Identifying, Assessment and Prioritization of the Existing or Potential Hazards in the Automotive Industry by Combining Three Methods: FMEA, Wiliam Fine and AHP

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Abstract

Aim: Every year, a huge number of incidents of irreparable damage to personnel and industries occur, most of which are predictable with identifying hazards as well as risk assessment and control. Therefore, in order to prevent occupational accidents, the automotive industry is one of the top priorities for evaluating and identifying the hazards.

Methods: The purpose of this study is to identify, control and rank the hazards of actions and processes in the hazardous automotive industry. This descriptive-analytical study was carried out in 2017 in one unit of Iran Khodro Company by using FMEA method. Also to accurately assess the health risks and make decisions for corrective actions to prioritize hazard risks, Wiliam Fine and AHP (Analytical Hierarchy Process) methods were used, respectively.

Findings: In this research, a list of 301 risks in 7 units including cutting line, assembly line, prototyping and modification, manufacturing, packaging, quality control, laboratory, and repair and maintenance were provided. The results of FMEA method indicated that the highest risk priority number (RPN) is related to the risks of particle swirling in grinding operations (336). Moreover, based on the results of William Fine method, the exposure to noise in the Kissing & Wessich Sersim Strandbauft operation was rated at 540 and 500, respectively, with the highest risk of evaluation. The risk of exposure to noise (Kicking operation) with a relative weight of 0/1904 was ranked the first.

Conclusion: The results of the hazard analysis showed that the effect of noise pollution that leads to hearing impairment in the staff is very high.

Keywords: Automotive industry, William Fine method, Noise exposure

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Introduction

Since the early 1970s, along with the expansion of the automotive industry in Iran, a major part of the material and spiritual capital of the country has been used in the automotive industry [1]. It is considered as a major industry that includes various units of work, such as production lines, quality control, repairs and maintenance, etc., and based on the nature of activities, unsafe acts, unsafe conditions, technological advances, increasing use of diverse machines, and existence of a variety of harmful factors. Hygienic, risk-taking trends and the probability of occupational accidents in the industry are increasing.

There are a lot of incidents of irreparable damage to personnel and industries occurring every year throughout the word including Iran, most of which are predictable through hazard identification and assessment and risk control [2]. Therefore, in order to prevent occupational accidents in the automotive industry, assessment and identification of hazards form priority. Risk assessment is considered to be the most important part of the health and safety management system, whose purpose is to identify, assess, and the control existing work environment hazards that may affect the health and safety of employees [3]. Risk assessment in the management of activities and its risks is well accepted in various industries [4]. There are different ways of identifying risks, given the complexity of the system, process type, location, staff experience and expertise of team members [5].

Nori (2010) used FMEA technique and integrated it with AHP method to assess the risk of a gas station [6]. In 2010, FMEA and AHP methods were used to assess the risk of fire at the gas station in Tehran [7]. In the study of Rezvashani et al., 154 risks in the casting industry were identified using FMEA method; 26% of these risks were in an unfavorable situation [8]. In Iran, the background to using William Fine method is not to identify, classify, and analyze the hazards of the old industrial units. But the following examples can be noted: Anvari (2012) using William Fein's approach assessed the cost-effectiveness of controlling the damage caused by accidents. A study by Heydari in the oil and gas industry conducted by William Fine method introduced the highest identified exposure to chemical substances [9]. Smoskey used William Fine method to assess the risk of the Russian Railways and Varnere railway line production lines in order to assess the risk of the WFP pipe plant, all of which showed that this method is a suitable tool for identifying hazards [10]. Shahraki used William Fine and FMEA methodologies in assessing safety and health hazards in different units of the manufacturing process [11].

Investigating the factors and identifying the emerging and hazardous points in automobile units are very important in preventing the potential accidents. Risks in this industry can have negative or positive effects on the goals of the organization. The outcomes of these events will directly affect the organization's time, cost, and quality. Therefore, identifying the risk and determining the extent of its positive and negative consequences on the organization's goals are of particular importance. The purpose of this study is to identify, control and rank the hazards of the activities and processes in the automotive industry.

Materials and Methods

This descriptive-analytical study was carried out in one of the parts of Iran Khodro Company using a Fracture Factor Analysis Method in 2017.

Sabzevar Kabul Automobile Company is a subsidiary company of Automobile Parts Group of Iran (Public Joint Stock Company) and the main business unit of Iran Khodro Industrial Group. Sabzevar Kabul Automobile Company is one of the companies involved in the manufacture of automotive parts in the design and production of all types of cables. Controls, Lifting Glasses, CNG Kits and Wiper Blades have been in operation since 1985.

In this research, identification of hazards was done by reviewing the related documents and records, holding hurricane sessions and using the knowledge and experience of occupational health and industrial safety experts.

The method of analyzing the failure factors has been introduced to the most authoritative risk analysis techniques [12]. This technique was first used by the US military in 1949 [13]. Then it used in the 1960s in the American air and space industry and later on by the atomic institutes in the 1970s and 1980s [14].

In FMEA method, after risk assessment, the risk estimation is performed by calculating the risk priority number (RPN) for each potential error condition and its effect. This variable is calculated by multiplying the three factors of the intensity of the effect (S), the probability of occurrence (O), the ability to detect the error (D) as follows:

$$RPN = S \times O \times D$$

These three factors are graded from scale one to ten. The risk priority number is the basis for prioritizing the failure scenarios. Given that the above three factors can hold numbers between 1 and 10, RPN will have a digit between 1 and 1000.

In order to decide on the determination of the risk level, RPN is defined at three acceptable, tolerable, non-tolerable levels (Table 1).

Table 1: Risk classification based on acceptance rate

Risk classification	Risk level
Acceptable	0-150
Tolerable	150-300
Intolerable	300-1000

Wiliam Fine method was used to accurately assess the health risks, decision making and prioritization of corrective action hazards according to the degree of risk. In this method, first, the outcome of the hazard, the probability rating, and the ranking of the call volume of each activity are determined. The implementation and implementation of this method requires the collaboration of the HSE ad hoc committee to identify and evaluate the risks. The hazard (R) has been calculated using the following equation:

$R = P \times C \times E$

Where, P is the score obtained from the probability rating table, C is the score obtained from the scoreboard, and E is the score from the inter-tabulation table. The rankings of the level of identified risks were performed, and the corrective actions that should be carried out in the stage of risk management and control were identified.

The most effective decision-making technique of Analytical Hierarchy Process (AHP) was first proposed by Thomas La Sacity in 1980.

A hierarchical analysis process can be used when decision-making practice with multiple competing choices and decision criteria can be applied. The basis of this method lies in the decision of the paired comparison. The decision maker begins with the process of bringing the hierarchical tree to the decision. The tree of the decision hierarchy is designed, the factors are compared, and the competing choices are evaluated in the decision. Then a series of pairwise comparisons are performed. The frequency criteria, the imposed cost, the severity of the outcome, and the potential for elimination are compared and weighed. The weighting of each of the factors is shown in Table 2 in line with the competing choices being evaluated in the decision. Finally, the logic of the hierarchical analysis process combines the matrices derived from the paired comparison to make the optimal decision.

Table 2: Degree of importance scale for a pair comparison in AHP

Value	Degree
Extremely preferred	9
Very strongly preferred	7
Strongly preferred	5
Moderately preferred	3
Equally preferred	1
Preferences between intervals	2-8-6-4

Findings

In this study, using a review of documentation and records, holding hurricane sessions and using the experience of occupational health and industrial safety experts, a list of 301 hazards in 7 units, including cutting line, assembly line, prototyping and modification, piecework, packaging, quality control, labs, repairs and supplies was prepared.

The most identified hazards are exposure to noise, flammable particles, muscular pressure, inhalation of smoke and fumes, and exposure to radiation.

According to FMEA method, the risks were first identified, and then their risk priority number was calculated. The highest RPNs were for particle loading risks in grinding operation (336), inhalation of welding fume (288) and muscular pressure ankle (288), respectively.

In Wiliam Fine method, the identified risks resulting from the company's activities were ranked by high risk, medium, low and high risk levels for making the decision to prioritize corrective actions. Exposure to noise in Kissing and Wright Sersme Strandbacht operations had the highest level of risk assessment with 540 and 500 risk scores, respectively. Among the identified risks, 41.75% (227 cases) ranked 0-89 and 24.18% (74 cases) ranked 90-199. The risks with the highest score in the company are shown in Table 3.

Table 3: Dangers identified in Wiliam Fine method

Number	Danger	Condition			
		Consequence	Contact	Probability of occurrence	Risk
1	Exposure to noise (Kitsing operation)	15	6	6	540
2	Noise exposure (Cord switch)	5	10	10	500
3	Exposure to noise (Carpastrand texture process)	15	6	3	270
4	Particle throw (Saws)	5	6	6	180
5	Collision of particles with skin	5	6	6	180
6	Finger entrapment	5	6	6	180
7	Exposure to noise (Fogging)	5	6	6	180
8	Contact of grease with skin	5	6	6	180
9	Inhalation of metal dome	5	6	6	180
10	Exposure to radiation	5	6	6	180

Then a hierarchical analysis process technique was used to evaluate and rank the hazards. At first, four criteria were selected. The weight of each criterion was then determined. In the next step, a comparison was made between the 10 basic hazards identified by FMEA and Wiliam Fine methods based on the criteria. In the final stage, priority was given to hazards. The results showed that the risk of exposure to noise (Kitsing operation) with a relative weight of 0/1904 was ranked first, and the risks of exposure to head and noise (Cord switch) and exposure to noise (Carpastrand texture process) with the relative weights of 0/1638, 0/1515 were ranked second and third, respectively (Table 4).

Table 4: Assessment and prioritization of the major risks of AHP industry

Number	Dangers	Relative weight	Priority
1	Pouring particles into grinding operations	0/1185	5
2	Inhalation of welding fumes	0/1395	4
3	Muscular muscle spasm	0/0796	6
4	Exposure to welding radiation	0/0309	10
5	Musculoskeletal pressure in displacement	0/0438	8
6	Exposure to noise (Kitsing operation)	0/1904	1
7	Noise exposure (Cord switch)	0/1638	2
8	Exposure to noise (Carpastrand texture process)	0/1515	3
9	Particle throw (Saws)	0/0479	7
10	Collision of particles with skin	0/0405	9

Discussion

Development and improvement of the automobile industry in the country, existence of risks, and lack of risks assessment of industrial hazards all necessitated the present research; however, due to the limited risk assessment in the automotive industry in Iran, the possibility of comparing results with a similar research was limited.

In Gholami's study, examining the risk of dangers of the plastics company using the JSA and Wiliam Fine method, the highest risk is for hand gripping under the machine. In 2011, Joanne introduced one of the highest risk of particles, which is in line with current research [15]. In the Halvani study, the most identified risk were in the production line. In the Khohnavard study, the hazards of the foam company using the method of William Fine, the highest number of risk associated with air pollution, muscular and muscular pressure identified and evaluated that is compliance with the present study.

In the investigation of work-related accidents, Mehrparvar referred to the use of equipment as one of the main reasons for the occurrence of occupational accidents. The results of this study suggested paying due attention to training workers, observing safety tips and using appropriate personal protective equipment, especially in high risk industries, which is consistent with the present study [16].

The reasons for the exposure of employees to the noise of the work environment were the use of high-quality knife switches, manual cutting, grinding, texting, textured strand, the Irmaf and Irplag handhelds by the staff, and the lack of adequate training of the staff.

As the results showed, the prioritization of hazards is different in FMEA and Wiliam Fine methods. Therefore, in risk assessment, one of the most important problems is a different judgment on the risk outcomes that needs to be addressed.

In this research, AHP was used to minimize the effects of judgments of individuals on how to evaluate risk [17]. In addition, the use of decision making methods to prevent the impact of individual assessment on risk management decision making and prioritization can be used. In this relationship, Singh emphasizes the use of decision-making methods in risk assessment and management [18, 19].

Conclusion

The results of the hazard analysis showed that the effects of noise pollution leading to hearing impairments in the staff are very high. The sound gain in the environment, the annoying sound and the vibrations caused by the machinery and hoods and local suction are among these. There is, therefore, the likelihood of a person having hearing impairment, increased heart rate, increased respiratory rate, high oxygen intake, high blood pressure, disorder in the brain activity, mismatches of thought, nausea, vomiting, and dizziness. Hence, corrective measures should be provided.

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