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Reducing The Health Risk of the Workers in the Engineering Industry Through Safety Engineering Systems

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Abstract
The mining industry, vital for global economic growth, carries significant risks to both human safety and the environment. Effective hazard identification and risk analysis are crucial to mitigating these dangers. This project proposes a comprehensive approach to hazard identification and risk analysis, integrating advanced methodologies, technologies, and collaborative frameworks to enhance safety. The primary goal is to create a holistic framework for identifying, assessing, and controlling risks throughout all stages of mining, from exploration to decommissioning. The approach combines traditional techniques, like hazard identification (HAZID) and failure modes and effects analysis (FMEA), with modern tools such as machine learning algorithms, real-time monitoring, and predictive analytics. By merging these innovative technologies with conventional methods, the project aims to improve the precision of risk assessments and enable proactive decision-making. It also stresses a multi-disciplinary approach, incorporating input from engineers, safety experts, environmental scientists, and workers, ensuring all potential risks are addressed. Through case studies and industry collaboration, the research promotes a safety culture where risk management is embedded in daily operations. By enhancing hazard identification and risk analysis, this project aims to reduce accidents, environmental damage, and operational disruptions, fostering a safer, more sustainable mining industry adaptable across various sectors.

Keywords: *Hazard identification, Risk analysis, Mining industry, Safety measures, Machine learning, Predictive analytics*

1. Introduction
The health and safety of workers in the engineering industry is a critical concern, as they are often exposed to various hazardous conditions. These risks include physical injuries, exposure to toxic substances, and ergonomic challenges, which can lead to long-term health issues. Safety engineering systems play a pivotal role in minimizing these risks by incorporating effective strategies to ensure the well-being of workers. These systems focus on identifying potential hazards, assessing risks, and implementing preventive measures to mitigate health risks in the workplace. The primary objective is to create a safe working environment through the application of safety protocols, engineering controls, and innovative technologies. This project aims to explore how safety engineering systems can be utilized to reduce health risks in the engineering industry. By integrating safety measures such as automated monitoring systems, ergonomic designs, and protective equipment, the goal is to protect workers from injuries and illnesses. Additionally, the use of data analytics and real-time monitoring helps in identifying emerging risks and providing immediate corrective actions. By fostering a culture of safety, this approach not only reduces accidents and injuries but also promotes worker productivity and morale. Ultimately, implementing comprehensive safety engineering systems is crucial for creating a sustainable and health-conscious engineering industry. [1]

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2. Literature Review

Recent literature on reducing health risks for workers in the engineering industry through safety engineering systems highlights the critical role of safety protocols, advanced technologies, and preventive measures. Several studies emphasize the importance of identifying and assessing workplace hazards to implement effective safety engineering solutions. For instance, a review by Lema et al. (2021) focuses on hazard identification techniques such as Failure Modes and Effects Analysis (FMEA) and Fault Tree Analysis (FTA), which help in understanding potential risks and creating preventive strategies. These methods are essential in ensuring that risks are proactively addressed before they lead to accidents or health issues. Recent advancements in automation and digital technologies have also been explored, with researchers like Zhang et al. (2020) showing how real-time monitoring systems, wearable safety devices, and automated safety alerts have transformed safety practices in the engineering sector. These technologies continuously monitor workers' environments and health conditions, detecting early signs of potential hazards such as exposure to harmful substances or physical strain, thus reducing the risk of health problems. Moreover, ergonomic improvements in workplace design have been shown to significantly reduce the risk of musculoskeletal disorders, which are common in the engineering industry. Studies by Kowalski et al. (2019) highlight the integration of ergonomic tools and machinery design in reducing physical strain on workers. Overall, recent literature underscores the importance of a multidisciplinary approach, combining engineering, technology, and worker input, to create effective safety engineering systems that enhance worker health and prevent workplace accidents. [2-4]

3. Problem Identification

The engineering industry, while critical to economic development, poses significant health risks to workers due to exposure to hazardous environments, machinery, and strenuous tasks. Workers are often exposed to physical injuries, repetitive strain, toxic chemicals, noise, and poor ergonomics, which can lead to long-term health issues such as musculoskeletal disorders, respiratory diseases, and hearing loss. Despite the implementation of safety protocols, accidents and health-related issues remain prevalent due to the inadequacy of traditional safety measures and the rapid evolution of technology and work practices. One of the primary problems is the lack of real-time monitoring systems and the insufficient integration of advanced safety technologies into daily operations. Many workplaces still rely on reactive safety measures rather than proactive approaches, which often leads to delayed responses to emerging risks. Additionally, worker training on safety protocols is often inconsistent, and there is limited focus on ergonomic design and proper maintenance of equipment. Furthermore, the complexity and variety of engineering tasks make it difficult to apply a one-size-fits-all solution to safety. There is a need for tailored safety engineering systems that can identify specific hazards for different tasks and environments. Addressing these issues through effective safety engineering systems is crucial for reducing health risks, improving worker safety, and fostering a safer working environment within the engineering industry.

4. Methodology

Health illnesses refer to conditions that affect the body’s normal functioning, leading to physical or mental impairments. These can range from acute illnesses, such as infections, to chronic conditions like heart disease, diabetes, or musculoskeletal disorders. In the workplace, health illnesses often stem from prolonged exposure to hazards such as harmful chemicals, excessive noise, poor ergonomics, or repetitive tasks. Engineering workers, in particular, are vulnerable to conditions like respiratory diseases, hearing loss, and repetitive strain injuries due to the nature of their work. Mental health issues, such as stress and anxiety, are also common due to high work pressures. Addressing health illnesses in the workplace requires preventive measures, such as safety protocols, ergonomic designs, proper protective equipment, and regular health monitoring to reduce long-term health risks and improve worker well-being. Data collection in this project involves gathering information on

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workplace hazards, health risks, and safety practices in the engineering industry. (Figure 1)

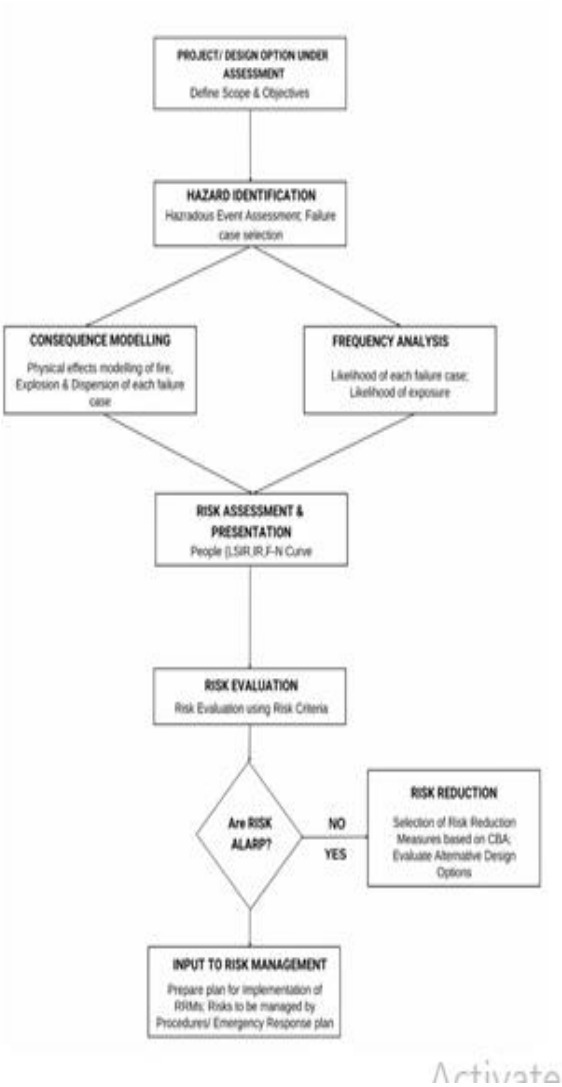

Figure 1 HIRA Flow

Table 1 Worker Illness Status

Sl. No.	Month	Total No. of illness	Illness in Ginding Process
1	Sep'23	12	12
2	Oct'23	11	11
3	Nov'23	13	13
4	Dec'23	15	15
5	Jan'24	14	14
6	Feb'24	11	11
Total		76	76

5. Data Collection

Data collection in this project involves gathering information on workplace hazards, health risks, and safety practices in the engineering industry. This includes measuring exposure to harmful substances, tracking worker injuries, and assessing ergonomics through surveys, interviews, and observation. Real-time data from wearable devices, such as heart rate monitors or environmental sensors, will also be collected to monitor workers' health and environmental conditions. Additionally, safety records, accident reports, and maintenance logs will be analyzed to identify patterns and common risks. This data will help develop targeted safety engineering systems to minimize health risks and improve overall worker safety. (Table 2) [5-8]

Table 2 Risk Identification

Problem in work place	Observation			
	Low	Medium	High	Very High
Nose, Eye Irritation		✔		
Hand itching				✔
Hand Allergy		✔	✔	
Heavy Noise		✔		
Body Sultry		✔		
Feel Discomfort			✔	
Cough	✔			
Acid smile	✔			
Breathing Difficult			✔	

5.1. Health Checkup for Workers (Pulmonary Test)

Medical plan is mandatory for hazards high level area/ process activities as per HIRA study. Yearly once all regular worker of grinding machines are to

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be pulmonary tested by authorized medical laboratory within company premises. Test report of all workers are collected and kept in report format for audit purpose to future health development. These reports are reviewed as per frequency. Workers are allowed further medical treatment based on test report. (Figure 2) [9]

5.2. Methodology Followed

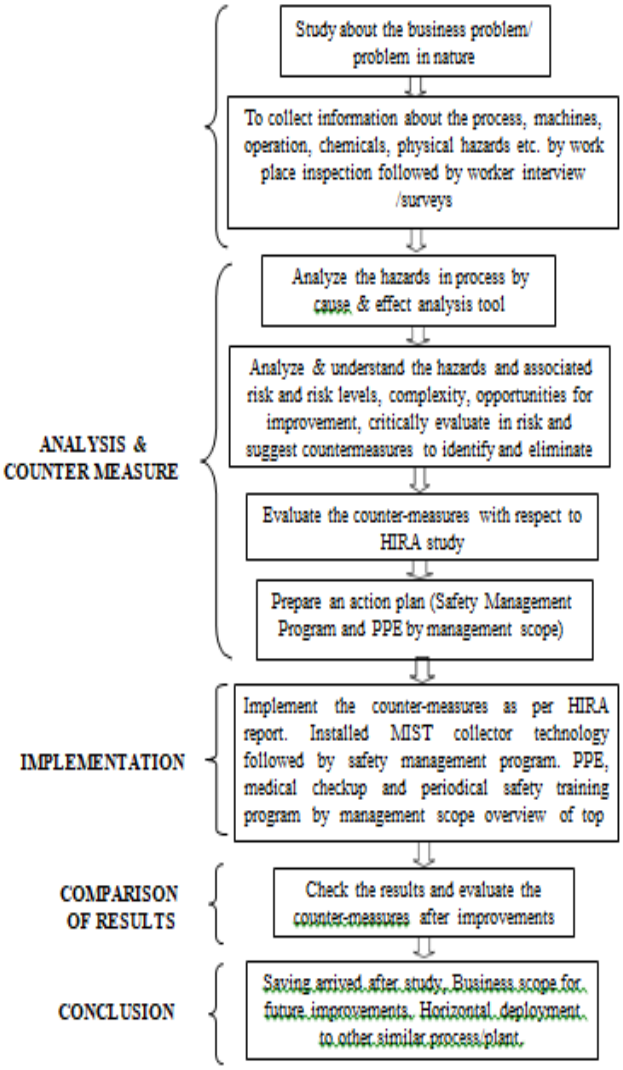

Figure 2 Methodology

These reports are reviewed as per frequency. Workers are allowed further medical treatment based on test report. Our organization is to be implement OSHA standards as per requirement of customer needs. So presently a safety officer is appointed to implement and develop safety systems to the organization. Safety officer is keeping past accident history and record of all safety related systems. He establishes safety procedure and follow up safety related performance monitoring activities. [10]

5.3. Reduction of Absent Trend

Through safety improvements done in this project like reducing hazards risk, improve safety systems the absenteeism trend reduced from 38.36% to 3.57% and there is a scope for further improvement. (Figure 3)

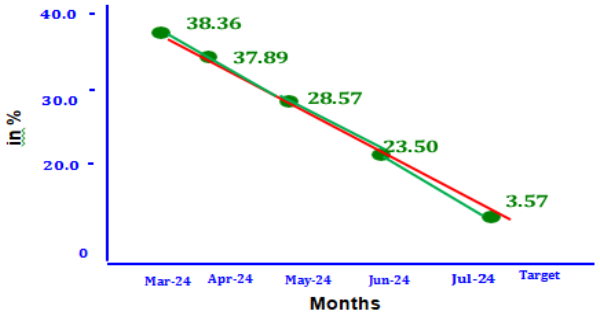

Figure 3 Work Man Absenteeism Trend

5.4. Reduce Hazards Risk

The cost benefits shown above are the achievement realized through safety system Kaizen. The improvement that increases machine's safety performance and minimize hazards risk is an excellent. (Figure 4)

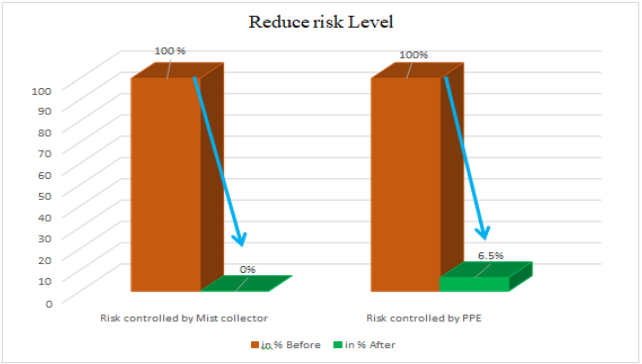

Figure 5 Hazards Risk Reduced Target Level

- Operator fatigue reduced
- High Worker's morale improved
- Improved safe working condition
- Inspiration towards work
- Timing dispatch without delay

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Table 3 Action Taken for List of Hazards

S. No	Health hazard	Health Risk	Risk (L/M/H)	Control method
1	Grinding Mist, dust particle are flying on surrounding area	Lungs affect	H	Mist collector technology
2	Skin contact with Handling of coolant oils	Skin problem, Itching	H	Gloves usage (PPE)
3	Air Noise due to camshaft Cleaning	Earing problem	H	Ear plug usage (PPE)
4	Inhale of Coolant vapour	Breathing problem	H	Mask usage (PPE)

5.5. Overall Expected Cost and Efforts

The highly appreciable element of the project is that direct work group of the machine suggested more HIRA study. The Safety performance of the machine is enhanced by more than 85%. Worker health issue has been completely reduced by installed mist collector technology, safety training, periodical medical checkup and PPE training. (Figure 6) [11]

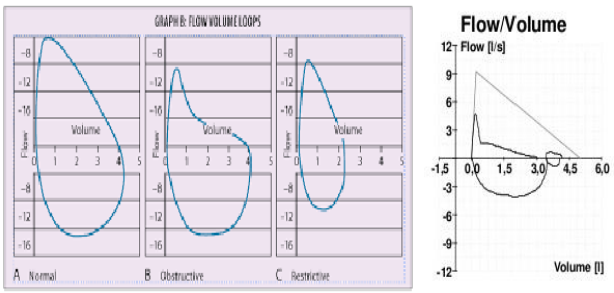

Figure 6 Pulmonary Test Report

The absenteeism of worker of the grinding machine is decreased by 3.57%. The dispatch rate is increased by 100%. Overall cost saving rate is 20% of turnover. By following the safety system concepts for reducing the hazards is more effective, since it is more considering the sustenance activities and it is being followed with the available workforce, it gives chance to improve knowledge of operators, machine conditions. Hazards risk reduction rate is also very good by monitoring & maintaining the basic conditions. Safety approach mainly considering the correction of basic conditions & also to maintain the basic conditions for better results in terms of reduction of health risk & Accidents. The discussion of the results, benefits accrued is encouraging and has given enough confidence to study further projects and arrive at conclusions similarly. The implementation of the project "Reducing the Health Risk of Workers in the Engineering Industry through Safety Engineering Systems" involves several key stages to integrate safety systems and reduce health risks in the workplace. The first step is a comprehensive risk assessment to identify hazards specific to different engineering tasks and environments. This will be done through data collection, including real-time monitoring of environmental factors, worker health, and safety records, as well as conducting surveys and interviews with workers to understand their concerns and experiences. Once risks are identified, the next stage is the development and integration of safety engineering systems, such as automated monitoring systems, wearable safety devices, and ergonomic design improvements. Automated systems will monitor environmental conditions like temperature, noise levels, and exposure to hazardous substances, triggering alerts when conditions exceed safety thresholds. Wearable devices will track workers' physical health, providing real-time data on vital signs and potential signs of strain or fatigue. Ergonomic improvements will focus on reducing physical strain by designing workstations, tools, and machinery that minimize musculoskeletal injuries. This may include adjustable workstations, anti-fatigue mats, and tools designed to reduce repetitive motion. Training and

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awareness programs are crucial for successful implementation. Workers must be trained on the proper use of safety equipment, the importance of health monitoring, and how to report potential hazards. This will be supported by a safety culture that encourages collaboration between workers, engineers, and safety experts to create a shared responsibility for safety. Lastly, continuous monitoring and evaluation will ensure the effectiveness of the safety systems. Regular health assessments, audits, and feedback from workers will help refine and improve safety engineering solutions, ultimately ensuring a safer working environment and reduced health risks for engineering industry workers. [11]

5.6. Analysis Counter Measures

In the context of reducing health risks for workers in the engineering industry, analysis countermeasures focus on identifying potential hazards and implementing strategies to mitigate or eliminate these risks. One of the primary countermeasures is the integration of real-time monitoring systems, which track environmental conditions such as temperature, noise levels, and exposure to hazardous materials. These systems enable immediate detection of unsafe conditions and prompt corrective actions, reducing the likelihood of worker health issues. Another countermeasure is the implementation of ergonomic designs in workstations, machinery, and tools. This approach minimizes physical strain on workers by ensuring that equipment and work environments are tailored to human anatomy, thereby reducing the risk of musculoskeletal disorders. Adjustable workstations, anti-fatigue mats, and ergonomic tools are examples of such countermeasures. [12]

5.7. Implementation

The implementation of the project "Reducing the Health Risk of Workers in the Engineering Industry through Safety Engineering Systems" begins with a thorough hazard analysis to identify potential risks in the workplace. This includes collecting data on environmental conditions, worker health, and safety performance using real-time monitoring technologies, such as wearable devices and sensors. These systems will continuously track factors like exposure to harmful chemicals, noise levels, and physical strain. Next, safety engineering solutions will be introduced, including ergonomic workstation designs, automated safety protocols, and personal protective equipment (PPE). These systems will be customized to the specific needs of different tasks and work environments, ensuring that workers are protected from injury and illness. [13]

Employee training programs will be conducted to raise awareness of safety procedures and proper equipment use. Finally, regular health assessments and safety audits will evaluate the effectiveness of implemented systems, ensuring continuous improvement and long-term safety. [14]

5.8. Comparison of Result

The comparison of results in the project "Reducing the Health Risk of Workers in the Engineering Industry through Safety Engineering Systems" will involve evaluating the effectiveness of safety systems before and after implementation. Key metrics include reductions in workplace injuries, illnesses, and absenteeism, alongside improvements in worker health and safety awareness. Real-time monitoring data, ergonomic assessments, and feedback from workers will be compared to baseline data. Additionally, the frequency of safety incidents and health-related conditions will be tracked to measure the success of integrated technologies and safety protocols in reducing health risks and improving overall safety in the workplace. [15]

Conclusion

The project is initiated to reduce the

- Hazards Risk
- Regular worker absents and
- Delaying of dispatch

Thereby to achieve higher profit and to meet customer schedule, data collections are carried out through Cause & effect analysis tool and analyzed through HIRA study. The equipment is thoroughly analyzed through PPE usage, implement mist collector technology through Safety Management Program (SMP) reduce the Hazard risk and thus to increase the productivity of the equipment and delay free dispatch to customer. [16]

Gains of the study: The project is carried out for a group of single machine in the layout. The methodology of this machine can be applied to rest of

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the machines of the layout, and then to all other layout of the organizations to increase the productivity of the machines and profit of the business of the concern.

Limitations of the Study: The success of the process depends upon the Safety systems and implementation of the ideas suggested. It may require some times higher initial investment and rigorous training of the personnel. One more important element is it needs more cooperation among different work group. To meet the customer's requirements, with respect to timing delivery, it is must to customer satisfaction. To do so it is very important to reduce the hazards and risk of equipment and increase productivity. The organization has many grinding machines which are highly mechanical, and to be maintained with safety systems and performance rate and decreased hazards risk associated with it. If Safety technology and systems are implemented the risk of hazards of the machines can be reduced. Also the process involves all work groups and so better morale can be achieved. There is very high demand in the company to widen the safety system to all machines in the area of the management and human resources. The improvements made through this project work are to be deployed to all similar operations and machines to get maximum safety and benefit to the worker of organization.

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