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ORIGINAL ARTICLE

Safety Risk Management of Automaker Industries Using Combination of Fuzzy FMEA and Vikor (Case Study: Pre-Paint Hall of Iran-Khodro Company)

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ABSTRACT

Human resources as the most important factor in the production and service have always been threatened by several factors. Among them, work-induced accidents are of the most important. Safety risk management plays an important role in reduction of their effectiveness. The purpose of this study is assessment and management of safety risk in automaker industries. This present study was carried out in pre-paint hall of Iran-Khodro Company (surface preparation process). In this regard, FUZZY FMEA method and VIKOR technique were applied to assess the potential detected failure modes and to prioritize corrective actions, as well as representation of appropriate solutions, respectively. Team of HSE experts included 15 persons were used for weighting and prioritizing corrective actions, criteria and scoring of risk factors. The result showed that 6 activities with the risk of “Electric shock”, “Collisions with objects and fire” and “Fire and Explosive” were identified in high level safety risks. Finally, some corrective actions likes “Using of insulation equipment, gloves and flooring”, “General safety training”, “Periodic visit of fire alarm” were used for management of the risks.

KEYWORDS: *Risk management, Safety risk, VIKOR technique, FUZZY FMEA, Automaker industries*

INTRODUCTION

During the modern era, along with the rapid development of industry and technology, many concerns about the associated adverse consequences, threaten human life (Craddock, 1997). Human resources as the most important factor in the production and service have always been threatened by several factors. Amongst them, work-induced accidents are of the most important (Arji, 1392). Some factors, such as human errors, excessive confidence in the safety of facilities, error of design, lack of preparation in critical condition and in less developed countries, non-compliance with HSE standards in technology transfer are considered as the major causes

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of accidents (Mearns, et al., 2001: Jozi and Atae, 2013).

Automotive industries, affect considerable adverse effects on employed work force, due to the use of heavy machinery, their diversity and governmental management policies in terms of number of cars produced per hour, remarkable labors employed, scheduling work cycles, etc. Unsafe condition can lead to accidents and injury to human, property, interruption in production and etc. Obviously, remove the risks completely is not possible, but they can be defined and known in a qualitative and quantitative method. Risk assessment as a systematic identification of potential risks in the workplace is to be considered as the first measure to control possible risks (Lee and Rieman, 2009).

Failure modes and effects analysis or FMEA was used for the first time in 1950 in an airline to assess the system safety and reliability analysis (Aaserud et al., 2001). This technique is applied to identify, assess, prevent, control or eliminate modes, the causes and effects of potential failures in a system, process, plan or service, before the final product reaches to the customer (Xu et al., 2002). Nowadays, studied method is widely used in automotive, aerospace and electronics industries to identify, prioritize, eliminate or reduce the potential failure modes in a system (Kumru et al., 2013).

These fundamental weaknesses of FMEA method are defined as below:

FMEA input variables values are often obtained from teamwork experiences and judgment of experts. However, sometimes due to errors, contradictions, uncertainty and ambiguity in their judgment, risk assessment using following index and in this manner seems to be insufficient (Kumru et al., 2013). Also, Different combinations of variables "Occurrence, Severity, Detection" can lead to produce the same values for failure modes, whereas, failure modes with similar RPN may have completely different risk definitions (Zang et al., 2011).

Due to problems, as well as inefficiency of traditional FMEA approach, many researches were carried out in order to develop and improve its performance (Wang et al, 2009). Some researchers attempted to improve this method (Spath, 2003). Wang et al, (2009) conducted risk assessments using Fuzzy FMEA with weighted geometric mean to overcome the limitations of traditional FMEA method. Sharma et al, (2008) designed a Fuzzy logic based decision support system for FMEA. This system had 384 if-then regulations which facilitate its use for inexperienced users. Tay and Lim (2006) suggested a general model to reduce the number of Fuzzy if-then regulations. They implemented the results of this model in a semiconductor parts fabrication factory and defined a weight, based on its importance to each Fuzzy regulation. Pillay and Wang (2003) in a new approach, simultaneously used Fuzzy regulations for FMEA.

In addition to these mentioned papers, other researches were published where Fuzzy FMEA was used as a method to solve the problem (Kumuru et al., 2013). Abdelgawand and Fayak (2010) represented a risk management system in construction industry using combination of FMEA and Fuzyy AHP. Chin et al., (2008) developed a product design system based on Fuzzy FMEA. Moreover, Guimar and Lapa (2004) applied the similar method to assess risk in a volume control system. Xu et al., (2002), profited Fuzzy FMEA to assess Diesel motor system in cars and Yeh and M-H (2007) used it in wastewater system assessment. In other hand, Hu et al., (2009) used Fuzzy FMEA to risk assessment in production of pieces called as Green pieces which are considered dangerous based on Europe union regulations.

Vikor method was first represented in 1998 and developed in 2002 (Opricovic and Tzeng, 2002). In 2012, Liu and colleagues used VIKOR to analyze potential failure modes in Fuzzy mode (Liu et al., 2012).

This technique was introduced for optimization multi-criteria problems in complex systems (Ekhtiari, 2012). VIKOR is a Multi Criteria Decision Making method for solving a discrete decision making problem with inappropriate criteria of different measurement units by Opricovic and Tzeng in 2004. (Amiri, 2007).

This technique was used in selection of ideal alternative. So that, Wei and Xiangyi in 2008 were used it as a method in ranking and selecting the best alternative in planning.

This study has been conducted in response to the question of "what is the most efficient compromise solution in order to reduction of safety risk in automaker industries? Given the issues raised, the main purpose of this study, is "Management and assessment of safety risk of pre-painted Hall of IKCO"

Iran-Khodro Industrial Group is located at Km 14 of Karaj highway where production factories and principal activity center is established at the core of the enterprise. The company, stretched in an area of 3375613 m^{2}, is composed of eight production halls as follows: press hall, body hall, paint hall, iron and aluminum casting hall, motor hall, gearbox hall, axle hall and decorating hall.

Of the most important parts of Iran-Khodro company that could have lots of risks on human resources, is paint hall (including pre-paint hall and paint hall). In this hall, various processes will be conducted in order to paint the body correctly. In this section, Pre Treatment process, carried out in pre-paint hall, is the first process that consists of four main stages (degreasing, the phosphate and washing with deionized water). Then electro Deposition step is started to spray the paint in an electrochemical manner on the body. After all these processes conducted, the quality of paint and process conduction is controlled (Iran-Khodro Company, 2015).

This study is descriptive-solving model in terms of method and is functional in terms of the objective. The present research was done in two steps that shown in (figure 1).

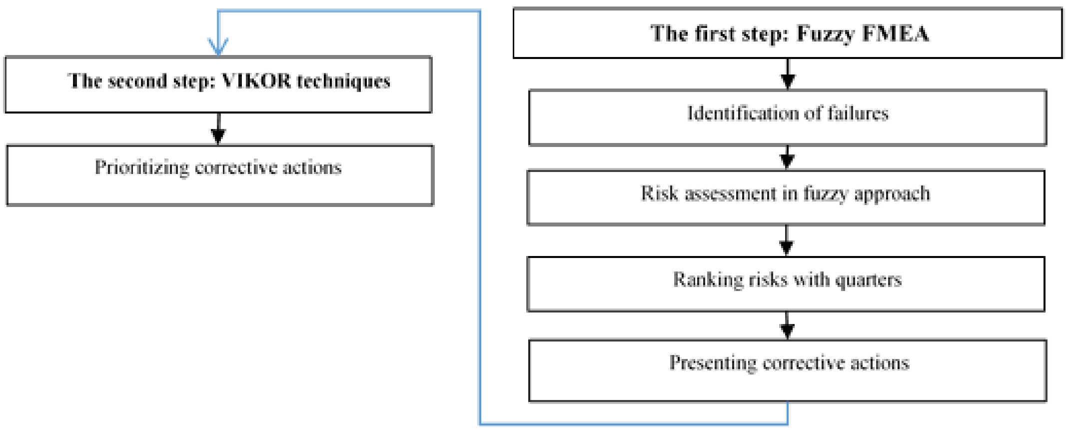

Fig 1. The main step of this study

The first step: Fuzzy FMEA

After literatures reviewing, visiting the process, interviewing with HSE responsible and employees of the pre-paint hall, and using of Delphi technique, potential failure modes and the consequences were identified.

Expert teams included 15 persons of HSE unit (according to Morgan table) who were people with at least 5 years of experience in automaker industries and familiarity with the surface preparation process and also who has a bachelor's degree in the field of HSE and safety.

In this regard, safety risk assessment factors were classified in Iran-Khodro Company with respect to the current situation, in four categories, including severity (S), the Extent of the risk (E), the Occurrence of the risk (O) and Detection of the risk (D).

- Occurrence: Risk occurrences within a specified period
- Extent: Risk domain or the number of risk centers
- Severity: Degree of injuries due to the risk
- Detection: The probability of facility or difficulty of risk identification

These factors were defined by linguistic values and then converted to crisp numbers. Then, using of some hypothesizes and MATLAB software were fuzzified. In this regard, the triangular membership functions were used. The hypothesis are as follows:

- Severity number is classified into eight categories from Fuzzy number (2, 0, 0), which represents no risk to Fuzzy number (10, 10, 8), which represents dangerous
- Occurrence Number is classified into six categories from Fuzzy number (2, 0, 0), which represents unlikely to Fuzzy number (10, 10, 8), which represents too much.
- Extent Number is classified into six categories from Fuzzy number (2, 0, 0) which represents the level of inside the activity place and Fuzzy number (10, 10, 9) which represents the outside of the company.
- Detection Number is classified into six categories from Fuzzy number (2, 0, 0) which represents safe and Fuzzy number (10, 10, 9) which represents no risk.

It is worth nothing that for definition of these hypothesis used some references (Kutlu & Ekmekcioglu., 2012; Liu, et al., 2011; Kumuru et al., 2013)

Results of applying triangular membership functions are described in Table 1. Assumptions provided by expert workgroup are as follows:

Table 1. Safety risk assessment fuzzified criteria

Detection		Extent		Occurrence		Severity		Definite number
Description	Triangular Number	Description	Triangular Number	Description	Triangular Number	description	Triangular Number	
Safe	(٢، ٠، ٠)	Work station	(٢، ٠، ٠)	unlikely	(٢، ٠، ٠)	No	(٢، ٠، ٠)	١
Probable	(٤/٤، ٣، ٢/٧)	One-line	(٤/٤، ٣، ٢/٧)	Low	(٤/٤، ٣، ٢/٤)	Low	(٣/٧، ٢/١، ١/٧)	٢
Medium	(٦، ٥، ٤/٥)	Multi-line	(٦، ٥، ٤/٥)	Medium	(٦، ٥، ٤)	Medium	(٦، ٥، ٤)	٣
Low	(٧/٦، ٧، ٦/٣)	Hall	(٧/٦، ٧، ٦/٣)	Much	(٧/٦، ٧، ٥/٦)	much	(٨/٣، ٧/٩، ٦/٢)	٤
No	(١٠، ١٠، ٩)	Inside company	(١٠، ١٠، ٩)	Very much	(١٠، ١٠، ٨)	dangerous	(١٠، ١٠، ٨)	٥

After safety risk assessment in Fuzzy Logic, RPN numbers were defuzzied, based on Equation 1.

$$Merits\ (M) = \frac{w1(a) + w2(b) + w3(c)}{w1 + w2 + w3} \quad (1)$$

Given weights were considered based on the probability of occurrence and the suggestion of Nosrati Nahook and Eftekhari (2013) for numbers a, b and c considered 1, 4 and 1, respectively, (Nahook and Eftekhari, 2013).

Then, identified risks classes were classified based on the analysis in Excel 2010 into four categories (high, medium, low and very low). To do this, the first, second and third quarters were calculated. The classification of risk level was shown in Table 2:

Table 2: Classification of risk levels

Risks classification	Risk domains
VL	$X \leq 8$
L	$8 < X \leq 17.1$
M	$8 < X \leq 17.1$
H	$X > 24.3$

The second step: Vikor method

Prioritizing corrective actions based on VIKOR technique was done and finally a compromise strategy was presented. To perform this procedure, six criteria were identified based on expert opinion and prepare a screening questionnaire to prioritize corrective actions. Its validity and reliability was calculates by expert consensus and Cronbach's alpha coefficient respectively. Then, Shannon entropy method was used for weighting the criteria. Shannon entropy method steps are as follows:

Pij Calculation

$$P_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \quad (2)$$

Identification of entropy for each criterion

$$E_j = -\frac{1}{Ln(m)} \sum_{i=1}^{m} P_{ij} Ln(P_{ij}) \quad (3)$$

M= the number of alternatives (in this study is equivalent to 15 experts)

Identification of unreliability or standard deviation for each criteria (d)

$$d_j = 1 - E_j \quad (4)$$

Determination of weight for each criteria (Wj)

$$W_j = \frac{d_j}{\sum_{j=1}^{n} d_j} \quad (5)$$

In the next step, the decision making matrix using a 5-point Likert spectrum and surveys of experts (according to criteria to assess the importance of alternatives) was prepared and eventually VIKOR technique was conducted as follows:

Evolution of VIKOR technique starts with following LP form:

$$1 \le p \le \infty, j = 1,2,...j \qquad L_{pj} = \left\{ \sum_{i=1}^{n} \left[w_i (f_i^* - f_{ij}) / (f_i^* - f_i^-) \right]^p \right\}^{1/p}$$

(6)

Descaling, in order to normalization of decision making matrix (Mohanty and Mahapatra, 2014)

Xij* = Xij / (Xij MAX)

for positive criteria (7)

Xij* = (Xij MIN) / Xij

for negative criteria (8)

- Determine the best and the worst values of all criterion ratings, j=1,2,…,n

$$f_j^* = Max\ f_{ij} \quad , i = 1,2,..., m$$
$$f_j^- = Min\ f_{ij}, j = 1,2,..., n$$

(9)

- Compute the values Si and Ri, i=1,2,…,m, by the relations

$$S_i = \sum_{j=1}^{n} \frac{w_j (f_j^* - x_{ij})}{f_j^* - f_j^-},$$

(10)

$$R_i = \max_i \left(\frac{w_j (f_j^* - x_{ij})}{f_j^* - f_j^-} \right).$$

(11)

Where, wj is the weights of criteria, expressing their relative importance.

- Compute the clause Qi, i=1,2,…,m, by relation

$$Q_i = v \left[\frac{S_i - S^*}{S^- - S^*} \right] + (1 - v) \left[\frac{R_i - R^*}{R^- - R^*} \right]$$

(12)

Where,

$S^* = \min_i S_i, S^- = \max_i S_i, R^* = \min_i R_i, R^- = \max_i R_i$

and υ is introduced as a weight for the strategy of maximum group utility, whereas $1 - \upsilon$ is the weight of the individual regret. The value of υ is set to 0.5 in this study.

- Rank the alternatives $\left(A^{('')}\right)$, sorting by the values S, R and Q in ascending order. The results are three ranking lists.
- Propose as a compromise solution the alternative which is the best ranked by the measure Q (minimum) if the following two conditions are satisfied.

C1: Acceptable advantage: $Q\left(A^{(')}\right) - Q\left(A^{('')}\right) \ge DQ$ where $A^{(')}$ is the alternative with second position in the ranking list by Q $DQ = 1/(m-1)$.

C2: Acceptable stability in decision making: The alternative $A^{('')}$ must also be the best ranked by S or/and R. This compromise solution is stable within a decision making process, which could be the strategy of maximum group utility (when $\upsilon > 0.5$ is needed), or ‘‘by consensus” $\upsilon \approx 0.5$, or ‘‘with veto” $(\upsilon < 0.5)$. Here, υ is the weight of decision making strategy of maximum group utility.

✓ Alternatives $A^{('')}$ and $A^{(')}$ if only the condition C2 is not satisfied,

Or

- ✓ Alternatives $A^{('')}, A^{(')}, ..., A^{(M)}$ if the condition C1 is not satisfied; $A^{(M)}$ is determined by the relation $Q\left(A^{(M)}\right) - Q\left(A^{('')}\right) < DQ$ for maximum M (the positions of these alternatives are ‘‘in closeness”) (Liu et al, 2012)

RESULTS

After visiting the paint preparation process in pre-paint hall, interviewing with responsibilities, workers in each part of the process, HSE unit and investigation of HSE unit documents, all activities, risks and their consequences were identified and coded (Table 3)

Table 3. All identified activities and their consequences

Coding	consequences	Risks	activities	Activity implementation place	definitions
1Ca	Injury to human resources	Fall of a non-aligned surface	Body hanging on hangers and separation the body from the air hangers	reception and discharge the body	In this step, the body is laid on the lift of the pre-paint hall entrance. Hangers' shoulders picking up the body from the bottom part and discharge it on Line F1.
1Cb	Injury to human resources and resources destruction	Fall of objects			
1Cc	Injury to human resources	Collision to the objects			
1Cd	Injury to human resources	Entrapment between two objects			
2Aa	Injury to human resources	Collision to the objects	Hook installation	entrance to hooking up (F2)	After third rinsing and phosphate stabilizer by hook, the body enters to line F3 (this line is used to buffering or turning the used body)
2Ab	Injury to human resources	Fall into a aligned surfaceز			
2Ac	Injury to human resources	Entrapment between two objects			
3Ba	Injury to human resources	Collision of particles	primary washing of the body with water jet device	Pre-cleaning	In this step, the body is passed from a tank and washed manual or by a water jet.
11Aa	Injury to human resources	Fall of objects	Replacement of the dishes contained chemical matters using lift track and pallet track	Logistic of chemical matters in phase 1	Dishes containing chemical materials and paint are transmitted using lift track and pallet track-charging the pallet track is done using electric power
11Ab	Injury to human resources	Accident			
11Ba	Injury to human resources	Electric shock	charging the electric pallet track		
12Aa	Injury to human resources	Collision of objects	charging PT and ED materials	PT and ED	
12Ab	Injury to human resources	Contact with chemical materials			
15Aa	Injury to human resources	Fire			Some layers are coated with a steel

15Ab	Injury to human resources	Electric shock	giving high voltage to body	Cathode paint laver	plate and connected to high voltage trans which cause implementation painting the body. Finally, they transmitted to line F16 to implement buffer operation.
15Ba	Injury to human resources	Entrapment between two objects	Body transfer to the F١٦ (Heber)		
15Bb	Injury to human resources	Fall of objects			
16Aa	Injury to human resources	Collision of objects	transmission of the tanks containing paint and thinner to circulation	Paint circulation	In this step, tanks containing paint are transmitted to circulation pump and pumped out to body. Ultimately, wasted thinner is discharged and applied in a returned flow. At the final step, tanks are washed.
16Ba	Injury to human resources	Contact with chemical materials	Pump outing the thinner and discharge of returned thinner from system as well as discharge of waste thinner		
16Bb	Injury to human resources	Collision of objects Fire			
16Aa	Injury to human resources and resources destruction	Collision of objects			
16Da	Injury to human resources	Explosion	Preparation and pump out the paint in the circulation tanks and washing the tanks		
16Db	Injury to human resources	Contact with chemical materials			

Table 4. High level risks

RPN	Consequences	Risks	Activity	Coding
64.5	Injury to human resource	Electric shock	Giving Strong voltage to the body	15 Ab
40	Injury to human resource	Fire	Giving Strong voltage to the body	15 Aa
40	Injury to human resource	Explosion	Circulation	16 Ca
40	Injury to human resource	Explosion	Preparation and pump out the paint in the circulation tank and washing the tanks, as well	16 Da
38.7	Injury to human resource	Collision with objects	Preparation and pump out the paint in the circulation tank and washing the tanks, as well	16 DC
29.3	Injury to human resource	Electric shock	Charging electric pallet tract	11Ba

Based on the provided classification, High level risks (H), were determined according to Table 4.

In relation to the risk of electric shock, fire and explosions and collisions with objects, many corrective actions can be taken into account and in the present study, the most appropriate one was determined using VIKOR technique. In this regard, considered some criteria and finally weighted with Shaanon entropy (table 5).

A: Safety of corrective action
B: Facility in applying the corrective action
C: Personnel satisfaction
D: Cost of investment and implementation
E: Efficiency in risk control
F: Persistence and duration of the effect

Table 5. Weighting to criteria using Shannon Entropy method

F	E	D	C	B	A	Index
0.168	0.169	0.168	0.163	0.168	0.168	*W*

According to the above-mentioned Tables, the criterion of "efficiency in risk control", with Total weight of 0.169 was identified as the most important corrective action criterion. Afterwards, "safety of corrective action" and "persistence and duration of effect" with final weights of 0.168 are less important.

To manage any identified risks, appropriate corrective actions were selected for each risks (Table 6).

Table 6. Corrective actions (alternatives) appropriate for each identified risks

Corrective actions determined to prevent Fire and explosion	Corrective actions determined to prevent collision to objects	Corrective actions determined to prevent electric shock occurrence	Number
safety training, use of isolation clothes and alarms signs	Assurance of closeness of elevator protection	assurance of electric equipment connection to earth network	I
Catching work safety license before washing tanks	Done correctly Pm of warehouses and airlines, connections, pumps and equipment under pressure	existence of flow control key and interruption of robots power outage before washing operation	II
Periodic visit of fire alarm and fire-fighting equipment, ventilation systems, adjustment of humidity and ambient temperature	General safety training, use of individual protection equipment and alarm signs	use of insulation equipment, gloves and flooring	III
Standard storage of barrels containing flammable material and timely discharge barrel-empty	obey from safety instruction in working with robots	periodic pm of electric equipment and visit of protections and related interlocks	IV
Satellite transmission in circulation, and modification of epoxy anti-static in its surface	....	lock of MC doors and electric tableaus and use of alarm signs	V
....	....	catching work safety license before starting the work	VI

The result of Vikor technique was shown in table 12. Finally, Suitable Value (S), regret values (R) and VIKOR index (Q) for each alternative was determined (Table 7). (Coefficient = 0.5 was considered which represents a compromise view of experts).

Table 7: Determination of VIKOR technique criteria and compromise solutions

	S						R						Q					
	Electric shock	Rank	Collision to objects	Rank	Fire and explosion	Rank	Electric shock	Rank	Collision to objects	Rank	Fire and explosion	Rank	Electric shock	Rank	Collision to objects	Rank	Fire and explosion	Rank
I	۰/۲۸۸۳	۱	۰/۴۰۰۳	۱	۰/۶۱۱۵	۲	۰/۱۶۳۹	۲	۰/۱۴۸۷	۱	۰/۱۶۸۳	۳	۰/۱۸۸۸	۲	۰/۰۰۰۸	۱	۰/۶۶۲۴	۳
II	۰/۵۹۵۹	۴	۰/۵۵۶۲	۲	۰/۸۰۷۹	۵	۰/۱۶۹۸	۶	۰/۱۶۸۴	۳	۰/۱۶۸۴	۴	۰/۷۷۵۲	۵	۰/۷۹۰۴	۲	۰/۸۸۳۷	۵
III	۰/۳۳۸۰	۲	۰/۶۴۱۷	۴	۰/۳۶۴۲	۱	۰/۱۶۰۴	۱	۰/۱۶۹۸	۴	۰/۱۶۸۲	۲	۰/۰۴۸۱	۱	۱/۰۰۰۲	۴	۰/۳۷۳۷	۱
IV	۰/۵۰۱۶	۳	۰/۵۹۳۲	۳	۰/۶۱۵۵	۳	۰/۱۶۷۳	۳	۰/۱۶۸۳	۲	۰/۱۶۹۸	۵	۰/۵۵۸۸	۳	۰/۸۶۴۲	۳	۰/۷۸۳۷	۴
V	۰/۸۴۷۸	۵			۰/۷۲۰۸	۴	۰/۱۶۸۳	۴			۰/۱۶۳۹	۱	۰/۹۲۰۷	۶			۰/۴۰۶۱	۲
VI	۰/۸۷۲۴	۶					۰/۱۶۸۴	۵					۰/۶۵۹۹	۴				

According to Table 7, regarding Electric Shock risk

C_1 *Acceptable Advantage*: DQ = 1/ (6-1) = 0.2

$Q(A^{(')}) - Q(A^{('')}) \geq DQ \longrightarrow$ 0.1407< 0.2

But $Q(A^{(')}) - Q(A^{('')}) \geq DQ \longrightarrow$ 0.5588- 0.0481> 0.2 therefore the positions of alternatives III and I are “in closeness”.

C_2: Acceptable *stability in Decision making*

Alternative III is the best ranked by Q, R. This compromise solution is stable within a decision making process, by consensus.

According to Table 7, regarding collision to the objects risk:

C_1: *Acceptable Advantage*: DQ = 1/ (4-1) = 0.33

$Q(A^{(')}) - Q(A^{('')}) \geq DQ \longrightarrow$ 0.7896 > 0.33

C_2: Acceptable *stability in Decision making*

Alternative III is the best ranked by Q, R and S. this compromise solution is stable within a decision making process, by consensus.

According to Table 7, regarding fire and explosion risks:

C_1: Acceptable *Advantage*: DQ = 1/ (5-1) = 0.25

$Q(A^{(')}) - Q(A^{('')}) \geq DQ \longrightarrow$ 0.0324< 0.25

But $Q(A^{(')}) - Q(A^{('')}) \geq DQ \longrightarrow$ 0.6624- 0.3737 > 0.25 therefore the positions of alternatives III and V are “in closeness”.

C_2: *Acceptable stability* in *Decision making*

Alternative III is the best ranked by Q, S. this compromise solution is stable within a decision making process, by consensus.

CONCLUSION

Automaker industries due to mass production and application of different technologies have always faced environment with dangerous risks potentially.

In the present study, Fuzzy FMEA and VIKOR technique were applied to risk assessment and prioritizing presented corrective actions. Ultimately, with respect to the scores obtained for the risk of electrical shock, collision to objects, fire and explosion the following corrective actions were selected as compromise solutions, respectively: "use of insulation requirements, gloves and flooring ", "ensuring of closeness of the elevator protection" and "Pm and periodic visit of fire alarm and firefighting equipment, ventilation systems, adjusting the humidity and ambient temperature".

In this regard, kutlu in 2012 evaluated some risks with FMEA in fuzzy environment. The highest risk including dropping and burning on work. At the end of it, presented some corrective actions like safety belts.

Chin et al. in 2008 used FMEA in fuzzy approach in product design system, then presented some corrective actions. Abdelgawand et al in 2010 evaluated some risks in construction industry. In this study, electrical shock achieved the highest score. It is worth nothing that the present study approved that results.

In fact the differences between the present studies are using of VIKOR technique for prioritizing corrective action. The result of this study, showed the safety regulation are still ignored in automaker industries. So attention to them, could prevent from happening them.

ETHICAL ISSUES

The authors hereby certify that all data collected during the study are as stated in IKCO, and no data from the study has been or will be published separated elsewhere.

COMPETING INTERESTS

The authors declare that they have no conflict of interest.

AUTHOR'S CONTRIBUTIONS

The authors contributed and were involved in the problem suggestion, experiments design, data collection, and manuscript approval.

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