fivefold increase of under loading charge in a single year time span. Accordingly, data pertaining to 25,578 RRs of subsidiary "M" in 2017-18 & 2018-19 stored in Coal Net platform were subjected to data analytic exercise and the revelation from it was contrary to the above hypotheses as depicted below:

The above data shows that:

- There were a total of 91 customers in 2017-18 which **decreased** to 84 in the next year. Out of them 78 were common to both years.

- The number of customers exclusive to the respective years were minimal being 13 & 06 respectively. Even the ranking of top 5 customers (in terms of under loading loss) who together contributed □ **92 Crores out of a total of □ 179 Crores** had remained more or less the same as would be evident from the table below:

Table 2A: 5 Top Underloaded (in terms of charge paid by "M")

	2018-19			2017-18		
Customer	**Rank**	**Qty_Loaded (MMT)**	**Under Loading Charges (Cr)**	**Rank**	**Qty_Loaded (MMT)**	**Under Loading Charges (Cr)**
M/s A	1	5.23	39.35	1	4.78	7.01
M/s B	2	5.99	16.36	3	6.28	2.62
M/s C	3	3.84	14.20	2	3.92	2.69
M/s D	4	2.08	11.97	Not in top 5 (Rank 6)		
M/s E	5	3.17	11.05	4	3.52	2.05
M/s F	Not Present in 2018-19			5	2.30	1.94
TOTAL (for 5 customers)		**20.32**	**92.93**		**20.80**	**16.31**

- Almost all of the under-loading charge paid by "M" in 2018-19 was on account of the same common customers. Nearly 177 Crores out of 179 Crores of under loading charges (99%) in 2018-19 was attributable to these same common customer group.

- **All the above indicates that the customer matrix in both years have changed very little in "M".**

If customers were mostly same in 2017-18 & 2018-19 and the average distance of coal transportation is similar, then a question arose as to what else could have caused the massive difference in underloading charges paid by "M" between those years? **Whether instead of factors like loading weight, distance or customer mix could the way of billing for under load charge be somehow matter**? This necessitated a look into individual RRs and the way CIL's billing process to the customer for the "idle capacity". The result was a very counterintuitive picture as given below:

Table 3: Better Coal loading, still more under loading-Charge?

Party Name	**RR No.**	**RR Date**	**Rly. Permissible Cap MT**	**Qty Loaded in Rake MT**	**Under-loading Qty as per "M"**	**Under loading Charge paid by "M"**	**Mine**
M/s "G"	461000413	07/11/18	**4012**	**3759.4**	000.0 MT	0.00	"BH"
M/s "G"	461001277	20/03/19	**3990**	**3778.6**	228.3 MT	88,945.68	"BH"

The puzzling point that emerges from the above two cases of transport is how, despite loading more coal in the second case (which means lesser underload) MCL paid for an underload of 228 MT while it was zero in the first case? Incidentally, although treated the first case as zero underload, Railway charged the customer for the full PCC of 4012 MT that included an underloaded quantity of 252.44 MT

Cloistered factors: Upon noticing more such apparently anomalous cases, the exact billing process followed by CIL was scrutinized closely. **It was then found that three other significant but lesser-known factors are at play as far as the quantum of under loading charge are considered.** They owed their origin to the way "idle capacity" has been stipulated in the Fuel Supply Agreement (FSA) between the Coal Customers and a CIL subsidiary. It is therefore necessary that the conditions that bring these factors in underload billing are examined:

"11.3 Idle freight resulting from under loading of wagon, as per Clause 11.2, shall be adjusted in the bills. Idle freight should be reckoned as:

(i) For non-coking coal of GCV exceeding 5800 Kcal/Kg and coking coal of Steel Grade I, Steel Grade II, Washery Grade I, Washery Grade II, Semi-coking Grade I, Semi-coking Grade II and washed coal, the difference between the freight charges applicable for the standard carrying capacity, as shown on the wagon or carrying capacity based on the actual tare weight or permissible carrying capacity as notified by the Railways (route-wise) for any particular type of wagon from time to time, in which case the stenciled carrying capacity as shown on the wagon is more than the permissible carrying capacity, as the case may be, and the freight payable as per actual recorded weight of Coal loaded in the wagon.

(ii) For all other Grades of Coal, the difference between the freight charges applicable for the stenciled carrying capacity, as shown on the wagon or carrying capacity based on the actual tare weight, as the case may be, plus two (2) tonnes and the freight payable as per actual recorded weight of Coal loaded in the wagon. However, in the cases where permissible carrying capacity is less than the stenciled carrying capacity, as mentioned above. , the difference shall be reckoned between the freight applicable for permissible carrying capacity and the freight payable as per the actual recorded weight of coal loaded in the wagon."

These factors are: *Type of coal (Coking vs. Non-coking), Quality of Coal (GCV) and Type of Wagon*. Out of these, the third factor interestingly plays a much bigger role that what one would have presumed. It may be recalled that one of the determinants of under loading charge is the quantity of unutilized carrying capacity of a wagon. The natural definition of idle capacity is simply the difference between PCC of a wagon and the actual weight of coal loaded into it. But clause 11.3(ii) of FSA alters this natural definition as far as CIL's liability towards under loading charge is concerned making it dependent upon whether the wagon's stenciled Carrying Capacity (CC) exceeds the Permissible Carrying Capacity (PCC) or not.

Table 4: "Idle capacity definition" [As per 11.3(ii) of FSA]

Case	Actual Loading Quantity (Q)	Under load Admitted by CIL	Underloading as per Railways	Who Pays for Underloading
CC < PCC	(CC+2) <Q<PCC	0	PCC – Q	Customer
	Q<CC+2	(CC+2)-Q	PCC – Q	CIL & Customer
CC = PCC	Q < PCC	PCC – Q	PCC – Q	CIL Pays entire under loading charge
	Q > PCC	Over loaded	Over loaded	Customer pays for over load

CC= carrying Capacity of wagon, Q= Quantity Loaded, PCC = Permissible Carrying capacity of a wagon

The impact of this sub-clause becomes very much pronounced in case of the two most common type of wagons provided by Railways to transport coal: BOXN & BOXNHL. This is so because the Stencilled Capacity of these two wagons vis-à-vis their PCC is totally different and a major difference creeps in the CIL's definition of "Idle Capacity" in an under-loading scenario.

Table 5: Design Capacity two common Coal carrying wagon

Type of Wagon	Typical SCC(*)	Typical PCC	Case Category
BOXN	58	67 to 68	PCC > CC
BOXNHL	70	68 to 70	PCC <CC

**Stencilled Carrying Capacity (SCC is usually same as carrying capacity (CC).*
Note: PCC may vary at different seasons of the year and route

In case of BOXN type wagon, Stencilled Carrying Capacity (CC) is usually 58 MT while the PCC, as stipulated by Railway is 68 MT. Therefore, as per Clause 11.3(ii) of FSA, CIL recognizes idle capacity only if the loading in such type of wagon goes below CC+2 i.e. 58+2=60 MT. So, suppose a BOXN wagon is loaded to 61 ton, Railways would charge the customer freight for full PCC i.e. 68 MT. Thus, actual idle capacity in this case, implied by Railways, is 7 ton (68 MT –61 MT). On the other hand, as per FSA, the idle capacity admitted by CIL in this case will be zero since the load (61 ton) is more than CC+2 i.e. (58+2=60 MT). Taking another loading scenario, suppose the same BOXN gets loaded with 55 MT. In such a case the Railways defined idle capacity would be 13 MT (68 MT -55 MT) while CIL would admit only 5MT [(CC+2)-55] as underload as per FSA and reimburse freight charges for that amount.

The balance real idle capacity of 8 MT (=13MT as per Rly-5MT as per CIL) will have to borne by the customer. But if the wagons involved in the above example was of BOXNHL Type (whose CC & PCC both are 68 MT), then the under-load liability for loading 55 Ton would have been 13 Ton (68 - 55) both as per Railway and CIL.

The apparent anomaly of two rakes by the same customer described in Table 3 where subsidiary "M" paid more under-loading charge for better coal loading can now be explained as the effect of application FSA Term 11.3(ii). In the above case, the first rake which did have significant quantum of idle capacity (i.e 253 Tons below Railway's permissible capacity) but did not attract under load charge because it had more BOXN wagons in the rake while the other one comprises of mostly BOXNHL wagons.
The above example shows that how the type of wagon composition in a rake can influence the financial repercussion arising out of wagon under loading. Thus, the possibility that subsidiary "M" might have received more BOXNHL type of wagons in 2018-19 compared to 2017-18 could have been a major contributor for the abnormal rise in under loading charge it experienced in 2018-19.

The Case of M/s "X" Revisited

The case of M/s "X" described earlier shows how the "distance" factor had propelled the under-loading liability of subsidiary "M" to stratospheric level exceeding even the basic value of coal. A closer look at the Railway Receipt showed the composition of the rake to be: 57 BOXNHL wagons (each with PCC of 70 MT) and 1 BOXN wagon (PCC 68 MT). Thus the PCC of the rake was 4128 MT (58 x 70 + 1 x 68). As against this the weight of coal actually transported by that rake on that day was 3211 MT i.e deficit of 917 MT or 22.22% of rake PCC. In other words, there was an average underload 15.80 Tons per Wagon. Such level of under load is discernible to even a casual loading operator and does not require any sophisticated loading equipment or great technical accuracy. More such cases were found in the rake population of "M" showing that the bulk of under loading charges are actually contributed by rakes where level of under load would have been visible to common eye.

The abnormal increase of under loading charges for subsidiary "M" in 2018-19 (See customer matrix) can now be explained from realization of above various factors. As has been narrated earlier, the customer matrix in both these years remained more or less same signifying little variance in the average distance of transportation for subsidiary "M" as a whole. In such short time span of two years, neither the type of coal nor the quality of coal is expected to undergo significant change. Such inexplicable rise in under loading charge (U_C) can only be attributed to the actual average of coal loaded in the wagons (W_C) and change in wagon type (W_D) that must have been happened in 2018-19. When all the RRs of subsidiary "M" were subjected to analysis, it was found that indeed the average load per wagon in 2018-19 (3616.6 ton/rake) had decreased from what it was in 2017-18 (3713.93 ton/ rake). This decrease in the average capacity utilization of wagons in 24168 rakes, dispatched during 2018-19, coupled with larger population of BOXHNL type wagon where the natural contractual tonnage could not be derived were the real cause behind rise of under loading charge from Rs.35 crores to Rs.179 crores. This statistical distribution of under loaded quantity in each rake corresponding to different quartiles of charge distribution is depicted below:

Putting all dimensions together:

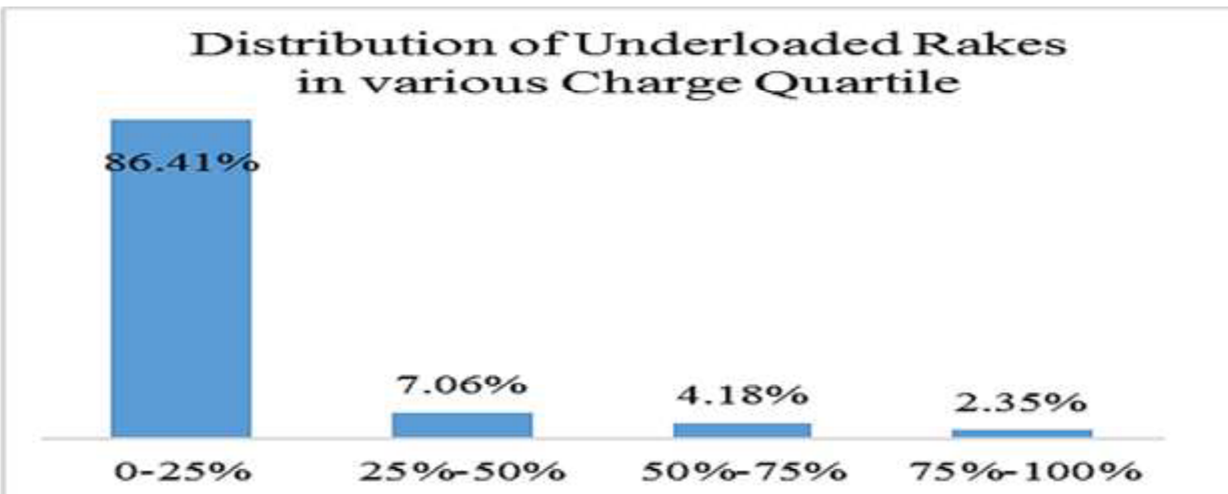
$$U_c = f(W_c, D_c, Q_c, T_c, W_d)$$

Uc	**Under loading charges paid by CIL to customers**	**Normal factor**
Wc	**Actual weight of coal loaded into wagons**	**Normal factor**
Dc	**Distance of transportation**	**FSA factor**
Qc	**Quality of coal (greater or lesser than 5800kcal/kg)**	**FSA factor**
Tc	**Type of coal (Coking/Non coking)**	**FSA factor**
Wd	**Wagon type and its design capacity**	**FSA factor**

Rail Loading (MMT)	87.38	No of Rakes analyzed	24168
Total Under Load (MMT)	1.38	Average billed load per Rake	3616.16
Underload per dispatch	1.58%	Total Underload Charges (in Crs)	179.62

From the revelation of the above table, it was found that the actual overwhelming portion of the rake population suffered 0 (zero) under loading (see numbers for the first charge quartile). In contrast, the average under loading per rake in the 4th quartile amounts to extraordinary 412.94 ton/rake. This kind of under loading would be discernible even by common eye and do not require sophisticated sensor-based weight measuring instrumentation like Pay loaders with electronic sensor for determining precise

UL_Chrg Quartile (25% of 179.62 Crs)	Quartile Range	Rakes (cum %)	% of Rakes in Quartile	Rakes (cum No)	No of Rakes in Quartile	Mean UL_Qty (Quartile)	Stdvn. UL_Qty (Quartile)	Median UL_Qty (Quartile)
First Quartile	0-25%	86.412%	86.41%	20884	20884	25.11	48.30	3.17
Second Quartile	25%-50%	93.475%	7.06%	22591	1707	193.50	76.07	188
Third Quartile	50%-75%	97.654%	4.18%	**23601**	1010	290.71	107.51	304.125
Fourth Quartile	75%-100%	100.000%	2.35%	**24168**	567	412.94	171.80	386.8



weight in each bucket. Average under loading per rake in the 3rd and 4th quartiles eliminates 50% of the under loading charges for subsidiary "M". Hence, achieving accuracy in weight through technological means is simply not required for removing at least 50% of the under loading charges.

Implementable Solution

1. Concentration on few focus-customer rakes: Simply take care to avoid extreme under loading (beyond 3% to 4% of rake load) for top 20 long distance customers. The fact that among equally under loaded rakes, transportation distance plays a crucial role should be driven into the minds of all those who handle the loading process in siding and their controlling officers at Area- level. The list of such "focus customers" can be easily retrieved from Coal-Net and analyzed.

2. Sensitization: There is a great need to sensitize field officials to be become extra-careful for rakes with predominant BOXNHL type wagon composition. The most alarming red flag therefore is "Long-distance customers with BOXNHL wagon dominated rakes leaving the siding on any given day". Advance information on the schedule of such rakes for long distance customers should be forewarned to the contractor and loading staff for observing due care.

3. Monitoring: Area GMs to make available to subsidiary management [GM (M&S)] an Exception Report containing the list of customers and details of rakes dispatched with under load on the very next day.

4. Investigation: *All rakes dispatched with under loading exceeding 3% of total permissible capacity of the rake (for a typical BOXN rake it would be around 180 Tons) must be investigated by the concerned Area and a report put up within 3 days to higher management for appropriate* ***action as needed.***

IMPLEMENTATION AND IMPACT

CIL management took immediate steps to implement the above solutions. The result exceeded even the wildest expectation. In 2018-19, expense incurred by CIL towards under loading was ₹ 772 Crores and expected to reach a level of ₹ 863 Crores by 2019-20. Instead, the loss on this account was only ₹ 530 Cr in 2019-20 resulting in an absolute saving of ₹ 242 Cr. This loading was ₹ 772 Crores and expected to reach a level of ₹ 863 Crores by 2019-20. Instead, the loss on this account was only ₹ 530 Cr in 2019-20 resulting in an absolute saving of ₹ 242 Cr. This was ₹ 333 Crores lesser than the trend line projection. In addition to the financial saving this also resulted in an additional 20 lakh MT of coal being carried in the same number of rakes as were indented last year. Had it not been the case these 20 lakh MT of coal would have to be carried by road requiring a fleet of nearly 1 lakh trucks incurring higher transportation costs not to speak of the obvious adverse impact on environment due to increased PM2.5 & PM10 emissions. Sustainability of these data-analytic driven solutions are got further corroborated when under loading charges in 2020-21 dipped further to ₹ 459 Cr which is ₹ 512 Cr lesser from the trend line projected figure of ₹ 971 Cr for that year.

Can under loading charges be eliminated altogether?

While overwhelming part of charges sustained by CIL can be eliminated by controlling extremities in the distribution of underload quantities among the rakes that generate higher under loading charges, it is practically impossible to eliminate this phenomenon altogether. This is because **Not Just one, but 3 Uncertainties** are at play.

1st Uncertainty: This is the uncertainty that takes into account the natural error of measurement done through Payloader at loading end. The most technically advanced Payloader, even if equipped with an electronic sensor that automatically measures the content of coal in each bucket, will have its own margin of error.

2nd Uncertainty: This uncertainty stems from the way the net weight of coal is measured by Railways. Universal method of ascertaining the net weight of a commodity carried in a container is to calculate the difference between the gross weight and the tare weight of a container. However, Railways measures only the gross weight of a wagons in a rake from which "Designed Tare weight" of the same wagon to arrive at the net weight. As a matter of fact, the designed weight gets changed due to natural wear and tear and patch repair in workshop/field during its lifetime which increases or decreases the designed tare weight. Thus, the second level of uncertainty creeps in. Railways contend such variation to be compensatory in nature due to normal distribution around designed tare weight. Nevertheless, even if one presumes it to be true, the financial consequence of that variation is not compensatory since the freight liability arising out of such variation is not compensatory.

3rd Uncertainty: Obviously the error introduced by assumption of Designed Tare Weight of wagon can be eliminated by double weighment process i.e. one in loaded condition and the other in empty condition. Although, such measure will obviously impact the turnaround time of rake for Railways adversely. The natural tolerance of a Railway Weighbridge (said to be around ± 2%). This uncertainty in the form of Railway Weighbridge's own instrumental error, normally said to be 0.5% of the gross load, which in a typical rake can be about 20 Ton distributed neither in a particular wagon nor in even or uneven manner.

Under loading uncertainty is function of

$$U_c = f(U_{Pay\ load\ er}, U_{Wagon}, U_{Weigh\ bridge})$$

From the above study of three inherent uncertainties, it is evident that a total elimination of under loading is probably not possible with existing technology. What is possible is to eliminate very large part of under loading charges sustained, as actually happened in two areas after implementing the insights gained from the aforesaid data analytic exercise.

The CCL Case Study - The failure of contractual solution to the problem

The result of uncertainty has recently been evidenced when one of the coal subsidiaries, CCL, floated a tender where a condition was incorporated to recover any under-loading charge sustained by the subsidiary from the concerned loading contractor. It was hoped by the authorities that such a clause would force the contractor to load coal accurately in the wagons and ensure no under loading. The bidders who readily participated in this tender initially had not noticed this new clause. After bid opening when they noticed it they immediately backed out preferring to lose their Earnest Money Deposit. They did not budge even after the subsidiary management threatened them for blacklisting, which they eventually did.

Case Analysis: The reason for this is simple. The contractor, with best possible equipment and practice, can at best eliminate one of the three uncertainties i.e. Pay loader uncertainties. But he still will be unable to address the other two uncertainties i.e. tare weight uncertainty and Weighbridge uncertainty. If so happens the financial consequences of any one of these uncertainties for outweighing the remuneration he gets for per ton coal loading. For instance, if a BOXNHL wagon is found to be under loaded by even one ton (after weighment in Railway Weighbridge) even after the contractor ensures its perfect loading, under loading charge for that one ton will be levied by Railways. This will result in CIL paying under loading charge for 1 ton to the customer. The freight charge for 1 ton for an average coal lead of 600 km is nearly Rs.1200 (Rs.2/NTKM x 600). As opposed to this a typical loading contractor is paid by CIL only Rs.8 to 10 per ton for wagon loading. Since the contractor's loss even for a single ton of under loading far exceeds the remuneration he receives from the loading contract, the risk sustained by him in case he agrees to a 'recovery clause', would be highly unsustainable. No wonder, the contractors decided to withdraw from the tender even at the cost of forfeiting their EMD and being blacklisted.

The only way to completely eliminate the under loading is by installing Silo with Pre-weighed bins in each loading siding and getting the said weighing system certified by Railway authorities. However, installation of such Rapid Loading System equipped with Pre-Weighed bin mechanism has a cost implication with additional annual maintenance expenditure. Not all sidings with lower volume of real dispatch can justify installation of such system. Installation of RLS is already a part of CIL for achieving coal production of 1BT by 2023-24. In phase-1, 35 mines of 4MT & above have been identified as a part of first mile connectivity project. However, the lesson learnt from the above exercise would still be very useful for the sidings where cost benefit/ economics does not justify installation of such loading system.

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SARAS-NCL's Approach towards Innovation and Sustainable Development through Scientific Research

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ABSTRACT

Research and Development (R&D) has a major role in economic development. As the pace of technology is accelerating and newer technologies and processes are becoming important, R&D is becoming a crucial factor in success of the companies and economies in a globalised and competitive world.

In the current global scenario, Indian firms have to reorient themselves to R&D-based innovation, as their products have to compete with highly technology-based products of advanced nations in local and international markets. Amid the current rapid pace of technological innovation, the demands of society are becoming more diverse and sophisticated, including a rising awareness of the need for a sustainable society, respect for human rights, and a focus on ensuring health and safety.

Northern Coalfields Limited has taken a remarkable initiative of establishing a dedicated centre for innovation and R&D, called as "Science & Applied Research Alliance and Support (SARAS)" for improvement in overall productivity of the company in its operations and processes with a focus on thrust areas crucial for its sustainability and competitiveness.

This paper gives an account of NCL's efforts in adopting innovation, scientific studies and R&D Projects along with some strategic initiatives under SARAS to ensure socio- economic sustainability in the long run.

Keywords—Research & Development (R&D); Northern Coalfields Limited (NCL); Innovation;

INTRODUCTION

Research and Development (R&D) plays a crucial role in economic development and has been the driver of change around the world to provide accessible and affordable solutions to the ever changing consumer needs.

With a population of 1.3 billion, India is the second most populous country in the world and the third largest economy (measured by power purchasing parity). To achieve rapid growth, India needs to view its many economic and social challenges as opportunities for growth and renewal. Companies need to challenge conventions, invest in innovation and R&D, and unlock vested interests embodied in the antiquated infrastructure, which continues to hamper India's growth.

Achieving universal energy access for all at affordable prices is of the highest priority. Over the past decades, India has made significant progress in village electrification and providing electricity connections to households. India's share of the population with access to electricity rose from 43% in 2000 to above 99% in early 2019. The focus has now shifted to ensuring sustained electricity access, reliability and quality of supply.

India's coal supply has increased rapidly since the early 2000s, and coal has become the largest domestic source of energy and for electricity generation. Between 2003 and 2014, total coal supply grew by 8.5% per year on average. In 2016, domestic coal production (hard coal and lignite) accounted for 71% of total coal supply. The remaining 29% was imported, as India's thermal coal is generally not of high quality nor is there a large quantity of coking coal.

Coal India Limited (CIL), a Maharatna CPSU, is the single largest hard coal producer in the world with core competence across the entire gamut of Coal business value chain starting from exploration, planning & design, production, beneficiation and marketing. CIL presently contributes about 84 % of the country's entire coal output. CIL functions as the apex holding company for the seven coal producing subsidiaries and CMPDI, the exploration, planning and Design Company.

Northern Coalfields Limited (NCL) a Mini Ratna Subsidiary Company of Coal India Limited (CIL) is engaged in coal mining through its mega sized highly mechanized ten deep opencast mines contributing to about 14% of total national coal production i.e. about 16.7% of CIL's total coal production.

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It is also the highest volume handling subsidiary company of CIL accounting for more than 25% of total volume of CIL. In order to address numerous challenges in managing mega size deep opencast coal mines, NCL has taken an initiative named Science & Applied Research Alliance and Support (SARAS) for sustainable development through Innovation and Scientific Research.

A. Singrauli Coalfields of India

Northern Coalfields Limited (NCL), Singrauli is a major contributor to energy requirement of the nation. NCL is a Public Sector Company (Mini Ratna-Category-I) since 2007 and is a wholly owned subsidiary of Coal India Limited, under the Ministry of Coal, Government of India. NCL is producing coal since February, 1965. It is an ISO 9001:2008, ISO 14001:2004 and OHSAS 18001:2007 certified company. About 94% of the coal produced is dispatched to Power Sector. The company's gross turnover for the fiscal 2018-19 was 230520 Million Rupees.

Singrauli Coalfield is spread over 2202 Km^2, comprising of two basins, viz. Moher sub-basin (312 Km^2) (Fig. 4).and Singrauli Main Basin (1890 Km^2). It has total coal reserve of 10.06 BT (6.83 BT in Moher Sub-basin and 3.23 BT in Main Basin). Major part of the Moher sub-basin lies in the Singrauli district of Madhya Pradesh and a small part lies in the Sonebhadra district of Uttar Pradesh. All the coal mining operations of NCL are at present concentrated in Moher Sub- basin through 10 numbers of highly mechanized opencast mines. Singrauli main basin lies in the western part of the coalfield and is largely unexplored.

Fig. 1 Moher Sub-Basin - Operating Mines of NCL

NCL produced 108.05 MT in 2019-20, approx. 15% of the total coal production of India. The target for coal production in 2020-21 is 113 MT. The coal supplies from NCL have made it possible to support about 10515 MW of electricity from pithead power plants having power generation of 13295 MW. In addition, NCL is also supplying coal to up-country power plants of different states of the nation.

ABOUT SARAS

Being a major contributor to the energy requirement of the nation, Northern Coalfields Limited, Singrauli has recognized the potential of coal production through socially sustainable inclusive development. To meet the increasing demand of coal, NCL is fully aligned to the needs of adapting to advanced mining technologies and continuously upgrading itself through research and development. In view of the importance of R&D centre and the paradigm shift it can make, NCL has established a R&D centre i.e. Science & Applied Research Alliance and Support (SARAS) in collaboration with Indian Institute of Technology (BHU), Varanasi. SARAS, setup in 2018, is the outcome of vision and mission of NCL.

The core research areas of SARAS lies in advancement of mining technologies, clean coal technologies, climate change, waste management, carbon capture utilization, renewable energy, efficiency improvement and cost reduction besides providing scientific support to NCL units for improving availability, reliability and efficiency.

SARAS emphasizes on enhancing the overall productivity of mines by enhancing the performances of Heavy Earth Moving Machineries (HEMMs), Coal Handling Plants (CHPs) as well as developing greener technologies which in turn will translate into cost reductions as well as cleaner future. SARAS is also keen in collaborating with Institutes/ organizations for research related to development of cost economic technologies in its core mining field as well as in the field of climate change, new & renewable energy, efficiency & reliability enhancement of its overall units.

The Government of India is promoting Research and Development for the Indian energy sector through different R&D programmes. Northern Coalfields Limited, Singrauli promotes science and applied research leading to technology development in the energy sector through SARAS. In view of current requirement of improvement in existing mining practices, need for advanced technologies in mining and development in Renewable Energy, all R&D Projects of NCL through SARAS are categorized under following heads:

I. Advanced Mining Technologies

II. Renewable Energy

III. Environment
IV. Strategically implementation of new Projects
V. Alternative uses of bi-products/waste management

The focus of SARAS- R&D of NCL w.r.t. the scale of time is given below –

a. **Short Term issues**: Operational efficiency issues, cost reduction and sale value enhancement issues.
b. **Medium Term issues**: Environment friendly andefficient Technology adoption issues, Project implementation issues, EC/FC issues, Manpower, commercial exploitation of incidentals (OBR, Water), Land Management (Land), recruitment and Technical competence development for fresh employees. Digital/smart/ integrated management, ERP implementation
c. **Long Term Issues**: Land acquisition, Sustainability, Competition from Commercial Mining, Diversification for survival and smooth transition, social acceptability for expansion, environment pollution mitigation, infrastructure development in main basin, Integrated Basin planning, lay out and environment friendly coal evacuation issues for very deep OC and UG mining, alternate use/ clean coal initiatives for Main basin (Coal Gasification/ Liquefaction).

Forward looking initiatives require collaboration with the educational and technical institutes for hand holding and sharing of expertise. Therefore, NCL has undertaken collaborative approach for development of its R&D initiatives. The Technical and Scientific Studies/ Investigations and R&D proposals under SARAS are being taken up through institutions of CSIR and other technical scientific institutions of repute under the Govt of India viz. IITs, NITs and other institutions of national importance. In order to integrate innovations and research, NCL has come up with a unique strategy under which following 3 wings of SARAS are being developed in parallel mode:

- Integrated Laboratory Facility (Development of Technology on Lab scale): It is the main R&D wing of SARAS which comprised of technical laboratories. The main purpose of this wing is to facilitate fundamental research and scientific works. The laboratory consists of Design & Simulation Lab, AI & Big Data Analytical Lab, Remote Sensing Lab, Geotechnical Cell Lab , Drone & Automation Lab and Environmental Management Lab.

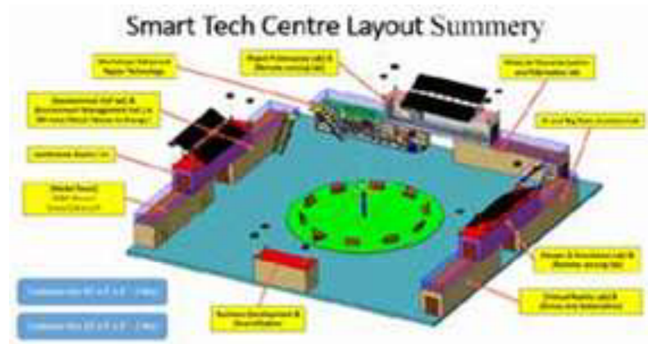

Fig. 2 Integrated Laboratory Facilities – SARAS

- Technology Centre (Technology Demonstration): In order to provide a central facility of testing, fabrication and training, a state of art Technology Centre is being developed by NCL and Indo- German Tool Room, Indore.
- Incubation Centre (Commercialization of Technology): This wing of SARAS comprises of various startup companies selected through different Govt Programmes on pan Indiabasis as well as Innovation groups/societies of the students of IIT (BHU). The main purpose of this wing is to involve young and creative minds in developing the end solutions/scale up facilities for the R&D/scientific works in the field of mining and its allied activities.

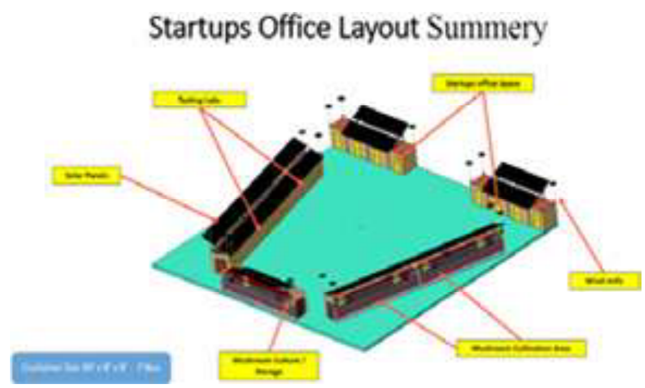

Fig. 3 Incubation centre - SARAS

COLLABORATIVE APPROACH FOR EXECUTION OF R&D/SCIENTIFIC PROJECTS

NCL has identified the different grey areas for improving productivity, safety, Environment along with production through execution of R&D/Scientific Projects in collaboration in the following R&D Areas-

a) Development of new innovative productive systems for enhancing the overall asset value of the organization.
b) Optimum Utilization of different operational facilities

at NCL by using in-depth theory and application of Operations Research.

c) Core Research in technology advancements and their application in the field of advanced mining technologies, coal gasification, coal liquification, CBM/ CMM and membrane reforming system, carbon sequestration, capture & storage/ utilization, Mine water treatment and utilization in domestic and industrial application.

d) Implementation of new projects and strategic initiatives.

e) Alternative uses of bi-products /wastages, e.g. OB, e-wastage, industrial waste recovery.

RECENT INVESTMENTS AND DEVELOPMENTS

The R&D activity in NCL started with the MOUs with IIT BHU for setting on 24th Nov'18. It was envisaged to play a role of a typical 'in-house' R&D set up. Thus, its activities encompassed the traditional spectrum that most in-house R&D departments of the times were built to perform. These were:

I) Supporting the ongoing production activity.

II) Value addition by extending the product line.

III) Improving the quality of the products.

At present, SARAS has awarded following Scientific/ technical studies to different institutes:

A .Indian Institute of Technology (IIT), BHU

1. Stability Evaluation of Dump Slopes and Developing Slope Stability Models for Design of Long Term Stable Dump Slopes through proper benching and vegetation.
2. Detailed Study on the Effect of Mining as well as Thermal Power Stations on Natural Water Bodies in Singrauli Region and Recommendation Thereof.
3. Optimization of Capacity Utilization of Draglines deployed in NCL through Big data Analytics.
4. Contribution of Neighboring Industries Over the Air Quality of the Mining Area.
5. Study for Impact Assessment of Back Filling of Fly Ash in Abandoned Gorbi Mine and Treatment/ Management of Acidic Water to Avoid Contamination of Ground Water and Soil.
6. Evaluation of ground behavior in open cast and underground excavations using TDR and Machine Learning Techniques.

B. CSIR - National Environmental Engineering Research Institute (CSIR-NEERI):

1. Source Apportionment study of Singrauli region and Capacity building of Environmental Monitoring & Management of Northern Coalfields Limited, Singrauli, Madhya Pradesh.

C. Visvesvaraya National Institute of Technology (VNIT Nagpur):

1. Risk investigations for slope failure of benches and dumps using geo-technical characteristics of rocks and their monitoring mechanism in Jayant & Dudhichua Opencast Mines of NCL.

TRATEGIC INITIATIVES IN CSR UNDER SARAS

Beside the ongoing scientific studies, SARAS has commenced one study on impact assessment of CSR activities done by NCL in last 6 years in Singrauli region. Skill development programs for the tribals are also being carried out by SARAS in the field of Mushroom cultivation, Khadi & Handloom, Pearl Cultivation and Zero Budget Organic Farming as well as Food Processing & Packaging for the socio-economic upliftment of people of Singrauli region. The concept of community radio, digitalization of Community Centres (upgrading these as Training & Processing Centres) and e-commerce platform of SHGs is also in the final stage of launching under SARAS.

OTHER SCIENTIFIC RESEARCH INITIATIVES

Use of Drones:

1. UAV Based Aerial Survey for generation of Ortho-photo mosaic, digital terrain model, contour maps and volume computation of stock piles using airborne LiDAR has been successfully completed.
2. In view of the encouraging results of the above study, NCL has taken up the following work through hiring of drones:

- High Resolution images for densely populated areas to be acquired and physically possessed i.e. Singrauli, Morwa Township, Jayant.
- Monitoring of dump height and dump slopes.
- Vegetation Assessment- Every year plantation is being carried out on dumps and dump slopes, so drones can be used to assess the vegetation cover as well as % survival rate and current status of the plantation.
- For inspection of parts of high mast equipment like dragline boom, boom head pullies of shovel and draglines etc
- Inspection of CHP structures and silo tops which are inaccessible and for safety monitoring in blasting

zones.

- Inspection of transmission lines.
- Surveillance of operations and security in mining areas.

3. A S&T projects is proposed for development of Drone-mounted optical sensor based continuous monitoring of PM 2.5 and PM 10 at Railway sidings.

At Present, scientific research is being done through following ongoing R&D projects:

A . Indian Institute of Technology (ISM), Dhanbad:

1. Development of Virtual Reality Mine Simulator (VRMS) for improving safety and productivity in coal mines
2. An integrated geo-physical approach for tectonic study in main coal basin of Singrauli Coalfields (CF) using 3-D inverse modeling of Gravity, Magnetic and AMT data
3. Multiple layer trial blasting for better recovery with less diluted coal.

B. SAMEER & IIT Mumbai:

1. Indigenous development of early warning radar system for predicting failures/slope instabilities in open cast mines.

C. BIT Mesra:

1. Development of guidelines for design of all tiers of shovel-dumper dump above dragline dump, with delineation of phreatic surface, within dragline dump.

D. NSCR/ISRO:

1. Development of a methodology for regional air quality monitoring in coalfield area using satellite data and ground observations.

ACTION TAKEN/ FUTURE ACTION PLAN

The Centre has identified Big Ticket ideas & Focus Area for immediate Action in the field of R&D/Scientific studies/Business Development which are as follows:

1. Use of Overburden (OB) as Sand, Road foundation material, Bricks, Ceramics: The overburden generated from the mines consists mainly of Sandstones and Shales. Among these two, sandstones predominate. Sandstone is the rock formed by cementing of sands composed largely of quartz and silicate minerals. The cement that binds the clasts may be argillaceous, calcareous, siliceous, and ferruginous. Utilization of this OB material will add to our Environmental Protection & Green initiatives and also will be very useful for us to address space constraint for OB accommodation.

NCL is having 10 numbers of highly mechanized opencast mines with average stripping ratio 1:4 and is increasing every year with increasing depth. Approximately 325 MCum of OB was removed to produce 108.05MT of coal for the FY 2019-20. The rate of OB removal is continuously increasing. With an aim to become **Aatma Nirbhar** on Coal (vision of our Prime Minister), Ministry have set the target of 1BT Coal Production by the FY2023-24. Out of which NCL's contribution in coal production will be 130 MT. In order to achieve the targeted coal production for NCL for FY 2023-24, 436 Mcum of OBR have to be removed. There is and will be the acute shortage of space to accommodate the huge quantity of OB removal in the mines. The height of internal dumps at present is continuously increasing.

In order to address the scarcity of space for OB accommodation in internal dumps and to convert the problem into a great opportunity now it is planned to explore the possibility of converting waste i.e. Overburden to Wealth. There is a possibility of use of Over Burden for various purposes like - sand, road filling & foundation material, bricks, ceramics etc. Ministry of Coal, MOEF and Ministry of Mines is also supporting such initiative in view of itspositive outcomes as a green initiative through various communication and guidelines.

To properly understand the potential of OB for its application, physical and chemical analysis of OB samples collected at various benches is undertaken. The preliminary report indicates presence of about 60 (Silica) % construction grade sand. The consumption pattern of sand in five bordering states of Singrauli Coalfields indicates potential market of about 200 MT. It is envisaged to fulfil atleast 10% demand through conversion of OB to sand. This will result in 5 fold benefits:

a) Sustainable development through avoiding the exploitation of river bed for sand production.
b) To enhance safety through reducing the amount of OB in the dumps and addressing the shortage of space issue.
c) This initiative will pave a road as a succession plan for business coal to OB diversification.
d) By integrating the process of OB removal into sand and construction material production along- with various byproducts will create additional avenues of revenue generation substantially
e) This process of OB to various biproducts is likely to

generate additional employments of about 3000 to 4000 local youths.

2. Solid Waste Management: Initiative in pipe line, it will be important for Swachh Bharat and green initiative.

3. Solar Initiatives: 50 MW at Nigahi is in pipeline and there is huge potential for long term contribution towards energy security and sustainability. The company has target of contribution of 280 MW in Solar power generation in the country by 2023-24.

4. Establishing Satellite Incubation Center at NCL for systematic support, platform, scaling and networking of startups with our PAPs and their co-operatives, Farmers in surrounding area, our co-operatives: Huge potential to address the stakeholder especially the land oustees.

5. System Efficiency improvement of grey areas through continuous improvement initiatives, scientific studies, R&D: like - Dragline planning, operations & system management.

6. Long term integrated plan, implementation road map and action plan for basin as a whole with advanced techniques and tools (Recasting Master Plan): Huge possibilities for conservation of resources and focused management, alternate optimum/efficient ways and OC Mining layouts for greater depths >300 m through advance simulation systems.

7. Alternative avenues for long term & for sustainable growth of Company: New blocks, diversification, identifying the potential areas and suitable models for proper diversification as a succession plan for continuous growth of the company.

8. OB Removal without blasting, Digital Mine.

9. International Conferences on Opencast Mining and Sustainability (ICOMS): International Conference (ICOMS) was held from last 2 years i.e. ICOMS-2018 on 14-15 Dec'18 (1st ICOMS) and ICOMS-2019 on 13- 14 Dec'19 at Singrauli in association with IIT (BHU) for ensuring the association of industrial experts, academicians and researchers with NCL on a single platform.

Fig. 4 Glimpse of ICOMS

SARAS is a singular combination of the academy and business, being halfway between a university campus and an industry. SARAS is committed to grow continuously and support the industry for ensuring energy security to the nation.

WAY FORWARD

- STRENGTHENING: Strengthening of SARAS through collaboration with leading R&D Organizations and setting up new Centre (s) of Excellence as per plan.
- IMPLEMENTATION : Implementing the approved R&D/S&T Projects as per the Standard Procedures.
- SCALING: Scaling up the innovations and R&D results from lab to field will enhance the production & Productivity.
- SUSTAINABILITY: Effective use of SARAS for suitable solutions to meet the challenges for long term sustainability like exploitation of resources from main basin.

CONCLUSION

The sapling of SARAS is maturing into a plant and is expected to grow a huge tree in due course and will define the business domain and will be basis for sustenance in next millennium. The succession of business, diversification and overall sustainable development of eco-system in and around Singrauli coalfields will be based on the outcome of initiatives under SARAS.

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Determination of Maximum Production Capacity at Optimal Traffic Density in an Open Cast Mine

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ABSTRACT

The favourable mining and geological characteristics like a substantial seam thickness at a comparatively shallow depth has resulted in opting for opencast mining as a technological option, but with the burgeoning coal demand there has been a corresponding increase in the number of equipment in mines. The deeper coal deposits have necessitated the handling of a large volume of Overburden, resulting in more traffic in the mine. High traffic density has become a matter of important concern for mines with a higher stripping ratio. Restriction in the availability of land area for developing more haul roads, on an account of socio-economic & environmental factors aggravates the issue. Determination of production capacity for existing mines necessarily requires addressing the issue of traffic density, while complying the extant stipulations regarding safety & environment.

This paper aims to establish a relation between the maximum production capacity and optimal traffic density, within the proviso of extant conditions regarding safety and environment.

Keywords: Maximum Production Capacity, Optimal Traffic Density, Haul road traffic.

INTRODUCTION

In the modern mining industry, with the increasingly competitive environment and unit costs, it is necessary to evaluate mineral resources optimally from the aspects of the economy, safety, and environment. On the other hand, production increase is another reality and obligation for today's mining operations. The activities related to the extraction of coal consist of risky operations, which can make a great impact on mine profitability. Therefore, in terms of feasibility, it is very important to determine optimum production capacity with due consideration to safety. In open- pit mine planning, many factors affect production capacity, such as traffic density, safety, and percentage of coal recovery, particularly when the mine goes deeper, geomechanical features of the coal seam and surrounding rocks, diggability and slope stability related to the overall slope angle. In this study, the emphasis has been given on all physical parameters with due care of factor of safety; it is targeted to determine the optimum production capacity of a mine.

Factors affecting Mine Production Capacity:
Mining Methods
Environmental Factors
Material Transport

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PROBLEM STATEMENT

In this the study, the parameter under consideration is generally assessed employing previous experience. Such an approach to the problem may or may not furnish a rational outcome. But, taking into account the limited reserves of coal it is very essential to establish a mathematical model to optimize the production level. The model proposed can be regarded as the most proper for determination of the optimum production capacity in the pre-feasibility phase since it embraces all connected factors: traffic density, density factor, and percentage of recovery of coal with due consideration of all the obligations. In this study, for a given reserve and stripping ratio the optimum production level (capacity) is determined analytically using a mathematical model. To illustrate the model utilized in this article, a numerical example is also made.

METHODOLOGY

To calculate the maximum production capacity of a mine, traffic density has been considered as the limiting factor while complying the extant stipulations regarding safety & environment. Density is also an important measure of the quality of traffic flow, as it is a measure of the proximity of other vehicles, a factor which influences freedom to maneuver and the psychological comfort of drivers. For these reasons, we used the traffic density as the primary measure for calculating uninterrupted flow of material.

Traffic Density is defined as the number of vehicles occupying a given length of roadway at a particular time. To determine the maximum material flow capacity of a haul road, it is assumed that the traffic density is fixed i.e. the gap between the dumpers/Tipping trucks (L) and speed (S) is fixed at a specific limit.

Traffic density = 1000/L (Numbers of Trucks/per Km)

Fig: 1

⇒ Number of Dumpers/Trucks pass a specific point in one hour = 1000/(L/S) = 1000*S/L

⇒ No. of Working Hours = N

⇒ Number of Dumpers/Trucks pass a specific point in one DAY = 1000*S*N/L

⇒ Assuming Traffic density Factor = F

⇒ Volume carrying capacity of Dumpers/Trucks = C
Total Material pass through a road in one day = 1000*S*N*C / (L*F)

Fig: 2

MODEL

Considering a mine has two flank roads (peripheral) that is developed to transport overburden to dump and coal from upper seams to CHP/Coal yard. A central haul road (main entry) is developed at the mine floor level to transport coal from bottom most seam to CHP/Coal Yard.

The mine has draglines and a Shovel- dumper combination for transportation of Coal and OB. Assuming that some portion of OB (Top Layers) has been outsourced due to less departmental transport capacity. Separate haul roads have been developed for light vehicles, O/S trucks, and departmental dumpers.

Fig: 3

Considering the Outsourcing agent has deployed the tipper truck of capacity C_1. The departmental working is carried out by dumpers having capacity of C_2 and four draglines (two in each section) having total digging capacity "D".

⇒ Annual Material Cast by Dragline D*90% (on 90 % efficiency)

⇒ Daily Material Cast by Dragline D1 = D*90%/365

⇒ Average Daily Material Transport from Outsourcing Road P_1= 2*1000*S_1*N_1*C_1 / (L_1*F_1)

⇒ Average Daily Material Transport from Departmental Road P_2= 2*1000*S_2*N_2*C_2 / (L_2*F_2)

Departmental peripheral road will be used for OB removal as well as for coal transportation. Assuming the current stripping ratio of the mine is "R" and the current ratio of bottom most seam thickness to upper seams thickness is J. The average specific gravity of coal is Sp.

⇒ Average Daily Coal transportation from peripheral road (K)= (P_1 {Sp*R(1+J)+1}

⇒ Average Daily Coal Production = (1+J)*K = (1+J) * (P_1 + P_2 + D_1) *Sp/{Sp*R(1+J)+1}

⇒ Average OB transport from Peripheral road = P2– K/Sp

Following parameters are considered based on general practices:

Table No: 1

Paramerters (Assumed)		Value	Units
Current Stripping Ratio	R	5.4	Cum/ Te
Width of largest size light Vehicle	T_1	4.3	m
Width Of O/S Truck	T_2	4.3	m
Width of Largest size Dumper	T_3	9.75	m
Traffic Density Factor for O/S	F_1	2	
Traffic Density Factor for Deaprtmental dumpers	F_2	10	
Maximun Allowed Speed ofO/S trucks	S_1	30	Km/Hr
Maximun Allowed Speed of Deaprtmental dumpers	S_2	30	Km/hr
Strike Length of Mine	S_t	4000	m
Daily Average Working HoursO/S	N1	20	Hours
Daily Average Working Hours Departmental	N2	20	Hours
Volume capacity of O/S Trucks	C1	17	Cum
Volume Capacity of Depart-mental Dumpers	C2	37	Cum
Minimum Distance Between consecutive trucks	L1	40	m
Minimum Distance Between consecutive Dumpers	L2	40	m
Total Capacity of Draghline (system factor =0.964)	D	15.8	Mcum
Daily Material Cast by Drag-lines (at 90% capacity)	D1	38982	Cum
Specific Density Of Coal	Sp	1.5	T/Cum
Ratio of Turra/Purewa Seam	J	0.7	

Table No: 2

Traffic Density Factor for O/S	Avg Daily Material Transport from O/S Road (Cum)	Annual OBR from O/S (MCum)
1	510000	186.15
2	255000	93.075
3	170000	62.05

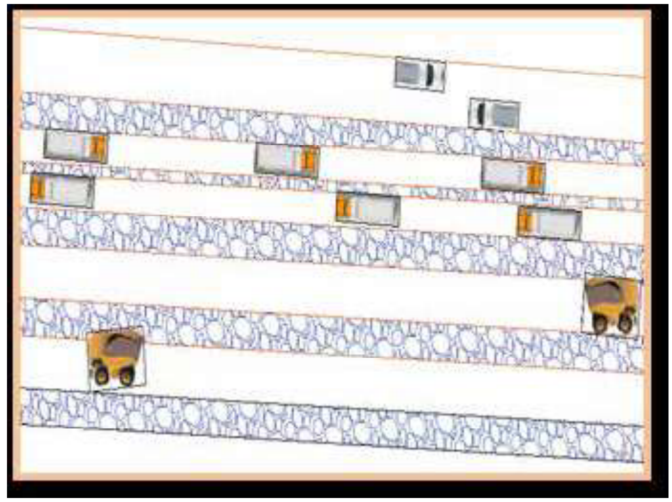

Fig: 4 -Haul Road Traffic

From the table No: 2, it can be seen that for Traffic density factor 1 (Gap between tippers = 40m), maximum OBR from O/S tippers can be 186.15 MCum per annum which is not possible in real mining situation, therefore for further calculation of departmental OBR, traffic density factor for outsourcing tippers is considered as 2 (Gap between tippers = 80m).

For O/S OBR =2,55,000 Cum/Day

Table No: 3

Traffic Density Factor for Depart. Dumpers	Total Depart. OBR (Cum)	Total OBR (O/ S+Depart.)	Annual Coal Prod (MTe)
1	385	478	88.47
2	196	289	53.50
3	133	226	41.84
4	101	194	36.01
5	83	176	32.51
6	70	163	30.18
7	61	154	28.52
8	54	147	27.27
9	49	142	26.30
10	45	138	25.52
11	41	134	24.88
12	38	132	24.35
13	36	129	23.91
14	34	127	23.52
15	32	125	23.19
16	31	124	22.90
17	29	122	22.64

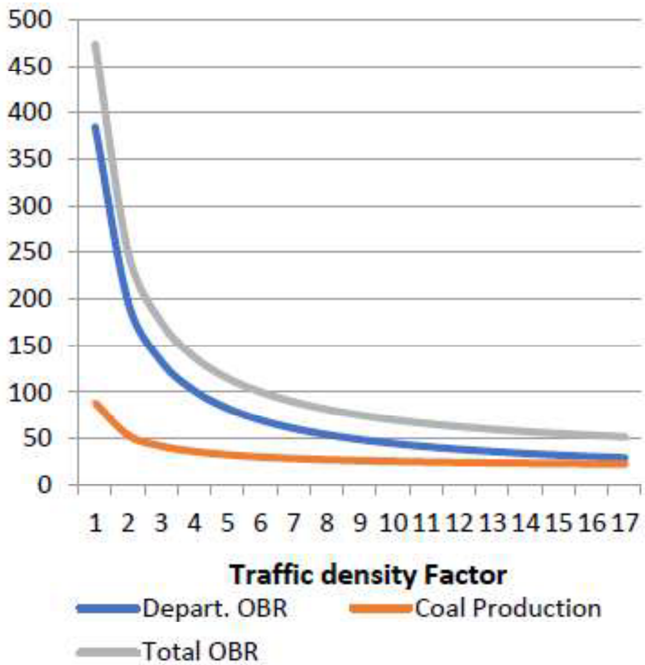

Figure 5

As evident from table no: 3, for departmental traffic density factor 17 (Gap between dumpers = 680m), total OBR is 122 MCum and coal production is 22.64MTe.

Hence, it can be easily seen that there is a scope to increase traffic on departmental haul roads only.

It can be argued that the outsourcing OBR can be increased by developing multiple haul roads. Yes, it can be, but it will reduce the percentage recovery of coal from the bottom most seam and increase the percentage of rehandling, ultimately it will increase the cost of production and affect the economy of mine.

CONCLUSION

From the above mathematical model, it can be inferred that the production enhancement is possible either by deploying higher capacity equipment in outsourcing working or adding transport equipment to the existing fleet in case of departmental workings.

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Deep Hole Drilling, Charging And Blasting" A Case Study of Challenges In 21St Cut Dragline Bench of Khadia Project (14 MTPA)

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ABSTRACT

This paper aims to draw attention towards the challenges faced by the project while blasting for 21st Dragline cut. Two number of dragline namely Somnath dragline (33/74) capacity and Baidhynath dragline (15/90) capacity in horizontal tandem were to be deployed.

The biggest challenge was the cut was full of hindrance for dragline formation level preparation. Base workshop and diesel dispensing units of M/s IOCL were in the 21st cut pathway. It was mainly due non availability of land for shifting of base workshop from cut area to new site. The new site was not available due to non-shifting of KBJ railway line diversion executed by M/s RITES. The shifting of KBJ line was delayed by more than a decade due to land acquisition problems.

A total of 45 blasts were done for chainage upto nearly 2200 metres. The depth of hole for dragline bench blasting varied from 32 metres upto 52 metres.

This paper aims to highlight the challenges faced while drilling, charging and blasting of 52 metres hole.

INTRODUCTION OF BLASTING

Blasting is the principal method of rock breakage in mining throughout the world. This may be probably due to distinct advantages like economy, efficiency, convenience and ability to break the hardest rock. However, only a portion of the total energy of the explosive is consumed in breaking rocks while the rest is dissipated. With increasing mining activities in areas close to human settlements, ground vibrations has become a critical environmental and social impacts as it can cause human annoyance and structure damage.

The mining & explosives industries rapidly embracing new technology in order to improve overall performance, efficiency & cost effectiveness in various types of blasting & also to mitigate its adverse effect. Most recently technology that is developed to improve techno-economics & reduction of adverse effects in usage of explosives & blasting is "precise & accurate delay timing- Digital & electronic detonators system". Accurate & flexible timing allows blasters to make small hole to hole & row to row changes to account for drilling in accuracies. The mining method at optimum is multi-seam mining, using dragline in successive parallel strips 70 m meters wide and upto 2200 m long. This method involves removing the top soil to a depth of approximately 190 meters, drilling and blasting the overlaying waste material and the removal of this overlaying burden by draglines. The timing/ delay element of blasting of blast hole firing is enabled through a delay element in the detonator.

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The long awaited arrival of high accuracy electronic detonator provides new opportunities to the explosive end user. The blasting community can become better equipped and able to improve upon the current approaches and methodologies used in blast design. The last few years have seen dramatic progress in blasting technologies, the quality and performance of products. The high accuracy detonator brought with it new meaning to one of the fundamental aspects of blast design: accurate controlled sequence of blast hole detonation is one of the most critical parameters that has a direct impact on overall blast performance in many ways.

LOCATION AND GEOLOGY OF PROJECT

Khadia project is located in Singrauli area of M/s Northern Coalfields Limited between latitude 24 deg 7' 26" & 24 deg 8'47" and between longitude 82 deg 41'40" & 82 deg 44'47" has been named after Khadia village located in the south of the block. The Area is covered under the Topo Sheet No.63 L/12 & special sheet no. .9 & 11 of Survey of India. It is connected by Metalled road to NCL HQ, Singrauli and to Shaktinagar - Varanasi Highway as well as to Rewa Highway. Nearest Railway station being Shaktinagar, Eastern Railway. It is bordered in northern side by MP Forest Land, in south side by Shaktinagar Super Thermal Power Station of NTPC, Shaktinagar, in the western side by Dudhichua Project and in the eastern side by Krishnashila project.

The Rocks of Barakar formation belonging to Damuda Sub group are exposed in this project alongwith recent soil/alluvium cover at places. Predominated rock types of Barakar formation is sand stone followed by shales and occasional clay horizons. The sand stones where exposed on the top of the plateau are massive and weathered and escarpment, face is characterised by boulders of sand stone rolled from top of the plateau. The sand stone consists of quartz and feldspar. The Khadia block stands out as a plateau above the plains on its south. The plateau is pronounced by steep escarpment facing south, rising from an elevation of 290m at the base to 425m at the top of the plateau.. The area on the top of the plateau is gently undulating, except one hill in the north-east corner having an altitude of 489m. The general elevation of the plateau varies from 420 to 400m.

Structure: The strike is NW – SE in the west which swing to ENE – WSW in the eastern part of the area. The strike is E –W in the central part of the area. The dip generally varies from 20 to 30 (1 in 20 to 1 in 25). There is no exposure of Coal within the Project. The coal seams occurs incrop in the property. Five Coal seams occur namely, Kota, Turra, Purewa bottom, Purewa Top & Khadia in ascending order. The Kota & Khadia seams are not considered for exploitation because of thinness, interbanded and inconsistent.The overview of the Khadia Project is presented in Fig. 1. Fig. 2 depicts the cross sectional view of the Khadia project.

PROBLEMS ENCOUNTERED IN THE 21ST CUT

The patch of 21st dragline had base workshop, which was to shift in the area to be vacated by diversion of KBJ rail track. It can be seen from the following facts that it was delayed by more than a decade. So, the mid portion chainage from 1200 to 1500 metres of the cut could not be decapped out timely resulting in drilling patches for dragline of more than 50 metres.

THE REASONS FOR DELAY IN DIVERSION OF KBJ RAIL TRACK

Diversionof KBJRailway Line, apassengerlineof Eastern Railway (now Eastern Central Railway) in a stretch of 6.5 Kms near Shaktinagar Railway Station: Construction of 10 Bridges including 4 major bridges, earthwork in high embankment and cutting, pile foundation with 1.0m diameter bored cast in- situ piles requiring rock drilling, Permanent way works. The work was awarded to RITES by Northern Coalfields Ltd. on turnkey basis. This work was a left over work, earlier partly executed by IRCON. Work in formation was started and continued as per RDSO Guidelines. Work involved day to day supervision, quality control, adherence to specifications processing of claims and certification of contractor's bills. This work was executed in the year 2003-2004. This contract was however, foreclosed midway due to land availability issues. After clearing all the issues, NCL again approached RITES for completing the balance works. NCL re- engaged RITES in September 2013 for providing PMC services for this. The field work was actually started in July 2014 and completed in October 2015. Since it was a passenger line, CRS clearance was obtained and line was opened to traffic 15.09.2018 on diverted route.

Fig. 1. Overview of Khadia Project

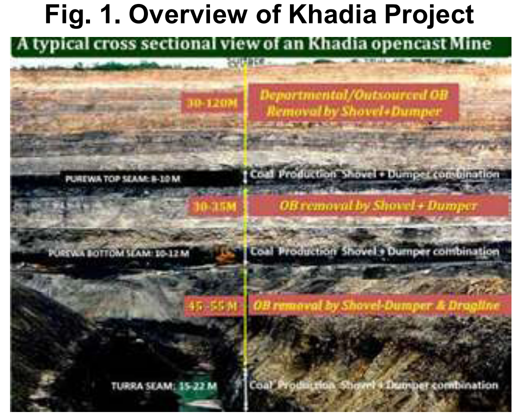

Fig. 2. Cross sectional view of Khadia Project

METHOD OF WORKING ADOPTED

Khadia Opencast mine is having an overall stripping ratio of 4.29 t / cum and strike length of about 4.5 Km. A combined system of Mining deploying Draglines and Shovel-Dumpers combination has been adopted as suggested in Project report. The mine has been divided into two sector Western and Eastern Section. There are three coal seams as stated above and the top cover above Purewa top coal seam is about 77m, parting between Purewa Top and bottom coal seam is about 35 m and the parting between Purewa bottom and Turra coal seam is about 55m. Thus the total overburden is about 167m. Overburden up to about 132m is taken by Shovel-Dumpers combination and draglines are deployed in the lower 35m for OB removal. The cut length of dragline varies from 70-80m which is worked by one no.33/74 and two nos. 20/90 Draglines operated with extended bench method. Coal is extracted after dewatering of coal face by Shovel–dumper combination through main entry. This entry is for extracting the Turra coal seam all along the cut of the Dragline in a safe manner by marinating proper haul road, drain, sump, and corridors etc.

CASE STUDY

Drilling challenges

Khadia project has one number of 311mm drill for its dragline patch. This DMH make 311 mm diameter had the capability to drill a blast hole of 52 metres. Earlier DMH drill was used for drilling upto 43 metres using three rods attachment (each drill rod of 15 metres in length). Fourth rod was in the drill machine but was not used for drilling. Service Engineer of equipment manufacturer of DMH was called, who was reluctant initially to allow use of 4th rod, citing compressor capacity limitations. **The water column in bore hole was upto 18 metres.** This made drilling even more difficult as after joining of third rod a lot of mud slush was encountered. Lot of care was taken to avoid of rods getting struck in the hole. It had to be cleaned after each rod drilling resulting in barely drilling 02 to 03 holes in a day due increased rod changing time. There was enormous pressure at the rotary head and feed systems. There were increased vibrations transmitted from drill strings to drill head, thus decreasing rod penetration rate.

Table 1. Blast Design Parameters adopted

Date of Blast	08.10.19
Name of Mine	Khadia, NCL
Face location	West Dragline bench
Strata	Medium Hard Strata (OB)
Face condition	Cut side free
Bench Height	48.00 to 50.00 mts
Depth of drilled holes	52.00 mts
Dia. Of drilled holes	311 mm
No. of rows	5
Pattern of holes	Square pattern
No. of holes	26+3(Pilot holes)
Average spacing	10 mts
Average Burden	12 mts
Sub grade drilling(if any)	1 m
Name and type of explosive used	IOCL(IBP) –SME - 106850 kgs
Type of initiation used	Electronic Detonator—Solar
Explosive charge per Hole	3684 kgs
Maximum charge per delay	3684 kgs
Percentage of booster	0.2%
No. of decks(if any)	Two deck – 3 mts each
Stemming Material used	Drill cuttings
Water column In hole(if any)	15-18 mts
Length of stemming (top)	6.0
Volume of rock blasted	180960 cu.m
Powder Factor	1.69 cu.m / kg
Blast results	
i. Fragmentation	Very Good
ii. Throw	10-12 mtrs from face on previous blasted side
iii. Percentage of boulders	1 to 2 %
iv. Vibration	13.76 mm/sec at 0.5 km distance.
v. Noise	Very low
vi. Muck Pile profile	Power trough of 5 mts at back

B Charging challenges and Difficulties faced and alterations adopted while charging blast holes of depth 52m to 58m at Dragline bench

Hose reel attached with pump truck was extended from 40m to 60m for effective down the hole charging. Due to extension of Hose reel, pressure exerted by flow of Bulk Explosives increased, which was monitored carefully. Lubrication by water was increased and maintained in line with the flow of explosives. Density of explosives throughout the charge column (especially at the extreme bottom of hole) was maintained in such a manner that it does not exceeds the critical density required for effective blasting Length of Electronic Detonator was to be increased from 40 m to 60 m, as per the depth of blast hole.

CONCLUSIONS

Based on the study, the following conclusions are drawn:

i. Use of electronic detonator made the blasting of 52 metres very effective with good fragmentation and low vibrations.

ii. Better blast efficiencies/fragmentation has been acknowledged by Dragline Section. While mucking, ease in digging and handling had been reported by dragline operational group.

iii. It is being envisaged that there will be prominent increase in life of dragline bucket, its tooth points, adaptors and drag/ hoist rope used during operation on account of better blast fragmentation.

iv. No complaints have been received from local residents in the vicinity of the mine boundary.Blast frequency records for blasting with E-det were good as far as damages in structures are concerned.

The details of 52 metres of holes drilled, charged and blasted

S. No.	Date of blast	Drilling depth (Mtrs)	Drill hole Dia (mm)	Spacing x Burden (Mtrs)	No.of rows X column ofholes	No.of holesin the blast	SME used in (Kg)	SME Charge /hole (Kg)	PF (CuM/ Kg)
1	**08.10.19**	**52**	**311**	**12x10**	**2x7+3x4+3**	**29**	**106850**	**3684**	**1.69**
2	**13.10.19**	**52.5**	**311**	**12x10**	**3x5**	**15**	**57040**	**3803**	**1.65**

Details of blasts report of Dragline Bench of 21st cut

S. No.	Date of blast	Drilling depth (Mtrs)	Drill holeDia (mm)	Spacing x Burden(Mtrs)	No.of rowsX column of holes	No.of holesin the blast	SME used in (Kg)	SME Charge/hole(Kg)	PF (CuM/Kg)
1	06.10.18	33	311	12x10	6 x 10	59	127720	2165	1.86
2	16.10.18	33	311	12x10	6 x 4	24	49690	2070	1.91
3	01.11.18	33	311	12x10	4 x 11	44	99330	2258	1.75
4	18.11.18	37.5	311	12x10	4 x 8	32	82680	2584	1.74
5	05.12.18	35	311	12x10	3 x 8	25	67580	2703	1.49
6	25.12.18	33.5 to 38	311	12x10	6 x 7	41	108170	2638	1.63
7	21.01.19	34 to39	311	12x10	5x7	35	92300	2637	1.71
8	04.02.19	38	311	12x10	5x7+2	37	98970	2675	1.70
9	18.02.19	38 to 39	311	12x10	5x7+4	39	105990	2718	1.70
10	15.03.19	38	311	12x10	5x7+6	41	111070	2709	1.68
11	12.04.19	38	311	12x10	8x7+3	59	153432	2601	1.75
12	06.05.19	36	311	12x10	3x7	24	46284	1929	1.95
13	04.06.19	37	311	12x10	4X7	32	78652	2458	1.58
14	13.06.19	36	311	12x10	7x7	56	156362	2792	1.35
15	20.06.19	38	311	12x10	3x7	30	84924	2831	1.12
16	28.06.19	36	311	12x10	3x7	30	89114	2970	1.02
17	26.07.19	40	311	12x10	3x7+2	23	71182	3095	1.55
18	29.07.19	40	311	12x10	4x7+4	39	91593	2349	1.67
19	08.08.19	38	269	9X10	4x8+5	37	79659	2153	1.59
20	17.08.19	37	269	11x9	2x9+5	23	46704	2031	1.80
21	23.08.19	36	269	11x9	2x8	16	31240	1953	1.82
22	30.08.19	38	269	11x9	2x8+2	18	35978	1999	1.88
23	06.09.19	36	3,11,269	11x10	5x7+1	36	81290	2258	1.75
24	15.09.19	40	3,11,269	11x10	4x7+3	31	85831	2769	1.59
25	25.09.19	42	311	12x10	3x6	18	55592	3088	1.63
26	08.10.19	52	311	12x10	2x7+3x4+3	29	106850	3684	1.69
27	13.10.19	52.5	311	12x10	3x5	15	57040	3803	1.65
28	13.10.19	41	2,69,311	9x8	2x5+5	15	25694	1713	1.72
29	28.10.19	42	311	10x12	3x7	21	64974	3094	1.63
30	03.11.19	43	311	12x10	3x7+5	26	81668	3141	1.64
31	10.11.19	43	311	12x10	4x7+1	29	88642	3057	1.68
32	16.11.19	43	311	12x10	4x7+1	29	83422	2877	1.79
33	22.11.19	41	311	12x10	4x7+2	30	87040	2901	1.69
34	29.11.19	38.25	311	12x10	5x7+5	40	112318	2808	1.63
35	16.12.19	35	2,69,311	11x10	5x7	22	45516	2069	2.95
36	21.12.19	35	269	11x10	5x7	45	79492	1766	1.69
37	26.12.19	32	269	9x11	4x7	38	65056	1712	1.36
38	29.12.19	32	2,69,311	10x12, 9x11	4x7	21	41224	1963	2.38
39	02.01.2020	32	2,69,311	10x12, 9x11	4x7	51	108764	2133	0.90

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Best Practices in Maintenance and Operation in Opencast Coal Mines for Economizing the Power Cost

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ABSTRACT

The World over, energy recourses are getting scarcer and increasingly exorbitant with time. The share of energy costs in total production costs is significant in Open Cast Coal Mines. Reduction in energy cost can be achieved by improving the efficiency in maintenance and operation of HEMMs & other electrical equipment .The various innovative approaches are to be applied to each important equipments, processes and plants at all stages of Production in coal mines such as use of More efficient equipments, Minimizing idle/redundant running of major energy consuming equipments ,Equipment operation at optimum capacity, avoidance of wasteful energy-use ,Preventive/ Regular/ Breakdown Maintenance facilities

,End use minimization & Use of Technology upgrades. The various implementable measures shall be used for reduction of power cost in Opencast Coal Mines i.e. Short-Term Measures: Reducing energy consumption by Operational improvements with little or no investment. Benefit-Immediate pay back (within one year), Medium-Term Measures/Low Cost Alternative:

-Making low-cost modifications and improvement to existing equipment Benefit- Pay-back period less than two years, Long- Term Measures, High Cost Alternative: Making equipment changes or implementing new techniques and new technologies involving large investments leading to more capacity utilization and energy savings .-Benefit-Pay back more than 2 years. Analysis in Specific Electrical Energy Consumption are to be taken. The following steps are to be taken to economize power cost by using energy efficient Lighting, Power Factor Improvements, improving Power distribution System by proper loading of Power/Distribution transformers, avoiding idle running of Machines/HEMMs, Efficient method to be used for Pumping/ Dewatering Operations in Mines, Staggering of Maximum Demand by centralized control through Single Point Metering and reducing demand charges. Detailed innovative comprehensive Action Plan is to be adopted to achieve Mega Savings to the tune of 5% of total energy cost in Open Cast Mines. It becomes successful, not only by the Top management but participation of the total work force.

Keywords— Power Cost, Short-Term Measures, Medium-Term Measures, Long-Term Measures, Pay-back period, Comprehensive Action Plan, Mega Savings

INTRODUCTION

In a developing country like India striving for rapid industrialization for National development, Energy cost saving and its efficient utilization are of paramount importance deserving the greatest attention of the planners, power supply industry, industrialists and the common man. Electricity is the key to economic development and India's current shortages of electricity have hampered industrial growth. The most important aspect is to adopt best practices in maintenance and at each stage of operation for reduction of electrical energy consumption strategy of the coal mines. Further identification of the problem areas and implementation of remedial measures in this regard are required must. Energy conservation has been recognized as a National priority for a very long time. Conservation and efficient use of energy in industry have for a long time been a priority of the Government of India. Employee on COAL Industry became aware of the seriousness and did their best to conserve and preserve this energy. New technologies with state-of-the art machines, new processes introduced and best practices are adopted in maintenance and operation in coal mines for saving of electrical energy.

A. BEST PRACTICES ADOPTED IN MAINTENANCE AND OPERATION IN MINES

1. Nitrogen Injection Fire Prevention System (NIFPS)

Best practices adopted towards electrical safety of large power transformer above 10MVA capacity is by installing Nitrogen Injection Fire Prevention System (NIFPS) for quenching the fire hazards occurring at transformer installation.

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Fig.1: NIFPS in transformer

2. LOTO - Lockout/Tagout

Best practices adopted towards electrical safety in various Control Relay Panel installed in control room of large power distribution system is achieved by installing Lockout-Tagout (LOTO) procedure to prevent accidental or unauthorized access to electrical power sources that are undergoing maintenance or other work. With this secured process, all individuals working on the same circuit or equipment have individual locks that they use to disconnect device before working on the system. The LOTO procedure also requires that each worker fills out a tag that is hung from their lock, including their name and a description of the work they are doing.

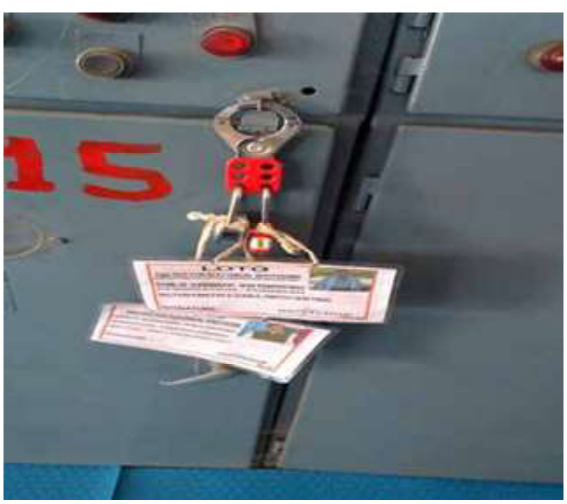

Fig.2: Lockout arrangement

Fig.3: Tagout arrangement

3. Best Practices in Energy Saving in Electricity bill through TOD (Time of Day) Consumption

As per tariff applicable for HT Consumers, the Energy charges are 20 % less in off peak night hours from 10pm to 6am as compared to basic energy charges applicable in day time & in peak time in MP group of mines. Best practices adopted for energy saving is that Possible Non important electrical loads are being staggered from peak hours to off peak hours in UP & MP group of Mines with the consent of production and operating Engineers to reduce power cost without production loss. As a result Net rebate on Time of Day consumption during Off peak/ Night hour from 10PM to 6 AM in MP group of Mines has been obtained in Monthly electricity bill.

TABLE I: TOD for MP group of mines

TIME OF DAY	MP GROUPE OF MINES	TARIFF APPLICABLE IN MP GROUPE OF MINES
PEAK HOUR	6PM TO 10PM =4 Hrs	Normal rate of energy charge
OFF PEAK HOUR	10PM TO 6AM =8Hrs	(-)20% of Normal rateof energy charge
DAY HOUR	6AM TO 6PM= 12 Hrs.	Normal rate of energy charge =Rs.7.05/KWH

TABLE II: TOD for UP group of mines

TIME OFDAY	UP GROUP OF MINES	TARIFF APPLICABLE
PEAK HOUR	**5 PM TO 11 PM = 6Hrs**	**(+)15% of Normal rate of Apparent Energy charge**
OFF PEAK HOUR	Summer(April to Sept) 5 AM to 11AM = 6Hrs. Winter(Oct to March) 11PM TO 5AM=6Hrs	(-)15% of Normal rate of Apparent Energy charge
DAY HOUR	Summer(April to Sept) 11 AM to 5PM=6Hrs 11PM to 5 AM=6Hrs Winter(Oct to March) 5AM to 5 PM =12Hrs	Normal rate of Apparent Energy charge =Rs.6.80/KVAH

4. Best Practices in Energy Saving in Electricity bill through Demand Management

Best practice adopted towards Demand Management front in coal Mines is by explaining the method of charging of maximum demand charges to HT Consumer as per latest provision of Electricity Regulatory Commission tariff .It is informed to all Power Engineers, Authorised Electrical Supervisors, Operating Engineers of Mines that Maximum Demand for the Month is determined by the maximum load used in any 5 minute slot available in a month (starting from first date of billing cycle in a month i.e.00:00 hrs to 00:00 hrs of last date of billing cycle).If Maximum Demand recorded in a Month is Below 90% of Contract Demand=Than, it shall be charged minimum 90% of CD at Normal rate. If MD between 90% to 115% of Contract Demand, it shall be charged on Normal Rate. If MD between 115% to 130% of Contract Demand, it shall be charged at 1.3 times the Normal rate. If MD is above 130% of Contract Demand, it shall be charged at 2 times the Normal rate .Further in open cast coal mines of NCL, Centralized control of maximum demand is established by Purchasing Power at Single Point Metering at 132kv Nigahi substation connection point- Feeding Industrial power to Jayant, Dudhichua, Amlohri, Nigahi & CWS Jayant & at 33 kv Bina substation connection point – Feeding power to mines & township of Khadia, Krishnashila, Bina & Kakri and further also at 33 kV DCH/ NGH township point- Feeding domestic power to DCH, NGH, AML,NSC office /colony ,CMPDIL office / colony, Central store, CMPF office /Colony. NO PENALTY PAYMENT made against OVERDRAWAL OF POWER due to accurate prediction of demand by adopting of above best practices and using technique of Hourly recording and monitoring of Maximum Demand at various HT Sub stations.

5. Best Practices in Energy Saving in Electricity bill through Power Factor Economy

As per latest tariff of MP Regulatory Commission, if Power factor of consumer is between 0.90 to 0.95 than no penalty be claimed and no incentive shall be payable to consumer. If Power factor is between 0.95 to 1.0 than Power factor Incentive shall be payable as follows:

TABLE III: Power Factor Incentive In Mp Group of Mines

Power Factor	Percentage incentives payable on billed energycharges
Above 95% and up to 96%	1%
Above 96% and up to 97%	2%
Above 97% and up to 98%	3%
Above 98% and up to 99%	5%
Above 99%	7%

By adopting best practices such as installing capacitor bank in various sub stations in mines and explaining the power factor impact on electricity bill in tariff structure to concerned officers and electrical supervisors , Power factor is improved and maintained above 0.95 in mines and townships of NCL as a result good incentive has been received in monthly electricity bill.

6. Best Practices in Conservation of Energy in open cast coal mines

Best practices applied for Energy efficient lighting and power factor improvements, improving power distribution system by proper loading of power/ distribution transformers, avoiding idle running of machines/HEMMs for conservation of energy in open cast coal mines. High watt luminaries/conventional fittings i.e. 400W HPSV, 250W HPSV, 150W HPSV, 40W tube light fittings were replaced by newly procured energy efficient LED Luminaries i.e. Industrial High Bay light Fittings 200-240w , Flood light Fittings 190- 210w , Street light Fittings 120-140w , High Bay light fittings 100-150w , street light Fittings 70-85w , street light Fittings 35-45w, LED Tube rod 4 ft 16/18/20/ 24w, Pin type LED Lamp 9w, 12-15w etc from M/S EESL and through GEM Portal for their use in Offices, Street lights, Mines lightings & Township Areas in various projects/units of NCL.As a result 50% of total energy cost saving achieved by using above energy efficient LED's against existing conventional fittings . The expenditure made towards replacement of above LEDs was got payback within one year. Efforts are made to reduce Transmission losses, Transformation losses, Distribution losses, Utilization losses in overhead line and various equipments used in mines. The percentage of power consumption in various equipments used in opencast mines are tabulated below:

TABLE IV: % Of Power Consumption In Various Equipments/Areas Used In Opencast Mines

Equipment/Areas	% of Total
Draglines	36 - 38
Electrical shovels	30 –34
Township Lighting	16 –18
Coal handling plant	7 – 8
Electrical Drills	6 – 7
Mines lighting	3 –4
Water pumping	2 – 3

7. Best Practices applied in Coal Handling Plant

NCL has adopted its linked customer to evacuate coal through Belt Pipe Conveyor (BPC) system in Coal Handling Plant. This new system is more efficient, productive and eco-friendly as compared to conventional Bucket Trolley System and Roller Pulley conveyor system. Further, in compliance to the directive of Ministry of Coal, crushing of coal to (-) 100 mm size has been carried out from the existing CHPs to ensure 100 % sizing of coal to (-) 100 mm. Various Road weighbridges and Rail weighbridges are installed at different locations of NCL for weighment of coal. Dust extraction system is used regularly for controlling the dust during coal feeding to create environment friendly for operation as well as maintenance work force. Further, sprinkler system is used to avoid dust generation during stacking, reclaiming & storage.

Fig.4: Mechanically Actuated dust suppression system on the conveyors of CHP

Automatic Mechanical Samplers (AMS) are installed in different Silos of opencast mines of NCL to fasten as well as to ensure precision in coal sample collection process. NCL has 5 numbers of NABL accredited labs having highly sophisticated laboratory equipment and other facilities related to coal sample collection, preparation, testing and analysis.

Fig.5: AMS at CHP

8. Best Practices applied Dewatering operation in mines

All the mines of NCL have adequate pumping arrangement for dewatering of the mines. Suction pipes of pumps are normally be of at least 20-25% higher diameters than delivery pipes. for efficient working of pumps. Maximum possible number of pump sets are installed on Pontoons for dewatering of the mines during Monsoon.

Fig.6: Pontoon Pumping of dewatering in mines

INNOVATIVE APPROACH ADOPTED FOR ECONOMIZING THE POWER COST

The innovative approaches applied for economizing the power cost are on each important equipments, processes and plants at all stages of Production in coal mines of NCL. These are achieved by using more efficient equipments, Minimizing idle/redundant running of major energy consuming equipments, Equipment operation at optimum capacity, Avoidance of wasteful energy-use, Preventive/ Regular/ Breakdown Maintenance facilities, End use minimization, Use of Technology upgrades. The specific electrical energy consumption of each open cast mines are to be reduced from 3-5% as compared to previous year by adopting various implementable guidelines. These will help in reduction of power cost in Opencast Coal Mines in NCL through adopting; **Short-Term Measures:** Reducing energy consumption by Operational improvements with little or no investment- **Benefit-I**mmediate pay back (within one year) **Medium-Term Measures/ Low Cost Alternative:** Making low-cost modifications and improvement to existing equipment - **Benefit-** Pay- back period less than two years. **Long-Term Measures, High Cost Alternative:** Making equipment changes or implementing new techniques and new technologies involving large investments leading to more capacity utilization and energy savings - **Benefit-**Pay back more than 2 years.

1. Short-Term Measure

Energy savings up to 10% or more are achieved through operational improvements and good housekeeping. Harmonic Filters and synchronous drive are provided in Dragline and Shovels resulting saving about 4% energy in the system. Dynamic Reactive compensation introduced by installing capacitor banks of adequate capacity ensuring Nil drawl of Reactive power from the Electric Utility Company getting power factor incentive from DISCOM. HT Induction motors are operated at full load to achieve optimum motor efficiency resulting energy conservation. Automatic load control and microprocessor based equalization running of compressor system has been introduced for efficient operation of air-conditioning plants, refrigeration units reducing unnecessary energy losses. An effective preventive maintenance programme has been introduced to decrease machine and bearing friction of various equipment for reduction of energy loss. The equipment and instruments are checked and tested for energy efficient performance at regular intervals. Lower efficacy lamps such as tungsten- filament incandescent lamps used for general lighting, office lighting, high-pressure discharge lamps, Metal Halide lamp used in mines lighting are replaced with higher-efficacy LEDs resulting higher luminous output per watt of energy consumed. In future we are planning to replace all other light fittings by LED light fittings only.

Now, less than 5% of ceiling fans produced in India are star rated while the Bureau of Energy Efficiency plans to bring ceiling fans under mandatory labeling from 2022, the high upfront cost will be another barrier. We need innovative business models that can attract manufacturers to produce efficient technology at scale and bring it within the purchasing capacity.

India needs a nationwide consumer awareness campaign on energy efficiency. Only a forth of Indian household are currently aware of these star levels. While awareness levels are high among residents of metros and tier-1 cities. The majority in small town towns and rural areas remain unaware. To bridge this divide, we need a decentralized and consumer centric engagement strategy. State governments, DISCOMS, and retailers need to be at the forefront of power renewed efforts to create mass awareness about energy efficiency.

Fig.7: Power Distribution system

2. Medium-Term Measures

The following modification and improvements are incorporated to existing equipment:
Retrofitting/ Minor Modifications of existing equipments. Power factor correction equipment by installing capacitor banks resulting considerable power saving. Ordinary A.C. induction motors drives are replaced by high-efficiency motors though 10-25% costlier. This makes system energy efficient and improve s power factor as additional advantages. The investment made will pay off within two years. Overpowered drives are replaced by correctly powered motors taking into account maximum torque, maximum starting current, R.P.M., possibility of speed variation and a safety margin.

3. Long-Term Energy Conservation Measures

Replacement/ Installation/ Modernisation of old and inefficient existing equipment and systems are planned as below: New techniques and technologies involving large investments are introduced for higher production/ performance with assured substantial energy saving in place of old and inefficient existing equipment and systems. Investment decisions are based on expected financial return on the capital invested. From above Strategic Managerial model, following 3 stages of implementation adopted in NCL.

DETAILED INNOVATIVE COMPREHENSIVE ACTION PLAN ADOPTED FOR MEGA SAVINGS IN NCL

The detailed innovative comprehensive action plan proposed to achieve mega saving to the tune of 5% of total energy cost in open cast mines by adopting following 03 cost alternatives. It becomes successful not only by the top management but participation of the total workforce.

1. No Cost Alternative

Transformer load management by cyclic loading of 10, 5 MVA, 33/6.6KV Transformer at coal & OB substation, Cyclic loading of distribution transformer in CHP, Workshop, pump house, crusher, Maintain 6.6KV voltage by automatic operation of OLTC at mines sub- stn, Maintain 34KV on 33KV bus at Main substation of projects/units, Reduce idle running of shovels, Reduce idle running of dumpers, By stricter administrative and technical control on Electrical energy, Alternate switching off transformers at various Townships, Staggering of load from peak hour to off peak hour / night hour resulting net saving in power cost in energy bill. Switching off 50% of road lights in colony, Excess lamps are reduced in main colony Sub Station based on Illumination level, Replacement of lamps with LED for external lighting, Replacement of incandescent lamps with LED lamps in quarters, Replacement of metal halide lamp with LED luminaries at T/ship, Timers provided for street light control, Replacement of incandescent lamps with LED at residential buildings, Reduction in voltage for colony lighting, Alternate switching off CHP lighting Distribution Transformer, Reduction of excess luminaries and switching off bay lights in workshop, Timers provided for Switching off some of the lights of shovel maintenance shed and dumper repairing sheds during night, Timers provided for Switching off time office lighting, Timers provided for Switching off bay light in sump, Disconnection of FL lamp and its replacement by LED in control room building, Timer control for mine lighting, Switching off 2/3rd street light in T/S, Avoid idle running of Shovels (20cum/ 12.5cum/ 10cum), Regulated water supply by providing overhead tanks.

2. Low Cost Alternative

Reactive compensation by installing capacitor banks in various 6.6KV Feeders and minimizing line losses, Reactive compensation by installing capacitor bank in various 415V motors in CHPs, Suitable capacity of 3 phase energy savers are used in lighting circuit of CHP's, 700 KVA 3 phase energy savers are used in each project sub-station

3. High Cost Alternative

Use of high efficiency motors, Energy monitoring system (use of digital panel meters at Mines substation), Reduction of station transformer capacity at project main substation, Static variable frequency drive are provided at various 300 KW booster water pumps in CHPs.

Recent Indigenous development Proposed to be adopted in advanced electrical equipment in NCL by using High temperature Super conductor cable system, Super conducting fault current Limiters, Fully digitalized Sub Stations, Process Bus Technology, Helicopter based aerial patrolling for monitoring transmission line using high resolution camera, Wide Area Energy Measurement System (WAMS) towards Smart distribution for real time monitoring.

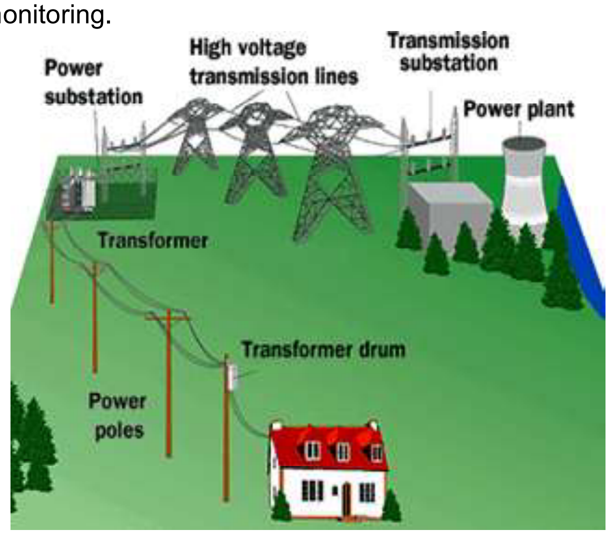

Fig.7: Indigenous Development on Power System in mines

CONCLUSIONS

The efforts were continued to accrue the maximum benefits on account of economizing the power cost by implementing various measures and cost alternatives. This is possible only by active involvement and co-operation from all fronts of the organization. Continuous interaction/discussion among the mining personnel/ managers (operation), other officers and staffs towards power cost reduction made realistic, practical and implementable. Energy management program (EMP) in NCL became successful, not only by the Top management who show ample interest towards achieving its goal; but also co-operation from grass root level workers take active interest in this regard. Total participation of the NCL workforce accomplished the task of economizing the power cost in mining operation. The technology up-gradation and modification are taken up by the Engineers and Managers; the housekeeping measures and best practices in maintenance and operation are carried out by technicians and helpers. Suitable training on Energy awareness Programmes at mine/area level and introducing the Energy management Theme in the NCL assisted schools/colleges are organized to achieve the objective. We need to improve the availability and affordability of energy efficient appliances.

We need to monitor supply quality and changing consumption pattern on a real time basis. We should deploy smart meters to measure actual savings and demonstrate the benefits of energy efficient devices to build user confidence. India has tasted success in recent years by using LED luminaries under government's UJALA Scheme which reduces its annual carbon emission by nearly 82 million tones. Despite the projected escalation in production cost, Indian coal will continue to be the cheapest available source of energy in 21st century. With proper energy management power crises in coal industry can be solved and also fulfill the demand of power generation in global scenario. The Energy Industry must take lead in sustainable development.

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Modified Tandem Operation Of Draglines

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ABSTRACT

There are 23 draglines working at different projects of Northern Coalfields Limited of various bucket capacities that is, 10,15,20,24 and 33 cum. with boom length varying from 70 m to 96 m. Four numbers of Draglines are working in its five large opencast projects. The working of most of these mines are centrally divided into two sections with central road at Turra floor level and the Dragline cut commences from central part of the mine and terminates at the boundary of mine at the two sections. As two numbers of Draglines works in each section of mine so most of the period two draglines in each section works in Tandem. Normally both the Draglines work in Lowwall In-Pit bench method of working where advancing Dragline takes the key cut and creates a extended bench/Bridge at a lower elevation by sitting at lowwall (spoil side). This is a single pass two lifts lowwall operation employing a highwall chop method of digging in the first lift and a pullback digging operation in the remaining lifts. The dragline bench in the lowwall side is about 4 to 6 m below the pre blasted surface. The overburden is blasted so as to achieve maximum throw. The retreating dragline then sits at the In-pit /extended bench/bridge created by advancing Dragline and takes the box cut in pull back operation by further exposing the coal and dumping for further widening of the extended bench required for the final no coal/rehandling material removal from final sitting position. For final sitting the dragline moves backward and removes the remaining solid material and rehandling material and dumps into the final spoil room by swing in the opposite direction as from the swing direction for previous two sittings of advancing and retreating dragline. In order to improve the productivity of both the draglines in tandem operation another variant Modified Dragline working in tandem operation can be practiced by deploying advancing dragline as per Standard Extension Bench method along Highwall and creation of extension bench for retreating dragline by creation of extended bench/In-pit bench/bridge adjacent to the block under excavation at a lesser swing angle. Here the productivity of advancing Dragline becomes very high not only with respect to Lowwall in-pit bench method but also higher than standard extension bench method. The retreating/ lagging dragline sits at lower level than the pre blast level and removes the box cut solid material and rehandling material. The reduction in rehandling volume is achieved by having the sitting level as low as possible while having space for sufficient spoil room.

The working methodology for the most productive tandem operation of Draglines that is, Highwall and Lowwall Extended Bench tandem operation of Draglines working at different horizons is discussed in detail in this paper for all the sittings position of advancing and retreating dragline.

MODIFIED TANDEM OPERATIONS OF DRAGLINES

The Modified Tandem Operations of both advancing as well as Retreating Dragline is detailed for all the sitting positions of both the draglines.

1. Key Cut by Advancing/Leading Dragline –

A. Dragline Sitting level and Position of Dragline for Key Cut by Advancing or Leading Dragline-

(1) Placement of Dragline-

a. **Dragline sitting level** – It will be same as the original pre-blast level (or the adjacent unblasted corridor level) of the dragline block.

b. **of Dragline** - The Dragline sitting position is along the New Highwall that is, the intersection point of Dragline sitting level with the vertically upward projection from the midpoint of New highwall toe (to be formed) and Key cut Toe (at a distance of half the width of Bucket say, 3 m from new highwall toe or 12 m from new highwall crest). The sitting position is same as standard Extension bench Method working.

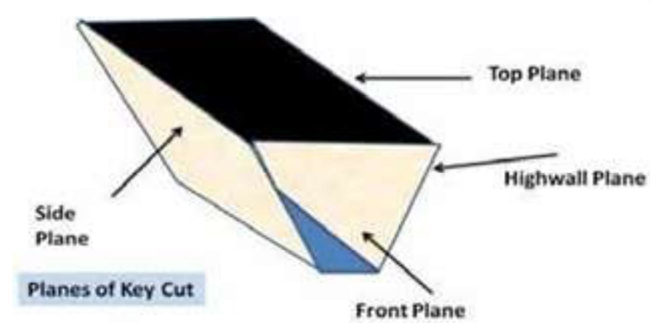

Fig.1. Key Cut Planes

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c. Key cut width at the bottom level or Coal Roof level – The width is same as the Dragline bucket width say, 6 m. Then Key Cut widening is done with bottom width of 22 m and top width of 60 m. The slope of cut at dump side is at 45°.

(2) Working Methodology

a. Digging Method during Key Cut– Digging method same as Standard extension Bench Method is followed. Here underhand digging method of dragline is followed for the Key cut material excavation. The dragline works along highwall and digs material below its tub level in different sub blocks layerwise.

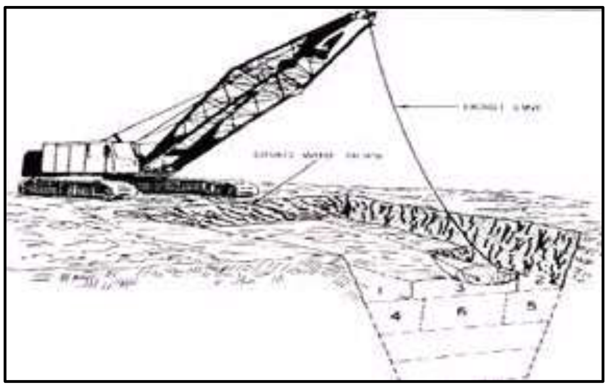

Fig.2. Layer-wise Key cut Operation

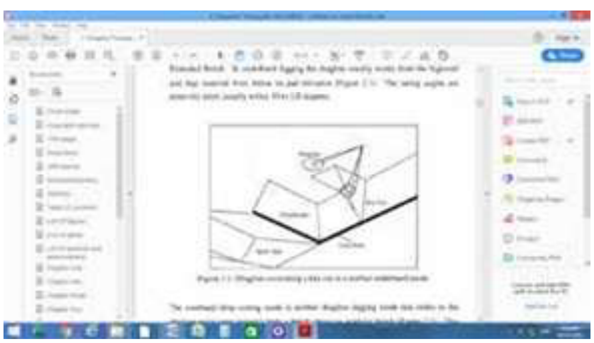

Fig.3. Underhand Digging Operation by Dragline

This is the best digging method (under digging method) as productivity of dragline is highest compared to other two digging methods (chop down or pull back digging method). Bucket filling time is less whereas bucket fill factor is highest. Less operator skill is required. The bucket line breakdown is also minimum.

The Key cut excavation is accomplished with the formation of new highwall with the accomplishment of good highwall dressing and desired.

Depending on the Dragline first sitting position from highwall the highwall material (a triangular patch) immediately 5 m (approx.) from dragline face crest is not excavated completely (from the current block under excavation) but this material is excavated as well as highwall is dressed from the next Key Cut sitting of dragline along highwall. In order to eliminate this problem the best sitting position for center of tub of dragline shall be at the crest line of Highwall. In order to achieve this sitting for Dragline the blasting of dragline formation level corridor (5 m depth only) upto a width of 20 m is required for providing the loose base material for the cushion of Dragline tub as well as its walking shoes.

b. Dumping of excavated material and formation of Extended Bench/Bridge

The key Cut material is dumped at an average swing angle of less than 60° at decoaled side for the formation of Extended bench adjacent to the block under excavation.

Fig.4. Dragline Working at Key Cut Position

There is difference in the place of dumping in this method of Dragline working as compared to standard extension bench method where the excavated material from the current block is dumped in the Next bridge formation adjacent to the block in which the dragline sits. So the average swing angle in case of bridge formation from Key cut material in standard extension bench method is much higher that is, 90° compared to 60° in this method. This reduction in average swing angle has tremendous impact on the productivity enhancement of the advancing dragline for Key Cut operation.

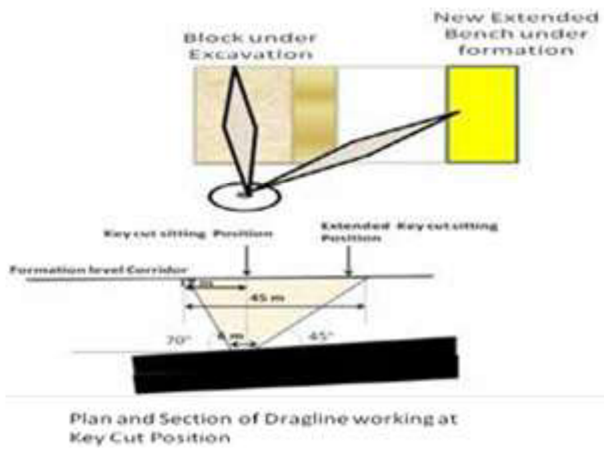

Fig.5. Plan and section showing Dragline Working at Key Cut Position

There is variation in the place of Dumping in this method compared to standard extension bench method (Single Dragline) because in standard Extension Bench Method the dragline which removes key cut material and creates extension bench adjacent to the block on which it is sitting and then the same dragline has to sit in the new bridge/ extended bench for the removal of Box cut material and no coal/ rehandling material (so the average angle of swing is higher say, 90°). In this method there is no requirement of leading dragline to prepare extension bench for its own sitting so it creates extension bench adjacent to block it is excavating at a lesser swing angle say,60° for the box Cut and no Coal/ Rehandling sitting of lagging dragline (2nd Dragline).

While dumping during the formation of extended bench for further working of lagging dragline every care should be taken to keep the level of extended bench to 6 to 8 m below the sitting level of leading dragline so that minimum dozing is required for leading dragline while preparing the sitting level at 6- 8 m or below the leading dragline.

B. Extended Key Cut by Advancing/Leading Dragline

Requirement of second position/ sitting for Extended Key Cut/ Partial Box Cut Excavation by Leading/ Advancing Dragline –

a. The material excavated during the key cut is not sufficient to create the required extended bench/ Bridge for the lagging dragline due to depth of overburden, which is not very high compared to coal seam thickness. In order to create the required width of extended bench for the box cut and no coal sitting of lagging/retreating dragline the extended key cut is excavated by advancing/ Leading dragline.

b. With due consideration of the productivity of both the draglines in tandem operation the workload of leading and lagging dragline is balanced and width of extended key cut and volume of material to be handled for Extended Key cut/part of box cut by Leading Dragline is decided.

c. To eliminate the unproductive inclined cutting by dragline from key cut position for taking the wider key cut.

(1) Placement of Dragline for Extended Key Cut Position

a. **Dragline sitting level** – It will be same as the original pre-blast level (or the adjacent unblasted corridor level) of the dragline block.

b. **Position of Dragline** - The Dragline sitting position is about 40 m from the New Highwall crest. The sitting position is same as Standard Extension bench Method working.

(2) Working Methodology

a. **Digging Method during Extended Key Cut**– Digging method same as Standard extension Bench Method is followed. Here underhand digging method of dragline is followed. The dragline works digs material below its tub level by sitting at a distance of 40 m from highwall crest.

b. **Dumping of Excavated material and widening of Extended Bench/Bridge**– The Extended key Cut material is dumped at an average swing angle of less than 60° at decoaled side for the widening of Extended bench already prepared by Key cut material. The material is dumped at an average swing angle of less than 60° at decoaled side for the formation of required width of Extended bench adjacent to the block under excavation for the sitting of retreating/ lagging Dragline. This is the most productive phase of leading dragline because here free face is available for excavation, no highwall dressing is required from this position and the dragline works at lesser swing angle (less than 60°).

While dumping during for the widening of extended bench for further working of lagging dragline every care should be taken to keep the level of extended bench to 6 to 8 m below the sitting level of leading dragline due to three requirements. Firstly, the required width of extended bench/bridge/in pit bench for the working of lagging dragline for box cut excavation and final rehandling material excavation will be prepared. Secondly, minimum dozing will be required for lagging dragline while preparing the sitting level at 6- 8 m or below the leading dragline working level. Thirdly, as we know that the depth of the extended bench affects the amount of rehandling, so a significant reduction of rehandling can be achieved by keeping the extended bench level/bridge level as low as possible while still providing sufficient spoil room. Thus for achieving all the above requirements in-pit bench (extended bench/ bridge) in a lower elevation instead of normal bridge is formed. There is also less restriction on the level of the in-pit bench than in standard extension bench.

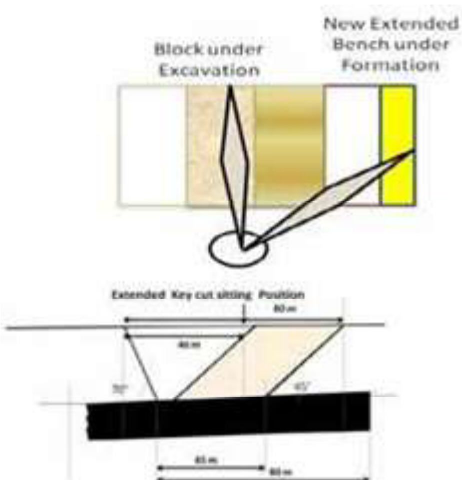

Fig.1. Plan and Section showing Dragline Working at Extended Key Cut position

BOX CUT MATERIAL REMOVAL BY RETREATING/ LAGGING DRAGLINE

a. Dragline sitting level – It will be 6-8 m below the the original preblast level (or the adjacent unblasted corridor level) of the dragline block.

b. Position of Dragline - The Dragline sitting position is about 91 m from the New Highwall crest. The sitting position is same as Low wall In pit Bench Method working for Box cut position.

(1) Working Methodology –

a. Digging Method Box Cut excavation-Lagging/ Retreating Dragline sits in the dump side at a distance of 91 m from highwall crest on the in- pit bench (extended bench/bridge) in a lower elevation instead of a normal bridge created by Leading Dragline. The Dragline excavates the material by pull back operation from spoil side. The material is excavated by dragline upto the toe position of extended key cut.

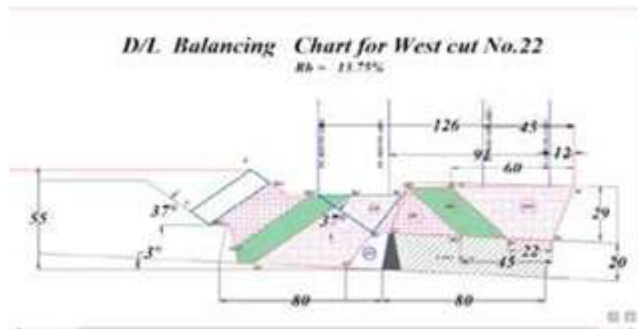

Fig.2. Dragline Balancing Diagram showing all four sitting position of both the Draglines

b. Dumping of Excavated material– For dumping the excavated material from Box cut sitting position the Dragline swings at a direction opposite to the swing direction of leading dragline at an angle varying from 100° to 120°. The productivity of dragline is very less compared to the productivity of leading dragline working for key cut and extended key cut sitting as the swing angle is almost doubled.

B. Balance Box cut material and Rehandling material Removal by Retreating/Lagging Dragline-

a. Dragline sitting level – It will be 6-8 m below the original preblast level (or the adjacent unblasted corridor level) of the dragline block, as we know that the depth of the extended bench affects the amount of rehandling, so a significant reduction of rehandling can be achieved by keeping the extended bench level/ bridge level/ In-pit bench level as low as possible while still providing sufficient spoil room.

b. Position of Dragline - The Dragline sitting position is about 126 m from the New Highwall crest. The sitting position is same as Low wall In pit Bench Method working. This is the final sitting of Lagging Dragline. The position of final sitting is decided by the requirement of safe dump profile as determined by scientific study as the final sitting position will be in alignment to the crest line/edge of dragline sitting level corridor.

(1) Working Methodology –

a. Digging Method Box Cut excavation – The final dragline sitting position is in line with the crest or edge of the dragline sitting level corridor. Lagging/ Retreating Dragline sits in the dump side at a distance of 126 m (say) from highwall crest on the in-pit bench (extended bench/bridge) in a lower elevation instead of a normal bridge created by the lagging Dragline The Dragline excavates the remainder solid material which could not be excavated by dragline from previous sitting during box cut material excavation and the entire rehandling material is excavated. The excavation is done by underhand digging method.

b. Creation of Safe Dump Profile: From Dragline Dump safety point of view the excavation by Dragline from this position is very critical as the required safe dump profile is to be achieved from this final sitting of Dragline. Extreme care should be taken during the excavation from this sitting as required corridor widths at Coal roof sitting level and dragline sitting level along with the required slope angle between the two corridors has to be achieved from this final sitting position of Dragline. Until and unless the safe dump profile is achieved no shifting of dragline from this position should be allowed.

c. Dumping of Excavated material– For dumping the excavated material the Dragline swings in a direction opposite to the swing direction of the dragline in previous sitting position for box cut material excavation. The swing angle of the Dragline varies from 60° to 90° for excavating the material and accommodating in the final dump. The productivity of dragline is very high compared to the productivity of lagging dragline working for box cut in its previous sitting due to lesser swing angle.

CONCLUSION

In the Modified Tandem Operation is preferable due to following advantages-

1. In this method the Productivity of Advancing Dragline is very high for key cut and Extended Key cut excavations as detailed below:

a) The advantages of Standard Extension bench method with **highly productive underhand digging method** instead of Pull back digging method (as in case of Low Wall In Pit Bench Method of Dragline Working) is utilized. The Underhand Digging Method is the most productive digging method due to less bucket filling time, less bucket line breakdown (higher reliability of Dragline) as well as requirement of less operational skill of Dragline operators.

b) Advancing Dragline removes Key Cut and Extended Key cut at an average swing angle less than 60° which is very less compared to 90° in case of Low wall In Pit Dragline working as well as in case Normal Standard Extension Bench Method Working.

2. Less rehandling by Retreating dragline is also achieved by reducing the sitting level of retreating Dragline beyond 8 m below the preblast level.

Thus we get the most productive tandem operation by the Draglines with very high rate of coal exposure and higher reliability of Dragline with minimum bucked line breakdown.

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Bina Extension to Bina Kakri Amalgamation Open Cast Project: A Sustainable Coal Mining Approach from 7.5 to 17.5MTPA Production

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ABSTRACT

Bina Extn. project is opencast coal mining project of Northern Coalfields Limited with present production capacity of 7.5 MTPA. The project report of Bina Kakri Amalgamtion Opencast has been approved by CIL Board on 25th August 2020 for peak production of 17.5 MTPA. This paper discusses the various measures being taken up by the project for enhancing the coal production from 7.5 MTPA to 17.5 MTPA in environmentally sustainable manner. It include steps like reclamation work/ plantation activity, air pollution mitigation, water pollution mitigation, bio diversity conservation, and attaining zero liquid discharge of mine water by development of an eco-park.

Key Word: Sustainability, Open cast coal mining project, Zero liquid discharge, Eco-park

INTRODUCTION

Bina (Extn.) Opencast Project is running opencast mines in Northern Coalfields Limited. Since July-2006, Northern Coalfields Limited, a subsidiary of Coal India Limited is a prime producer of non-coking coal, mainly power grade, in the country. It operates coal mines in the states of M.P. and U.P. It is producing coal from different coal seams of Singrauli coalfield in the district of Singrauli in M.P and Sonebhadra in U.P.

The present project is an extension of earlier Bina Project which is producing coal since 1974. The initial production of the project was 4.5 MTPA which underwent 1st extension of 6 MTPA in 2006. Further, 2nd extension was carried out in the year 2014 to enhance the capacity to 7.5 MTPA. In further expansion the new project namely Bina Kakri Amalgamation OCP has been approved by CIL Board on 25th August 2020 for normative capacity of 14.0 MTPA with peak capacity of 17.5 MTPA.

The present paper focuses on various initiatives taken to develop the Bina-Kakri Amalgamtion OCP as one of the state of the art project as gradual moving towards peak capacity of 17.5 MTPA. It includes detailed description on various steps taken to improve on the environmental aspect (air, water, biodiversity etc.) to progress in more sustainable way while increasing the production capacity from 7.5 MTPA to 17.5 MTPA.

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CHALLENGES FOR AN OPEN CAST COAL MINING PROJECT: ENVIRONMENTAL POINT OF VIEW

The challenges faced by open cast coal mining project are immense from environmental point of view. With increase in production capacity, the environmental challenges will also enhance. The environmental challenges are as follows:

a) The increase in OB production leads to increase in blasting activities and thus increase in dust generation contributing to Suspended Particulate Matter (SPM) and Respirable Suspended Particulate Matter (RSPM).
b) Transportation of overburden as well as coal will further increase the vehicular movement within mine premise and thus giving rise to vehicular emission like PM10, NOx and CO.
c) HEMM operation and maintenance will increase the generation of solid and liquid hazardous waste (category 5.1 and 5.2).
d) With the increased in catchment area the make of water per day will also increase and thus effluent treatment facility need to be enhanced.
e) Land degradation will also increase.

AIR POLLUTION AND ITS MITIGATION AT BINA EXTN. PROJECT

The major sources of air pollution in open cast coal mining projects are blasting, coal stock yards, transportation road, and fugitive emission from other sources. To overcome the above a proactive approach is required at planning stage. The enhanced coal production from 7.5 MTPA to 17.5 MTPA includes deployment of 1 no. of surface miner which reduces the blasting activity and thus reduces the dust generation. Further, a new CHP of 9.5 MTPA is proposed for Bina Kakri Amalgamation OCP which will cater to the requirement of additional capacity for coal loading and transportation. The location of ground bunkers are so proposed that the overall transportation of coal through haul road is minimized. At present, various steps are being taken to reduce the concentration of pollutants at source itself. Fixed water sprinkling system on major coal transportation road is under construction phase at Bina Project. The fixed sprinkling system is being installed all along the RCC road in total stretch of about 1.4 Km from main mine barrier entry to coal yard which is one of the busiest road in mine area. The water for sprinkling system is sourced from ETP treated mine water which is another step towards achieving zero liquid discharge.

There are 2 no. of truck mounted mist spray gun deployed at Bina Extn. project in the month of January and March 2020 to reduce the fugitive emissions (Refer Fig. 1).

Fig.1. Mist Spray Gun at Bina Project

The machines generate small size mist particles for effectively supressing dust on haul roads as well as residential roads. The total capital cost of initiative is approximately 96.64 lakhs.

Also along with this 1 no. of domestic road sweeping machine has been deployed in the month of March 2020 (Refer Fig. 2) with total capital expenditure of about 53.71 lakhs.

Fig.2. Domestic Road Sweeping machine at Bina Extn. Project.

In addition to above measures, there are already existing 6 no. of departmental water tankers (28KL and 70 KL) for suppression of dust at haul roads and other transportation road. 1 additional no. of water body is created near coal stock yard no.2 which is presently working as additional tanker filling point for water tankers and catering the need for water sprinkling in and around coal stock yard. The steps involve are shown in Fig. 3(a) to 3(d).

Fig.3(a) Creation of water body; 3(b) Gabion wall for silt control; 3(c) Installation of Pump; 3(d) Tanker filling system.

All the transfer points like crushers house, silos (rack loading) etc. are already installed with fixed water sprinklers which are in continuous operation. Further, it is proposed to install two number of fixed cannon guns at wharfwall and coal yards which will further help in curtaining dust generation during loading and unloading processes.

WATER POLLUTION AND ITS MITIGATION AT BINA EXTN. PROJECT

The major sources of water pollution in an open cast coal mining project are as follows:

a) Mine Water: Containing only TSS.
b) Effluent from Workshop: Containing TSS, Oil and Grease and COD.
c) Effluent from CHP, ground bunkers: High TDS and small amount of oil and Grease.
d) Effluent from De-shaling plant: High TDS.
e) Waste water from residential colony: Source of TDS, BOD, COD.

Bina (Extn.) project has its own effluent treatment plant of 31.2 MLD. (Refer to Fig. 4)

Fig.4. ETP of 31.2 MLD at Bina Extn. Project

The existing capacity of ETP is being enhanced to 31.56 MLD to further meet the need of effluent generated from de-shaling plant. An approved scheme for further technological up-gradation of the existing ETP is under progress. The up-gradation of ETP will include all the modern technologies for effluent treatment including multi grade filters and activated carbon filter for tertiary treatment of water. It will also be equipped with filter press for better handling of sludge generated from ETP. The final treated water is reused in various activities like dust suppression, fire fighting etc. The total cost of the scheme is approximately 17.73 crore rupees.

Bina Extn. Project has existing sewage treatment plant of 2.5 MLD for treatment of domestic sewage generated from residential colony. (Refer to Fig. 5)

Fig.5. STP of 2.5 MLD at Bina Extn. Project

The existing STP is based on activated sludge process (ASP) and commissioned on 31st December, 2000. The sewage treatment plant is also being technologically upgraded. As it is proposed, after completion of up-gradation/ modification work, tertiary treatment will be provided using activated carbon filters and multi grade filters and the treated water will be 100% utilized in various horti-culture works within the premise of residential colony, thus, achieving zero liquid discharge from Bina residential colony. Thus total cost of up-gradation of existing sewage treatment plant is approximately Rs 7.6 crore.

CONSERVATION OF BIODIVERSITY AND ACHIEVING ZERO LIQUID DISCHARGE THROUGH BINA ECO PARK

The foundation stone of Bina Eco-Park namely "*Chandrashekhar Azad Eco Park*" was laid by Honourable Home Minister, Government of India on 23rd July 2020. The eco- park is being developed around the siltation pond near Office of Area General Manager, Bina Extn. Project, Sonebhadra, UP. Aerial view of the existing location of the park area is shown in Fig. 6.

Fig.6. Aerial view showing location of Chandrashekhar Azad Eco-Park.

The siltation pond was developed since inception of Bina Project with a purpose to arrest the silt flowing into the reservoir during monsoon. This is also a step towards achieving zero liquid discharge for Bina Mine. The pond is spread over a total area of approximately 70000 sqm having an average depth of about 3 m, Therefore, approximate volume to carry water of 210000 m^3. The total area of the eco-park (including siltation pond) is approximately 14.00 ha over which development work is being carried out. The estimated cost of development along with five year maintenance of eco-park is approximately 8.56 crore rupees and the work will be completed by the end of financial year 2022-23. The proposed amenities along with layout are shown in Fig.7.

Fig.7. Layout plan of Chandrashekhar Azad Eco park

The source of water for this eco- park is treated mine water from ETP and thus serve as one of the examples of utilization of mine water and maintaining zero liquid discharge mine. Due to abundance of fruit bearing plants and water source it becomes habitat of aquatic species, mammals and birds species. One of the major sightings are the large size bats commonly known as flying foxes (scientific name as *Pteropus medius)*.Thus, other than achieving zero liquid discharge for Bina Extn. Project, the development of eco-park is also a step towards biodiversity conservation.

RECLAMATION OF OVERBURDEN DUMPS AND PLANTATION ACTIVITY

Overburden dumps generated during the mining process are technically and biologically reclaimed in Bina Extn. Project. The overburden are stabilised through benching and further retaining wall/gabion are constructed at the toe of each bench. After completing the process of technical reclamation, biological reclamation is carried out by massive plantation activity. Fig.8 shows final dump after technical and biological reclamation.

Fig.8. Plantation on overburden dumps at Bina Extn. Project

Total 32.26 lakhs no. of plants have been planted in Bina Project since inception. Out of which around 3.34 lakhs no. of saplings were planted in plain area including green belt development. The total area covered through plantation is about 418.28 Ha since inception. The details of plantation activity at Bina project on yearly basis for last five years are given in Table I.

Table 1: Plantation in OB Dumps at Bina Extn. Project from 2016-17 to 2020-21.

S. No.	Year	Plantation	
		No. of Plant	Dump Area (in Ha.)
1	2016-17	25000	10
2	2017-18	17500	7
3	2018-19	30000	12
4	2019-20	25000	10
5	2020-21	17500	7
	Total	**115000**	**46**

As per the proposed scheme the biological reclamation and plantation activity will increase manifolds for Bina Kakri Amalgamation OCP as shown in Table II.

Table II: Proposed Plantation in OB Dumps at Bina Kakri Amalgamation OCP from 2030-31 to 2035-36

Year	Overburden DumpArea to be techni- cally & Biologically reclaimed (Ha.)	No. of Plants to be planted @ 2500 /ha. (Proposed)
2030-31	20	50000
2031-32	20	50000
2032-33	25	62500
2033-34	40	100000
2034-35	60	150000
2035-36	59.384	148460
Total	**224.384**	**560960**

CONCLUSION

The coal production is to be enhanced to meet the growing energy needs of the country. As a part of the efforts to fulfil the energy demand, coal production of the Bina Extn. Project is being enhanced from 7.5 MTPA to 17.5 MTPA gradually with onset of Bina Kakri Amalgamation project. At project level various activities like providing sufficient nos. of tanker filling points, use of advance mist spraying system and fixed sprinklers are already being executed to maintain the air quality standards. Use of surface miner and new CHP of 9.5 MTPA are proposed steps towards green coal mining.

The proposed up-gradation of effluent treatment plant and sewage treatment plant for carrying out tertiary treatment will lead to complete utilization of treated mine water and domestic waste water within the mine area and thus make Bina Kakri Amalgamation OCP a zero liquid discharge mine. Steps are being taken for conservation of biodiversity by development of Chandrashekhar Azad Eco-Park. Technical and biological reclamation of OB dumps are being carried out as part of mine closure activity, which is a step towards bringing back the degraded forest land in its original form. Thus, efforts are being made to enhance the coal production from 7.5 to 17.5 MTPA in environmentally sustainable manner.

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Hurdle to Headway: Planning, Design, Development & Maintenance Four Lane Haul Road amid Heavy Rainfall at Nigahi OCP, NCL

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ABSTRACT

Open Cast Mine produces more than 95% of Coal in the country. During monsoon, it is observed that coal production drops up to 20% due to improper design and maintenance of Haul Road. Coal Mines Regulation Act, 2017 also envisages various conditions under Section 101. In this paper, a case study of Nigahi OCP is being presented. In which, recommendations of expert committee were implemented. Vision of India's 1st four lane haul road was successfully executed. 04 lane haul road has ensured more than 15% greater production during monsoon months.

Keywords— Haul Road, Open cast Mining, Monsoon Planning etc.

INTRODUCTION

Singrauli Coalfield is spread over 2202 Sq.Km, comprising of two basins, viz. Moher Sub-basin (312 Sq.Km.) and Singrauli Main basin (1890 Sq.Km.). NCL has total coal reserve of 10.06 BT (6.83 BT in Moher Sub-basin and 3.23 BT in Main Basin). Out of this reserve, the industry has extracted 1.7 BT of coal from Moher Sub-basin till March 2019. Major part of the Moher sub-basin lies in the Singrauli district of Madhya Pradesh and a small part lies in the Sonebhadra district of Uttar Pradesh. All the coal mining operations of NCL are at present concentrated in Moher Sub-basin through 10 numbers of highly mechanized opencast mines. Singrauli main basin lies in the western part of the coalfield and is largely unexplored. Nigahi Opencast Mine is situated in Singrauli district of Madhya Pradesh and forms a part of Singrauli Coalfields. Nigahi block is located to the west of Jayant Project and to the East of Amlohri Project. It stands out as a hilly plateau with elevations of about 400-450 Mts. Above means sea level. The block has 473.24 Mill. Tonnes of mineable reserves in Turra, Purewa (Bottom, Top and Combined) seams at an average stripping ratio of 4.68 for 25 Mtpa, the life of the Project will be about 21 years (As on 01-04-2020).

Mining haul roads are a critical component of surface mining infrastructure and the conditions of these haul roads has a direct impact on operational efficiency, costs and safety. A significant proportion of a mine's cost is associated with material haulage and well-designed and managed roads contribute directly to reductions in cycle times, fuel burn, tyre costs and overall cost per tonne hauled and critically, underpin a safe transport system. However, condition of Haul Road Design depends on various Geo-Technical parameters such as Drainage Pattern, Average Rainfall, physical properties of OB Material etc.

General Topography of the Singrauli Coalfields is provided:

- General topography of the coalfield shows plain country to the South
- East & West has a gentle slope towards the Rihand river in south of the coalfield forming main drainage of the area
- Kachni river, Ballia nala, Bijul nala and Tippa- Jharia nala are the important streams for drainage of the coalfield
- Kachni river drains a major part of the area in the west, Ballia nala drains the eastern part, Bijul nala drains the northern part and Tippa-Jharia nala drains the north-eastern part
- Drainage Plan of the Singrauli Coalfield is attached in Fig. 1.

Average rainfall of the Singrauli Coalfields is approximately 1300-1600mm. However, during 2016 monsoon rainfall was more than 2000mm, created havoc resulting in huge financial loss. Major rainfall pattern of Singrauli Coalfields is given below:

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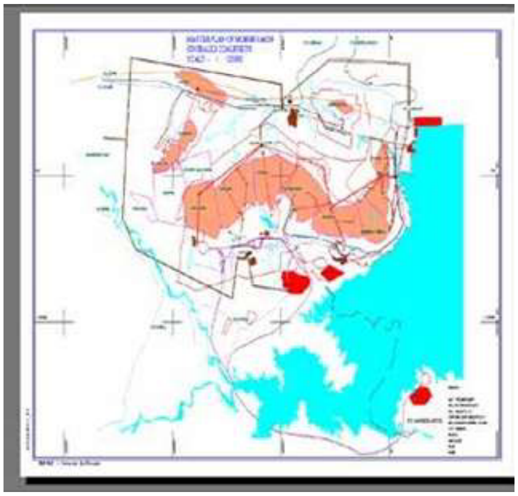

Fig.1. Drainage Plan of Singrauli Coalfields

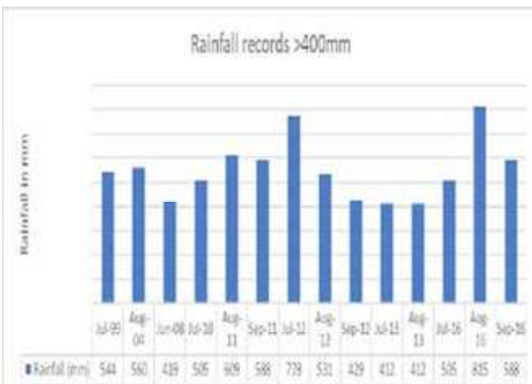

Fig. 2. Rainfall records >400mm in Singrauli Coalfields

From the above graph it is evident that during 2016, rainfall passed 500mm benchmark in three consecutive months i.e. July, August & September. Haul Roads and other mining infrastructures were severely affected. An expert committee was established during 2016, to assess the situation and suggest a sustainable solution for this issue.

Fig.3a. Haul Road Pictures Monsoon

Fig.3b. Haul Road during Monsoon

METHODOLOGY

As per Coal Mines Regulation (101), all roads for trucks, tippers, dumpers or other mobile machinery shall be constructed to suit their load capacity and maintained in good condition. In addition, various designing parameters has been categorically prescribed in Coal Mines Regulation. However, as per CMR centralized planning is emphasized for Haul Road Design.

Haul Roads are essential component for an Open Cast Mine, also contributes to more than 60% of all the accidents occurring in mines. Expert Committee formed during 2016, has also made following observations regarding Nigahi OCP:

i. OB consists of a mix of fragmented rocks and loose soil. The OB dumps of outsourcing patches have high proportion of loose soil. Moreover, these are fresh dump and are not compacted. Hence the OB dumps of outsourcing patches were more affected by the high intensity rainfall
ii. The nature of soil in OB of mines in Singrauli Coalfield is mostly silty-sand type, which has very less cohesion between particles. This causes heavy erosion during rains. Further, infiltration of rain causes saturation of slopes, resulting in decrease in shear strength. This leads to sliding of large chunks/sheets, formation of large rain cuts, etc triggering flow of silt along with rainwater.
iii. Due to high rate of progress of OB removal in outsourcing patches, large water accumulation and catchment area is created ahead of coal working faces.
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vi. Due to high rate of progress of OB removal in outsourcing patches, large water accumulation and catchment area is created ahead of coal working faces.

Expert Committee submitted its report & following recommendations were made in respect of Haul Roads:

i. A distance of 150m from toe of the dump on one side of the entry to the other side should be maintained so that sufficient space for Haul Road, power lines, drains, retaining walls and sump/siltation pond is available.

ii. With cut height of Dragline reduced to 25-27m, this much squeeze of dump is practically possible.

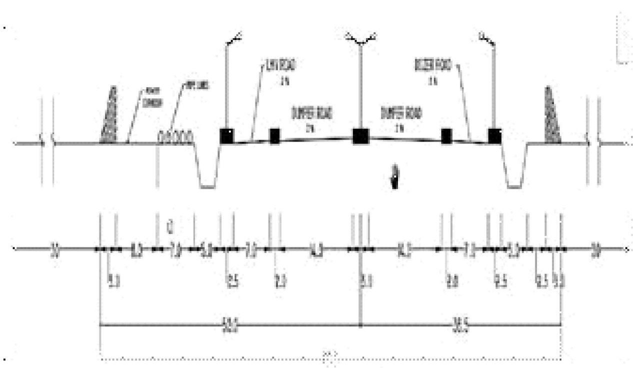

Fig.4. Sectional Layout of Haul Road

Ultimately, water management during monsoon was taken into prime consideration. Due heavy rainfall during 2016, mines was closed as slurry mud was all over the Central Entry, Haul Roads. Production Operations were disrupted for days.

Following steps were taken to ensure a proper designing, maintenance & preparation can be done:

1. Water coming from Drain cuts/ Dumps was diverted to ensure minimum impact over planned Central Entry.
2. A centralized plan was drafted including Dump Management Plan, Haul Road Design Parameters, Old Dump Plans etc.
3. A dedicated team was created to perform their duties for proper execution of the task.
4. Proper Drainage was constructed to evacuate water. In addition, to minimize the possibility of any disruption in planned area. It was planned in such a manner that in the dipping side a siltation pond has been prepared. For connection between either side of the Haul Road, Hume pipes and underground drainage was prepared.

Further, Siltation Pond at the toe of the OB Dump Bench was also envisaged to avoid possible water accumulation at Central Entry Haul Road. Siltation pond of different capacity at either side of the Central Entry was also constructed to ensure proper flow of water away from Central Entry.

Table 1.Personnel Deployed for Monsoon Preparation

Designation/ Specifications	Number of Person
In-charge (Executive)	02
Supervisor	02
Dozer Operators with dedicated Dozer	02
Grader Operator	02
Driver	02
Total Working Shifts	02

5. Drain cuts were then filled. A completely Dump Bench was created by readjusting the OB material accumulated from rain cuts by Dozing operations. Further Benching was done at 30m bench height.

Fig.5. Central Entry

6. Haul Roads were planned with cross fall sloping to ensure water percolation by its side.

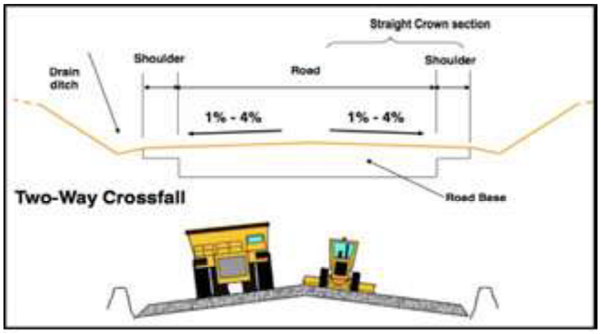

Fig.6. Haul Road Properties

Table II. Cross Fall Sloping W.R.T. Gradient

Road Gradient	Minimum cross fall – low rainfall or smooth surface.	Maximum Cross fall – high rainfall or rough surface
0 – 3%	2%	5%
4 – 6%	2%	3%
6 - 10% (maximum grade)	1%	1.5%

7. Filling at the Central Entry up to 1km distance from 404m RL to 409m RL was done. Approximately 0.75MCuM material was used to fill the Central Entry to mitigate water management issue.

Fig.7. Nigahi Mine Plan

Fig. 8. Nigahi haul roads

8. After filling & dozing operation were simultaneously conducted. A proper maintenance schedule was planned and trained operators were deployed to execute the work.

Table III. Scheduled Haul Road Maintenance Plan

System	Action Taken	Frequency
Ad hoc blading	Reactionary maintenance management in response to poor haul road functionality. Typically managed by daily inspection of the road network and a subjective assessment of road segment functionality and maintenance priorities.	Twice a week
Scheduled blading	Road network is maintained according to a fixed schedule or frequency, irrespective of the actual functionality of the road segment being worked.	Every 02 days
Managed maintenance systems (MMS)	Road network is analysed to determine rate of functional deterioration of individual segments, based on roughness progression, traffic volumes, etc. and segment blading frequency determined to minimize segment and network total road-user costs.	Once in a fortnight
Real-time road maintenance	Instrumented truck fleet to determine vehicle response to road functionality, both in terms of rolling resistance and individual (isolated) functional defects. Maintenance managed real-time through mine truck dispatch and data management systems.	Daily

RESULTS & OBSERVATIONS

First ever four lane Central Entry Haul Road was successfully constructed in Nigahi OCP, NCL. In upcoming years with implementation of recommendations made by Expert Committee. NCL has been successful in reducing its accidents occurring at Haul Roads.

Fig. 9. Nigahi Mine Four lane central entry haul road

Statistics given below:

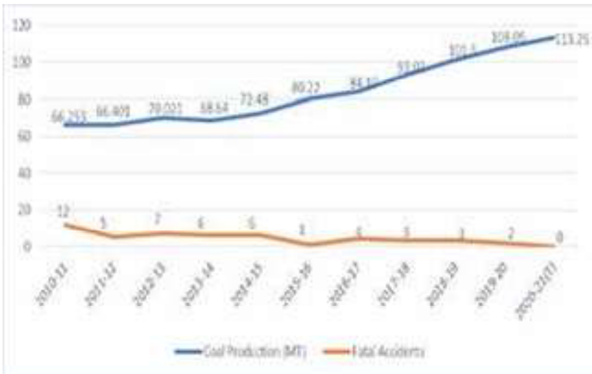

Fig. 10. Coal Production vs Fatal Accidents in Nigahi OCP

However, it is imperative that production performance of NCL has remained stable during monsoon months. NCL is one of the pillars of Monsoon action planning. Monsoon action plan is prepared at centralized level, thus a proper mechanism for monitoring & implementation scheduling is also developed.

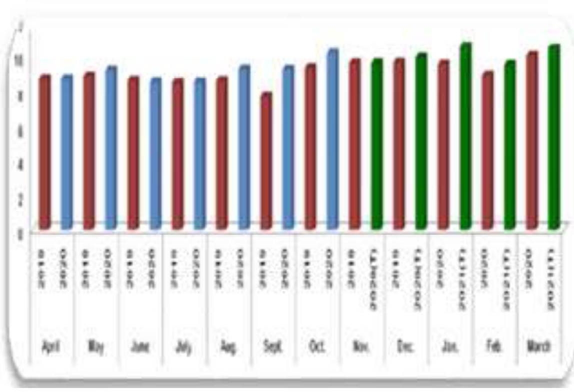

Fig. 11. Comparison of monthly production of Nigahi OCP during Monsoon

Thus, it is imperative from above, that with proper planning and dedicated execution. Things can turn out to be benevolent. Here accidents were bought down, production during monsoon months is very little impacted, Overall layout of the mine is very helpful for block scheduling and production planning.

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A Study of the Performance of Autonomous Haulage Systems (AHS) –Cost Benefit Analysis and Application

U S Shukla*

ABSTRACT

In this paper the author has discuss the need of automation in mining industry for productivity improvement and advantages of autonomous haulage systems used in open cast mines across the globe. Autonomous technology refers to self-driving vehicles in particular mine haul trucks. It is an important topic because the global demand for minerals is increasing and mining is becoming more challenging. Mining companies seek to reduce costs and make operations safer. Autonomous haulage trucks have recently been developed for open pit mines. To predict the benefits of an Autonomous Haulage System (AHS), a theoretical model for medium scale open pit mining operation mine with 10 numbers of converted autonomous trucks is discussed and compared with manual system for productivity, safety, and labor costs.

Key Words: Autonomous Haulage System (AHS), GNSS, LiDAR, Millimeter wave Radar

INTRODUCTION

In the open-pit mining industry, trucks and shovels are the mining technology of choice; however, it is widely recognized that the operation of these trucks and shovels contributes significantly to the overall operation cost. Fortunately, there exist many opportunities to reduce the cost of the truck and shovel operation.

Operationally, the main challenges have been to effectively deploy truck resource and to maintain a steady, reliable supply of ore material at the highest possible efficiency. Most mining companies develop and implement the truck dispatching system as an integrated multi-stage system. The first stage involves an allocation of truck resource given a production requirement. These truck solutions are then implemented using a real-time dispatching system, with or without the interaction of the truck dispatcher.

Background on autonomous technology comes from research on the state of personal autonomous vehicles. A comparison between the requirements and conditions of automating personal automobiles versus mine haul trucks explain why autonomous haul trucks are performing better. Mining operations are continually searching for means to improve efficiency and reduce costs via the usage of new technology. Autonomous Haulage Systems (AHS) or colloquially 'Self-Driving Trucks' is one such set of technologies that has demonstrated success in this area and is expected to further improve in the future.

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Autonomous vehicles enable productivity improvements and cost benefits; figures used for cost and efficiency metrics such as labor, maintenance costs, utilization rates and G&A costs are in line with those published by the major miners currently utilizing AHS. In addition to the proven effects above, the study provides a conceptual analysis to evaluate the potential benefits of mine design and mine planning optimizations enabled by AHS. The potential improvements include haul road narrowing and catch bench restriction.

The Autonomous Haulage Systems (AHS) have evolved with the improvement in networking technology and has reached the optimum level of maturity, although it is still evolving and its penetration across industry is still in its infancy. AHS is being in use in large opencast mines for more than 10 years and has shown great benefits both in term of economics and in safety standards.

REQUIRMENT OF AUTOMATION IN MINING

Present environment is requiring mining companies to improve efficiency and be rigorous about cutting production costs, including improvements to efficiency made by optimizing all aspects of their mine operations, not excluding improvements to mine safety, and further reductions in operating costs achieved through innovation. Employee safety is also a challenge given that mines are inherently dangerous workplaces. Autonomous haulage systems (AHSs) for the autonomous operation of dump trucks have attracted attention as one way to achieve these rationalizations. Dump trucks are the largest use of labor at opencast mines. An AHS eliminates the need for a driver in these dump trucks, which are used for the hauling and dumping of ore and earth under the supervisory control of a central control system. Driverless dump trucks not only reduce labor costs, they also have the potential to provide economic benefits in the form of longer operating time (by eliminating the time spent on work breaks and shift changeover), and lower fuel consumption and longer machine life (by using machine control to drive the trucks in an efficient and appropriate manner). There is also the potential to make overall mine operation more efficient by coordinating management of the hauling process with the production management system.

Key drivers for automation

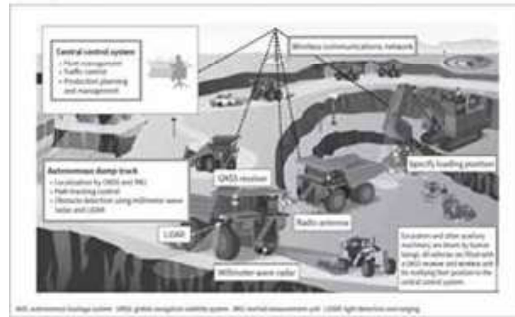
Generally automation is thought to perform more efficiently, reliably and accurately than a human operator. Also, there is an expectation that the automated control system can perform a function at lower cost than the operator can.

In general, while developed mainly for safety or efficiency reasons, automated and new technologies have been summarized into the following broad categories:

- Removal of operators from hazardous situations;
- Lower costs of production; requirements for enhanced
- Precision (as with automated blast hole drilling);
- Less environmental impact;
- Ability to mine previously inaccessible areas;
- More data and information available and reduced manning of equipment

AUTONOMOUS HAULAGE SYSTEMS (AHS)

Dump trucks are the largest use of labor at opencast mines. An AHS eliminates the need for a driver in these dump trucks, which are used for the hauling and dumping of ore and earth under the supervisory control of a central control system. Driverless dump trucks not only reduce labor costs, they also have the potential to provide economic benefits in the form of longer operating time (by eliminating the time spent on work breaks and shift changeover), and lower fuel consumption and longer machine life (by using machine control to drive the trucks in an efficient and appropriate manner). Use of machine control should also improve safety by reducing human error in the driving of dump trucks. There is also the potential to make overall mine operation more efficient by coordinating management of the hauling process with the production management system.



How AHS works

The mine site is segmented into autonomous and non-autonomous zones. All vehicles, including non-AHS vehicles in the autonomous zone, are fitted with GPS transponders so they may be tracked and avoided by AHS trucks.

Components Installed In Autonomous Dumper

While the trucks maintain a minimum safety distance from other tracked vehicles, they also utilize object detection systems (RADAR and LiDAR) to detect potential collisions with any object which will efficiently stop the truck. The AHS trucks are capable of automatic positioning beneath digger buckets and automatic tipping at material destinations, including both crusher stations and stockpiles. All vehicles entering the autonomous zone are fitted with GPS transponders that ensure tracking and a safety perimeter or exclusion zone. The trucks receive commands from the control room (located remotely) over the communications network to navigate using waypoints.

Object Detection And Collision Avoidance

Digging units have a location sensor for the trucks to park underneath the bucket appropriately. The trucks can tip into a crushing station, run-of-mine (ROM) pad or waste dump. Staff in the control room can issue commands to trucks that are transmitted over wireless (wi-fi or LTE/4G) networks. Object detection systems (RADAR and LiDAR) are programmed to stop the truck should anything get in its way.

AUTONOMOUS HAULAGE SYSTEM COSTS

Study has been conducted in Australia regarding implementation cost of AHS by converting 10 nos of 180 te existing dumpers fleet into Autonomous dumpers.

The analysis explains the benefit of an AHS implementation in a single context: converting an existing mining fleet from manned trucks to autonomous (ie retrofitting existing equipment at an operating mine). The implementation of an AHS includes a number of fixed and variable costs. Fixed costs apply to the site for installation, while variable costs apply according to the workforce and number of vehicles installed with the system.

The total cost to install an AHS is therefore determined by the scale of implementation. The costs in below table represent actual installation costs for a modern medium-scale mine site in an easily accessible area.

ITEM	COST (In AUD)	COST TYPE
Project Planning	1 Million	FIXED
AHS Truck Cost	1 Million	PER TRUCK
AHS Ancillary Vehicle	0.15 Million	PER VEHICLE
AHS Software	1 Million	FIXED
AHS Configuration	0.5 Million	FIXED
Control Room	0.4 Million	FIXED
Communicatio nUpgrade	1 Million	FIXED
Physical Infrastruc-ture	0.5 Million	FIXED
Implementatio nService	1 Million	FIXED
Misc	1 Million	POTENTIAL

1 Australian Dollar (AUD) = 50 Indian Rupee (INR)

Assuming that the mine site has ten trucks and 14 ancillary/ support vehicles engaged in the AHS, the total estimated cost to undertake the exercise of converting the haulage fleet for this example is approximately 18.5 million AUD or 92.5 crores INR.

Autonomous haulage system benefits

The implementation of an AHS is principally a capital cost to operating cost trade-off analysis, with incremental additional benefits in safety, productivity, tyre life, maintenance, personnel management and environmental stewardship.

Production benefit

The benefits have been modeled based on operational experience at AHS sites. The principal benefit is increased production due to increased equipment utilization. Typically, haul trucks in an open pit mine are scheduled for approximately 5500 to 6000 engine hours per year. AHS sites achieve significantly higher utilizations, resulting in higher annual engine hours. AHS sites are known to schedule up to 7000 hours per year, an increase of around 16-18 per cent. It is therefore a conservative assumption to model an annual increased utilization metric of 1000 hours. A simplified benefit of an increase in operating hours of 1000 hours per year for a single haul truck is outlined and it is noted that this increase in operating hours modeled is congruent with actual annual hour increases from mine sites that are currently operating an AHS (Rio Tinto, 2015; Fortescue Metals Group, 2015).

Additional incremental production of upto 9 lac tons of ore/coal will result in additional revenue of 30-35 million AUD or 150-170 crores INR.

Wage impact benefit

Adopting autonomous haulage will impact the production workforce wage bill. The modeled net wage reduction in the adoption of an AHS is A $2.73 million AUD or 13.65 crore INR per annum.

Tyre life benefit

Mine sites that utilize an AHS typically achieve significantly longer tyre life. Tyres typically last approximately 5000 hours at manned fleet mining operations, while autonomous mining operations can budget on a 7500-hour tyre life. The tyre life benefit is derived from several critical changes at sites that utilize an AHS, including that the truck operates only on a programmed basis and incidents such as vehicle collision, direct impacts, tyre sidewall punctures and improper use of the truck occur less frequently and with less associated impact. The modeled annual benefit is $1.2 million AUD or 6 crore INR.

Non-quantified benefits (Safety)

The quest for zero harm in the workplace is never- ending, and autonomous vehicles are expected to play a significant role in improving occupational health and safety in the future. Trucks that operate autonomously can make mines safer by removing people from repetitive front-line tasking.

It is anticipated that autonomous trucks will have significant maintenance benefits. The trucks typically experience higher costs in brakes, due to the service brake being utilized in every event of obstacle detection, these benefits will crystallize over the years once AHS trucks complete a full life cycle. At present, AHS trucks have been in continuous operations for around nine years, which is not yet a full life cycle of an off-highway heavy haul truck.

Utility of increased production

A number of key issues exist that impact cost-benefit analysis work undertaken by mine operators on the potential implementation of automation. A critical question to answer is whether the mine operator will make use of the additional tonnes or instead retire underutilized equipment. In the example modeled in this article, the trucks produce an extra 15 per cent in tonnage. The job of 9 manual trucks can be done by 7 AHS trucks hence reducing cost of production and capital savings.

Haul road maintenance

The site will require an increased focus on haul road maintenance. This increased focus does not necessarily relate to increased cost, but haul roads are more important at an AHS operation than a manned one because the AHS safety system will detect oversize rocks as stationary objects and stop the truck if the roads are not graded to a high standard.

Operator training

An AHS utilizes modern technology and requires an increased reliance on communication networks and higher-skilled staff members. Although the technologies that deploy an AHS are well known, the technical skills to operate and maintain it are usually of a different background to truck operators. Therefore, there is the potential for increased operational issues during the transition phase, but the benefits appear to outweigh the risks and potential negative impacts.

USAGE OF AHS

There are two original equipment manufacturer (OEM) AHS operating in the Pilbara – Caterpillar Command for Hauling and the Komatsu Front Runner – and the three major iron ore miners (Rio Tinto, BHP and Fortescue Metals Group (FMG)) were leaders when it comes to using autonomous trucks. FMG is the largest operator of autonomous trucks in the Pilbara – making it effectively the largest in the world – with 128. Rio, meanwhile, had 96 up and running, with BHP having a total of 50, as per publicly released data. FMG has plans to automate all of their trucks, including the first non- OEM trucks on an alternate OEM system.

Since beginning trial operations in 2008, there have been zero injuries attributed to haul trucks equipped with autonomous haulage system (AHS), which highlights the technology's significant safety advantages, in the Pilbara region of Rio Tinto. Ten years after Rio Tinto began a trial of its autonomous trucks, they have reached a one-billion-tonne milestone. Driverless trucks have also proven to be more efficient than their manned counterparts, the company said, with autonomous vehicles operating 700 hours longer last year and with 15% lower unit costs. Rio says more than 80 autonomous Komatsu trucks are currently operating and the miner plans increasing the number to more than 140 by the end of 2019.

CONCLUSIONS

The current operators of autonomous vehicles achieve a lower unit cost due to increased productivity and lower maintenance costs and enjoy a better tyre-wear profile. Simplified analysis of the cost and benefits associated with operating an AHS. It demonstrates that the benefit from an increase in production is 85 per cent of the annual benefit, while the wage reduction is ten per cent of the benefit and tyre life increases by less than five per cent. These calculations validate that the economic rationale for automating trucks is primarily related to increasing production, which lowers the delivered cost per tonne, and is not solely related to the removal of truck operators.
The adoption of autonomous trucks is expected to reduce fuel consumption by more than 10%. Maintenance costs, in turn, should fall by another 10% and off-road truck tyres,

are expected to have 25% lower wear. The overall gains translate into a 15% increase in equipment life, reducing investments in new acquisitions and reducing carbon dioxide emissions at the same time.

At present, an AHS requires cut-off thresholds that limit its application to large open pit mines. At present, the apparent complexity, capital constraint (due to market forces) and a lack of general awareness serves to limit the uptake of the technology.

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The view and analysis present in this paper are of authors only based on the available data and does not represents the view of the organization for which author works.

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Energy Benchmarking: The Driver for Mitigation of Climate Transition Risk Faced by Coal to Power from Opencast Mines

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ABSTRACT

Coal India fuelling the prime energy producers to the nation, the ethics of energy conservation in the coal sector is imperative and saving energy aims at the five pronged benefits including saving of energy by reducing power bills, prospects of coal conservation, energy conservation, saving the environment and exploring renewable trajectories that also helps to clean and protect the environment and leave it safe for the generations to come, thus fulfilling the global UN goal of sustainable development. Energy is universally recognized as the edifice of modern life and one of the most significant inputs for economic growth and human development. The need for conservation of coal as an energy resource has assumed tremendous proportions in the present world, especially in the backdrop of the global economic meltdown, triggered by the depletion of economically vital but finite energy resources (like coal, oil & natural gas), environmental degradation (like global warming & emission of greenhouse gases) and dependence on imported energy. These include the economic impact of crude oil prices and the inability to ensure energy security in times of emergency.

In spite of coal being the predominant fuel of India's energy matrix at around 55% of total energy mix, Coal power generation is, however, under pressure from increasing low cost, domestic renewable energy penetration in India's power system. This trend was initiated under India's solar and wind targets in the previous decade. It has been further strengthened under India's commitment to the Nationally Determined Contributions (NDCs) in the Paris Agreement, where renewable energy capacity is supposed to increase to 40% of generation capacity, or 350 gigawatts (GW) in absolute terms by 2030. This effect of coal power being under pressure is known as the climate transition risk, which connects climate related policy, legal issues, technology and market changes to the financial health of assets in companies. In this case, the implications are not only via countries' climate targets but also via rapidly falling costs of renewable energy and related technologies such as battery energy storage systems (BESS) and their interplay with policies and markets.

As the world mandates against burning of fossil fuels to reduce harmful emissions and carbon footprint, the coal sector in India faces the open challenge to mitigate and negotiate this climate transition risk by diversifying into renewable trajectories like solar energy. But this is not enough considering the fact that India holds the third largest coal reserves globally. Hence this paper addresses the mitigation of climate transition risk by using optimum blend of Energy Management and Risk Management strategies, also exploring green coal technologies like generation of Coal Bed Methane, underground and surface coal gasification, IGCC (Integrated Gasification Combined Cycle) and methanol economy to substitute for 10% of crude.

INTRODUCTION

Climate Transition Risk In The Backdrop Of India's Coal And Power Trajectories

The climate transition risk that the coal industry in India is facing is as unprecedented as the present pandemic that we are living in our lifetimes. This global disruption is for real; the virus is surreal; the pandemic has shaken and changed the world forever and the VUCA world has arrived! VUCA is a managerial acronym that stands for "Volatility, Uncertainty, Complexity and Ambiguity" and today best describes the present situation in the global context, be it the crumbling economy, the falling markets, the undefined workspaces in the virtual world, the social distancing norms to be followed in a tightly knit social fabric or the mask and sanitizer combo, the new normal.

Considering the limited reserve potential of petroleum & natural gas, eco-conservation restriction on hydel projects and geo-political perceptions of nuclear power, coal will continue to occupy centre-stage of India's energy scenario. Coal has been the most important component of India's energy matrix for a long time, accounting for nearly 62% of the total supplies. India holds more than 155.6 billion tonnes of proven coal reserves as on 01.04.2019 and ranks among the top three coal-producing countries in the world. Owing to the pandemic, crumbling power demand during lockdown period and global

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meltdown of the economy, the total production of coal from the mines of Coal India Limited (CIL) during 2019-20 was around 602.15 million tonnes (Mt), registering a negative growth of around 0.78% as against a growth of 6.9% in 2018-19, contributes to about 80% of the country's coal production. However the positive growth in 2020-21 so far may be projected at around 1.25% The power sector, registering around 0.95% growth rate in 2019-20, which forms the backbone of the economic development of our country and is heavily dependent on coal as the predominant fuel of the present and the future is at crossroads, as shown below:

Table-1: Actual and projected coal and power trajectories

Year	Country's Power status			Contribution of CIL		
	Energy Availability (MU)	% energy shortage	% power short-age	CIL Coal Production (MTY)	Coal to Power (MTY)	% coal in power
2011-12	857.88	8.5	10.6	435.84	310.00	71.1
2012-13	908.65	8.7	9.0	452.21	353.83	78.2
2013-14	959.83	4.2	4.5	462.42	365.74	79.1
2014-15	1030.78	3.6	4.7	494.23	385.40	78.0
2015-16	1090.85	2.1	3.2	538.76	409.14	76.0
2016-17	1135.33	0.7	1.6	554.14	450.00	81.2
2017-18	1204.70	0.7	2.0	567.37	454.22	80.1
2018-19	1274.59	0.6	0.8	606.89	491.54	81.0
2019-20	1291.01	0.5	0.7	602.13	465.72	77.3
2020-21 (upto Jan 7th 2021)	831.94	0.3	0.3	405.98	324.24	79.9
In the year 2019-20, Coal production growth : (-) 0.78%, Thermal power growth : 0.95%						
The coal and power trajectories are a grim reminder and clarion call for change and both coal and power sectors need to recognize the climate transition risk faced by coal and plan to mitigate this risk for a sustainable future						

The power landscape of the country has undergone a paradigm change with the country's installed capacity leaping to 374,199 MW with 231,321 MW (61.8%) from the thermal sector and coal alone contributing around 199,595 MW (53.3%) and renewables including solar, wind, tidal and geothermal contributing around 90,399 MW (24.2%), as reported by the CEA (Central Electricity Authority) in the MOP (Ministry of Power) release, 17.12.2020. In spite of all- out efforts in the right direction, the country is still facing an energy shortage of around 0.3% and a peak power demand shortage of around 0.3% that desires a lot to be done. Now that the coal to power scenario is under transition to renewables, Energy Management for thermal and renewable power and Risk Management gain centre-stage to mitigate the climate change and energy transition risk. Coal India (and the Government of India) should not only acknowledge this risk but also explore avenues for reducing the risk, potentially diversifying Coal India into more climate friendly activities, such as mining other minerals of value or investing in renewable projects above and beyond what is currently planned. This presages a potential future transition away from coal towards renewables in the Indian power sector and practical applications of green coal or clean coal technologies. In the longer-term the future of coal in India will also depend on the success of the transition to variable renewables and clean coal technologies, as discussed in this paper

Diversification Initiatives Taken By Coal India To Make Itself Future Ready

- CIL board has also approved the formation of SPVs for a solar power value chain (ingot- wafer-cell-module) business vertical and new and renewable energy business vertical
- Central Coalfields Ltd (CCL), a wholly-owned subsidiary of Coal India Ltd, will develop an integrated aluminium complex

The Board of Directors at Coal India Ltd (CIL) has approved a plan that marks one of the most expansive and decisive diversification initiatives taken by the state-run coal miner in its history, that of venturing into the solar power value chain and aluminium value chain. At a meeting held on Thursday, December 24th, 2020, the Board of Directors at CIL, accorded its 'in- principle' approval to venture into aluminium value chain (Mining-Refining-smelting) and solar power value chain, Coal India Ltd said in a regulatory filing to the stock exchanges. Coal India Ltd already has plans to set up 14 rooftop and ground-mounted solar power projects of 3,000 megawatt (MW) capacity by financial year 2023-24 (FY24) at an investment of about Rs 5,650 crore, the Maharatna coal PSU had said in November. This has set the ball rolling for the Indian coal giant to extend its clout beyond the conventional fuel sector into a segment that will ensure its survival after coal is phased out or used for clean coal options by the turn of 2040.

ENERGY MANAGEMENT AND ENERGY BENCHMARKING COUPLED WITH RISK MANAGEMENT: STRATEGISING MITIGATION OF CLIMATE TRANSITION RISK

Energy Benchmarking and setting energy targets for each Opencast Mine/Project of CIL

Energy Benchmarking is the practice of comparing the performance metrics or measured performance of a device, process, facility, or organization to itself, its peers, established norms or best practices available in the industry globally, with the goal of informing and motivating performance improvement as well as the bottom line of business productivity. Dimensions typically measured are quality, time and cost. When applied to mines, benchmarking serves as a mechanism to measure energy performance of a single mine/Project, relative to other similar mines/Projects, or to modeled simulations of a reference mine built to a specific standard to arrive at a “Benchmark”. Benchmarking is used to measure performance using a specific indicator (cost per unit of measure, productivity per unit of measure) resulting in a metric of performance that is then compared to others. Benchmarking may be a one- off event, but is often treated as a continuous process in which organizations continually seek to improve their practices.

In this paper it is proposed to apply the tools of Project Management to “benchmark specific electrical energy consumption for the mines/projects of CIL”, mine/ Project wise to arrive at an “Internal Benchmark” and consequently comparing the same with other Opencast mines/Projects of other coalfields in India and further with the best practices globally to arrive at an “External Benchmark”. This will help us set the energy goals for the respective mines/Projects of CIL, as against their coal production targets. Energy Benchmark will be in kWh/Te of coal production, Cum/Te of OB (overburden removed) production and Cum/Te of composite production.

As a case study we will consider one Opencast mine/ project of CIL and benchmark its specific energy consumption to set the energy target for the coming year for that specific Mine/project as against its coal production target. Investment Appraisal for quantified energy saving measures will be in the form of Pay-Back period as it would be one-time investment.

PERT, CPM techniques for project planning, Earned Value Management System for cumulative time and cost monitoring & scheduling, Pay-Back Period method for Investment Appraisal & Probability-Impact Matrix for Risk Management would be useful to mitigate the climate transition risk.

Energy Audit and Energy Conservation: the stepping stone of Energy Benchmarking

Energy Saving Recommendations along with their Investment Appraisal

Energy Audit involves quantifying existing electrical energy use for coal production as in coal mining operations and coal transportation, for colony, offices, common areas for welfare activities, pin-point areas of energy wastage, suggest energy saving measures to be taken to reduce a quantified amount of energy use thus reducing the power bills with Investment Appraisal for each energy saving recommendation in form of Pay- back period method as it is a one-time investment. This will help a mine /Project to curb its energy use, reduce energy wastage, reduce its power bills and will be the first step for Energy Benchmarking for that particular Mine/Project.

CIL being an energy producing company, energy conservation measures such as installation of meters in incoming main receiving mine feeders, on individual equipment where possible and colony houses for measuring and monitoring, realigning of pumping networks & routes or rearranging of pumps, reducing idle running of conveyor belts and HEMM, use of soft starters for heavy starting current of Shovel and Dragline motors, reducing colony load by creating awareness, quantifying energy wastage and installation of energy efficient initiatives like 5-8W LEDs, electronic regulators for fans, slim tubes of 23 W, star rated air conditioners in homes and offices saving energy will result in five-fold benefits as described above.

Project Management and Risk Management tools to mitigate transition risk

The following tools need to be applied in all Projects to be covered for Energy Audit and Energy Benchmarking which is a continuous process of monitoring, measuring and implementation:
Risk Management, Company Risk Charter, Quantitative and Qualitative Risk Analysis, Risk Register, Corresponding Probability and Impact Matrix

Team Work models and Conflict Resolution techniques to be applied in all unit structures of the organization

Communication skills to be sensitized and Leadership roles well defined with “Empathy” as a must while we live in a pandemic and all team members are going through trying times

Earned Value Management System would help monitor planning with implementation stages of a Project

Issue Management and Issue Register for all unforeseen issues occurring in Project path

Strategy for Implementation

The steps for implementation of Energy Benchmarking and setting energy targets for each Opencast Mine/ Project of CIL with timeline

The Energy Audit recommendations/energy saving measures to be implemented to reduce electrical energy consumption wherever recommended, Time 2 weeks, Cost worked out by Payback Period Method as mostly they involve one time costs

After trend analysis of calculated, measured and obtained input data from field authorities, data is analysed by “Trend Analysis” for best equation generated in straight line form y = mx+c for existing load where y = total energy consumption, mx denotes variable energy that depends on coal/OB/composite production and c = constant energy consumption in a mine, independent of coal/OB/composite production, Time 5 weeks, including 2 weeks of data collection and measurements taken over different periods of load cycles, included in energy audit part that is implemented as above step.

After reduction of energy saving from the respective energies, there will be a set of 3 new equations for y1, y2 and y3 as respective reduced energy required for coal, OB and composite production for the coming year. This energy divided by respective coal/OB/ composite production figures for the next year as the target production will benchmark the specific electrical energy consumption figures in Te/kWh of coal, Te/ Cum of OB and Te/Cum of composite production as the benchmarked specific energy consumption figures for the coming year and y1, y2, y3 will give the equations for the energy target goals of the mine for target production in the coming year, Time 1 week, included in Energy Audit.

The cost of energy saving measures is calculated by Payback Period Method as they are one-time costs Time 1 week, included in Energy Audit.

Energy Audit Time 7 weeks, Implementation Time 2 weeks.

Case study of an opencast Mine/Project of CIL

Summarised data showing results on Benchmarking of Energy consumption (Electrical) of the Opencast Project of CIL under study, conducted in 2019

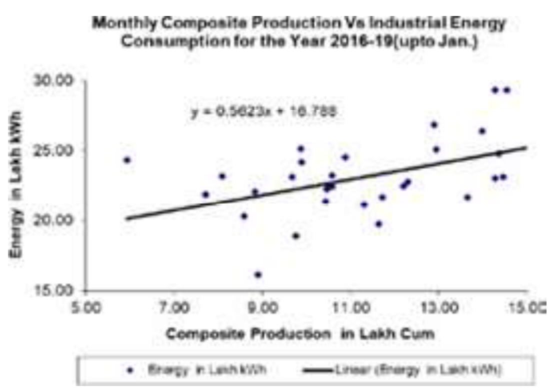
Sl. No.	Description	Quantity
1.0	Coal Production (2017-18)	8785,000 Tonne
2.0	OB Removal (2017-18)	8136,000 cum
3.0	Composite Production (2017-18)	13767,000 cum
4.0	Electricity Consumption (2017-18)	33.287 M kWh
5.0	**Specific Energy Consumption (Existing)**	**2.41 kWh/cum ofcomposite Prod**
		3.79 kWh/tonne of coalproduction
6.0	**Saving Potential in different areas as per study forBenchmarking of energy consumption:**	
6.1	Replacement of 150 W HPSV lamps by 70 W LED fittings	0.1752 lakh kWh/annum
6.2	Replacement of 250 W HPSV lamps by 120 W LED fittings	0.1993 lakh kWh/annum
6.3	Replacement of 400 W HPSVlamps by 190-210 W LED fittings	0.1314 lakh kWh/annum
6.4	Power factor improvement.	0.5649 lakh kWh/annum
6.5	Pumping System	9.701 lakh kWh/annum
7.0	Electricity Consumption as perBenchmark	32.21 M kWh
8.0	**Benchmarked Specific Energy Consumption**	**2.36 kWh/cum ofcomposite Prod**
		3.67 kWh/tonne of coalProd
9.0	**Investment Proposed, one time**	**Rs. 105.07 Lakhs**
10.0	**Financial Saving as perBenchmark, per annum**	**Rs. 95.55 Lakhs**

Benchmarking in the opencast Mine/Project of CIL

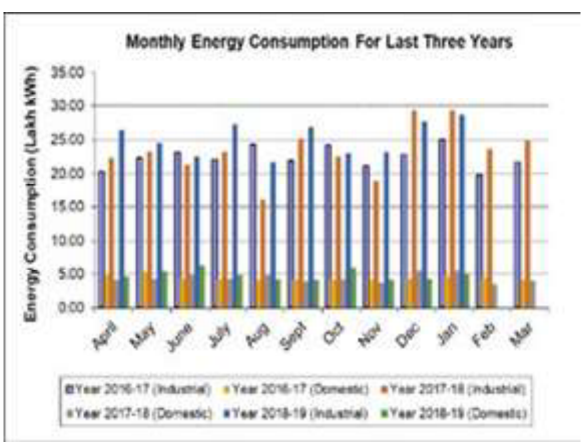
For the purpose of target setting and benchmarking, avenues for energy conservation by proper monitoring and application of energy efficient devices has been also considered. Total saving in energy comes to the tune of

1.077MkWh/annum. By reducing saving potential from the fixed energy, target for fixed consumption for benchmarking is considered to be 32.21 (33.287-1.077) MkWh/year. Considering the composite production (13.767 McuM), specific energy consumption is benchmarked as 2.36 kWh/CuM of composite production. Considering the coal production of 2017-18 i.e 8.785 MT, specific energy consumption is benchmarked as 3.67 kWh/Te

Different service buildings of the opencast Mine/ Project of CIL under study is having potential of roof top solar power plant with a total installed capacity of around 950 – 1000 kWp say 1 MWp. With a combined utilization factor of around 17%, projected energy generation from these plants will be around 14.8 lakhs kWh/year with an investment of around Rs. 550 lakhs.



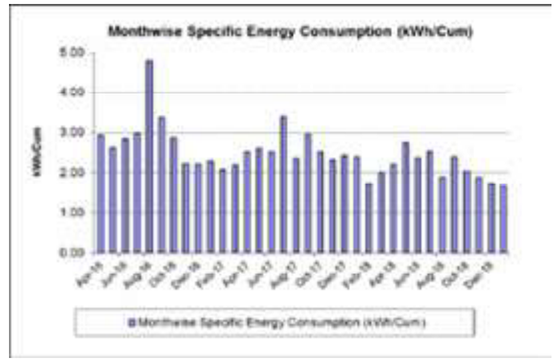
Typical representative figures during trend analysis

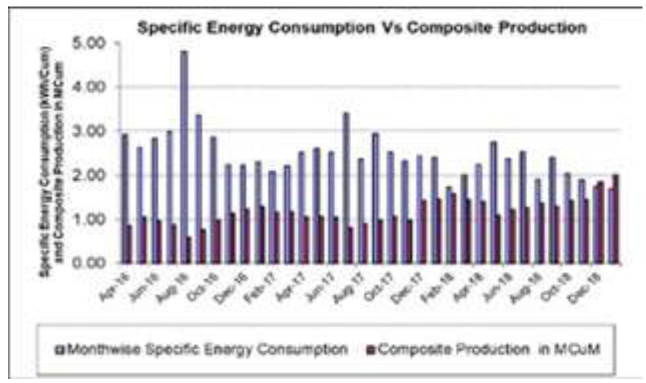


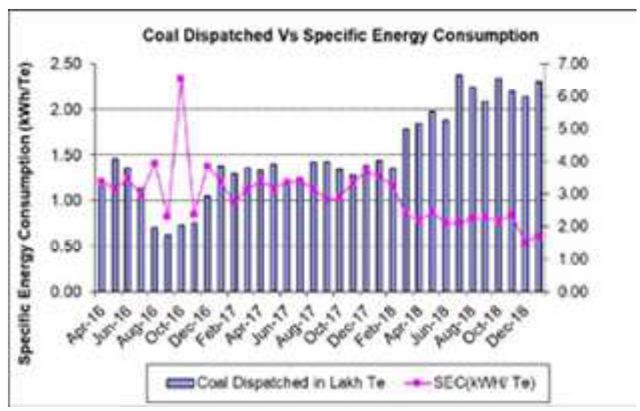
OTHER CLEAN COAL TECHNOLOGY OPTIONS FOR COAL UTILIZATION TRANSITION

India is a signatory to Paris Agreement, 2015 (ratified by India on 2.10.2016) for NDC targets -

1. Reduce emissions intensity of its GDP by 33- 35%







by 2030 from 2005 level.

2. Achieve about 40% cumulative electric power installed capacity from non-fossil fuel based energy resources by 2030 with the help of transfer of technology & low cost international finance including from Green Climate Fund (GCF).
3. To create an additional carbon sink of 2.5 - 3 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030.
4. Based on India's NDC, CIL is taking steps to contribute towards these target.

Need for Clean Coal Technology (CCT)

1. Coal is liable to contribute GHG emissions &

Particulate Matter in Fly Ash.

2. These emissions, including Particulate Matter, contribute to global warming & are potential hazard to environment.
3. CCT includes measures for:
4. conversion technologies to provide the coal consumers with technical tools for better environmental controls.
5. To reduce harmful environmental effects by using multiple technologies to clean coal and contain its emissions.
6. To meet Paris climate agreement goals.
7. Coalbed Methane (CBM) and its sub-sets like Coal Mine Methane (CMM) and Abandoned Mine Methane (AMM) and Underground Coal Gasification (UCG) are emerging non- conventional, clean energy resource which are being pursued by CIL/CMPDI.

Surface Coal Gasification

1. In utilizing coal feedstock for chemicals, the first stage would be gasification of coal to Syn gas.
2. Surface Coal Gasification is a flexible, reliable and commercial clean coal technology that can turn variety of low value feed stocks into high value products.
3. Helps in reducing countries' dependence on imported oil, natural gas and various chemicals.
4. Can provide alternative source for ammonia/ fertilizer, fuels, Synthetic Natural Gas (SNG) and many other chemicals.
5. Methanol has great potential as it can be directly used as fuel or blended with:
6. Gasoline pool & relatively easily converted to Di-methyl Ether which may be substitute for LPG.
7. Methanol can also be converted into light olefins, ethylene and propylene (feed stocks for petro-chemicals).
8. Recognizing the potential of coal as game changer in the Indian energy sector, SCG would be suitable CCT for future and may be proved in the interest of India's energy security, import and macro economy.

Coal Bed Methane

1. CBM Policy put in place in July 1997;
2. MoPNG Nodal Ministry and DGH nodal agency for CBM;
3. MoU signed between MoC and MoPNG in Sept. 1997;
4. Coal companies will have the right of CBM exploitation in their working mines including pre and post mining operations;
5. Production is coming from eight CBM blocks with reportedly current production of around 2.0 million standard cubic meter per day.
6. Out of these allotted blocks, 2 blocks i.e: Raniganj and Jharia CBM blocks have been allotted to the consortium of CIL and ONGC by the Govt. of India.
7. These blocks have entered into development stage as the development plan for these blocks has been approved by the Government.

Development of Underground Coal Gasification (UCG)

1. UCG is one of the priority areas of development. To expedite development of UCG following initiatives have been taken.
2. MoC issued Gazette notification dated 13th July, 2007 which specifies production of syn gas obtained through coal gasification (underground and surface) and coal liquefaction to be end uses for the purposes of Coal Mines (Nationalization) Act, 1973.
3. Gazette notification dated 20th Feb. 2014 specifies production of cement, syn-gas obtained through coal gasification (underground and surface) and coal liquefaction to be end uses for the purposes of MMDR Act,1957.
4. MoC constituted Inter Ministerial Committee (IMC) for identification of areas for UCG on the line broadly similar to the existing policy of CBM development.
5. 14 nos. of potential blocks in coal & lignite (7 in coal & 7 in lignite) identified & under consideration of the IMC for commercial development.
6. A Model Contract Document & Bid Documents prepared through a consultant (M/s CRISIL) which is under consideration of IMC.

CMM Project – Moonidih, BCCL/CIL

EPILOGUE

"We have not only inherited the earth from our forefathers; we have also borrowed it from our children." This is the mantra for sustainable development. This cosmos is too precious a legacy to be destroyed by environmental threats. The vision for unlimited development is futile with finite resources. The coal and power trajectories are a grim reminder and clarion call for change and both coal and power sectors need to recognize the climate transition risk faced by coal and plan to mitigate this risk by energy benchmarking, setting energy targets as against coal production targets, going into renewable trajectories and establishing practical use of green coal or clean coal options for a sustainable future.

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Impact of Seasonal Variation on Physicochemical Status of Bansagar Dam, Shahdol, India

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ABSTRACT

Water is a leading natural resource, water contributes systems, and drinking water inacces sibility in rising countries is a global concern, The piece of research is carried out to study the water quality and suitability of Bansagar dam, Shahdol for irrigation and consumption prospects. Three water samples each were collected from three specific sites which serve as the foundation of drinking water at diverse locations of Bansagar dam. Samples were analyzed for physicochem ical individuality during 2019 and 2020 to assess the impact of seasonal virations in the water of the dam by observing different physicochemical parameters viz pH, hardness, total dissolve solids, dissolved oxygen, biological oxygen demand, free CO_2, alkalinity and chloride different seas ons. Basically, all investigated paramters expressed their normal and below status recommended by WHO and ISI for drinking and applicability of water. Parameters were under seasonal alteration range, Hence, it can conclude that Bansagar Dam water was affected due to the involvement of geographical organization and their seasonal alterations, other than water progressively attention towards eutrophication which points towards and suggested the accessibility of secure dam water in expression of drinking and irrigation exploitation.

Keywords: Bansagar dam, physicochemical, characteristics, seasonal variation.

INTRODUCTION

Prime natural resource water is full fill essential human require and a valuable positive feature, in the nonexistence of which no socio-economic developmental activities can maintain. Systems of water storage and supply in good deed of drinking water inaccessibility in mounting countries are a universal apprehension that entitles for instant action. Millions of people in the world immobile do not acquire their drinking water from supported sources, and just about all of these people are in rising regions (WHO/ UNICEF, 2010). Natural water encloses disparate types of impurities are commenced into the aquatic structure by means of different means such as weathering of rocks and leaching of soils, suspension of aerosol particles from the impression and from quite a lot of human activities, together with mining, processing, and the employ of metal-based materials (Adeyeye 1994). India is rich in surface water supply with the rapid augment in the population; require for irrigation, human and industrial utilization of water has amplified considerably, thereby causing a reduction of water resources. Water quality can have an immense influence on the capability of aquatic organisms to live on and cultivate in a stream, pond, lake, reservoir, river, and dam. Dam storage water is one of the important conservation foundations that play an imperative role in living organisms including human.

The water chemistry is influenced as a result of the input materials like minerals. Water chemistry reveals much about the metabolism of the ecological unit and gives details in the account of hydrobiological relationship (Basavaraja Simpi et al. 2011). The fundamental role of dam water plays as a source of freshwater for humans' well-being as well as many water ecosystems, which cannot be underestimated. The study of hydrobiology in expressions of the Physico-chemical constraints of any aquatic ecosystem is obligatory since the Physico-chemical parameters influence its biota to a large extent. Water alkalinity not only assists regulate the pH of water. Alkalinity varies greatly due to divergences in geology and so there are no common averages for alkalinity body and the metal content (APHA, 2001). Based on different Physico-chemical findings of direct relation exist in favor of phytoplankton, zooplankton, macrophytes production. Bansagar reservoirs are presently evaluated for their Physico-chemical status which has been created on the Son River at Deolond, Dist. Shahdol. As this assignment having a huge water body on Son River, it forms the best ecosystem intended for the aquatic flora and fauna.

BANSAGAR DAM

The Bansagar Dam is multipurpose, with hydro-electric power generation and irrigation, constructed across the Son River. The dam site is situated near Deolond bridge on Rewa-Shahdol road, at a distance of 50.7 km from Rewa, coordinate with $24^0$11'30'N $81^0$17'15'E, The Son

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river initiated from Amarkantak in Shahdol district at an altitude of about 1066.8 m. The river runs 508.54 km in Shahdol and Sidhi, Madhya Pradesh and the river flows 96 km length cover Uttar Pradesh, Thereafter it enters Bihar, and then meets with the Ganga river (Fig. 1 and Fig.2).

The study of the Physico-chemical status of water is difficult to understand the biological activities of water bodies exclusive of enough knowledge of water chemistry. There are several abiotic factors, which directly or indirectly influence the growth and biodiversity of aquatic environments. The Physico-chemical characteristics of water features include physical, chemical, and biological constraints which conclude its nutrient position and contamination level.

MATERIAL AND METHODS

The explore work was carried out in 2019-2020 with the help of the following methodologies: The samples were collected from different three specific sampling points incorporate in the investigation as site or station A, B, and C. the seasonal (Rainy, summer, and winter) sampling of water was done and water was collected in wide-mouthed glass bottles and kept in an icebox (at low temperature). The investigation was done in the laboratory of department of Environment Science, AKS University, Satna, M.P. Investigating parameters included pH measured through electrode in water. Total dissolved solids and Total alkalinity was recorded with standard method APHA, 1995 and APHA, 2005, Total hardness, bicarbonate, Chloride, and Alkalinity were determined by titration with EDTA. The turbidity is expressed in Nephelometric Turbidity Units (NTU), Free carbon dioxide was determined through APHA, 2012. BOD and DO was analyzed by Winkler's method. The chlorides and bicarbonate present in water were calculated by the titration method.

SAMPLING SITES/STATIONS

Station A: It lies around the Mahadev temple of the dam and has a literal and undisturbed area to the interferences of human beings with a water depth range between 1 m. to 1.5 m.

Station B: It is situated near the Vijay Sota Railway Station and is characterized with almost semi disturbed area particularly to human activities with a water level to be vitiated between 1m. and 1.5 m.

Station C: It lies in the main gate area of the dam and relatively has higher disturbance of human, with a water depth range between 1 m. to 1.5 m.

Fig. 1: Satellite view of Bansagar dam

Fig 2: Location map of Bansagar dam

RESULTS AND DISCUSSION

pH:

pH gives the concentration of the ionized hydrogen which in turn gives indirectly in a sequence of free CO_2 content, alkalinity, dissolved o xygen, dissolved solids as well as thus possibly will serve as a test of several environmental situations (Sheeja, 2005). Water PH is a significant environmental issue that influences the metabolism of all the water life forms. Usually slightly alkaline water pH (7.5) is confirmed to be more prolific and suitable for biota. pH is equivalent to negative log10 of hydrogen ion attention which points out acidic or basic scenery of water. The dissimilarity of pH of Bansagar dam decided at all sites throughout the study period 2019 and 2020, status is represented in the mean of the pH assortment (6.85 to 8.60) in study duration (Table 1)., there are very few seasonal variations were examined in pH values of dam water.

The values of pH ranged 6.84 to 8.62 for the extent of the year 2019 whereas 7.46 to 7.85 in 2020 (Table 1). The mean±SD values of pH were evidenced during 2019 in winter season as 7.41±0.01 at station A, 7.34±0.03, and 7.08±0.005 for station B and station C. The mean ±SD status of pH were recorded in summer spell as 8.60±0.01 at station A, 6.95±0.03 and 7.47±0.01 for station B and station C through study tenure 2019 (Table 1). In rainy season mean±SD values of pH were recorded as 6.85±0.01, 7.23±0.04 and 6.73±0.01 in concern to station A, station B and station C respectively in 2019. Maximum mean pH values were recorded in summer (8.60) followed by winter season (7.41) and minimum (6.85) in rainy season during 2019. Usually disinterested or slightly alkaline water pH is established to be mo re creative and appropriate for biota. A number of documented data illustrated that there are constructive associations among the water quality parameters (Gupta and Mahrotra, 1986).

The mean±SD values of pH were recorded during 2020 in winter as 7.46±0.005 (station A), 7.30±0.005 and 7.59±0.005 for station B and station C. The mean±SD values of pH were confirmed in summer as 7.60±0.005 at station A, 7.38±0.005 at station B and 7.50±0.005 at station C through 2020 (Table 1). In rainy season mean±SD level of pH were recorded as 7.84±0.01, 7.24±0.011 and 7.61±0.005 at station A, B and C respectively. Overall the maximum mean values of pH were accounted in rainy season (7.84) at station A, followed by 7.61 at station C and minimum was also observed in rainy season (7.24) at station B in study duration 2020 (Table 1).

The pH esteems in Harsool-Sangavi dam range justify as 7.9 to 8.6, similarly, 7.5 to 8.7 pH range were reported in Charghad dam in Amravati, with the most raised pH occurrence during the winter, pH levels rise in the mid of winter and fell in rainstorms and winter (Shinde et al., 2011). Makode (2020).

The pH range of 7.7 to 8.9 was accounted with the most minimal quality in winter and the best in the spring Sharma and Jain (2000). Most elevation in pH was established during the winter.

Table 1: Effect of seasonal variation on pH (at 25°C), EC (µmhos/cm) and Turbidity (NTU) during 2019 and 2020.

Parameters (Mean±SD)		2019				2020			
		Winter	Summer	Rainy	Yearly average	Winter	Summer	Rainy	Yearly Average
pH	Station A	7.41±0.01	8.60±0.01	6.85±0.03	7.62±0.15	7.46±0.005	7.60±0.005	7.84±0.01	7.63±0.15
	Station B	7.34±0.03	6.95±0.03	7.23±0.04	7.17±0.035	7.30±0.005	7.38±0.005	7.24±0.011	7.30±0.010
	Station C	7.08±0.005	7.47±0.04	6.73±0.01	7.09±0.018	7.59±0.015	7.50±0.005	7.61±0.005	7.56±0.008
EC (µmhos/cm)	Station A	547.6 ± 0.57	153.3 ± 0.57	215.66±0.57	305±0.55	178.66±0.57	4.66±0.57	215±1.0	196.10±0.71
	Station B	472.33±0.57	174±1.0	177.66±0.57	274.66±0.70	193.66±0.50	209.66±0.52	245.66±0.54	216±0.52
	Station C	433±1.0	264.66±1.15	225.33±0.57	307.33±0.99	217.30±1.15	247.66±0.54	269.66±0.57	244.87±0.75
Turbidity (NTU)	Station A	1±0.0	2.66±0.57	4±0.0	2.55±0.19	8.0±0.0	6.0±0.06	5.0±0.0	6.33±0.6
	Station B	3.66±0.57	8.66±0.57	1.0±0.01	4.44±0.54	4.66±0.57	6.66±0.57	7.66±0.57	6.32±0.57
	Station C	2.66±0.57	4.66±0.57	7.66±0.57	4.99±0.54	6.66±0.57	4.0±0.0	5.66±0.57	5.44±0.39
Value were expressed in n=3 mean±SD									

The electrical conductivity determines the total dissolved solids and is in a straight line recounted to total solids. Seasonal dissimilarity in water conductivity evidenced at diverse position of Bansagar dam (Table 1). During the 2019, water conductivity change with mean±SD among 433±1.0 to 547.6±0.57 μmhos/cm in winter, 153.3±0.57 to 264.66±1.15 μmhos/cm in summer and 177.66±0.57 to 225.33±0.57 μmhos/cm in rainy season.

In 2020 minimum and maximum water conductivity was recorded with mean±SD of 178.66±0.57 and 217.30±1.15 μmhos/cm in winter, 194.66±0.57 and 247.66±0.57 μmhos/cm in summer and 215±1.0 and 269.66±0.57 μmhos/cm in rainy season respectively (Table 1).

Turbidity

The turbidity determines the total dissolved solids and is directly communicated to the solids. The seasonal disparity in turbidity is evidenced at diverse stations of Bansagar dam (Table 1). All through 2019 water conductivity varies with mean±SD stuck between 1±0.0 to 3.6±60.57NTU in winter, 2.66±0.57 to 8.66±0.57 NTU in summer, and 1.0±0.0 to 7.66±0.57 NTU in rainy weather. Water conductivity as minimum and maximum was confirmed with mean±SD of 4.66±0.57 and 8.0±0.0 NTU in winter, 4.0±0.0 and 6.66±0.57 NTU in summer and 5.0±0.0 and 7.66±0.57 NTU in rainy season respectively during 2020. Turbidity settles on the water's reasonableness for utilization. The rising point of turbidity influences the water's fitness for drinking and cultivating. The average turbidity esteem in the rainstorm was 10.5 NTU, yet in the winter it was 1.0 NTU, as indicated next to their inspection (Medudhula et al., 2012). A comparable perception has been prepared in current application somewhere high turbidity was moreover evidenced during the rainy (Garg et al., 2006).

Total hardness

The total hardness of Bansagar dam water fluctuated from 167-192 mg/l during winter, 14-94 mg/L during summer and 54-82 mg/L during the rainy season in 2019. The maximum and minimum value of total hardness as 192 mg/L and 14 mg/L was recorded in winter and summer respectively at station A (Table 2). The mean±SD value of total hardness recorded at station A was 190.66±1.15 mg/L, 14.33±0.57 mg/L and 67.66±0.57 mg/L in winter, summer, and rainy season respectively. At station B, the mean±SD status of total hardness was 175.33±1.15 mg/L, 21.66±0.57 mg/L and 54.66±0.57 mg/L in winter, summer, and rainy. In the case of station C, mean±SD status for total hardness was 167.66±0.57 mg/L, 93.66±0.57 mg/L and 81.33±1.15 mg/L in winter, summer, and rainy term (Table 2). The permissible limit of hardness for drinking water is 600 mg/L as per Indian standards. Hardness as such has got no adverse outcome on human health. The finding showed high fluctuations in the Physico-chemical constraints indicating the strength of pollution (Rokade and Ganeshwade, 2005).

During 2020 the total hardness of dam water varied from 55-74 mg/L during winter, 62-86 mg/L in summer, and 78-94 mg/L during rainy. The maximum value of total hardness i.e 94 mg/L was recorded at Station C and Minimum 55 mg/L was evidenced at Station A during rainy and winter respectively. The mean±SD value of total hardness recorded at station A was 55.66±0.57 mg/L, 63.33±1.15 mg/L and 77.33±1.15 mg/L in winter, summer, and rainy respectively. The mean±SD value of total hardness recorded at station B was 61.33±1.15 mg/L, 71.0±1.0 mg/L, and 81.33±1.15 mg/L in winter, summer, and rainy weather. Mean±SD status of total hardness in terms of station C was 73±1.73 mg/L, 85.66±0.57 mg/L and 93.33±1.15 mg/L in winter, summer, and rainy seasons. Hardness was seen to be mostly raised in the winter and least in the rainy weather. Our finding justified with Hulyal and Kaliwal (2011) that suggested higher hardness in the late spring and lower in the winter.

Total dissolve solids (TDS)

Total dissolve solids (TDS) in dam water recorded in the range of 91-338 mg/L in 2019 and 113-147 mg/L in 2020 at different stations. Mean was calculated with deviation in total dissolved solid is presented in table 2 which was 337.66±0.57 mg/L, 288.66±0.57 mg/L and 269.33±0.57 mg/ L in winter; 91.66±0.57 mg/L, 118.66±0.57 mg/L in summer and 127.66±0.57 mg/L, 110.33±0.57 mg/L, and 131.66±0.57 mg/L in the rainy season at Station A, B and C respectively during 2019. In 2020 Total solid of dam water recorded with mean±SD of 113.66±0.57 mg/L, 120.66±0.57 mg/L and 138.0±1.0 mg/L in winter season; 137±1.0 mg/ L, 130.66±1.15 mg/L and 154.66±0.57 mg/L in summer and 141.66±0.57 mg/L, 116.33±0.57 mg/L, and 146.33±0.57 mg/L in the rainy season at stations A, B, and C respectively (Table 2).. Arya et al., (2013) found that TDS levels were most diminished in winter and most elevated in the late spring and monsoon. High TDS recorded at the stage in the storm because of overflow water conveying filth and sand, just as the appearance of wastewater, trash, just as sewerage to the dam water. Saravanakumar et. al., (2011), express the water quality constraints of groundwater observation also which justify the finding under the physicochemical overview.

Table 2: Effect of seasonal variation on Total hardness, TDS, Chloride, Bicarbonate and Total Alkality status, during 2019 and 2020.

Parameters (Mean±SD)		2019				2020			
		Winter	Summer	Rainy	Yearly average	Winter	Summer	Rainy	Yearly average
Bicarbonate	Station A	220.33±0.57	68.33±0.57	50.66±0.57	111.10±0.57	75.66±0.49	75.66±0.47	83.66±0.57	78.32±0.54
	Station B	200±0.49	73.33±0.57	44.33±0.50	1.5.88±0.52	81.33±0.57	82.66±0.51	93.66±0.51	85.88±0.55
	Station C	185.33±0.51	124.33±0.57	82.66±0.57	130.770.53	100.33±0.48	89.66±0.57	101±1.0	96.77±0.71
Total hardness	Station A	190.66±1.15	14.33±0.57	67.66±0.57	90.88±0.76	55.66±0.57	63.33±1.15	77.33±1.15	65.44±0.95
	Station B	175.33±1.15	21.66±0.57	54.66±0.57	83.88±0.76	61.33±1.15	71.0±1.0	81.33±1.15	71.22±1.
	Station C	167.66±0.57	93.66±0.57	81.33±1.15	114.21±0.76	73±1.73	85.66±0.57	93.33±1.15	83.99±0.57
TDS	Station A	337.66±0.57	91.66±0.57	127.66±0.57	185.66±0.57	113.66±0.57	137.0±1.0	141.63±0.57	130.77±0.71
	Station B	288.66±0.5	118.66±0.54	110.33±0.57	172.55±0.54	120.66±0.57	130.66±1.15	116.33±0.53	122.55±0.75
	Station C	269.33±0.57	177.33±0.57	131.66±0.57	192.77±0.57	138.0±1.0	154.66±0.57	146.33±0.57	146.33±0.71
Chloride	Station A	68.33±0.57	12.0±0.0	30.66±0.57	36.99±0.38	14.66±0.57	16.66±0.57	21.66±0.50	17.66±0.57
	Station B	54.33±0.57	17.66±0.57	27.33±1.15	33.10±0.76	17.66±0.57	22.33±1.15	26.67±0.56	22.21±0.76
	Station C	47.66±0.57	25.66±0.57	23.33±1.15	32.21±0.76	18.61±0.57	18.66±0.57	20.66±0.51	19.32±0.57
Total Alkality	Station A	180.0±0.081	56.33±0.54	41.66±0.57	92.66±0.38	61.63±0.51	63.66±0.51	70.33±0.52	64.52±0.54
	Station B	163.66±0.57	59.66±0.5	36.33±0.57	86.55±0.54	65.66±0.57	67.66±0.51	73.66±0.54	68.99±1.20
	Station C	152±1.0	101.33±1.15	67.66±0.57	106.99±0.90	81.33±1.15	73.33±1.15	86.33±1.15	80.33±1.12
Value were expressed in n=3 mean±SD									

Bicarbonate content

In 2019 and 2020 bicarbonate level was determined at all stations During 2019, the minimum and maximum bicarbonate i.e. 50 mg/L and 220 mg/L was measured at station A, 44 mg/L and 201 mg/L at station B and 82 mg/L and 186 82 mg/L was recorded at station C. Bicarbonate alkalinity mean±SD status in 2019 were recorded as 220.33±0.57 mg/L (station A), 200±0.57 mg/L (station B), and 185.33±0.57 mg/L (station C) for winter. 68.33±0.57 mg/L, 73.33±0.57 mg/L and 124.33±0.57 mg/L in summer and 50.66±0.57 mg/L, 44.33±0.57 mg/L and 82.66±0.57 mg/L at station A, B and C respectively in the rainy season 2019 (Table 2). In the year 2020 minimum bicarbonate i.e.75 mg/L was noted in station A during winter and summer whereas maximum bicarbonate was recorded at station C in rainy. Bicarbonate alkalinity mean±SD status in 2020 evidenced was 75.66±0.57 mg/L, 81.33±0.57 mg/L and 100.33±0.57 mg/L in winter, 75.66±0.57 mg/L, 82.66±0.57 mg/L and 89.66±0.57 mg/L in summer and at station A, B and C bicarbonate were accounted as 83.66±0.57 mg/L, 93.66±0.57 mg/L and

101±1.0 mg/L respectively during rainy 2020. Disintegrated oxygen levels were most raised in the winter and least in winter. The example extent dissolves oxygen necessity for freshwater, as concurring ICMR (1975) and ISI (1991) models are 5 to 6 mg/L. Subsequently, the disintegrated oxygen level in the dam is almost regular for a characteristic of the dam. Our discoveries are steady with those of Yadav et al., (2013).

Chloride content

Chloride can be considered as one of the basic parameters of classifying water bodies polluted by sewage into different categories. The chloride content of dam water varied as of 47-69 mg/L, 12-26 mg/L, and 22-31 mg/L in winter, summer, and rainy in 2019. Maximum Chloride content (69 mg/L) and a minimum chlorine content (12 mg/L) of dam water were monitored on winter and summer seasons respectively at station A (Table 2). Mean±SD value estimated in favor of chloride content at station A was 68.33±0.57 mg/L (winter), 12.0±0.0 mg/L (summer), and 30.66±0.57 mg/L (rainy) season respectively. Mean±SD value for chloride content at station B was 54.33±0.57 mg/L, 17.66±0.57 mg/L and 27.33±1.15 mg/L in winter; summer and rainy season similarly chloride content at station C was 47.66±0.57 mg/L, 25.66±0.57 mg/L, and 23.33±1.15 mg/L were calculated in winter, summer, and rainy season as mean±SD value respectively.

In 2020 chloride content of dam water varied from 14-19 mg/L, 16-23.0mg/L and 20-27 mg/L in winter, summer and rainy weather. Minimum 14 mg/L and maximum of 27 mg/L chloride content was observed at station A and station B in winter and the rainy season (Table 2).

In 2020, mean±SD value calculated on behalf of chloride content at station A was 14.66±0.57 mg/L, 16.66±0.57 mg/L, and 21.66±0.57 mg/L in concern to winter, summer, and rainy seasons. The mean±SD value for chloride content at station B was 17.66±0.57 mg/L, 22.33±1.15 mg/L and 26.66±0.57 mg/L in winter, summer, and rainy season and chloride content mean±SD value observed at station C was 18.66±0.57 mg/L in winter and summer and 20.66±0.57 mg/L in the rainy season. The chloride content was expressed to fluctuate between in mg/L. Summer represents the most elevated level of chloride, despite the fact that winter has the least levels. Most chlorides was estimated in mg/L in the blustery season in 2020, anyway minor chloride was estimated in the winter. Chloride levels are mostly raised in the spring and least in the rainy.

Total alkalinity

The alkalinity of the water body is mainly possible due to the presence of salts and hydroxide ions. It expresses an index of nutrients' position in the water body. The total alkalinity of the dam water showed the irregular trend of variation throughout the study 2019. During winter total alkalinity ranged from 151-180 mg/L, 56-102 mg/L in summer while in the rainy season it varied from 36-68 mg/L. The maximum alkalinity (180 mg/L) was found at station A during the winter season and minimum alkalinity was recorded at station B (36 mg/L) during the rainy season. One important environmental outcome of alkalinity is the capability of a water body to endure acidification due to sour precipitation as well as atmospheric evidence. A water body might have a fairly neutral pH, except its alkalinity is low down, it will readily be acidified. waterbody by means of same pH excluding with elevated alkalinity will have greater buffer ability and as a result, a better confrontation to acidification (APHA, 2005).

Comparatively less variation in alkalinity was observed in 2020. In the winter season it was ranged from 61-82 mg/L, in summer and rainy season it was in the range of 61-74 mg/L and 70-87 mg/L respectively. The maximum alkalinity (87 mg/L) was found at station C during the rainy season and minimum alkalinity (61 mg/L) was recorded at Station A during the summer season. Our results on the Bansagar reservoir are reliable with that of Sharma and Sarang (2004), Makode (2012), Manjare, et al., (2010), Hujare (2008), and Pawar and Pulle (2005).

Dissolved oxygen (DO)

Dissolved oxygen (DO) represents the oxygen attention in water sample. DO in water samples gathered from three different stations of Bansagar dam in 2019 and 2020 (Table 3 and fig 3). DO in dam water demonstrated marked dissimilarity at different stations. Deviations of DO estimated at three stations of Bansagar dam in investigating duration (Table 3). The minimum and maximum status of DO fluctuated between 7.50 to 7.9 mg/L at station A, 7.1 to 7.6 mg/L at station B, 6.8 to 7.9 mg/L at station C, with a mean±SD value of 7.83±0.057, 7.4±0.0 and 6.83±0.057mg/L at station A, B and C respectively in 2019 monitoring (Table 3).

In the summer season, the mean±SD values of DO were recorded as 7.86±0.057, 7.16±0.057, and 7.36±0.057 at stations A, B, and C respectively. Similarly, the mean±SD values of DO were observed as 7.66±0.057 mg/L at the station A, 7.33±0.057mg/L at station B and 7.86±0.057 mg/L at station C during rainy. Pawar et al., (2006) has studied the water samples from a highly polluted industrial area. Sample was analyzed for Physico-chemical parameters via adopting the standard methods in favor of an examination of water and wastewater. The analyzed samples obtained a high value, compared with drinking water standards.

During the study period of 2020 mean±SD values of DO were recorded as 7.76±0.057 mg/L at station A, 7.56±0.057 mg/L at station B and 7.56±0.05 mg/L at station C for the winter season. In the summer season, the mean±SD status of DO monitored was 7.53±0.057 mg/L, 7.3±0.0 mg/L, and 7.33±0.057 mg/L at stations A, B, and C respectively. DO with mean±SD values recorded during 2020 in rainy season were 7.56±0.057 mg/L, 7.56±0.057 mg/L, and 7.66±0.057 mg/L at the station A, B and C respectively. The oxygen cycle in water engages a quick decrease all through the winter, trailed via a consistent increment by means of the rainy weather, finishing in a more significant level in the winter. Our findings are steady with those of Thirupathaiah et al., (2012) and Yadav et al., (2013)

Table 3: Effect of seasonal variation on DO, BOD, COD and free CO_2 status, during 2019 and 2020

Parameters (Mean±SD)		2019				2020			
		Winter	Summer	Rainy	Yearly average	Winter	Summer	Rainy	Yearly average
Dissolved oxygen (DO)	Station A	7.83±0.057	7.86±0.04	7.66±0.05	7.78±0.057	7.76±0.057	7.53±0.051	7.56±0.052	7.61±0.056
	Station B	7.4±0.02	7.16±0.05	7.33±0.03	7.29±0.038	7.56±0.057	7.3±0.07	7.16±0.05	7.34±0.031
	Station C	6.83±0.057	7.36±0.051	7.86±0.04	7.35±0.054	7.56±0.05	7.33±0.017	7.66±0.057	7.51±0.041
Free Carbon dioxide	Station A	1.6±0.0	2.33±0.11	3.63±0.15	2.52±0.08	4.06±0.05	3.66±0.057	3.4±0.01	3.70±0.038
	Station B	1.56±0.057	4.36±0.051	4.0±0.12	3.30±0.071	6.0±0.06	4.76±0.057	4.4±0.02	5.05±0.019
	Station C	2.16±0.057	2.56±0.057	3.73±0.23	2.80±0.28	4±0.01	3.06±0.0257	3.26±0.057	3.44±0.038
BOD	Station A	1.83±0.05	0.05±0.01	0.01±0.05	0.63±0.016	0.01±0.05	0.01±0.01	0.01±0.06	0.01±0.08
	Station B	4.76±0.05	2.4±0.01	1.43±0.05	2.86±0.033	0.01±0.07	0.01±0.05	0.01±0.04	0.01±0.05
	Station C	5.56±0.05	1.76±0.05	2.16±0.05	3.16±0.05	1.45±0.07	1.3±0.05	0.85±0.69	1.2±0.025
COD	Station A	15.66±0.57	8±0.01	6.33±0.57	9.99±0.38	3.66±0.57	3.06±0.11	3.8±0.2	3.50±0.29
	Station B	51±1.0	15.66±0.57	10.33±0.5	25.66±0.71	5.66±0.5	4.0±0.02	6.33±0.57	5.33±0.38
	Station C	60.33±0.51	11.66±0.51	15.33±0.54	29.25±0.57	10±0.01	8.0±0.02	10±1.07	9.33±0.33
Value were expressed in n=3 mean±SD									

Free Carbon dioxide

Water expressed the highly soluble Carbon dioxide. The basis of free carbon dioxide in water is not the air because CO_2 is a creation of aerobic and anaerobic decomposition of organic substance and it closely bounds in the composite carbonate-bicarbonate stability. The CO_2 concentrations were quantified at three stations of Bansagar dam during the course of study i.e. 2019 and 2020 (Table 3). The minimum and maximum assessments of free CO_2 varied between 1.5 to 4.4 in 2019 and 3.0 to 6.0 during 2020 along with diverse seasons.

Free CO_2 in dam water be evidence designed for variation at diverse stations in 2019 and 2020. Free CO_2 with mean±SD of 1.6±0.0 mg/L, 1.56±0.057 mg/L and 2.16±0.057 mg/L in winter; 2.33±0.11 mg/L, 4.36±0.057 mg/L and 2.56±0.057 mg/L in summer and at station A, B, and C free CO_2 were accounted as 3.63±0.15 mg/L, 4.0±0.1 mg/L, and 3.73±0.23 mg/L respectively in rainy weather during 2019. From the data collected it can be concluded that the inverse relationship, which is known to exist between pH and CO_2 (Table 3). A higher level of free CO_2 concentration incomitant by way of increasing temperature for the period of summer might be due to the dumping of garbage in the dam and rapid decomposition of organic matter. This is strengthened via the remark of Joshi et al., (2016) and Sharma (2017) who have monitored the addition of drainage to be the main causal factor used for increase in CO_2 in water bodies. During 2020 free CO_2 with mean±SD recorded were 4.06±0.057 mg/L, 6.0±0.0 mg/L and 4.0±0.0 mg/L in winter, 3.66±0.057 mg/L, 4.76±0.057 mg/L and 3.06±0.057 mg/L in summer and 3.4±0.0 mg/L, 4.4±0.0 mg/L and 3.26±0.057 mg/L at station A, B and C respectively in rainy season. CO_2 levels were most noteworthy throughout the winter and rainy weather and least throughout the late spring. The measure of CO_2 in the water is dictated by the temperature, thickness, and natural material biodegradation, basic structure of the surface, and land and physiological parts of the landscape encompassing the water. Free CO_2 levels are most elevated in winter and least in the late spring (Shastri and Pendse 2001).

Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

In 2019 BOD and COD values varied from 1.8-5.6 mg/L and 16-60 mg/L during winter, 0.05-2.4 mg/L and 8.0-16 mg/L in summer and 0.01-2.2 mg/L and 6.0-16 mg/L during rainy weather respectively. The maximum value of BOD (5.6 mg/L) and minimum value of BOD (0.01 mg/L) was recorded at Station C and Station A during the winter and rainy seasons respectively. Maximum BOD value of (5.6 mg/L) was recorded at station C in winter and a minimum (0.01 mg/L) was recorded at station A during rainy weather (Table 3), Whereas BOD and COD value in 2020 did not show marked variation at diverse stations. BOD ranged from (0.01-1.5 mg/L) in winter, 0.01-1.3 mg/L in summer and 0.01-1.6 mg/L in rainy season respectively. COD value in the winter season, summer, and rainy season ranged from 3-10 mg/L, 3-8 mg/L and 3.6-11 mg/L respectively respective COD distinguishes the presence of a range of natural biodegradable and non-biodegradable matter, as the degree of toxins in the water. The BOD worth ascents as the measure of biodegradable natural matter in the water rises. BOD levels are most noteworthy throughout the late spring just as rainy seasons and least throughout winter; similarly, the COD is the measure of oxygen used to oxidize the natural utilizing a solid synthetic oxidant. It's utilized to decide how contaminating family and mechanical poisons are with a few deviations. Over time 2020, the most noteworthy COD was recorded in mid-winter, while the least COD was recorded in winter. COD was seen to be mostly raised in the spring just as stormy season and least in the winter. Our outcomes are justified in parallel with Harney et al., (2013).

CONCLUSION

It is concluded that the present study of physicochemical parameters of Bansagar dam suggested that DO, BOD, CO_2, were found with partial fluctuation due to indirect seasonal impact in the dam water. The pH, Total hardness, total dissolved solids, alkalinity, and chloride were within the permissible limit as suggested by ISI and WHO in the dam water. Hence, it can be concluded that dam water has become very little contaminated and eutrophicated, but the present status of water was safe in favor of irrigation drinking and aquaculture purpose.

Conflict of Interest
There is no Conflict of Interest.

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