



Studies on the Usability and Design Parameters of a Respiratory Mask Protection, Perficient for Workers of Mining Enterprises

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ABSTRACT

Illegal and localized coal mining is persistent within the weaker sections of the society especially in countries like India and US. Research conducted proves that harmful gases are omitted during the process of coal mining cause respiratory diseases and increase chance of death when inhaled by the miners. It adversely affects their health and productivity. Various studies, news and focused groups have helped authors identify the depth of this problem in the mining community. A team of innovators have designed the 'Perficient Mask', a cheap and easily accessible mask, which was invented to prevent entry of these harmful gases. This study is aimed at analysing the usability and efficiency of this mask with respect to the protection it provides to vulnerable miners. The study includes a description of the various materials used in the mask such as activated charcoal and aluminium formate which help filter harmful gases such as carbon dioxide, methane, carbon monoxide, hydrogen sulphide etc. through various methods which will be elaborated on further in this study. Users acquainted with the mask will be protected against these deleterious gases while participating in coal mining activities.

Keywords: respiratory diseases, harmful gases, vulnerable miners, activated charcoal, aluminum formate, coal mining.

1. Introduction

As the sudden surge of coal mining sites were observed in developing and overpopulated countries such as India where illegal and localized coal mining is persistent to meet the necessities of a growing population, a concern was raised regarding the increasing rate of fatalities primarily due to the inhalation of deleterious gases and chemicals omitted during the burning of coal.[1] In developing countries like India, coal fuels 70% of the electricity grid and India also plans to reopen 100+ old mines to meet the needs of a growing population. These miners who work 6-8 hours per day don't possess adequate protection they need for their safety, due to insufficient funds to acquire these overpriced and standardized gas masks which are not suitable for the purpose. The miners are compelled to make use of products like cloth which are available at home in hopes of safeguarding themselves. Toxic gases and chemicals are further inhaled when local miners burn heaps of coal for 6-8 hours per day to make it usable as fuel. This affects the members of the family as well as the locality by causing various deadly diseases. Burning of coal pollutes the air and health impacts can range from asthma and breathing difficulties, to brain damage, heart problems, cancer, neurological disorders, and premature death. [2]

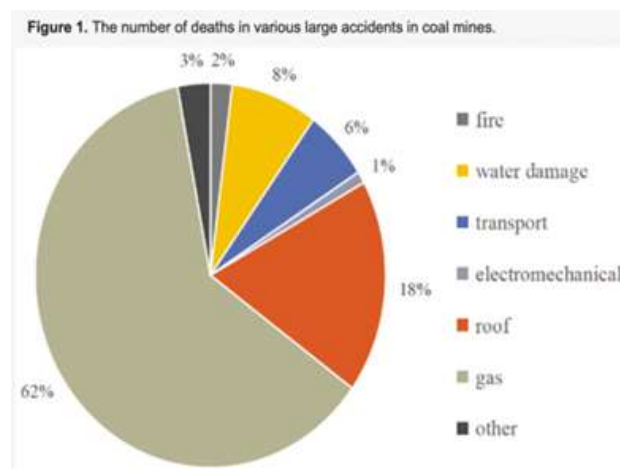


Fig 1.1) – The number of deaths in various accidents in coal mines [9]

Gases such as Carbon Monoxide (CO), Methane, Hydrogen Sulfide, Carbon Dioxide etc. resulted to various problems such as CO poisoning, dizziness, nausea, slurred speech, vision problems, memory loss, facial flushing etc. If a mask is not worn when working in a coal mine, hazardous gases, fumes, and mist will enter the workers' bodies and lead to a variety of illnesses like bronchitis and asthma. The study focuses on this problem because of its severity and the alarming rise in fatalities in the rural regions of India. The study also investigates the usability of the Perficient Mask and how it supports the case. Case studies and research show that approximately 150 patients are affected by gases omitted during coal burning and are admitted to local hospitals as symptoms worsen. [3]



Figure 1.2) Graph showing number of fatal accidents caused in coal mines per year. (Debi Tripathy, Charan Ala, 2018)

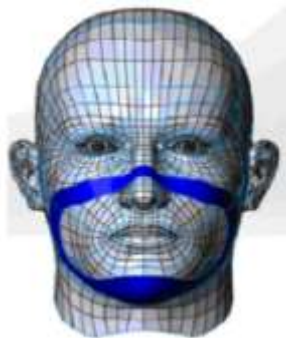
2. Materials and Methods

2.1 Structure of the mask

The Perficient mask designed by the authors consists of two layers that complement each other to provide optimum protection to the user. Our gas mask actively uses aluminum formate (ALF) and Activated charcoal as our key materials. The materials will be present in the central mesh-like structure located below the protective eyewear made of glass which is attached to the main structure of the mask. The protective glassware is present to protect the user's eyes from dust particles and gases present in coal mines.



Figure 2.1) Image showing mask coverage.



Figures by: Vasyi Holinko, Ivan Cheberichko, kiki, Ukrainian School of Mining -2019) Figure2.2 Side view of the filter portion of the Perficient Mask



Figure 2.3) Structure of the Perficent Mask

2.2 Activated Charcoal

Activated Charcoal is vital to absorb methane, carbon monoxide and hydrogen sulphide thus filtering it and preventing occupational hazards. It works as an adsorbent for coal particles found in mines.[4] It allowed breathed gases to escape. Charcoal, available in abundance is heated in the presence of a gas to create activated charcoal. The price of activated charcoal varies depending on the market. Activated charcoal, is on an average sold in the Indian open market for 200 rupees per kilogram.

2.3 Aluminum Formate

The second material of the mask is aluminium formate (ALF) which will be used to filter CO₂ gas. It is both cheap and widely available. To produce this material, aluminium hydroxide, and formic acid, two chemicals that are plentiful and easily accessible on the market are used. This material is up to 100 times less expensive than other materials with comparable characteristics, costing less than 81 rupees per kilogram. ALF traps excess CO₂ molecules thus preventing the higher concentration of CO₂ in the mask. There are research efforts underway to convert the captured CO₂ to formic acid which is not only a naturally occurring organic material but also one of the two constituents of ALF.[5] If the research proves successful ALF could become part of a cyclic process where ALF removes CO₂ from the exhaust streams, and that captured CO₂ is used to create more formic acid. The ALF filter will be placed away from the user's face, in front of the activated charcoal to filter CO₂ entering the mask before it reaches the activated charcoal to prevent a chemical reaction. The outer covering of the mask is to be lined with silicon which will help make it flexible so that it can adjust according to the shape of the user's face.

3. Results and Discussions

Miners practicing in rural areas receive lower income hence they are subject to immense loss when put forward with diseases acquired from the inhalation of harmful gases. It takes a toll on their overall livelihood and physical wellbeing. Miners are vulnerable to the various gases omitted at coal mining sites as they cannot afford specialized gas masks that provide the necessary protection. As mentioned previously, they often depend on the use of cloth covers around their faces which doesn't provide protection against gases like carbon dioxide, carbon monoxide, methane, and hydrogen sulphide. The Perficent mask is cheap and can (easily be accessed) by local miners as the materials used are plentiful in the market and are comparatively cheaper than their counterparts. Miners working in the fields experience adverse side effects on their health which decreases productivity necessary in the ever-growing market for coal. The coal miners who are affected by these problems are often the sole breadwinners of their respective families thus the primary sources of income for these families cease as short-term and long-term effects caused by the inhalation of harmful gases affect the overall livelihood of the community. The average cost of coal mining mask in Indian industry is ₹10,000 whereas on the other the average price of Perficent mask is ₹4,000. Our mask has just one filter, which lowers the cost. The silicone covering is flexible and can be adjusted to fit the miners' faces. This mask is affordable since it employs less expensive replacements. Large-scale effects of our mask include a decrease in the number of persons who succumbed to death overtime because of inhaling lethal gases during coal mining and related operations, including coal miners and residents of adjacent communities. Our mask strives to successfully reduce the risk and lives at stake by following government safety regulations.

Various research papers and studies such as the paper study titled 'Activated charcoal filter layer for gas masks' published in 1991 [6] and many others published in consecutive years conclude that activated charcoal is a material that can be used in gas masks as it has high adsorption performance and low flow-through resistance. Furthermore, activated charcoal filter methane, carbon monoxide and Sulphur dioxide which are most prominent on the coal mining field. Articles published by journals such as the Journal of Ecological Engineering state that activated charcoal is an adsorbent that has the highest CO adsorbing ability as it has better surface area compared to other adsorbents [7]. Lastly, activated charcoal blocks solid particles like standard filters but possesses special properties that help them adsorb harmful gases such as Sulphur dioxide and nitrogen oxides according to filtration experts in FILTRON [8]. When the ALF and the activated charcoal work together they will be able to filter all the harmful gases omitted during the process of coal mining successfully. The Perficent mask will thus be able to provide optimum protection for the user.

Although the mask is designed and proven to be effective, some of the limitations the product may face include large scale distribution of the mask to local miners not working under an organization. It has not been concluded that the mask is able to retain its effectiveness after multiple uses. The Perficient mask will be advertised via social media awareness platforms as well as more generic media such as website pop-ups, SEO (Search engine optimization), newspapers, radio, etc. To spread awareness of the mask among mining communities, it will also be displayed at mining conventions.

4. Conclusion

The weakest sectors of society continue to engage in localized, illegal coal mining, particularly in nations like India and the US. Research has shown that breathing in dangerous gases released during coal mining increases the risk of respiratory illnesses and mortality for workers. It has a negative impact on their productivity and health. The extent of this issue in the mining community has been identified by writers with the assistance of several research, press reports, and focus groups. The purpose of this study is to evaluate the efficiency and usefulness of the Perficient mask in protecting vulnerable miners. The study includes a description of the various components used in the mask, including aluminum formate, and activated charcoal, which help filter harmful gases like carbon dioxide, methane, carbon monoxide, and hydrogen sulfide, among others, using a variety of techniques that will be covered in more detail in this study. Users who are familiar with the mask will be protected when engaging in coal mining operations from these harmful gases.^[1]_{SEP}

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