ENGINEERING DESIGN-G3

Group members:

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Motivation:

Working in mines is very dangerous. Workers are exposed to toxic gases, high temperatures and thousands of other potential hazards at any moment. Smart helmet is one of the systems that prevents damage to mine workers. The purpose of this system is to protect the health of miners. There are 7 types of gas in mines, which can lead to various respiratory disorders. Dust inhalation or coal dust is one of the most common concerns for miners. The ongoing inhalation of coal dust can cause what is colloquially known as ‘miner’s lung’ or ‘black lung’. Miner’s lung is a form of the occupational lung disease group pneumoconiosis. It varies in severity, but symptoms include shortness of breath and scarring of lung tissue, which can cause ongoing respiratory issues. This problem motivated us to come up with a helmet equipped with an air purity sensor and a charcoal mask. A common health risk that miners face is thermal – or heat – stress. Mining environments are often very hot and humid, particularly those in outback Australia, which over time can cause thermal stress in workers. Overexposure to heat and humidity can cause the body

to become fatigued and distressed. This can result in heat stroke or more serious ongoing health problems. To deal with this, temperature and heart beat sensors will be made a part of this smart helmet.

Picture showing the harsh conditions in which miners work

Also most of the mines are low heighted and lack proper illumination which can lead to accidents. This has motivated us to install height determination sensors present at the upper part of the helmet and also an automatic light control sensor to avoid such accidents.

Problem Statement:

Optimisation of the present design of mining hat by installing various sensors to avoid accidents because of the hazardous situations in mines.

Background Research:

Mining has always been among the most hazardous of occupations, and with the increasing demand for coal and minerals safety in mines assumes even greater importance. The hazards covered are: accidents, dust (including poisoning by certain ores), toxic gases, and miscellaneous other hazards.

At least 6,500 employees have died on duty at factories, ports, mines and construction sites in five years, the Union labour ministry has informed Parliament.

Experts, however, said many deaths go unreported, or may be termed as injuries, if the person dies after two weeks of the accident, and the actual numbers could be higher. International attention is drawn when high casualties are reported, for instance, the gas leak at the LG Polymer plant in Andhra Pradesh, where 12 people were killed last year and at least 585 sustained injuries, they added.

Miners' nystagmus is a disease which incapacitates a large number of coal miners, and is estimated by doctors to cost the country 100,000la a year. It is characterised by rapid involuntary movements of the eyes, associated with defects of vision, photophobia, and night-blindness.

- Mining Hazards :

    - Mine Dust and air purity : The ongoing inhalation of mine dust can cause what is colloquially known as ‘miner’s lung’ or ‘black lung’. Miner’s lung is a form of the occupational lung disease group pneumoconiosis. It varies in severity, but symptoms include shortness of breath and scarring of lung tissue, which can cause ongoing respiratory issues. For the purpose of reducing the hazards due to the dust in the mines, we are using a mask which uses a charcoal based dry paste to adsorb the dust.

- Health Monitoring: Generally , in mines , there is no arrangement for measuring and monitoring the health parameters of the miner. These health parameters include pulse rate , heartbeat , oxygen saturation, etc. And sometimes there are some problems which happen to the miners and are asymptomatic , like the falling of pulse rate or the falling of oxygen saturation. To address this problem , we have involved a sensor , which will be on the rear side of the helmet, near the part where cerebellum is located , so that we can monitor the pulse rate and the oxygen saturation of the miner , and if the oxygen saturation and the pulse rate falls below a particular level , the sensor will immediately give indication and thus the required actions can be taken.

- Lighting Problem: Lighting is also one of the major issues , since limited power is available in the mines and for a limited time. To address this , we are using an automatic light , which will only glow in darkness , and turn off as soon as there is a certain amount of light available. In this way much power can be saved.

The conventionally used mining hats which are already in use are just meant to protect the miners' heads. Sometimes in addition to this a mask is used to protect the miners from inhaling the dusty air in the mines.

Ideation and Proposed solution:

- The hat will be of similar shape , light weighted and equipped with a flashlight as usual. The top peak will be mounted by a GPS to find the location of the miners in heavily dense caves and miners and to find the ones in need of medical support.

The band and interior of the helmet will be formed of a sheet of sensor to take the reading of the pulse and oxygen of the miner.

Heartbeat sensor will detect the heartbeat of workers in regular intervals and will report it to the main office in case the heartbeat falls below a certain threshold.
It will work on the same principle as a pulse Oximeter.

The air purity sensor will check purity of air around the workplace and detect the level of carbon dioxide in the air. If the level of carbon dioxide in the air increases beyond a certain threshold it will alert the worker.

We also have a charcoal filter mask and a gas gear . The filter will be equipped in front of the hat, needless to wear externally. The filter will be made of colloid coagulation components like charcoal to reduce the toxicity of the air intake.

In case of a medical emergency or lowering of O_2 in the environment, the GPS will send a signal to the command center to take immediate medical attention.

A height determination sensor will check the height below the ground level at which the worker is currently operating.This will result in a great help in rescue work.

The exterior will be fully insulated. A height sensor right at the peak of the helmet, illuminating LEDs at the front forehead, a pulse monitor on the neck and a charcoal filter covering the front. For proper air inlets, sides will be equipped with slits with the same filters to avoid suffocation and good ventilation.

The interiors will be the central hub of circuits. A wired framework passing through the main skeleton of the helmet. As per the circuit design. The wiring and main circuit board will be confined to the backside of the helmet. It will also be skimmed with low weighted insulation using carbon fibres.

Planned work flow:

1. Base Ideology and Construction:
   The project will begin by establishment of a proper structure of the mining hat and will proceed by modifying the basis of the shape.

2. Simulations:
   The two components- electrical and mechanical will be constructed on online platforms like tinkercad or solidworks.

   These components will then tested out separately to ensure successful run

3. Final Model:
   Combining the simulations,a final model of the proposed design can be made implementing the additional features like GPS and a light sensor for efficient mining.

Decision matrix:

DESIGN	HELMET	COVERED MODEL	PURIFICATION HELMET	PROPOSED MODEL
COST	1	3	4	3
STRUCTURE AND DURABILITY	2	5	3	4
FEATURES	1	1	4	4

Comparative Analysis

Includes circuital functions restraining the use of external applications eg: gas mask and manual detection. Improved safety and protection to create a healthy environment to work in.
Simple design without most features except head protection. External equipment is required and requires a human intellect to handle. Broken easily and doesn't esure full fledged safety.

SCALE:

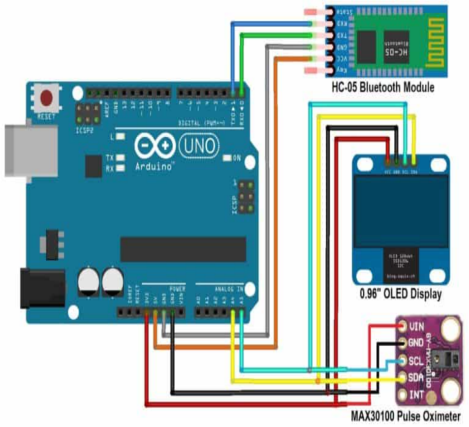
1)The covered model guarantees safety so 5 points on the protection scale but doesn't have many features so 1 for features.
2)The Helmet used is lightweight so it is not that durable so 2 for durability.
3)The purification helmet would stop all the hazardous gases and also trigger an alarm thus 4 points on feature scale and 3 on durability scale as it is made of quite durable material.
4)Proposed model is innovative, encapsulates many features, is durable and cost effective so 4 on features and durability scale.

Component	Points assigned	Reason
The covered Model	4	The covered model meets all its objectives
Helmet	4	Helmet is lightweight and durable.
Air filter & Alarm	5	It filters out the harmful gases and triggers an alarm if the level of toxic gases increases.
Health monitoring sensor	5	Keeps a check on pulse rate and monitors health,as the sensor is durable it would last long.
Height measuring sensor	4	Triggers an alarm under critical situations.

Final Solution and Progress:

The Final design will include the following features:

HEALTH MONITOR: The core objective of this project is the design and implementation of a smart health tracking system that uses Sensors to track patient health. Each of our bodies utilizes temperature and also pulse acknowledging to pursue understanding wellbeing. The sensors will track the status and the O2 level in the body.

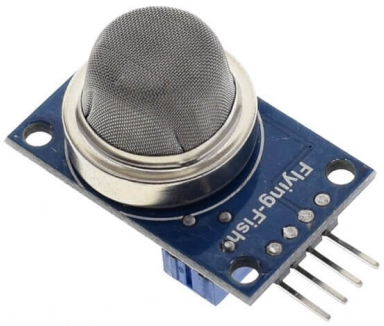


AIR PURITY CHECKER:

Air pollution index (API), calculated on the basis of suspended particulate matter (SPM), SO_2 and NO_2 concentrations was highest near the coal mining area.

The ambient concentrations of heavy metals (in PM10) also showed significant temporal and spatial variations at different sites around coal mining areas.

However, NO_2 levels as low as 0.1 ppm have been shown to cause respiratory discomfort in vulnerable populations such as asthmatics.. So, the sensor must alarm us when the concentration reaches 5 ppm and if the miner is an asthmatic, he must not be exposed to more than 0.1 ppm.

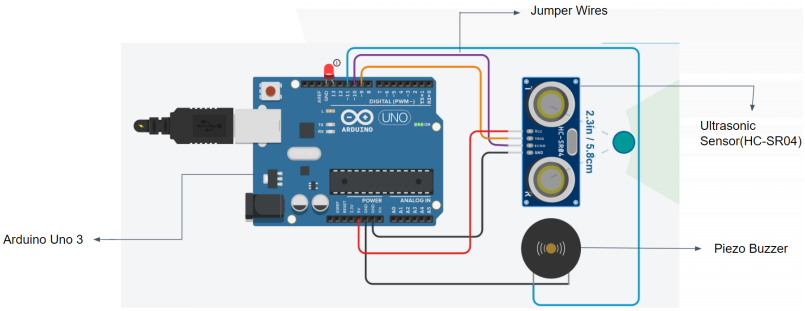


CHARCOAL FILTER: Using the concept of Adsorption by charcoal.
Traps particles less than 0.3 micrometers in size

These include smoke , oil fumes , VOCs (Volatile Organic Matter) , etc.
The design is made such that it has a layer of activated charcoal , through which the inhaled air will pass and the suspended particles in the air will get adsorbed on the charcoal before actual inhalation. Calcium Bentonite clay will also be used to clean the air.

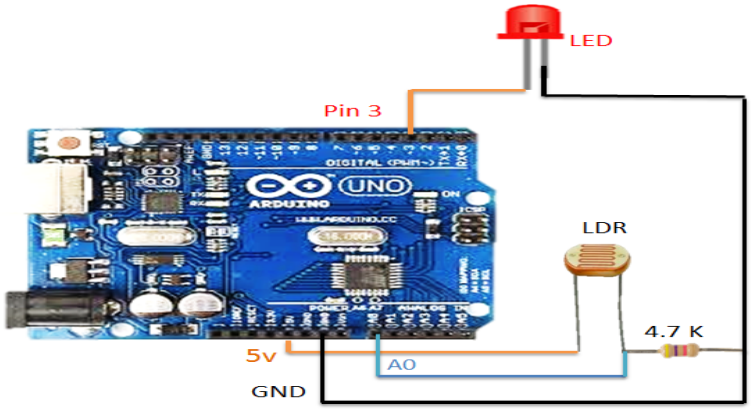
MINE HEIGHT DETECTION: Sometimes miners have to work in very congested and low heighted mines. Due to lack of proper illumination inside the mines, miners may sometimes misjudge the height of the mine and may end up in accidents which lead to injuries.

Ultrasonic Sensor(HC-SR)



Circuit diagram of height determination sensor

AMBIENT LIGHTING: Lighting is vitally necessary underground, and it is very important to ensure that there are no failures and the lamp used is as efficient as possible. To conserve the battery life the light will reduce and increase brightness as the surroundings.



FULL DESIGN: The helmet comprising of the above components will be designed in the following manner: For the safety in the mines, the exteriors will be insulated with light weighted carbon fibre frame, and covered outlets of only the sensors required to extract information from the surroundings The interiors will be made of a metal frame which is usually built in mining helmets for protection. The frame will also work as a base of the digital logic circuits and a hub for information.

Taking the full design into consideration The product will cost around ₹2500 to 3000.

Contribution of each member

Teamwork is the ability to work together toward a common vision. The ability to direct individual accomplishments toward organizational objectives. The purpose of this report is to discuss the effectiveness of our team to shape this idea.

- ## Innovation

  Each team member participated enthusiastically in discussing the problem statement. We had around 10 problem statements from all team members and from which we chose our current problem statement.

- ## Distribution of workload

  Every member divided the problem and worked on their parts with the help of peers and guides. Every member had a separate function of the product to handle.

- ## Team composition

  Our team includes

  - Haardik Ravat- B20EE021 (Model Design)
  - Vedant A. Sontake- B20ME078 (Mine Height Detection System)
  - Mohammad Zaid Shamshad- B20ME045 (Circuit Design)
  - Ankush Gupta -B20CH006 (Health Monitoring System)
  - Karan Jain- B20AI016 (Automatic Lighting System)
  - Abhinav Singh Tawar- B20CI004 (Charcoal Air Filter)
  - Vedasamhitha Challapalli -B20CS078 (Air Quality Check)

  Every member prepared slides related to the department chosen by them and also gave a presentation regarding their part.

- ## Collaboration

  Every week all the team members collaborated all their works in a presentation or report developing individual parts taken by them. This helped us reduce time as well as the presentation was informative as it was developed by the person who researched.

FUTURE WORK:

We,the group G3 have completely researched the project design, functions and the cost in this trisem. So, the plan for the future is to implement the information we have gathered into a physical product which is the mining cap. We are looking forward to designing the mining cap with all the circuits and sensors attached properly such that it is feasible to use. We will process the design via solid works initially to get a mini picture of the design, later we would extend it to a larger scale. We would also have to keep in mind the materials we are using for the design. After the design is ready, we would work on the simulation to ensure that the final product is handy, convenient and beneficial to use. In short, the two main tasks that we have for future work are product design and simulation. We are eagerly waiting for the design of the final product as we all have put in a lot of efforts for the research.

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Annexure:

Contribution by Vedasamhitha Challapalli(B20CS078):

I have actively participated in all the group discussions before the class and have also contributed equally as the other members. I have initially researched about the problems faced by the miners in coal mines, we as a group then jotted down the problems we researched about and started working on them individually.

I took the problem of air purity, where I had to find out the pollutants that are majorly present around the coal mines and the problems caused by them. During this research, I found out that the air in coal mines is mainly polluted by Sulphur dioxide, nitrous oxide and heavy metals. We then had to come up with a solution to these problems in the next class.

I then designed a sensor which could alarm us when the concentrations of the pollutants cross the allowed limit, thus the miners can be safe.

I have designed the sensor on tinkercad. I then made the corrections told by sir and the final thing we had to do was to calculate the cost and make sure that the cost was as minimum as possible. We did this as a combined effort.

Contribution of ABHINAV SINGH TAWAR (B20CI1004):

In this project of the course Engineering Design , I have actively participated in all the group discussions before the class and have also contributed equally as the other members. I initially researched about the problems faced by the miners in mines and I chose to work on air purification mechanisms for the inhaled air.

Firstly , I contributed to the literature research , where I searched for different problems that miners face in the mines and what measures are currently being used to address those problems. After that , I chose to work on designing the part of the helmet which is used to provide protection to the face. Also , I replaced the air filter with a charcoal air filter which adds very less to the overall cost of the helmet, as compared to the pre-existing ones.

During the research , we found that there were two types of mining helmets available , one which was just meant to give protection to the head, and the other which had a face shield to protect the face and was equipped with an air filter.

I redesigned the model and replaced the face shield with a mask and an eye gear. The mask uses a dry paste of charcoal and Calcium Bentonite clay. In this , we have taken in advantage the property of adsorption of charcoal which is accompanied by sodium bentonite.

Moreover , the pre-existing helmets which are equipped with the equipment which protect the face restrict the movement of the head of the miners. My solution overcame this problem as the design of the mask is made such that the movement of the miner's head is not restricted and also, the mask itself is flexible. After every session , I worked on the suggestions given by our respected instructors and arrived at the final design.

Contribution by Mohammad Zaid Shamshad (B20ME045):

I have actively participated in all the group discussions before the class and have also contributed equally as the other members.
I designed the internal circuit of our model,and decided where all sensors should be placed so that they work efficiently and don't affect the comfort of the helmet.

To fit all these sensors on the helmet was a challenging task for the whole team, so all the sensors were chosen keeping in mind the dimensions of the helmet.

I researched on all the sensors that were required and chose the most efficient one to improve the performance of our product.
Since all the sensors were to be connected to a single power supply I designed the circuit such that everything works properly and working of one sensor won't affect the other.

I first made the schematic diagram of the circuit ,and then made the circuit on Tinkercad (online circuit simulator).The circuit works perfectly as simulated on tinkercad.

I made the corrections as recommended by the Sir and made it cost effective by using less wires. Everything was completed in the stipulated time because of the guidance of our instructor.

Contribution by Ankush Gupta(B20CH006):

In this project of the course Engineering Design , I have actively participated in all the group discussions before the class and have also contributed equally as the other members. I researched about the Mining Hazards and came to a conclusion that if the workers know about their body temperature and pulse rate during work then they can be prepared to face any hazards accordingly.

So I decided that why not put a sensor on the helmet that would measure the pulse and temperature of the body at frequent intervals.So i decided to design the same on tinkercad and came up with the solution.The sensor work on the same principle as thermometer and oximeter but with a slight modification

Since we are having a GPS chip as well so I decided why not use it in my sensor and instead of only giving the details to the workers the details can also be transmitted to the head office so that they are also aware of their workers health.

I redesigned the model by putting these sensors on the helmet. Initially we were in a bit of difficulty to fit the sensor in our model but with our instructor guidance everything was conducted smoothly.

Contribution by Vedant A Sontake(B20ME078):

In this course Engineering Design, our group chose to make our project on the problem statement, "*Optimisation of the present design of mining hat by installing various sensors to avoid accidents because of the hazardous situations in mines."* We tried to identify various problems experienced by a miner while doing its job. We conducted several meetings and I actively participated in every group meeting and discussions carried out. Initially, I and every other group member equally contributed to the literature work of the project by finding various problems faced by the miners. After figuring out various problems, we decided to distribute them equally among the team members. I decided to work on the problem, 'accidents due to low heighted underground mines.'

While doing some research on this problem, I found some information emphasizing on how mining height affects the injury rates(Point 4 in Bibliography). One of the major highlights of it was that most of the accidents occur in low-heighted mines. To overcome this problem, I came up with the solution of helmets equipped with height determination sensors. I searched for different types of sensors available for this task and tried to find one with a small size so that it could easily fit into the helmet.

Finally, I found an Ultrasonic sensor(HC-SR04) which has a very compatible dimensions of 45mm x 20mm x 15mm for our helmet and is also cost efficient with one unit costing only ₹ 63. Next step was to design its circuit and make a fully functional height determination sensor. I designed its circuit - consisting of this sensor and other components like Arduino Uno 3, Piezo Buzzer and some jumper wires - on the Tinkercad platform and also wrote its code. The circuit works perfectly as simulated on the Tinkercad platform (circuit diagram attached in the 'Final Solution and Progress section' above). The buzzer blows with a tone of 330 Hz of frequency when the distance between the helmet and the ceiling of mine is less than 40 cm.

Contribution by Haardik Ravat(B20EE021):

In the duration of this course of Engineering Design, we worked to optimise the current mining helmet to better suit the needs of the miners. After careful observation of the models and coming up with a solution to prepare, I was given the responsibility to decide upon the model design and structure of the helmet.

For the above purpose, many models in existence, apart from the current one, were analysed to best suit the recommendations by the instructors and to ensure the safety of the miners.

To make a design to fix the sensors we are including in the project as well as to maintain a lightweight and sturdy structure, I came up with many possible solutions, one of which we preferred the best is currently being used as the design model of our project

Covering the specifications of the helmet and the positioning of circuits, the framework will be of carbon fibre, as it is quite durable and light. It will be the framework of the wired networking as well and lay a surface area to the attachments.

To assemble all in place, the base arduino needs to be at the backend, vents with purifiers at the rear and front, height detection sensor at an angle of 35 degrees to the apex, and the ambient lighting system at its original forehead spot.

All these details were refined as per the suggestions provided by our instructors and the drawback of previous models.

We believe that this will work effectively and efficiently providing a better solution to our problem statement.

Contribution by Karan Jain(B20AI016):

The success of any project is highly influenced by the project team tasked with delivering it. Even the best planned projects may fail to meet their objectives if the project team does not perform to the best of their ability.

In this project of the course Engineering Design, I have actively participated in all the group discussions and made myself useful to the best of my capabilities. I was highly active in the discussion of the problem statement and even suggested many problem statements to work on.

When the problem of mining hats was decided I gladly took the part to solve the lack of a proper lighting system in the mining hats. Since the current miner hats use a normal lighting system which leads to a lot of wastage of energy, I proposed to make an automatic lighting system so that energy wastage could be avoided.

I suggested using arduino to operate the lighting system along with other facilities. We will use a light dependent resistor so as to change the brightness of the lamp according to the amount of brightness in the environment.

I have even made the working model of the lighting system on the Tinkercad platform and have provided all the information in the slides. All the slides regarding the lighting system have been made by me.

I have done my best so as to make this project a success. After every session ,I worked on the suggestions given by our respected instructors and arrived at the final design.