INNOVATIVE APPROACHES TO DUST MEASUREMENT AND SUPPRESSION IN LIMESTONE MINING

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ABSTRACT
Burnt rock covers a portion of the stripped area of an open-pit mine in Xinjiang. Dust is more readily produced during blasting because burned rock is weaker and more brittle. The mechanical property parameters of burned rock were investigated, and the on-site operation's blasting parameter design was comprehended, all within the context of the mining region as the study backdrop. A numerical simulation program called LS-DYNA was used to do the blasting numerical simulation of the burned rock stage. The primary cause of the significant dust production during blasting operations is determined by analyzing the stress cloud and stress curve of the numerical simulation based on the angle of stress on the rock. This is because the burnt rock is crushed excessively following the action of the explosion wave, and the excessive explosive energy is converted into kinetic energy that causes the dust to escape. Through numerical simulation and orthogonal experiment, the original blasting parameters were optimized as 8-m hole spacing, 6.5-m row spacing, 0.21-kg/m³ unit explosive consumption, 1-m interval charge, and 55-ms short-delay blasting in order to increase the utilization rate of explosives and decrease the output of blasting dust. Dustproof and dust-reduction measures are implemented in the mining region via the use of dust-absorbing cotton and protective blankets. When combined with the ideal blasting conditions, the field test demonstrates an 82.4% dust removal efficiency.

I. INTRODUCTION

Dust is a byproduct of all significant open-pit mining activity. Dust is a typical consequence of mining operations, and it may have important implications not just for the health and safety of employees, but also for the environment in which they operate and the surrounding area. A variety of mining processes, such as drilling, blasting, crushing, loading, and transportation of minerals, all contribute to the production of dust in mines. It is made up of solid particles that get suspended in the air and ranges in size from big visible particles to small respirable particles that may be absorbed into the respiratory system. The health risks associated with breathing in these particles can be significant.

The kind of mining activity being conducted and the geology of the mineral deposit both have an effect on the composition of the dust that is produced in mines. It is possible forit to have a combination of several types of mineral particles, including silica, coal dust, metal dust, or other types of mineral ores, as well as organic materials, chemicals, and other types of pollutants. Workers in mines face possible health concerns, including the development of occupational respiratory disorders, due to the presence of harmful compounds in the dust that they breathe in.

Dust in mines may create dangerous working conditions and increase the chance of accidents, in addition to posing a threat to workers' health. This is because it can impair workers' vision. It is possible for it to contribute to poor air quality inside the mining environment as well as the regions around the mine, which may impair the well-being of employees as well as the populations who are nearby. In addition, the accumulation of dust on surfaces may hinder the functioning of equipment, raise the bar for required levels of maintenance, and contribute to the deterioration of infrastructure.

It is necessary for mines to have effective dust management and control in order to safeguard the health and safety of employees, minimise negative affects on the environment, and guarantee that mining operations are carried out effectively. Engineering controls, such as ventilation systems, dust suppression methods, and enclosed equipment; administrative controls, such as work practises, personal protective equipment (PPE), and dust monitoring programmes; these are all potential components of dust control measures.

It is essential to get an understanding of the properties, sources, and dangers connected with dust in mines in order to develop and execute effective management techniques and to maintain a working environment that is both safe and conducive to good health. The purpose of the studies and investigations being conducted on mine dust is to increase knowledge and produce best practises for dust management. Some of these best practises include dust monitoring, exposure assessment, risk minimization, and the development of suitable control methods. Mining operations may work towards enhanced occupational health, environmental stewardship, and operational efficiency by tackling the problems posed by dust in mines. These goals can be accomplished by resolving the dust issues.

Using the device, efforts have been made in this project to conduct dust monitoring and dust characterisation at the Zuari opencast Limestone mine project. These activities are being carried out in the Zuari opencast Limestone mine. Make: SKC Model:Sidekick- 51MTX

Objectives

Determine the exact amount of free silica that is present in the Dust.

To analyse the human dust exposure use the Personal Dust Sampler (Make: SKC Model: Sidekick);

• To carry out dust dispersion modelling utilising AERMOD;

• To perform dust dispersion modelling using AERMOD.

Conducting dust monitoring at a number of different places with the DustTrak II.

Determine the relative dimensions of the dust particles.

To the dust map of the mines, in order to calculate the amount of dust that has accumulated and to devise methods for its suppression.

The Execution Strategy

The major focus of the work plan was placed on the full investigation of the dust production, the effect that it has on the environment, and the suppression measures that are being taken to limit the dangers that are caused by the inhalation of dust by the workers in thelimestone mining activities. The key goals of this research are to describe the impacts that dust has on the health of workers, examine the influence that dust has on the creation of dust at different mining operations, and evaluate the impact that dust formed by mining operationswould have on the air quality in the region around the mines. A flowchart illustration of the work plan is shown here as figure 1.1.

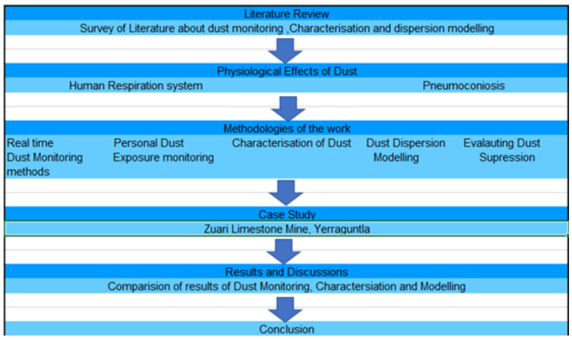

Figure 1. Plan of work

II. LITERATURE REVIEW

According to Mukherjee et al. (2005) [10], the risk of coal worker's pneumoconiosis was evaluated by assessing the respirable dust, the free silica content, and the personal exposure of the employees in nine coal mines situated in eastern India during the course of the years 1988-1991. These mines produced the most coal in India at the time. The FTIR was employed to do an analysis on the materials, and the MRE113 and AFC123 equipment were used in order to monitor the dust. It has been discovered that the levels of dust in the return air for both the B&P and the Longwall are greater than the permissible limit. This is the case for both of these mining methods. The most significant contributors to the emission of dust were the drilling, blasting, and loading operations. In B&P workings, the exposure of drillers and loaders was more severely impacted, while in Longwall workings, the exposure of DOSCO loader operators, power support face workers, and shearer operators was more severely impacted. Those who worked in open-pit mining, namely drillers and compressor operators, were the most likely to be affected by the disaster. With the exception of quarry loader and drillers operating in opencast mines, it has been established that the amount of free silica is less than 5 percent in the majority of cases.

In an opencast coal mine, modelling of dispersion was carried out by Mishra and Jha (2010) [9], and the conclusions were verified using data obtained from the actual area. The study that was carried out had the purpose of validating the FDM model that was being used. They evaluated the possibility for dust formation based on the activities that were going on and studied the link between distance and dust concentration to arrive at the conclusion that there is a zone of increased dust concentration that has an impact. The biggest contributors to environmental damage were the haul road and the way that coal was transported. Both the length of the transportation route and the pace at which vehicles went along it had an effect on the quantity of dust that was released from the mine. The fugitive dust modelling that was used for the dust dispersion modelling turned out to be accurate to an extent of ninety percent when it came to determining the dust concentration. They came to the conclusion that the bulk of dust particles are deposited within a radius of one hundred metres. The concentration decreases at an exponential rate as the distance from the source rises, reaching values similar to those found in the surrounding environment anywhere from 300 to 500 metres away from the point of emission that first caused it. In addition, the dust that is generated by the haul trucks has a particle size of 10 microns or more in eighty percent of the cases.

Trivedi et al. (2008) [14] Researchers went inside an opencast coal mine to explore the different sources of dust generation. They measured the quantity of dust that was produced by various point, line, and area sources. In order to carry out their modelling of the air quality, they made use of something that is known as the Fugitive Dust Model. When measured beyond a distance of 500 metres, the dust that is produced by the different mining activities does not add to the overall quality of the air. A slightly altered variation of the Pasquill and Gifford formula was used in order to arrive at an accurate estimate of the level emission rate. There was a disparity of between 68 and 92 percent between the anticipated value of suspended particulate matter and the actual value of the variable. It was observed that the concentration of TSPM would decline in a way that was exponential with respect to the distance from the source. Beyond a distance of 500 metres, the dust that was produced as a consequence of mining operations did not add to the ambient air. The key factors that led to the release of dust were the loading and unloading of coal, the overburden, and the haul road.

Research was carried out by Chaulya et al. (2002) [2] with the intention of calculating the emission rate for SPM in order to calculate the emission rate for a range of opencastmining operations. During the validation procedure, both the Point, Area, and Line source model (PAL2) and the Fugitive Dust Modelling (FDM) were used. In order to get estimated concentrations at a combined total of three receptor sites, both models are run separately while making use of the same data for each mine as input. It turned out that FDM was a better fit for the mining circumstances in India than any other method. Coal processing facilities, haul roads, and transportation routes were shown to be the leading contributors to the production of dust. It was found that the average accuracy between observed and predicted values for SPM at certain locations for the PAL2 model and the FDM model was between 60 and 71 percent, and that it varied from 68 to 80 percent accordingly. This was established based on the results of an investigation.

III. METHODOLOGIES FOR DUSTMONITORING, CHARACTERIZATION AND DISPERSION MODELLING

INTRODUCTION

The procedures that were used in the course of conducting the research studies can be found outlined in Fig.3.1.

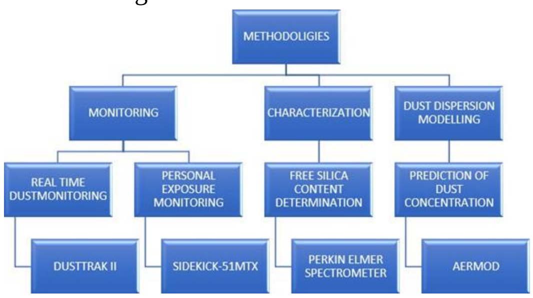

Figure 2: The methodology that will be used for the project's work

Dust Monitoring

The amounts of airborne dust particles in a variety of contexts, such as workplaces, building sites, and industrial settings, may be evaluated and measured with the use of several dust monitoring systems. These approaches contribute to the evaluation of exposure levels, guarantee compliance with regulatory criteria, and provide direction for the installation of effective dust control measures. The following are some popular ways for monitoring dust:

Gravimetric Sampling:

Gravimetric sampling entails collecting dust particles onto a filter or some other collection medium, which is then weighed before and after sampling to measure the mass concentration of dust. Gravimetric sampling may also be used to gather biological samples. When paired with size-selective sampling equipment, this approach not only delivers precise measurements of overall dust levels, but it can also be utilised to conduct an analysis of the distribution of particle sizes among the dust.

Real-Time Monitoring:

Instruments that are capable of providing immediate readings of dust concentrations are used in real-time monitoring approaches. These devices detect and measure airborne particles by the use of various technological processes, such as light scattering, laser diffraction, and optical sensors. Real-time monitors are able to offer instantaneous input on dust levels, which enables rapid modifications to be made to control measures.

Direct-Reading Instruments:

The concentration of dust in the air may be measured in real time using direct-reading sensors without the requirement for any kind of laboratory examination. A few examples of these tools include photometers, aerosol monitors, optical particle counts, and personal dust monitors (PDMs). They are easy to use, provide accurate readings of dust levels, and may be used either continuously or for random inspections.

Particle Counters:

A particle counter is a device that counts the number of particles of a certain size in a sample of air. They reveal data on particle sizes and aid in determining the existence of certain particle kinds or their points of origin. Cleanrooms, IAQ testing, and particle-source detection are just some of the many applications for particle counters.

Dust Sampling Pumps:

In order to gather airborne dust samples for the purpose of laboratory examination, dust sampling pumps are often used in combination with sampling cassettes or cyclones. These pumps pull a certain amount of air through the sample medium, which enables the assessment of dust concentrations based on either the weight or the chemical analysis of the collected particles.

Personal Sampling:

In order to quantify an individual's personal exposure to dust, personal sampling entails attaching sample instruments to that person while they are in the breathing zone. Using this approach, information on the real dust levels that employees are exposed to while doing their activities may be obtained. Personal sampling may be accomplished via a variety of approaches, including the use of wearable real-time monitoring or personal air sample pumps.

IV. DUST MONITORING, CHARACTERIZATION AND DISPERSION MODELLING- A CASE STUDY

Study Area: Zuari Limestone Opencast Project

The M/s Zuari Cement Limited Zuari Limestone Mine supplies limestone for the company's 5.4 MTPA cement and 4.3 MTPA clinker production facility. The Zuari Cement facility in Andhra Pradesh's Kadapa District is located within walking distance of the town of Yerraguntla.

Our firm has two internationally recognised certifications: ISO-9001 (for "Quality Management System") and ISO-18001 (for "Occupational Health and Safety Management"). The fact that the company has earned the ISO-14001 "Environmental Management System" certification speaks volumes about how seriously they take environmental protection.

Cement production occurs at the company's facility at Sitapuram, Suryapet Dist, Telangana; grinding occurs at facilities in both Chennai and Solapur.

The mining lease covers a total of 656.68 ha in the Yerraguntla Mandal, Kadapa District, Andhra Pradesh villages of Valasapalli and Koduru. There are no wooded areas included in the lease, and only roughly 60.33 ha of government waste land is included. The limestone used in the production of cement at the Zuari cement factory at Krishnanagar, Yerraguntla, comes only from the Zuari Limestone Mine, a captive mine owned by Zuari.

Physiography and environment: The area is characterised by a generally flat terrain, with an average elevation of 150.00–165.00 metres above sea level and a relief of 15 metres. Within a 1-kilometer radius, you won't find any trees. Vegetation is sparse in much of the surrounding areas. The region is drained mostly by the Papagni and Pennar rivers. Toposheet nos. 57J/10(Old) & D44G10 (New) correspond to the coordinates 140°37′00.9″ and 780°31′14.2″ (latitude and longitude), respectively.

The land does not have a clear drainage pattern. In most cases, the drainage and influx of water into the mine are not a concern. No adjacent water storage facilities such as canals, tanks,or reservoirs are available for use. The seasonal peddavanka nala flows along the lower contour on the eastern side of the mine property. As rainfall is generally low throughout the year, both during the wet and dry seasons, the daily rate of water input is modest. To prevent flooding, however, appropriate bunds and garland drains are constructed along the mine working.

Located 20 kilometres from Proddutur and just 3 kilometres from the Vempalle - Proddutur State Highway, the Mining Lease region is easily accessible. Additionally, the region is the District Headquarters and is located around 46 km east of Kadapa. This is the Mandal Headquarters, and it is linked to Yerraguntla by a black top road that is six km in length. The South-Central Railways Nandyal to yerraguntla Broad Gauge line stops at the Yerraguntla train station, about 1.5 km away. The closest airport is at Kadapa, about 37 km away.

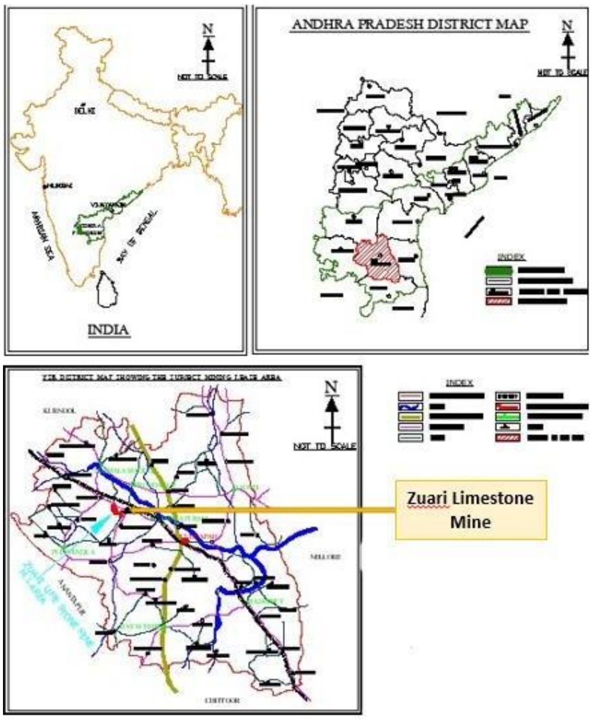

Figure 4.1 Position of the open-pit mining operation for Zuari Limestone

Figure 4.2 Location of the Zuari Limestone

Mine's Mining Site

Figure 4.3 Observation from space of the Zuari Limestone Mine

The investigation of the mining operation is organised generally under four topics, such as

"Real Time Dust Monitoring at Sources Using DustTrak II,"

"Personal Exposure Monitoring of Different Workers Using Sidekick 51 MTX," and so on.

Silica Content Determination Through the Use of FTIR for Characterization

Dispersion Modelling Through the Use of AERMOD

Real Time Dust Monitoring

It was determined to keep an eye on a number of dust-producing areas inside the mine, such as the loading area, the drill site, the blasting area, the haul road and the transit corridors. Because of the Metlliferous Mines Regulation (MMR) from 1961, the instrument had to be kept within a metre of the dust source in the downwind direction at all times. The zero calibration was first performed using a zero filter. After that, the dust concentration in various locations was measured over the course of an hour using a variety of size pickers, including PM10, PM4, PM2.5, and PM1. The resulting data were transferred to a desktop computer, where they were analysed using the TrakPro application. In addition to making graphs, TrakPro can do statistical analysis on the gathered data. The following table provides a size-specific breakdown of the dust concentrations observed in different locations.

Dust monitoring at Loading point (Shovel-Dumper)

It's conceivable that the loading point in a large open-pit mine generates a considerable quantity of dust. Every day, hundreds of dumpers were loaded with Limestone so that ZCL could meet its annual target of 4.0 million tonnes. The shovel-dumper, or loading point, of ZCL is seen in Fig.4.4. At the loading point, the different dust size fractions were analysed in contrast to one another. Dust concentration variations over time are shown in Figs. 4.5, 4.6, 4.7, and 4.8 for PM10, PM4, PM2.5, and PM1 respectively.

Figure 4.4 ZCl serves as the loading point for shovels and dumpers.

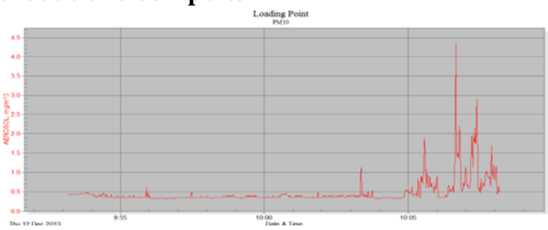

Figure 4.5 Graph showing the relationship between concentration and time for dust at the loading point in PM10

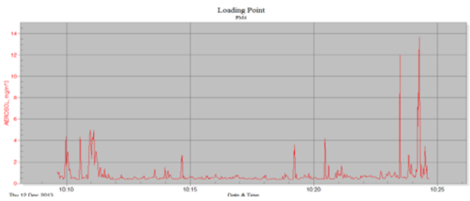

Figure 4.6 Concentration vs Time graph for dust at loading point in PM4

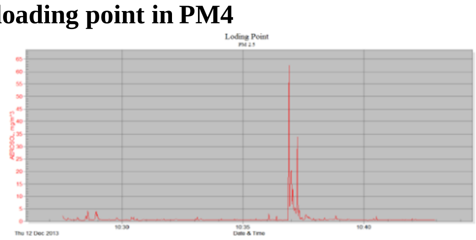

Figure 4.7 Graph showing the concentration of dust in PM2.5 as a function of time at theloading site

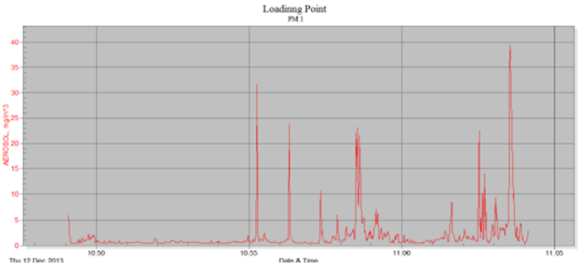

Figure 4.8 Graph showing the concentration of dust with time at the loading site for PM1

V. RESULTS AND DISCUSSIONS

Zuari Opencast Project

Data acquired from monitoring at multiple ZCL sources may be used to make comparisons between the various dust-generating sources. Average dust concentrations in PM10, PM4, PM2.5, and PM1 across different locations are shown in Fig.5.1. Conclusions may be drawn about which activities produced the most PM1 and which activities produced the most PM2.5, PM4, and PM10 emissions.

Minimum PM10, PM4, PM2.5, and PM1 concentrations for each location are shown in Fig.5.2. This proves that PM1, PM2.5, and PM4 levels were lowest at the surface miner compared to any other site. The concentration of PM10 at the drilling site was the lowest of all measured in the research.

The highest levels of PM10, PM4, PM2.5, and PM1 at each location are shown graphically in Fig.5.3. The conclusion that the drilling site picked up the most PM1, PM2.5, PM4, and PM10 particles seems plausible. The surface miner was the second-most-polluting source across all scales. Inadequate water utilisation during drilling and cutting at these sites has resulted in a high concentration of fine dusts.

Several workers' individual dust exposure is plotted in Fig.5.4. An explosive carrier's exposure was the highest, while that of a dump truck driver was the lowest. The majority of workers, however, were exposed to levels over the 3 mg/m3 threshold that is considered illegal.

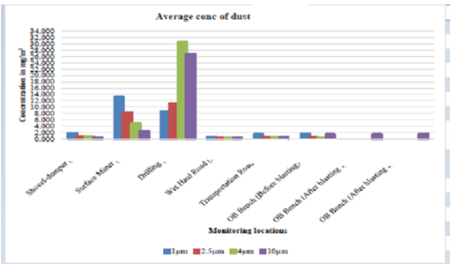

Figure 5.1 Comparison of average concentration of dust at different locations of ZCL

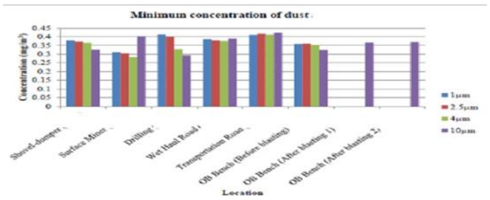

Figure 5.2 Comparison of minimum dust concentration at different locations of ZCL

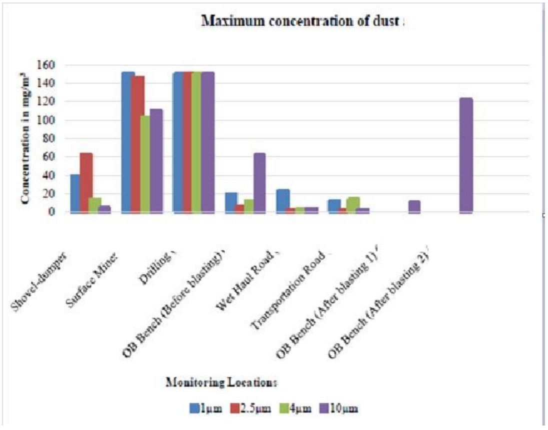

Figure 5.3 Comparison of maximum dust concentration at different locations of ZCL

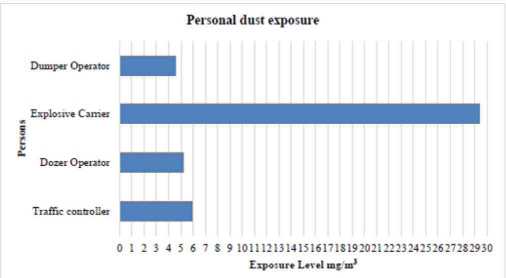

Figure 5.4 Personal dust exposure level of different workers at ZCl

VI. CONCLUSION

The following measures are taken for dust suppression in mines at ZCL Avoiding blasting when high winds are present; wet drilling. Wetting the muck pile before loading it. Automated Sprinklers are provided for use on transport routes. Water tankers will be made available for use on roadways in areas where sprinklers are not installed. Sprinklers installed near loading dock dump hoppers to prevent accidents.

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