SAFE DESIGN AND ENGINEERING STRATEGIES TO REDUCE HAZARDS IN MANUFACTURING FACILITIES

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Abstract. This study aims to investigate the effectiveness of safe design and engineering strategies to reduce risks in manufacturing enterprises. As a result of observations conducted over a 2-year period in 5 large manufacturing enterprises in Uzbekistan, strategies such as automation, ergonomic workplace design, substitution of hazardous substances, noise reduction, and improvement of fire protection systems were implemented. The results show that these measures reduced the number of accidents by 47%, the number of serious injuries by 62%, while increasing production efficiency by 18%, and the level of employee satisfaction with working conditions by 35%. The results of the study demonstrate the important role of safe design and engineering strategies in ensuring safety and increasing efficiency in manufacturing enterprises.

Keywords: industrial safety, safe design, engineering strategies, accident reduction, production efficiency.

Introduction. Safety is a major issue in manufacturing plants, directly affecting worker health and enterprise efficiency. This study aims to investigate the effectiveness of safe design and engineering strategies to reduce risks in manufacturing processes. The aim of the study is to assess the impact of safe design and engineering approaches on the number of accidents and injuries in manufacturing plants.

The issue of safety in modern manufacturing enterprises is becoming more urgent than ever. Along with the development of technologies and the complexity of production processes, attention to employee health and occupational safety is also increasing. According to the World Health Organization, 2.3 million people die every year due to industrial accidents and occupational diseases. These figures clearly indicate the need to strengthen safety measures in manufacturing enterprises. Safe design and engineering strategies are one of the effective ways to reduce risks in production processes and ensure employee safety. This approach requires an integrated approach to identifying and eliminating risks. The concept of safe design involves making not only production equipment and facilities, but also the entire working environment safe and comfortable. Engineering strategies, on the other hand, are aimed at reducing or completely eliminating existing risks through technical and

technological solutions.

The main objective of this study is to investigate the possibilities of reducing risks by implementing safe design and engineering strategies in manufacturing plants. The following tasks were identified within the framework of the study:

1.Identification and analysis of existing risks in manufacturing enterprises.

2.Develop and implement safe design and engineering strategies.

3.Assess the effectiveness of implemented strategies.

4.Study the relationship between safety measures and production efficiency.

The results of the study will serve as a basis for developing practical recommendations for ensuring safety at manufacturing enterprises. The information obtained can also be used to improve legislative and regulatory documents in the field of safety.

Methods. The study was conducted at 5 large manufacturing enterprises in Uzbekistan. The selected enterprises belong to various industrial sectors, including mechanical engineering, chemical industry, food production, textile and construction materials production. Such a selection allowed to assess the effectiveness of safe design and engineering strategies in different production environments.

The study was conducted over a period of 2 years and included the following stages:

1.Initial analysis: The existing hazards, accident statistics, and safety measures at each facility were reviewed. This included interviews with employees and management, observation of production processes, and analysis of existing safety documentation.

2.Strategy Development: Based on the results of the initial analysis, safe design and engineering strategies were developed for each facility. These strategies covered the following areas:

✓Automation and Robotization: Transferring dangerous and heavy work to automated systems.

✓Ergonomic workplace design: Creating comfortable and safe workplaces for employees.

✓Substitution of hazardous substances: Replace hazardous chemicals with safer alternatives whenever possible.

✓Noise reduction measures: Implementation of technical and organizational measures to reduce noise levels.

✓Improving fire protection systems: Installing modern fire safety systems and modernizing existing ones.

3.Implementation of strategies: The developed strategies were implemented in stages. During this process, special attention was paid to training employees and adapting them to new security measures.

4.Monitoring and Evaluation: Once the strategies were implemented, their effectiveness was monitored regularly. The following indicators were taken into account:

- ✓ Number of accidents and injuries
- ✓ Production efficiency
- ✓ Level of employee satisfaction with working conditions
- ✓ Working time losses
- ✓ Security-related costs

5.Data analysis: The collected data was statistically analyzed. The indicators before and after the implementation of the strategies were compared. The results in different enterprises were also compared.

The research was conducted in accordance with strict ethical principles. All participants were fully informed about the purpose and process of the research, and their personal information was kept confidential. The results were discussed with the management and employees of the enterprise, and their feedback was taken into account.

Results. As part of this study, observations and analyses conducted over 2 years at 5 large manufacturing enterprises in Uzbekistan led to a number of important conclusions. The implementation of safe design and engineering strategies significantly improved safety performance at enterprises and had a positive impact on production efficiency. The most important result was an average reduction in the number of accidents by 47%. This indicator varied from 38% to 56% at different enterprises, with the highest result achieved at the chemical industry enterprise. The number of serious injuries decreased even more significantly - by 62%. This result was especially evident at enterprises producing mechanical engineering and building materials, where heavy equipment and lifting operations were automated. Such positive changes had a positive impact not only on employee health, but also on the financial performance of enterprises, as the costs associated with accidents and the number of production downtimes decreased. As a result of increased safety measures and improved working conditions, production efficiency also increased. The average figure was 18%, with the highest increase (23%) observed at the textile enterprise. This was achieved mainly due to ergonomic workplace design and the introduction of modern, safe equipment. The level of employee satisfaction with working conditions also increased significantly - by an average of 35%. At the food production enterprise, this figure reached 42%, where noise reduction and air purification systems were improved. The attitude of employees to safety issues also changed. If at the beginning of the study only 45% of employees stated that they always follow safety rules, by the end of the study this figure reached 78%. This indicates an increase in the awareness and responsibility of employees in safety issues. According to the results of fire safety tests,

after the introduction of the new systems, the time to detect and respond to a fire was reduced by an average of 40%. This significantly reduced the potential fire risk. From an economic point of view, it was found that investments in safety paid off. Despite the high initial costs, an average economic effect of 15% was observed within 2 years due to the reduction of costs associated with accidents and production downtime. Overall, the results of the study clearly demonstrated the important role of safe design and engineering strategies in ensuring safety and increasing efficiency in manufacturing enterprises. These strategies not only ensure the health and safety of employees,It was also found that it serves to increase the overall operational efficiency of enterprises.

According to the research results:

- ✓ The number of accidents decreased by an average of 47%
- ✓ The number of serious injuries decreased by 62%.
- ✓ Production efficiency increased by 18%
- ✓ Employee satisfaction with working conditions increased by 35%

Discussion. The results show the important role of safe design and engineering strategies in reducing risks and improving overall efficiency in manufacturing plants. Automation and ergonomic approaches have not only protected workers from hazardous situations, but also increased productivity. Noise reduction and improved fire protection systems have helped prevent long-term health problems.

Further development and widespread implementation of these strategies in the future will further improve the level of safety in manufacturing enterprises. It is also important to continuously train and motivate employees in safety issues.

Conclusion. The results of this study suggest that implementing safe design and engineering strategies in manufacturing plants can significantly reduce risks and increase production efficiency. The effectiveness of this approach is demonstrated by the reduction in the number of accidents and injuries, as well as increased employee satisfaction.

In the future, it is advisable to conduct research in this area in the following areas:

1.Comparative analysis of the effectiveness of safe design and engineering strategies in different industrial sectors.

2.Assessing the cost-effectiveness of security measures.

3.Developing security methods based on modern technologies (e.g., artificial intelligence, big data analytics).

In conclusion, safe design and engineering strategies not only ensure the safety and health of employees, but also increase the overall efficiency and competitiveness of the enterprise. This approach should be widely implemented and continuously improved in manufacturing enterprises.

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