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Risk Assessment of a Ceramic Factory Using the Fine-Kinney Method

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Abstract: With increasing population in the world and in Türkiye, along with the growing demand for energy and raw materials, mechanization in production lines has become inevitable. As in every sector where machine and human activities are synchronized, serious occupational accidents can occur in the ceramic industry, if necessary precautions are not taken. Today, many professional companies conduct various studies to identify occupational hazards in a timely manner and implement acute preventive measures. The common aspect of these studies is the classification and identification of risks and the elimination of hazardous risks using academically recognized methods. In this study, a risk analysis was conducted using the Fine-Kinney method in a ceramic manufacturing plant to ensure a healthy and safe working environment by performing environmental measurements to prevent occupational accidents. Based on the risk scores obtained, potential hazard points were identified. The results indicate that a total of 150 risks were detected. The most significant hazards across the factory include dust (risk score: 4000) and fire (risk score: 6000), both posing high risks. Additionally, the noise risk score in the granule preparation and raw material sections (risk score: 4000) was found to be at an intolerable level. The identified risk levels within the facility have been reduced to acceptable levels through corrective actions.

Keywords: Fine-Kinney method, occupational health and safety, risk assessment, ceramic industry.

Introduction

The rapid advancement of technology and the increasing dependence on energy compel humanity to either find new energy sources or make better use of existing ones. In this process, every newly introduced machine or material in the production stage can pose a potential threat to both worker and environmental health and safety, increasing the risk of occupational accidents. Although fatal occupational accidents show a decreasing trend in developed countries, this rate continues to rise in developing and underdeveloped nations (Karadeniz, 2012).

According to data from the International Labor Organization (ILO), every 15 seconds, 160 workers worldwide experience occupational accidents. Annually, 270,000,000 occupational accidents occur, with over 313,000,000 workers suffering non-fatal injuries and 160,000,000 people contracting occupational diseases. These statistics indicate that 350,000 people die due to occupational accidents, while 2,000,000 lose their lives due to work-related illnesses. In developing countries, 651,000 workers die from exposure to toxic substances, and 10% of skin cancer cases worldwide are reported to result from workplace exposure to hazardous chemicals. It is estimated that asbestos alone causes 100,000 deaths annually. Another occupational disease, silicosis, which leads to fatal lung cancer, affects tens of millions of people. In Latin America, 37% of mine workers suffer from this disease, with the rate rising to 50% for those over 50 years old. In India, 50% of stone carving workers and 36% of stone crushing workers have been diagnosed with silicosis (T.M.M.O., 2018). Although this dust-related disease is primarily observed in the mining and construction sectors, it is also frequently encountered in the ceramic industry.

The loss of workdays due to occupational health and safety issues accounts for 4% of the global gross domestic product (GDP) and up to 6% in some countries. On a sectoral basis, the highest number of occupational accidents occurs in the mining, construction, and manufacturing industries (Çalışma Güvenliği ve Sağlığı, 2022). Occupational health and safety involve identifying numerous workplace hazards, assessing the risks they may pose in the future, and implementing measures to eliminate or minimize these risks (Horozoğlu, 2017). The identification and classification of these risks can only be achieved through scientifically accepted methods and systematically collected data.

Risk assessment involves classifying risks and determining control measures to prevent hazards in the workplace or external threats that could become risks. The regulation issued under Article 78 of Labor Law No. 4857 defines risk assessment and methods, making it mandatory for businesses to implement these internationally accepted approaches (Özkılıç, 2005). Under this regulation, employers are required to conduct a risk assessment or have it carried out by authorized external professionals in compliance with Article 10 of Occupational Health and Safety Law No. 6331 (Demir and Demir, 2016).

Risk assessment can be performed using various methods such as Failure Mode and Effects Analysis (FMEA), Fine-Kinney method, Event Tree Analysis (ETA), L-Type Matrix Analysis Method, X-Type Matrix, Preliminary Hazard Analysis, Hazard and Operability Analysis (HAZOP), What-if Analysis, and Checklists (Yılmaz and Şenol, 2017). Among these, the Fine-Kinney method is one of the most commonly used techniques for risk assessment across different industries. Many researchers from various disciplines have also utilized this method in their academic studies.

Kahya et al. (2021) conducted a risk assessment study in the offices of a large-scale manufacturing company, examining 311 locations in 18 units and 7 types of workplaces where white-collar personnel work, and identifying 110 hazard control points. Using the Fine-Kinney method, they assessed risks for 1,199 hazardous conditions. Birgören (2017) summarized six major challenges encountered in scoring risk factors and interpreting risk levels in the Fine-Kinney risk analysis method, particularly questioning existing errors using probability theory.

In another study, Ersoy et al. (2019) integrated the Grey Relational Analysis (GRA) method, one of the multi-criteria decision-making methods, with the Fine-Kinney risk analysis method. Their findings suggest that this integrated approach can be used to solve occupational health and safety-related problems, and set priorities for improvement programs. Yavuz (2021) conducted a Fine-Kinney risk analysis in a food distribution company, identifying and analyzing 35 risks.

Mutlu (2021) used the Fine-Kinney methodology to assess risks in a mining quarry. The study found that noise in the crushing and screening facility had the highest risk score, and dust was also identified as a significant hazard category.

Regarding the ceramic industry, the number of studies on risk assessment in the literature remains limited. However, recent research aims to bridge this gap (Genç, 2021). Kayabaşı and Cündübeyoğlu (2022) conducted a Fine-Kinney risk analysis in the hotel, pumice, and ceramic industries, comparing total risk scores before and after implementing control measures. They reported an improvement rate of 85.98% for hotels, 86.44% for pumice businesses, and 84.97% for ceramic businesses after implementing control measures. Depending on the hazard source, corrective and preventive actions were found to be beneficial at rates ranging from 70% to 95%.

In another study conducted by the same researchers, the application of a preventive action plan in a Fine-Kinney risk assessment study resulted in risk reductions ranging from 50% to 90%, with an overall success rate of 86.40% when applied across all identified risks (Cündübeyoğlu and Kayabaşı, 2022). Similarly, Akdeniz (2016) conducted a Fine-Kinney risk assessment in three large-scale ceramic tile manufacturing plants, analyzing the distribution of existing risks based on process sections, levels, and hazard types.

In this study, risk factors in a ceramic factory, one of the high-risk industries with limited literature coverage, were analyzed using the Fine-Kinney method. The aim was to minimize potential accidents and risks in all sections of the facility.

Materials and Methods

Study Area

The study was conducted in a private ceramic factory operating in the Aegean Region, covering an area of approximately 60,000 m². The company, which has investments in various sectors, is particularly focused on tabletop presentation ceramics. With a monthly production capacity of approximately 5 million units, the facility is one of the leading producers in Türkiye and employs nearly 1,200 personnel. The factory, where ceramic production takes place, consists of various departments, including raw materials, model workshop, shaping, kilns, laboratory and R&D, design, glaze preparation, glazing, screen printing, quality control, packaging, and shipment.

Methodology

As part of the study, risks were identified according to different production departments within the factory and evaluated using the Fine-Kinney method.

Workplace Risk Assessment

When conducting a risk assessment in a workplace, the choice of evaluation methods is highly important. An incorrect selection can lead to financial, physical, and psychological damages in the work environment. Before starting the risk assessment, meetings should be held, and training should be provided regarding the analysis to be conducted in the workplace. All employees, along with members of the management team, should participate in these activities. In order to clearly define potential hazards and assess their associated risks, specific data is required, and the most reliable source of this data is the employees themselves (Özkılıç, 2005).

The most fundamental classification in risk assessment consists of quantitative and qualitative methods. Quantitative risk analysis evaluates risks using numerical methods, whereas qualitative risk analysis assigns numerical values to factors such as the likelihood of a hazard occurring. These values are then incorporated into the process using algebraic and logical methods to determine the risk level (Özkılıç, 2005).

In this study, the Fine-Kinney method was applied as a risk assessment analysis to identify potential hazards and risks in the ceramic factory. The Fine-Kinney method is named after its creator. Initially recommended and developed by W.T. Fine in 1971, this method was later revised and expanded in 1976 by two Americans, Kinney and Wiruth, at the Naval Weapons Center in California. Although the original study by Kinney and Wiruth may appear outdated compared to today’s standards, it remains a relevant reference in modern risk assessment studies (Birgören, 2017).

The Fine-Kinney method categorizes potential risk outcomes by severity. It aims to determine the extent of damage to humans, the workplace, and the environment in case of a hazard. This method is widely used due to its simplicity and its ability to incorporate numerical workplace data. Based on the calculations, the company's risk values are determined, and preventive measures are identified and prioritized according to their significance (Aytekin et al., 2015).

This method is based on three key measurement scales: Probability (P), Severity (S), and Frequency (F), and the degree of risk (R) is calculated using the empirical formula (Kinney ve Wiruth, 1976):

$R = \text{Probability (P)} \times \text{Severity (S)} \times \text{Frequency (F)}$

In the Fine-Kinney method, after calculating the probability, severity, and frequency values, the risk levels are determined based on the obtained results. Preventive action plans are then prepared and corrective measures are implemented according to the magnitude and impact of the risk score (Erol, 2021). One of the most critical stages of the Fine-Kinney method is identifying existing hazards in the workplace. Once the hazards are identified, they are evaluated using the Fine-Kinney risk method, and the risks are scored based on the probability, severity, and frequency values shown in Table 1 (Cündübeyoğlu and Kayabaşı, 2022).

Using the values in Table 1, the risk score is calculated in the final stage and evaluated (Table 2) (Ünsa, 2019).

Results and Discussion

The Fine-Kinney method was used for the risk assessment conducted in the ceramic factory. Risk scores were calculated for both the entire factory and its different sections to identify potential threats.

In the sample, a total of 36 risks across the factory were classified as top-priority risks requiring immediate action. Among these the highest risk score was 6,000, associated with "smoking and open flames in enclosed areas.

The second highest risk score was 4,000, related to high dust levels throughout the factory.

Two risk factors ranked third with a score of 1,800 each:

- Dented oxygen cylinders and the absence of cylinder carts and chains.
- Electric shock and fire hazards due to electrical short circuits.

Risk Assessment in the Mass Preparation and Mill Loading Area

In the sample taken from the mass preparation and mill loading area, a total of 9 intolerable risks were identified.

As a result of the assessment, the highest risk score was calculated as 1,440, with the most significant hazards being noisy environment and dust formation from raw material mixtures.

Risk Assessment in the Granule Preparation Section

In the sample taken from the granule preparation section, a total of 20 intolerable risks were identified as top-priority hazards.

The most critical hazards, with the highest risk score of 4,000, are:

- High noise levels caused by spray dryer fan motors, pneumatic pumps, and vibrating screens.
- Dusty and humid environment resulting from dust accumulation on belts and in the granule filling hopper during production.

Table 1. Chart of probability, frequency and severity.

d	Category	Frequency	Category	Severity	Category
10	Certain expected	10	Almost constantly (several times per hour)	100	Multiple fatal accidents / environmental catastrophe
6	highly likely	6	Frequent (once or several times per day)	40	Fatal accident / severe environmental damage
3	Likely	3	Occasionally (once or several times per week)	15	Permanent damage/injury, job loss / environmental obstruction, complaints from nearby areas
1	Possible but low	2	Infrequent (once or several times per month)	7	Significant damage/injury, need for external first aid / environmental damage beyond site boundaries
0,5	Not expected but possible	1	Rare (a few times per year)	3	Minor damage/injury, internal aid / limited environmental damage within site
0,2	Not expected	0,5	Very rare (once a year or less)	1	Near miss / no environmental damage

Table 2. Risk assessment results.

Risk score	Risk assessment
400<R	Intolerable Risk: Immediate necessary measures must be taken and/or the closure of the facility, building, or environment should be considered.
200<R<400	Substantial Risk: Must be improved in the short term (within a few months).
70<R<200	Significant Risk: Must be improved in the long term (within a year).
20<R<70	Possible Risk: Should be implemented under supervision.
R<20	Insignificant Risk: Precaution is not a priority.

Table 3. Risks in mass preparation and mill loading area.

Risk	Fine Kinney	Score	Score after correction
Open Platform Covers	Intolerable Risk	720	120
Rotating Parts in Belt and Pulley Systems	Intolerable Risk	720	120
Noisy Environment	Intolerable Risk	1440	120
Dust Formation from Raw Material Mixtures	Intolerable Risk	1440	120
Electrical Cables in Contact with Water	Intolerable Risk	720	120
Material Transport with Pallet Trucks (Transpalet)	Intolerable Risk	720	120
Insufficient Ventilation	Intolerable Risk	720	120
Elevators and Loading Belts	Intolerable Risk	720	40
Mud Splashing into the Eyes During Mill Ventilation	Intolerable Risk	540	40

Table 4. Risks in the granule preparation section.

Danger	Fine Kinney	Score	Score after correction	Danger	Fine Kinney	Score	Score after correction
Exposed Mechanical Parts of Mixers	Intolerable Risk	1440	120	Absence of Occupational Health and Safety (OHS) Usage Instructions	Intolerable Risk	900	45
Open Electrical Panels and Lack of Plastic Insulation	Intolerable Risk	480	40	Lack of Residual Current Circuit Breakers in Electrical Panels	Intolerable Risk	1440	120
Exposed Mechanical Parts of the Granule Conveyor Belt	Intolerable Risk	1440	120	Stacking with Rechargeable Electric Pallet Trucks	Intolerable Risk	1440	120
Inadequate Lighting	Intolerable Risk	720	120	Dusty and Humid Environment	Intolerable Risk	4000	120
Improper Stacking of Big Bags	Intolerable Risk	1440	120	Accumulation of Static Electricity	Intolerable Risk	1440	120
Welding Operations for Maintenance and Repair	Intolerable Risk	1800	100	Absence of Emergency Exit Direction Signs	Intolerable Risk	720	60
Failure to Inspect Natural Gas Valves	Intolerable Risk	3000	150	High Noise Levels	Intolerable Risk	4000	120
Presence of Inappropriate Fire Extinguishers	Intolerable Risk	720	60	Lack of Personal Protective Equipment (PPE) and Workwear	Intolerable Risk	540	45
Insufficient Occupational Safety Warning Signs	Intolerable Risk	540	45	Absence of Handrails on Stairs	Intolerable Risk	720	120
Malfunctioning Emergency Stop Switches on Machines	Intolerable Risk	1440	120	Physical Risk Factors	Intolerable Risk	1440	60

Table 5. Risks in packaging department.

Danger	Fine Kinney	Score	Score after correction
The cardboard, paper, and adhesives used in packaging causing a fire.	Intolerable Risk	600	100
Irregular and non-compliant stacking.	Intolerable Risk	720	40
Foot entrapment during pallet jack use.	Intolerable Risk	540	60

Table 6. Risks in glaze preparation department.

Danger	Fine Kinney	Score	Score after correction
Entering underneath the mill while it is operating	Intolerable Risk	1800	50
Sparks splashing into the eye from sieves	Intolerable Risk	900	45
Intervening while the silo is being mixed in high-speed mixers	Intolerable Risk	720	45
Foot entrapment while operating a manual forklift	Intolerable Risk	450	45
Dust formation during the loading of minerals into the mill	Intolerable Risk	2400	120
Open electrical panels and the absence of an insulating mat	Intolerable Risk	3600	50

Among the assessed risks, another high-risk hazard was identified as the presence of flammable and combustible materials during welding operations. As a corrective action, it was ensured that no flammable or combustible materials were present in the designated area during maintenance, as required by regulations. As a result of this corrective measure, the risk score was reduced to 100, lowering it to a significant risk level.

Packaging Department Risk Assessment

The sample created in the packaging department includes three hazards that are intolerable and require immediate preventive measures.

The first intolerable risk identified in packaging is the fire hazard caused by the cardboard, paper, and adhesives used in packaging. The materials used during packaging processes directly contribute to fire hazards. Additionally, the presence of large quantities of paper, adhesives, and similar materials in the workspace necessitates immediate preventive measures. Risk assessment scoring has determined a value of 600 for this hazard.

As a corrective action, fire extinguishers must remain unobstructed, and personnel must receive fire safety training. Furthermore, emergency exit routes must be kept clear, and warning signs should be placed in the working area. After implementing these corrective actions, the risk score was reduced to 100, mitigating the significant hazard.

The second hazard was identified as irregular and non-compliant stacking. The risk assessment score for this hazard was calculated as 720. Corrective measures include providing training to personnel on proper stacking techniques and ensuring that storage racks are systematically arranged and secure.

Another critical issue requiring urgent action in the packaging department is foot injuries caused by pallet truck operations. The risk assessment score for this hazard was calculated as 540. To mitigate this risk, corrective actions include providing employees with steel-toe safety shoes, ensuring that they exercise extra caution in confined spaces, and conducting hands-on training on the proper use of pallet trucks. Following the implementation of these measures, the risk score was reduced to 60, bringing the hazard level down to an acceptable risk.

Glaze Preparation Department Risk Assessment

In the sample conducted in the glaze preparation department, a total of six intolerable risks were identified. The highest risk score was 3,600, attributed to open electrical panels and the absence of an insulating mat.

As a corrective measure, electrical panel covers must remain closed and should only be accessible to authorized personnel. Additionally, rubber insulating mats should be placed in front of the panels, and warning signs must be installed in the working area. Following the implementation of these corrective actions, the revised risk score was reduced to 50, lowering the hazard to an acceptable risk level.

Conclusion

The ceramic manufacturing industry is classified as a highly hazardous sector. In such an environment, workplace accidents and risk factors must be carefully assessed to ensure the safety of both the facility and its employees.

For risk analysis and assessments conducted in the ceramic factory, the Fine-Kinney risk analysis method was applied. The key results of the risk assessment are summarized below.

A total of 150 risk assessments were conducted throughout the factory. Among these:

- 104 risks were classified as 1st-degree risks,
- 37 risks as 2nd-degree risks,
- 9 risks as 3rd-degree risks.
- Following the implementation of corrective actions:
- 84 risks were reduced to 3rd-priority risks,
- 67 risks to 4th-priority risks,
- 3 risks to 5th-priority risks.

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