Noise Control through Active Noise Cancellation Technique in Mines

A THESIS SUBMITTED IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology

in

Mining Engineering

by

Ashesh Raghav

Under the guidance of

Dr. Singam Jayanthu

Department of Mining Engineering
National Institute of Technology
Rourkela

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C E R T I F I C A T E

This is to certify that the project entitled **"Noise Control through Active Noise Cancellation Technique in Mines"** submitted by **Mr. Ashesh Raghav** [Roll No. 108MN027] in partial fulfillment of the requirements for the award of Bachelor of Technology degree in Mining Engineering at the National Institute of Technology Rourkela (Deemed University) is an authentic work carried out by him under my supervision and guidance.

To the best of my knowledge the matter embodied in the project has not been submitted to any other university/institute for the award of any degree or diploma.

Date: 10th May 2012.

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Ashesh Raghav

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ABSTRACT

A critical analysis of the exposure of miners to high sound pressure level Noise (>90 dBA) is carried out. The Noise Exposure Index of different machine operators is also observed. And a theoretical solution in the form of a specially designed headphone incorporating Active Noise Cancellation and Band Pass Filter is established. The Noise level was found be above the permissible limits in GDK 10A incline and GDK 10 incline for most of the machinery. At face the noise was within permissible limit of 90dBA only at a distance of 20 m in Tirap mine. The machine producing least noise level among those observed was Mine Riding Car in GDK10A incine and the noise level produced was 74 dBA at 20 m. This very high noise level was hazardous for the miners exposed to them as well as it hampered the speech communication inside the mine.

A solution to it using conventional headphones has failed because of its inefficiency in allowing desirable sounds of person to person communication and the sound of the alarm of the 'Roof Fall'. This thesis illustrates a design of special headphone incorporating the techniques of ANC and Band Pass Filters for use in mechanized mines which allows all the desirable sound to pass through but filters out the undesired machine noise. The headphone would facilitate efficient speech communication inside the mines.

CHAPTER 1

INTRODUCTION

Provision of suitable work environment for the workers is essential for achieving higher production and productivity in both surface and underground mines. Noisy working conditions have negative effects on the workers' morale and adversely affect their safety, health and performance. It is brought to the knowledge of all concerned that Noise is emerging as an important and challenging health hazards for mine workers. With increasing mechanization of mining operations and use of heavy machinery the noise level in mines have increased over the years. Surveys conducted by various institutions have shown that noise levels in majority of the mining operations are higher than the recommended limit of 90 dBA. Repeated or prolonged exposure to excessive noise levels leads to hearing impairment.

Potential sources of noise emissions include compressors, drilling machines, crushers, and other mechanical equipment used at a mine. Increasing the distance between the noise source and the listener is often a practical method of noise control. Where such noise control measures are not possible, personal hearing protection devices, such as approved ear plugs or ear muffs, should be worn by every person exposed to noise levels exceeding 90 dBA. [1,14]

The results obtained after investigation indicated that the sound pressure levels of various machineries were higher than the acceptable limits i.e. >90dBA. In the mines under study, most of the mine workers were exposed to SPL (sound pressure level) beyond 90dBA due to machinery noise. Therefore, control measures should be adopted in mines for machinery as well as hearing protection aids should be supplied to the workers in order to protect the mine workers from NIHL (Noise induced hearing loss).

In order to assess the status of noise levels in mines, systematic noise surveys are needed to be conducted using appropriate statutory guidelines so that effective control measures can be taken up in mines. Keeping this in view, this paper elaborates the technical details of the level of exposure of the mine workers to noise. A proposed solution to this hazardous aspect, using the technique of Active Noise Cancellation and Sound Filtration has also been made in this paper. This paper also introduces the fraternity to a headphone for mining workers and mining engineers, which is devised using ANC and Sound Filtration.

1.1 Objective

1. To critically analyze the exposure of the miners to the high level noise (>90dbA) in various mines of India and abroad.
2. To carry out field observations in at least three mechanized mines of India to assess the noise produced by various machinery.
3. To design a special headphone incorporating Active Noise Cancellation technique.

CHAPTER 2

LITERATURE REVIEW

2.1Noise Level Standards

Some times because of noisy ambience inside the mines, the primitive indications of a roof fall in the form of bursting sound is neglected by the mine workers unintentionally which proves to be fatal in some cases and highly dangerous the other times.[2] These types of accidents are not directly because of exposure to noise but indirectly a dangerous consequence of noise. Because of noisy surroundings around the machine operators, it becomes very filthy task for mining engineers to instruct them while on work. The only option left with the engineers remains to instruct them to switch off the equipment first. This regular 'switching off' and 'switching on' of the equipment accounts for a heavy loss to the company in terms of energy consumption.

Table 1: Protective Measures against different Sound Pressure levels as per Indian Standards

Sound Pressure Level (dB)	Protective measures
< 85	Very little risk to unprotected ears
90-115	Danger of hearing impairment and deafness
115-130	Worker shall not be allowed to enter without ear protection
130-140	Person protective equipment is must
>140	No worker shall be allowed to enter

In an occupational health survey conducted in an below ground metal mine more than 80% of workers showed evidence of Noise Induced Hearing Loss of 27.7% and 13.1% had severe and profound hearing impairment. Noise Induced Hearing Loss was observed among all categories of mine workers but the prevalence was highest among workers engaged in drilling operations.[3]

The occurrence and severity of NIHL was related to the degree of exposure to noise and years of service in the mine. More exposed a mine worker is to the noise, more are his chances of NIHL. Apart from this, various other consequences of lesser potential are caused, but are potentially strong to cause a fatal accident in the mine. Some of them are listed in the following sections.

After detailed study of the level of exposure of mine workers to noise and the sound pressure levels of the machine noise, it has been found that most of the mining equipment were observed to be generating the noises exceeding the danger limit set by DGMS. Frequency spectrum analysis revealed low frequency dominant noise situations for almost all-mining equipment.

Table2: Operations and their Corresponding NEI in west Virginia u/g coal mine, USA;MSHA 2009

Machinery	**Operating Mode**	**Avg. NEI**
Mantrip	Mantrip	0.09
Coal Drill	Drill	0.61
Shuttle Car	Load	0.23
Cutting Machine	Cut	0.30
Rotary Roof Bolter	Drill	0.30
Loader	Load	0.51
Continuous Miner	Cut and Load	0.61
Stoper	Drill	17.10

Table3: SPL and their corresponding permissible exposure time limits for the miners[14]

Sound Pressure Level (dBA)	***Permissible Exposure Time (min)***
90	480
95	151.2
98	75.6
100	47.6
102	30.0
105	15
106	12.4
107	9.4
108	7.5
109	6.0
110	4.7
111	3.8
112	3.0
113	2.4
114	1.9
115	1.5

2.2Noise Cancellation Techniques

The efficiency of the manpower also decreases significantly. To its solution, a specially designed headphone is proposed, which is to be used by all the mine workers who are exposed to sounds of SPL >90dB. This headphone will be devised in a special manner to allow only the human voice to reach the ears. So as to filter out all the sounds having frequencies outside the human audible frequency range and will cancel out the undesired noise within human audible range. Basic principles behind the headphone are Active Noise Cancellation to cancel out the undesired noise within the audible frequency range and a Band pass filter to filter out noise which are outside the human audible frequency range. The noise dose of the operators handling noisy equipment, e.g., dozers, dumpers, drills, pay loaders, vibrating screens, mine exhaust fans, compressors, etc. were observed to be quite high.

Table 4: A summary of the work carried out by investigators in the field of Noise Cancelling Headphones

Year	*Author*	*Institution*	*Title*
June 2011	A Novel Approach for Single Microphone Active Noise Cancellation	IIT Bombay	Noise Cancellation in headphones for audiometry
August 2010	Monteith David	Wolfson Microelectronics	Ambient Noise cancellation comes to Mobile Phones
April 2008	Bellala Gowtham	ECES, Beijing	Active Noise cancellation Project
November 2002	Sethia Vikash	IIT Bombay	Noise Cancellation in Headphones
July 2002	Siravara Bharath, Loizou Philip	Texas Instruments, Texas	A Novel Approach for Single Microphone Active Noise Cancellation

Chapter 3

FIELD OBSERVATIONS

Field Observations on Sound Pressure Level were carried out in three mines viz. GDK 10 Incline, GDK10A incline of SCCL and Tirap O/C mine of NEC during different periods of the project. The details of the observations are given below.

3.1 GDK10 Incline, SCCL, Ramgundem:

The Mine was visited in Feb, 2012 for collection and measurement of Sound Pressure Level data. The Mine is located in Karimnagar District, Andhra Pradesh. The mine is owned by Singareni Collieries Company Limited. The Noise Survey was actually carried out in two phases. In the first phase, The Noise produced by the machinery was measured using a Sound Level Meter of METRAVI make. The measurements were taken at a horizontal distance of 1m, 2m, 5m, 10m and 20m at a vertical height of 1.5 m above the ground. The measurements were carried out for one machinery of each type say, the Drilling Machinery, the Excavation Machinery and the Haulage Machinery.For Drilling, the machinery they employ is Jumbo Drill. The measurements were taken for the machine and is tabulated below:

Table5: SPLmax, Leq observed for Jumbo Drill in GDK 10 Incline at distances

Distance from the Machinery	Leq (5 min)	SPL max
1m	108 dBA	112 dBA
2m	105 dBA	109 dBA
5m	104 dBA	108 dBA
10m	98 dBA	103 dBA
20m	91 dBA	99 dBA

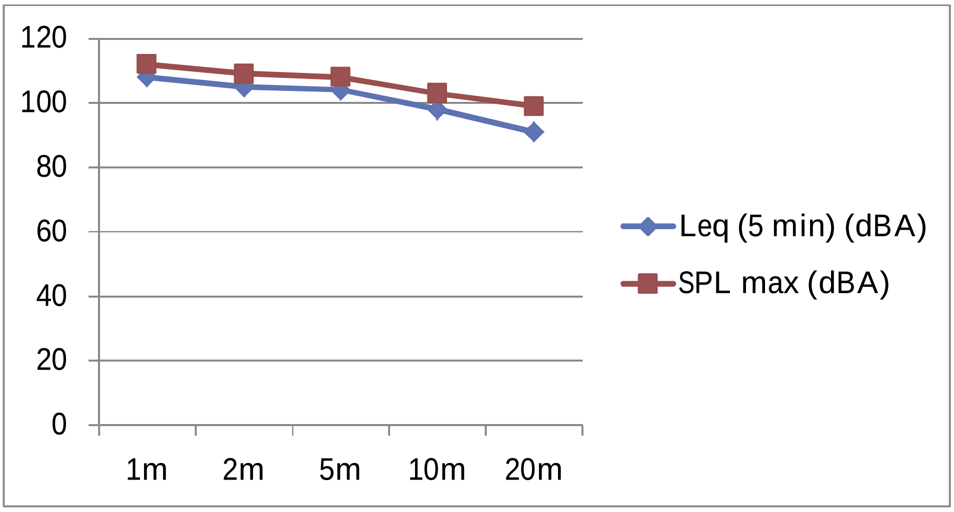

Fig 1. Graphical Representation of the Leq and SPL max of the Jumbo Drill in GDK 10 Incline

For Excavation, the machine employed there was LHD (Load Haul Dump). The machine operated in the mine and the measurements were taken while the machine was in operation and was hauling the coal. The measurements were taken for this machine at a horizontal distance of 1m, 2m, 5m, 10m and 20m at a vertical height of 1.5 m above the ground. The measurements are tabulated below:

Table6: SPLmax and Leq observed for Load Haul Dump in GDK 10 Incline at various distances

Distance from the Machinery	Leq (5 min)	SPL max
1m	103 dBA	105 dBA
2m	101 dBA	106 dBA
5m	99 dBA	101 dBA
10m	91 dBA	97 dBA
20m	84 dBA	91 dBA

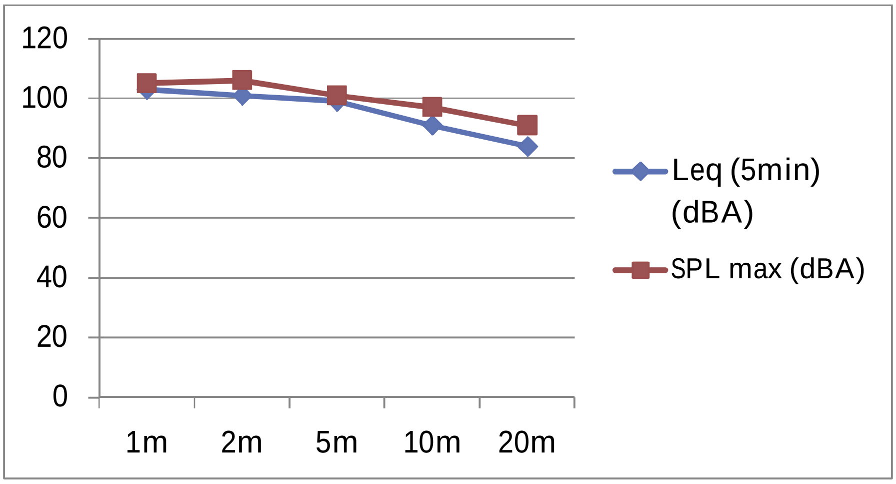

Fig 2. Graphical Representation of the Leq and SPL max of the LHD in GDK 10 Incline

It was found that, the workers were exposed to a very high level noise although there is a provision to use hearing protection devices. The devices used were passive headphones, ear muffs and a few barriers. The main reason for the devices to be ineffective is, they are not

efficient in noise reduction at low frequencies and the noise produced in the mines are mostly below 1kHz. The rotation of worker shifts may be efficient in reducing their noise exposure but it results in poor work qualityThe measurement for the Chain Conveyor was taken at a junction to facilitate the distance requirements. As along the gallery, the conveyor moves through out and so the measurement at a distance of 2m and above was not possible. So, to overcome this, the measurements were taken at the junction. The measurements were taken at a horizontal distance of 1m, 2m, 5m, 10m and 20m at a vertical height of 1.5 m above the ground.

For Haulage, the system used was Chain Conveyor) the system operated in the mine and the measurements were taken while the system was in operation and was hauling the coal. The measurements were taken for this machine at a horizontal distance of 1m, 2m, 5m, 10m and 20m at a vertical height of 1.5 m above the ground at the junction. The measurements are tabulated below:

Table7: SPLmax and Leq observed for Chain Conveyor in GDK 10 Incline at various distances

Distance from the Machinery	Leq (5 min)	SPL max
1m	101 dBA	103 dBA
2m	98 dBA	101 dBA
5m	94 dBA	99 dBA
10m	91 dBA	94 dBA
20m	84 dBA	91 dBA

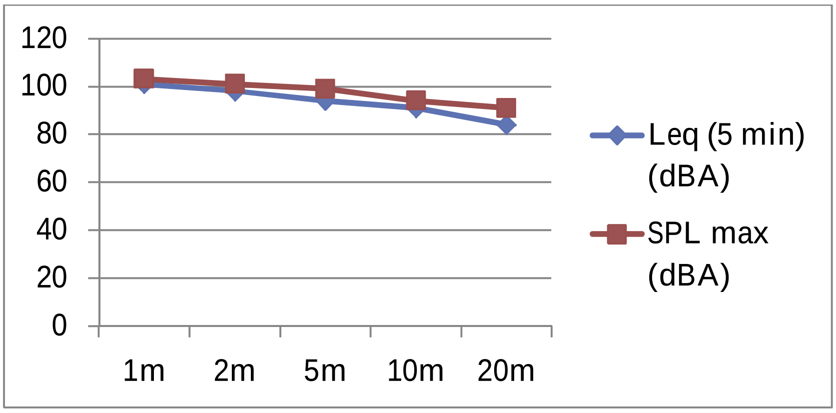

Fig 3. Graphical Representation of the Leq and SPL max of the Chain Conveyor in GDK 10 Incline

3.2 GDK 10A Incline, SCCL, Ramgundem:

The Mine was visited in Feb, 2012 for collection and measurement of Sound Pressure Level data. The Mine is located in Karimnagar District, Andhra Pradesh. The mine is owned by Singareni Collieries Company Limited. The Noise Survey was actually carried out in two phases. In the first phase, The Noise produced by the machinery was measured using a Sound Level Meter of METRAVI make. The measurements were taken at a horizontal distance of 1m, 2m, 5m, 10m and 20m at a vertical height of 1.5 m above the ground. The measurements were carried out for one machinery of each type say, the Drilling Machinery, the Excavation Machinery and the Haulage Machinery. For Drilling, the machinery they employ is Double boom Driller. The measurements were taken for the machine and is tabulated below:

Table8: SPLmax and Leq observed for Double boom Drill in GDK 10A Incline at various distances

Distance from the Machinery	**Leq (5 min)**	**SPL max**
1m	106 dBA	110 dBA
2m	102 dBA	107 dBA
5m	101 dBA	105 dBA
10m	97 dBA	103 dBA
20m	91 dBA	97 dBA

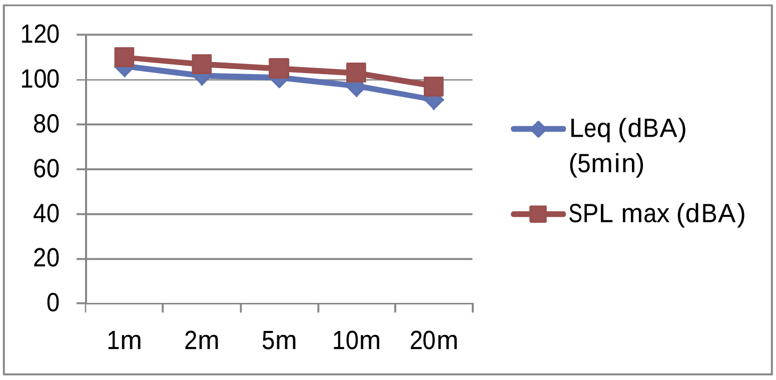

Fig 4. Graphical Representation of the Leq and SPL max of the Double boom Driller in GDK 10A Incline

For Excavation, the machine employed there was Long Wall Miner The machine operated in the mine and the measurements were taken while the machine was in operation.

Table9: SPLmax and Leq observed for Longwall Miner in GDK 10A Incline at various distances

Distance from the Machinery	Leq (5 min)	SPL max
1m	102 dBA	103 dBA
2m	101 dBA	106 dBA
5m	100 dBA	103 dBA
10m	93 dBA	98 dBA
20m	86 dBA	93 dBA

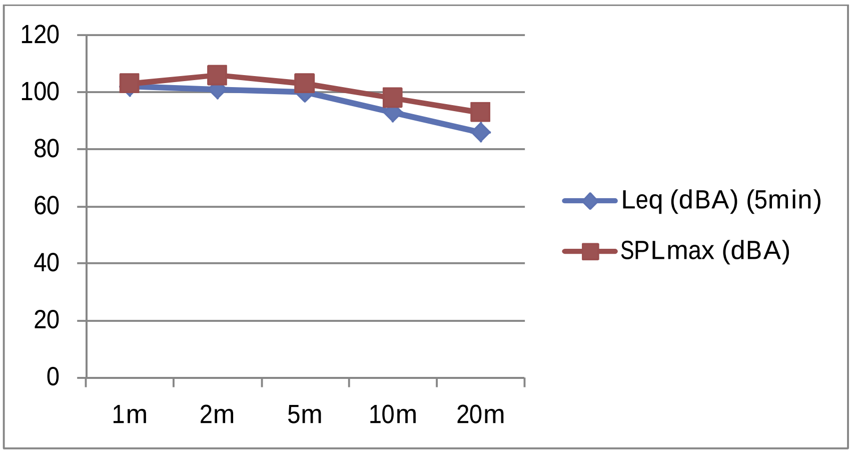

Fig 5. Graphical Representation of the Leq and SPL max of the Longwall Miner in GDK 10A Incline

It was found that, the workers were exposed to a very high level noise although there is a provision to use hearing protection devices. The devices used were passive headphones, ear muffs and a few barriers. The main reason for the devices to be ineffective is, they are not

efficient in noise reduction at low frequencies and the noise produced in the mines are mostly below 1kHz

For Haulage, the system used was Chain Conveyor) the system operated in the mine and the measurements were taken while the system was in operation and was hauling the coal. The measurements were taken for this machine at a horizontal distance of 1m, 2m, 5m, 10m and 20m at a vertical height of 1.5 m above the ground at the junction. The measurements are tabulated below:

Table10: SPLmax and Leq observed for Man Riding Car in GDK 10A Incline at various distances

Distance from the Machinery	**Leq (5 min)**	**SPL max**
1m	98 dBA	102 dBA
2m	95 dBA	100 dBA
5m	93 dBA	98 dBA
10m	86 dBA	91 dBA
20m	74 dBA	81dBA

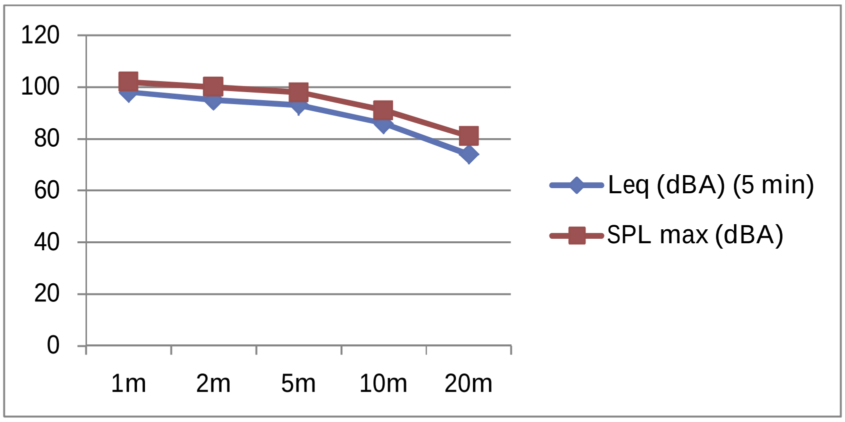

Fig 6. Graphical Representation of the Leq and SPL max of the Man Riding Car in GDK 10A Incline

3.3 Tirap O/C Mine, NEC, Margherita:

The Mine was visited in May, 2011 during my Industrial Training for collection and measurement of Sound Pressure Level data. The Mine is located in Tinsukia District, Assam. The mine is owned by North Eastern Coalfields, Coal India Limited. The Noise Survey was actually carried out in two phases. In the first phase, The Noise produced by the machinery was measured using a Sound Level Meter of METRAVI make. The measurements were taken at a horizontal distance of 1m, 2m, 5m, 10m and 20m at a vertical height of 1.5 m above the ground. The measurements were carried out for one machinery of each type say, the Drilling Machinery, the Excavation Machinery and the Haulage Machinery. For Drilling, the machinery they employ is Drillcon Driller. The measurements were taken for the machine and is tabulated below:

Table11: SPLmax and Leq observed for Drillcon Driller in Tirap o/c mine at various distances

Distance from the Machinery	Leq (5 min)	SPL max
1m	103 dBA	107 dBA
2m	101 dBA	105 dBA
5m	98 dBA	101 dBA
10m	95 dBA	99 dBA
20m	91 dBA	96 dBA

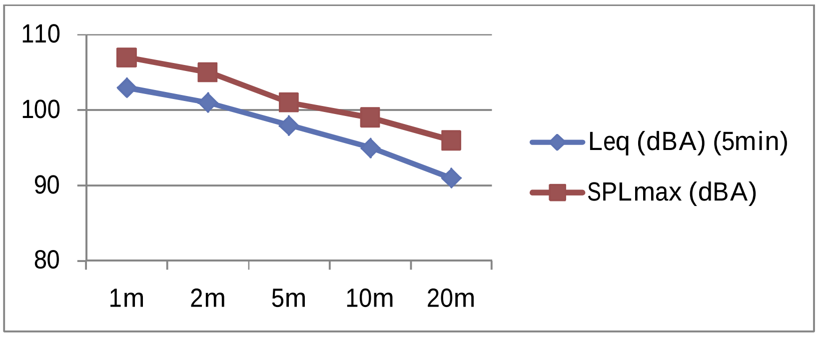

Fig 7. Graphical Representation of the Leq and SPL max of the Drillcon Driller in Tirap o/c mine.

For Excavation, the machine employed there was Komatsu Excavator The machine operated in the mine and the measurements were taken while the machine was in operation and was excavating the coal.. The measurements are tabulated below:

Table12: SPLmax and Leq observed for Komatsu Excavator in Tirap oc mine at various distances

Distance from the Machinery	Leq (5 min)	SPL max
1m	102 dBA	105 dBA
2m	100 dBA	105 dBA
5m	98 dBA	101 dBA
10m	91 dBA	96 dBA
20m	88 dBA	91 dBA

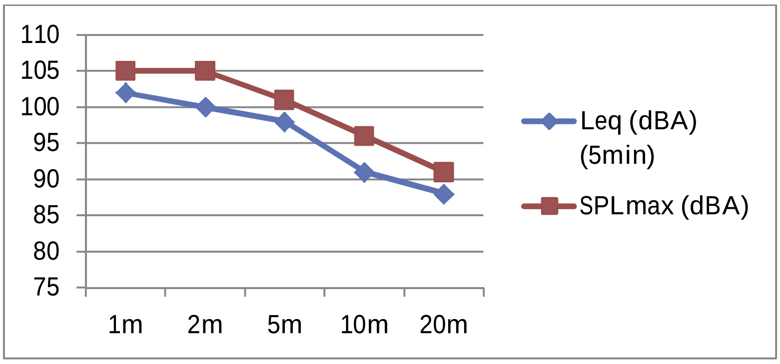

Fig 8. Graphical Representation of the Leq and SPL max of the Komatsu Excavator in Tirap o/c mine.

It was found that, the workers were exposed to a very high level noise although there is a provision to use hearing protection devices. The devices used were passive headphones, ear muffs and a few barriers. The main reason for the devices to be ineffective is, they are not

efficient in noise reduction at low frequencies and the noise produced in the mines are mostly below 1kHz.

For Haulage, the machinery used was Scania Dumper and the TATA Dumper. The measurements were taken for the Scania Dumper and the measurements were taken while the system was in operation and was hauling the coal. The measurements were taken for this machine at a horizontal distance of 1m, 2m, 5m, 10m and 20m at a vertical height of 1.5 m above the ground at the junction. The measurements are tabulated below:

Table13: SPLmax and Leq observed for Scania Dumper in Tirap o/c mine at various distances

Distance from the Machinery	**Leq (5 min)**	**SPL max**
1m	100 dBA	103 dBA
2m	97 dBA	100 dBA
5m	95 dBA	98 dBA
10m	88 dBA	94 dBA
20m	85 dBA	88 dBA

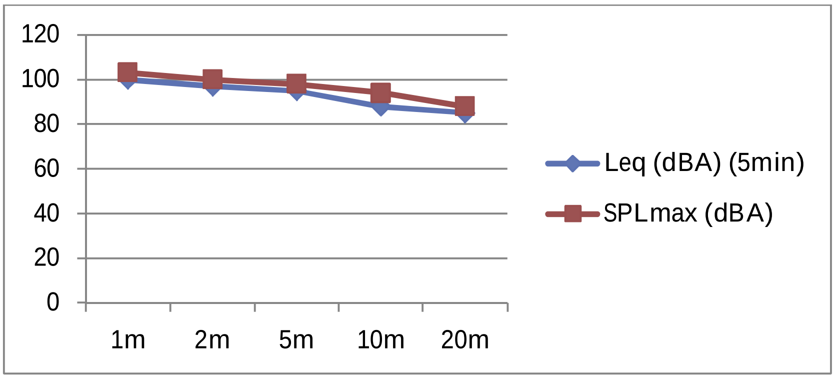

Fig 9. Graphical Representation of the Leq and SPL max of the Scania Dumper in Tirap o/c mine

CHAPTER 4

ANALYSIS

4.1 Machinery Noise

In the all the mines under study, the SPLmax and the Leq were above the permissible limits set by the Indian Standards. The reasons for the same being, either not so proper wear and tear of the machines or the manufacturing defects from the manufacturer. The miners thus had to work in a very noisy environment. The prolonged exposure to which may cause hearing impairment or temporary hearing shift. The machinery should be regularly oiled and greased to have proper wear and tear. This was also not taken proper care in most of the mines. . The Noise level was found be above the permissible limits in GDK 10A incline and GDK 10 incline for most of the machinery. At face the noise was within permissible limit of 90dBA only at a distance of 20 m in Tirap mine. The machine producing least noise level among those observed was Mine Riding Car in GDK10A incine and the noise level produced was 74 dBA at 20 m. This very high noise level was hazardous for the miners exposed to them as well as it hampered the speech communication inside the mine.

Also in most of the cases, the machineries having been imported from outside India, lacked proper supervision. In the inadequacy of which, untrained guidance caused machine to work in improper way and thus generating a lot of Noise.

4.2 Noise Exposure Index:

The noise exposure index (NEI) is defined as the ratio of actual exposure time at a certain noise level, to the permitted exposure time, that is:

NEI = C/T, Where, C = actual time (measured in mine)

T = permitted exposure time (as given in table 10).

If the noise level should change during the course of an employee's work shift, an NEI must be calculated for each different noise level. The total or accumulated NEI for that shift is then the sum of all the individual NEI's,

i.e, NEI = C1/T1 + C2/T2 + ...

where C1 = actual exposure time for noise level No. 1.

C2 = actual exposure time for noise level No. 2.

T1 = permitted exposure time for noise level No. 1.

T2 = permitted exposure time for noise level No. 2.

A worker is considered out of compliance if his daily total NEI exceeds unity. In practical terms, this means that his actual exposure time has exceeded the permitted exposure times as defined by table 3

Also the Noise Exposure Index Data for various machine operators were compiled from the MSHA website for West Virginia U/G coal mine and has been tabulated below. It has been found that, none of the operators were exposed to an NEI of greater than unity other than the one operating Stoper Drill. The NEI for stopper operator was 17.10.

CHAPTER 5

DESIGN OF HEADPHONE

5.1Technology

Two technologies influx are to be used for designing the headphone. The first one is the band pass filter and the second one is ANC (Active Noise Cancellation). Active Noise Cancellation (ANC) is a method for reducing undesired noise. ANC is achieved by introducing a canceling "antinoise" wave through secondary sources. These secondary sources are interconnected through an electronic system using a specific signal processing algorithm for the particular cancellation scheme. My proposed method is to build a Noise-cancelling headphone by means of active noise control and a band pass filter to be used by miners inside the mines. Band pass filter will filter out the noise having frequency lying outside the human audible frequency range. And then the noise, will be cancelled out by ANC technology. Essentially, this involves using a microphone, placed near the ear, and electronic circuitry which generates an "antinoise" sound wave with the opposite polarity of the sound wave arriving at the microphone. This results in destructive interference, which cancels out the noise within the enclosed volume of the headphone. This thesis demonstrates the approaches that I take on tackling the noise cancellation effects, along with results comparison.[4]

Noise Cancellation makes use of the notion of destructive interference. When two sinusoidal waves superimpose, the resulting waveform depends on the frequency amplitude and relative phase of the two waves. If the original wave and the inverse of the original wave encounter at a junction at the same time, total cancellation occur.

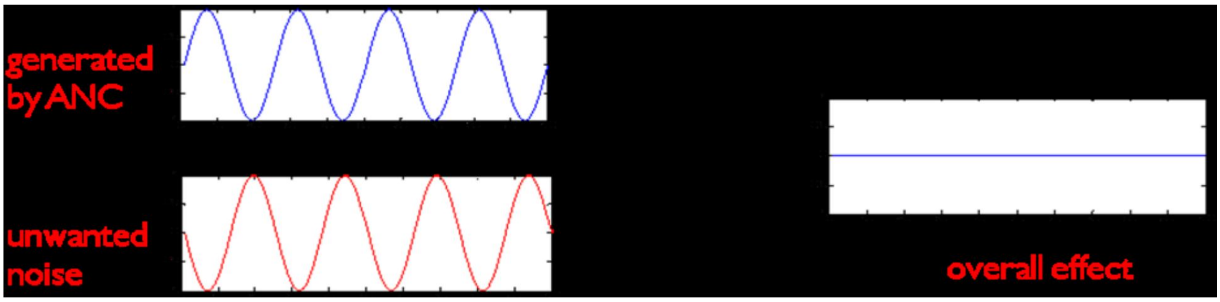

Fig10: Signal Cancellation of two waves 180^0 out of phase[5]

The challenges are to identify the original signal and generate the inverse without delay in all directions where noises interact and superimpose. Most importantly, ANC can block selectively. ANC is developing rapidly because it permits improvements in noise control, often with potential benefits in size, weight, volume, and cost. Blocking low frequency has the priority since most mine noises are below 1 KHz, for example excavator noise or noise from the compressor. This mainly led us to focus our project on low frequency noise cancellation.

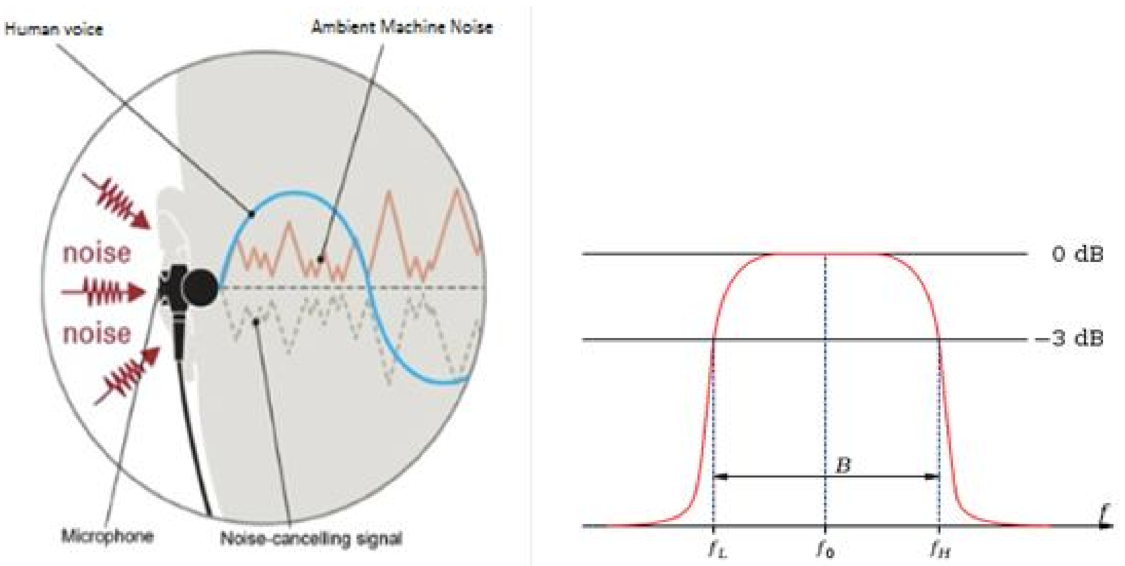

Fig11: Active Noise Cancellation Technology and the Band pass fiter (Romero and Lopez)

Since the characteristics of the acoustic noise source and the mine environment are time varying, the frequency content, amplitude, phase, and sound velocity of the undesired noise are non-stationary. An ANC system must therefore be adaptive in order to cope with these variations. Adaptive filters adjust their coefficients to minimize an error signal and can be realized as (transversal) finite impulse response (FIR), (recursive) infinite impulse response (IIR), lattice, and transform-domain filters. The most common form of adaptive filter is the transversal filter using the least mean-square (LMS) algorithm. Figure 12 shows a framework of adaptive filter. Basically, there is an adjustable filter with input X and output Y. My goal is to minimize the difference between ‘d’ and ‘Y’, where ‘d’ is the desired signal. Once the difference is computed, the adaptive algorithm will adjust the filter coefficients with the difference. There are many adaptive algorithms available in literature, the most popular ones being LMS (least mean-square) and RLS (Recursive least squares) algorithms. In the interest of computational time, I used the LMS.[6]

One of the main constraints in the choice of an adaptive algorithm is its computational complexity. For the application of ANC, it is desired to choose an algorithm which is computationally very fast. Taking this into consideration, LMS algorithm became an obvious choice over RLS. The update equation for the LMS algorithm is given by $w(n+1) = w(n) + \mu * e(n) * w(n)$ where μ is the step size, $e(n)$ is the error at time n and $w(n)$ is the filter coefficients at time instant n. The detailed MATLAB simulation is given in the following chapter[7][8][9].

5.2 MATLAB Simulation

LMS algorithm uses the estimates of the gradient vector from the available data. LMS incorporates an iterative procedure that makes successive corrections to the weight vector in the direction of the negative of the gradient vector which eventually leads to the minimum mean square error. Compared to other algorithms LMS algorithm is relatively simple; it does not require correlation function calculation nor does it require matrix inversions.

$$w(n+1) = w(n) + \frac{1}{2}\mu[-\nabla(E\{e^2(n)\}]$$

Where, w(n) →coefficient of the adaptive filter, μ is the step-size parameter and controls the convergence characterteristics of the LMS algorithm; $e^2(n)$ is the mean square error between the output and the reference signal.

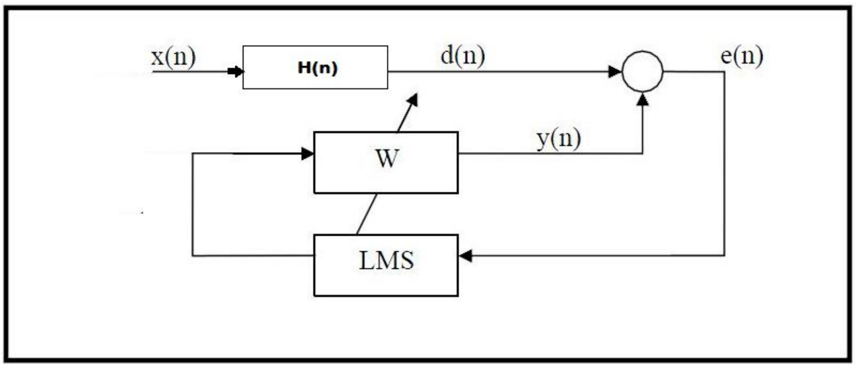

Fig 12: Frame work of adaptive filter incorporated in the headphone [10]

The error is given by:

$$e^2(n) = [d^*(n) - w^h x(n)]^2$$

The basic LMS algorithm fails to perform well in the ANC framework. This is due to the assumption made that the output of the filter y(n) is the signal perceived at the error microphone, which is not the case in practice. The presence of the A/D, D/A converters and anti-aliasing filter

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in the path from the output of the filter to the signal received at the error microphone cause significant change in the signal y(n). This demands the need to incorporate the effect of this secondary path function S(z) in the algorithm. One solution is to place an identical filter in the reference signal path to the weight update of the LMS algorithm, which realizes the so-called filtered-X LMS (FXLMS) algorithm. The FXLMS algorithm has been observed to be the most effective approach among all other solutions. Also this algorithm appears to be very tolerant to errors made in the estimation of S(z) thereby allowing offline estimation of S(z) as the most apt choice. Besides, the use of FIR filters to design W(z) makes this system very stable. But the downside is the use of high order filters that will make the algorithm run slow, and also the convergence rate of this algorithm depends on the accuracy of the estimation of S(z). The major disadvantage of this algorithm is the presence of acoustic feedback. The coupling of the acoustic wave from the canceling loudspeaker to the reference microphone will cause this acoustic feedback problem, resulting in a corrupted reference signal x(n). This can potentially lead to delayed convergence and possible non-convergence of the algorithm.[11]

5.3Output

In this project I have tried to counter noise using different Active Noise Cancellation techniques. Adaptive Filters have been used to implement ANC Techniques. A noisy environment may contain noise varying linearly or non-linearly. Depending upon various constraints like linear-noise or non-linear noise, efficiency, budget, environment of the noise there can be different algorithms to update the filter coefficients. Various methods like LMS Algorithm, FxLMS algorithm, Particle Swarm Optimization (PSO) Technique have been used to show the reduction of noise actively. The linearly varying noise is filtered using LMS Algorithm or FxLMS while if we want the filter to vary its coefficient non-linearly PSO Technique has been used.[12][13]

In conclusion, I have delivered a theoretical solution to workable ANC headset for both artificial and real world noise. More specifically, our ANC headset can deal with noise frequency ranging from 100 to 800 Hz. Furthermore, we have implemented and compared four variations of adaptive algorithms, namely FxLMS, FuLMS, Feedback ANC and Hybrid ANC.

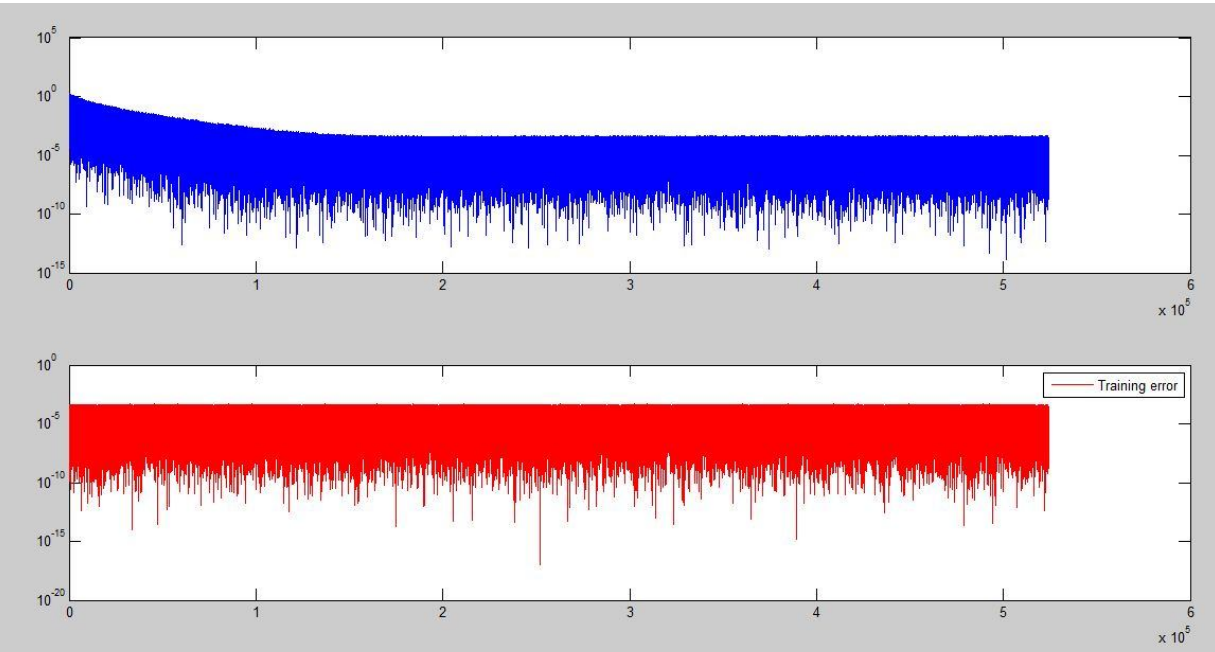

Fig 13: Resultant signal obtained after the test algorithm has been applied

CHAPTER 6

CONCLUSION

1. Out of the three mines studied, at the face, only in the Tirap o/c Mine, NEC the machinery was producing Noise within the permissible limit of 90 dBA i.e 87 dBA and that was at distance of 20 meters from the face.
2. The Maximum Sound Pressure Level Observed was 118 dBA by Drillcon Rock Breaker in GDK 10A incline, SCCL.
3. And the minimum Sound Pressure Level observed within a distance of 20 m from the machinery was 74 dBA by Man riding car in GDK 10A incline SCCL.
4. The Noise Exposure Index (NEI) was all within the safe limits (<1) in West Virginia u/g coal mine USA except for the stoper (NEI = 17.10), where the worker works in rotation.
5. The Theoretical Programming was developed using MATLAB and the result was found to be effective in Noise Reduction for Efficient Speech Communication.

CHAPTER 7

SUGGESTIONS FOR FUTURE WORK

1. The MATLAB programming generated can be used and simulated in a specially designed headphone for efficient speech communication in mines and also should be extended for high frequency noises.
2. The ANC technology, Band Pass Filter and the MATLAB programming generated thereof can be utilized to fabricate the headphone for use in mines for efficient speech communication.
3. The Hard-wares required for the fabrication would be:
    i. • A 3 starter board
    ii. • Microphones Cartridge 6MM.
    iii. • Stereo Headset 21V
    iv. • Noise Cancellation Headphone
    v. A circuit Board for D/A, A/D interface.

4. The total cost of the hardwares would come out to be Rs. 4000/- as of todays market price.

<u>CHAPTER 8</u>

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