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EVALUATING AND RANKING PERFORMANCE INDICES OF THE ORGANIZATION WITH OHSAS18001 STANDARD USING FUZZY ANP AND FUZZY VIKOR

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ABSTRACT
Safety systems are among the most important subsystems in hazardous jobs. Hence, sustainable development and competitiveness preservation of industrial enterprises depend on the creation and institutionalization of appropriate administrative domains. The aim of this study was to provide criteria and indices relating to occupational health and safety system (OHSAS18001) and to evaluate the system index in companies. This research was conducted based on the comments of safety committee members of the studied companies, the results of which indicated that review and corrective action criteria had the highest level of priority among the defined criteria in this system. Also, according to the survey conducted on the index, employee safety training had the highest ranking among the 17 defined indices. Finally, this ranking determined that, among the four studied companies, the second one had the highest ranking in terms of the system functionality and performance.

KEYWORDS: Safety;OHSAS18001; Ranking; Index

INTRODUCTION

The safety literature has been popular for over 20 years with recent attention placed on its conceptualisation, theory, and empirical scrutiny and practical applications. Certified occupational health and safety management (OHSM) systems have become an important instrument for companies in their efforts to ensure a healthy and safe work environment (Gallagher et al., 2001; Frick and Wren, 2000; Robson et al., 2007; Rocha, 2010). The OHSAS 18001 standard requires a company to establish an integrated management system with systematic procedures to govern, document and control the work environment. It includes working environment policy, procedures for identifying and controlling risks, performance measurements, and internal audits. The working environment must meet legislated standards. Finally, OHSAS 18001 requires continuous system improvement based on measurable goals and activities and performance. In1999, by Laitinen & et. al TR technique in the construction industry as the first first method is based on monitoring the safety standard was developed. Safety aspects observed in the TR method are: 1) work habits 2) Scaffolding and ladders 3) Machinery and equipment 4) Protection against falling 5) Electric and Lighting 6) regulation. In this method, if any of the criteria are consistent with the safety standard rating is correct otherwise the rating is incorrect.various authors stress the benefits of implementing the OHSAS 18001 standard. Certification allows the firm to guarantee to its stakeholders that it has an adequate health and safety management system with which to control occupational risks. Thus certification may strengthen the firm's relations with its shareholders and creditors, customers, suppliers, labour unions, insurers, or the public authorities, thereby increasing its bargaining power with them (Smallman and John, 2001). The OHSAS 18001 standard can be seen as a strategic tool offering an opportunity to firms that want to be competitive and to achieve a strong position in a global market like the current one.

Only if firms have a fully committed management and the involvement of their employees can they use OHSAS 18001 as a tool to manage their production processes efficiently and try to achieve zero accidents e the goal of all the parties involved (Mansilla and Rodríguez de Roa, 2005). In 2006 M.K.O. Ayonmoh and S.A.Oke presented a paper entitled A framework for measuring safety level for production environments. The paper demonstrates the feasibility of applying a new approach termed hybrid structural interaction matrix (HSIM) to the prioritization of safety parameters in an organization. Suphi Ural has been studied occupational health and safety assessment at surface mining in 2008. This paper compares the performance indicators in relation to safety in Turkey mine with other countries. Which ultimately led to the development strategy in order to take the necessary precautions and ultimately improve the mining industry

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in Turkey. The OHSAS 18001 standard specifies the requirements for implementing an occupational health and safety management system that allows the organization to develop and implement a safety policy, establish objectives and processes for achieving the commitments of the policy, take the actions necessary to improve the system's performance, and demonstrate its conformance with the requirements of the standard and with the legal obligations (Zeng *et al.,* 2008). Karapetrovic and Casadesús (2009) argue that this standard facilitates safety management in firms operating in different geographic areas of the world, the management between different firms working together, and the integration of occupational safety with the ISO 9001 quality system and ISO 14001 environmental system already implemented in the firm.

In 2010, P.A. Bragatto & P.Agnello to evaluate the effectiveness of safety management programs on the overall safety level. The proposed model is applied to optimize the allocation of resources in the areas of industrial inspection applications with the highest priority index. In 2012, Beatriz Fernandez & et.al offered an article entitled Occupational risk management under the OHSAS 18001 standard & analysis of perceptions and attitudes of certified firms. The current work examines the reasons why these firms implement OHSAS 18001, identifies the obstacles they have to overcome to obtain certification, and analyses their perceptions and attitudes about the audit process, using a sample of 131 OHSAS 18001 certified organizations. In that year, Hamidi et al studied effect of integrated management system on efficiency and safety indicators in Iranian cement industry. Accident reports and their review them in the past 6 years (2005-2010), three years before and three years after implementation of the system and its effects on reproductive parameters were studied to increase productivity and production rates.

In 2013, Jean-christophe Le coze presented outlines of a sensitizing model for industrial safety assessment. This paper introduces what is defined as a sensitizing model. This model has been developed to support empirical and methodological research and studies in different high-risk industries. Its purpose is to assist current and future practices of industrial safety assessments by taking into account input from the social sciences, reflecting in particular their insights on major accidents.
This research was carried out in three main steps. In the first step, two major accidents were In a decision making process, decision makers are usually faced with doubts, problems, and uncertainties. In other words, a natural language for understanding and judgment is always in a subjective uncertain or ambiguous manner. To remove ambiguity and subjectivity in judgment of a decision maker, theory of fuzzy sets was proposed by Zadeh (1965) for stating verbal terms in the decision making process.

Today, science of fuzzy management using the theory of fuzzy systems can be a novel approach for solving the problem or responding to the stated ambiguities in management systems. Science of fuzzy management reflexively accounts for economic and social situations. Therefore, management systems have more flexibility and governing large and complex organizations becomes feasible in variable environments. Numerous studies have been performed on safety; however, no research has been undertaken for investigating safety index in OHSAS18001 standard using two models of ANP and VIKOR in fuzzy environments. Thus, the aim of this study was to consider this point.

MATERIALS AND METHODS

The OHSAS18001 Standard

For those who have established OH&S systems, the implementation of OHSAS 18001 will not be a daunting task. The language and approach is very similar is to that used in ISO management system standards and follows the standard Plan-Do-Check-Act (PDCA) approach. So, for those organizations with quality and /or environmental management systems in place many of the requirements of OHSAS 18001 will already be established.for those with little in place, it is better to carry out an initial review in a simple step by step approach such as that described in Managing Safety the Systems way before trying tocomplete the full requirements outlined in the OHSAS 18001 approach .

OH&S Policy

Policy has many common requirements found in ISO 9001 and ISO 14001 with the express requirement of a commitment to prevention of injury and ill health.

Planning

OHSAS 18001 requires a system for identifying hazards, quantifying risks and establishing controls. The output from this process needs to be available for auditing including any actions taken to reduce unacceptable risks. For those

starting on this route, this is often the most challenging step. Failure to identify the hazards and effectively assess the risks will mean that the system may not deliver what the organization is trying to achieve.
The above, together with the list of legal requirements, provides information that should be used to determine an organization's objectives for OH&S and the management programme for implementing those improvements deemed necessary.

Implementation and operation

This stage has seven subclauses which are required to be addressed to ensure effective implementation of the policy and objectives and the necessary associated programmes. It requires the organization to establish accountabilities, roles, responsibilities and authorities and the provision of adequate resources.

Checking

The clauses on checking are also very similar to those found in ISO 14001. There are requirements for performance measurement and monitoring and evaluation of compliance.

Management Review

This clause defines the inputs and outputs from the management review process and is aligned very closely with ISO 9001 and ISO 14001.

Fuzzy sets and fuzzy numbers

Zadeh (1965) introduced the fuzzy set theory to deal with uncertainty due to imprecision and vagueness. A major contribution of fuzzy set theory is its capability in representing vague data. The theory also allows mathematical operators and programming apply to the fuzzy domain. A fuzzy set is a class of objects with the continuum of grades of membership. Such a set is characterized by a membership (characteristic) function, which assigns a grade of membership ranging between zero and one to each object.

A tilde $''\sim''$ will be placed above a symbol if the symbol represents a fuzzy set. A triangular fuzzy number (TFN), $\widetilde{M}$ is shown in Fig. 1. A TFN is denoted simply as (*l*/*m*,*m*/*u*) or (*l*,*m*,*u*). Parameters *l*, *m* and *u*, denote the smallest possible value, the most promising value, and the largest possible value that describe a fuzzy event, respectively.
Each TFN has linear representations on its left and right sides such that its membership function can be defined as:

$$\mu(x/\widetilde{M}) = \begin{cases} 0, & x < l \\ (x-l)/(m-l), & l \le x \le m \\ (u-x)/(u-m), & m \le x \le u \\ 0, & x > u \end{cases} \quad (1)$$

Based on the characteristics of TFN and the extension definitions proposed by Zadeh, given any two positive triangular fuzzy numbers, $\tilde{A}_1 = (l_1, m_1, u_1)$ and $\tilde{A}_2 = (l_2, m_2, u_2)$, and a positive real number, some algebraic operations of the triangular fuzzy numbers, $\tilde{A}_1$ and $\tilde{A}_2$ can be expressed as follows:

Addition of two TFNs:

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (2)$$

Multiplication of two TFNs:

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1 * l_2, m_1 * m_2, u_1 * u_2) \quad (3)$$

Multiplication of any real number r and a TFN:

$$r \otimes \tilde{A}_1 = (rl_1, rm_1, ru_1) \qquad l_i > 0, m_i > 0, u_i > 0 \quad (4)$$

Subtraction of two TFNs:

$$\tilde{A}_1 \ominus \tilde{A}_2 = (l_1 - u_2, m_1 - m_2, u_1 - l_2) \qquad l_i > 0, m_i > 0, u_i > 0 \quad (5)$$

Division of two TFNs:

$$\tilde{A}_1 \oslash \tilde{A}_2 = (l_1/u_2, m_1/m_2, u_1/l_2) \quad (6)$$

Reciprocal of a TFN:

$$\tilde{A}_1^{-1} = (1/l_1, 1/m_1, 1/u_1) \qquad l_i > 0, m_i > 0, u_i > 0 \quad (7)$$

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ANP method

ANP is the most comprehensive framework for analyzing corporate decisions. which allows for both interaction and feedback within the clusters of elements (inner dependence) and between clusters (outer dependence). Such a feedback best captures the complex effects of interplay in human society, especially when risk and uncertainty are involved. Elements in a cluster may influence other elements in the same cluster and those in other clusters with respect to each of several properties. The main objective is to determine the overall influence of all the elements. In that case, first of all, properties or criteria must be organized and then prioritized in the framework of a control hierarchy. Afterwards, comparisons must be performed and synthesized to obtain the priorities of these properties. Additionally, the influence of elements in the feedback system with respect to each of these properties must be derived. Finally, the resulting influences must be weighed by the importance of the properties and added to obtain the overall influence of each element (Onut, S. & et.al, 2009; Ramik, J. 2007).Modeling process can be divided into three steps for the ease of understanding, as described below:

Step 1: Pairwise comparisons and relative weight estimation

Before performing the pairwise comparisons, all the compared criteria and clusters are linked to each other. There are three types of connections, namely one-way, two-way, and loop. If there is only one-way connection between two clusters, only one-way dependencies exist and such a situation is represented with directed rows. If there is two-way dependence between two clusters, bidirected arrows are used. Loop connections indicate the comparisons in a cluster and the inner dependence. The Pairwise comparisons are made depending on the 1–9 scale recommended by Thomas L. Saaty, where 1, 3, 5, 7, and 9 indicate equal importance, moderate importance, strong importance, very strong importance, and extreme importance,
respectively, and 2, 4, 6, and 8 are used for compromising between the above values. The score aij in the pairwise comparison matrix represents relative importance of the component on row (i) over the component on column (j), i.e.,$a_{ij} = w_i/w_j$. Reciprocal value of the expression $(1/a_{ij})$ is used when component j is more important than component i.

If there are n components to be compared, matrix A isdefined as:

$$A = \begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\ \vdots & \vdots & \cdots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (8)$$

Once the pairwise comparisons are completed, like AHP, a local priority vector (eigenvector) w is computed as anestimate of relative importance accompanied by the elements being compared by solving the following equation:

$$A.W = \lambda_{max}.w \quad (9)$$

where λ_{max} is the largest eigenvalue of matrix A.

Step 2: Formation of the initial supermatrix

All obtained priority vectors are then normalized to represent the local priority vector. To obtain global priorities, the local priority vectors are entered into the appropriate columns of a matrix of influence among the elements, known as a supermatrix (Rezaei, M., et. al. 2013). Supermatrix as the representation of a hierarchy with three levels is given as follows:

$$W = \begin{matrix} \\ Goal\ (G) \\ Criteria\ (C) \\ Alternatives\ (A) \end{matrix} \begin{pmatrix} G & C & A \\ 0 & 0 & 0 \\ w_{21} & 0 & 0 \\ 0 & w_{32} & I \end{pmatrix} \quad (10)$$

where w_{21} is a vector that represents the impact of the goal on the criteria, w_{32} is a vector that represents the impact of the criteria on each of the alternatives, and *I* is the identity matrix. *W* is referred to as a supermatrix because its entries are matrices. For example, if the criteria are dependent among themselves, then the (2,2) entry of *W* given by w_{22} would be nonzero. Interdependence is exhibited by the presence of matrix element w_{22} of supermatrix W:

$$W = \begin{matrix} \text{Goal } (G) \\ \text{Criteria } (C) \\ \text{Alternatives } (A) \end{matrix} \begin{pmatrix} G & C & A \\ 0 & 0 & 0 \\ w_{21} & w_{22} & 0 \\ 0 & w_{32} & I \end{pmatrix} \quad (11)$$

Influence of a set of elements belonging to a cluster, on any element from another component, can be represented as a priority vector by applying pairwise comparisons (Saaty, T. L. 1980). Note that any zero value in the supermatrix can be replaced with a matrix if there is an interrelationship of elements within a cluster or between two clusters.

Step 3: Formation of the weighted supermatrix

An eigenvector is obtained from the pairwise comparison matrix of the row clusters with respect to the column cluster, which in turn yields an eigenvector for each column cluster. First entry of the respective eigenvector for each column cluster, is multiplied by all the elements in the first cluster of that column, the second by all the elements in the second cluster of that column and so on. Hence, the cluster in each column of the supermatrix is weighed, and the result, known as the weighted supermatrix, is stochastic. Raising a matrix to exponential powers gives the long term relativeinfluences of the elements on each other (Saaty, T. L,1996; Saaty, T. L., & Vargas, L. G, 1998).

Fuzzy ANP

ANP can easily accommodate the interrelationships existing among functional activities. In FANP, pair-wise comparison matrices are formed between each pairs of attributes at each level using triangular fuzzy numbers. The concept of supermatrices is employed to obtain the composite weights that overcome the existing interrelationships.Values of parameters are transformed into triangular fuzzy numbers and used to calculate fuzzy values. Furthermore, a scale of $\tilde{1} - \tilde{9}$ is used to state the preferences of the decision maker.,as shown in Table 1.

To evaluate the decision maker preferences, the m×n triangular fuzzy matrix is used. If $\tilde{A}$ is a pair_wise comparison matrix demonstrated in Eq. (12) as follows,

$$\tilde{A} = \begin{Bmatrix} (a_{11}^l, a_{11}^m, a_{11}^u) & (a_{12}^l, a_{12}^m, a_{12}^u) & \cdots & (a_{1n}^l, a_{1n}^m, a_{1n}^u) \\ (a_{21}^l, a_{21}^m, a_{21}^u) & (a_{22}^l, a_{22}^m, a_{22}^u) & \cdots & (a_{2n}^l, a_{2n}^m, a_{2n}^u) \\ \vdots & \vdots & \vdots & \vdots \\ (a_{m1}^l, a_{m1}^m, a_{m1}^u) & (a_{m2}^l, a_{m2}^m, a_{m2}^u) & \cdots & (a_{mn}^l, a_{mn}^m, a_{mn}^u) \end{Bmatrix} \quad (12)$$

Many fuzzy AHP methods have been proposed by various authors (Van Laarhoven and Pedrycz, 1983;Buckley, 1985; Chang, 1992, 1996; Cheng, 1997; Deng, 1999; Leung and Cao, 2000; Mikhailov, 2004)., which have systematic approaches to alternative selection and justification problem using the concepts of fuzzy set theory and hierarchical structure analysis.

Table1.Scale of Linguistic variable (Bojan and Yvonilde, 2008)

Scale of respected fuzzy number	Fuzzy number	Linguistic variable
(1, 1, 1)	$\tilde{1}$	Identical
(1, 3, 5)	$\tilde{3}$	A little more important
(3, 5, 7)	$\tilde{5}$	More important
(5, 7, 9)	$\tilde{7}$	Much more important
(7,9, 9)	$\tilde{9}$	Strictly more important
(x-1, x, x+1)	$\tilde{2}, \tilde{4}, \tilde{6}, \tilde{8}$	A value between 2 levels
$\left(\frac{1}{x+1}, \frac{1}{x}, \frac{1}{x-1}\right)$	$1/\tilde{x}$	Inverse triangular numbers

Decision makers usually find interval judgments more confident than fixed value judgments., because they are usually unable to explicate their preferences due to the fuzzy nature of the comparison process. In this study, Chang's (1992, 1996) extent analysis method was preferably used, because the steps of this approach are easier than those of other fuzzy AHP approaches. Steps of Chang's (1992, 1996) extent analysis approach are as follows: Let $X = \{x_1, x_2, \dots, x_n\}$ be an object set, and $U\{u_1, u_2, \dots, u_n\}$ be a goal set. According to Chang's (1992) extent analysis method, each object is taken and extent analysis for each goal, gi, is performed, respectively. Therefore, *m* extent analysis values for each object can be obtained, using the following signs:

$$M_{g_i}^1, M_{g_i}^2, \dots, M_{g_i}^m \qquad i = 1, 2, \dots, n \tag{13}$$

where all the $M_{g_i}^j$ (j= 1, 2, …, *m*) are TFNs.

Steps of Chang's extent analysis can be given as follows:

Step 1: Value of fuzzy synthetic extent with respect to the ith object is defined as:

$$S_i = \sum_{j=1}^{5} M_{g_1}^j \otimes \left[\sum_{i=1}^{5}\sum_{j=1}^{5} M_{g_1}^j\right]^{-1} \tag{14}$$

To obtain $\sum_{j=1}^{m} M_{g_i}^j$, perform the fuzzy addition operation of m extent analysis values for a particular matrix such that:

$$\sum_{j=1}^{m} M_{g_i}^j = \left(\sum_{j=1}^{n} l_i, \sum_{j=1}^{n} m_i, \sum_{j=1}^{n} u_i\right) \tag{15}$$

And to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{n} M_{g_1}^j\right]^{-1}$ perform the fuzzy addition operation of $M_{g_i}^j = (j = 1, 2, \dots, m)$ values such that:

$$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{g_1}^j = \left(\sum_{j=1}^{n} l_i, \sum_{j=1}^{n} m_i, \sum_{j=1}^{n} u_i\right) \tag{16}$$

Then, compute the inverse of the vector in Eq. (16) such that

$$\left[\sum_{i=1}^{5}\sum_{j=1}^{5} M_{g_1}^j\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{17}$$

Step 2: Degree of possibility of $M_2 = (l_2, M_2, u_2) \geq M_1 = (l_1, M_1, u_1)$ is defined as

$$V(M_2 \geq M_1) = \sup\left[\min\left(\mu_{M_1}(x), \mu_{M_2}(y)\right)\right] \tag{18}$$

and can be equivalently expressed as follows:

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & if\ m_2 \geq m_1, \\ 0, & if l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \tag{19}$$

where *d* is the ordinate of the highest intersection point *D* between μ_{m_1} and μ_{m_2}.To compare M_1 and M_2, both values of $V(M_1 \geq M_2)$ and $V(M_2 \geq M_1)$.

Step 3: Degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers M_i (i = 1,2, . . . , k) can be defined by:

$$V(M \geq M_1, M_2, \dots, M_k = V[(M \geq M_1) and\ (M \geq M_2)\ and \dots (M \geq M_k)] = \min V(M \geq M_i), \qquad i = 1, 2, \dots, k \tag{20}$$

Assume that,

$$d'(A_i) = \min V(S_i \geq S_k), \tag{21}$$

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For $k = 1, 2, \dots, n; \quad k \neq i$.
Then, the weight vector is given by

$$W' = \left(d'(A_1), d'(A_2), \dots, d'(A_n)\right)^T, \quad (22)$$

where $A_i (i = 1, 2, \dots, n)$ *and n* is elements.

Step 4: Via normalization, the normalized weight vectors are:

$$[W] = \left(d(A_1), d(A_2), \dots, d(A_n)\right)^T, \quad (23)$$

where W is a non_fuzzy number.

Fuzzy VIKOR

Based on the concept of fuzzy logic and VIKOR method, the proposed fuzzy VIKOR method was developed. The procedure of FVIKOR consists of the following steps (Chen & Wang, 2008):

Step1: Generating feasible alternatives, determining evaluation criteria, and setting a group of decision makers.

Step 2: Defining linguistic variables and their corresponding triangular fuzzy numbers.

Step 3: Integrating decision makers' preferences and opinions.; Preferences and opinions of n decision_maker with respect to j criterion for the ith alternative can be calculated by:

$$\tilde{X}_{ij} = \frac{1}{n}\left(\sum_{e=1}^{n} \tilde{x}_{ij}\right) \quad , i = 1,2,3, \dots, m \quad (24)$$

Step 4: Calculating fuzzy weighted average and constructing the (normalized) fuzzy decision matrix (D):

$$\tilde{W} = [\tilde{w}_1 \tilde{w}_2 \dots \tilde{w}_k], j = 1, 2, 3, \dots, k \quad (25)$$

$$D = \begin{matrix} & C_1 & C_2 & \dots & C_k \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \tilde{x}_{13} & \dots & \tilde{x}_{1k} \\ \tilde{x}_{21} & \tilde{x}_{22} & \tilde{x}_{23} & \dots & \tilde{x}_{2k} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \tilde{x}_{m3} & \dots & \tilde{x}_{mk} \end{bmatrix} \quad (26)$$

where $\tilde{w}_j$the is the important weight of the jth criterion (calculated by FANP).

Step 5: Determining the fuzzy best value (FBV) and fuzzy worst value (FWV):

$$f_j^* = max_i \tilde{x}_{ij}, f_j^- = min_i \tilde{x}_{ij} \quad (27)$$

Step 6: Calculating the values:

$$\tilde{S}_i = \sum_{i=1}^{k} \frac{\tilde{w}_j(\tilde{f}_j^* - \tilde{x}_{ij})}{(\tilde{f}_j^* - \tilde{f}_j^-)} \quad (28)$$

$$\tilde{R}_i = max_j \left[\frac{\tilde{w}_j(f_j^* - \tilde{x}_{ij})}{(\tilde{f}_j^* - \tilde{f}_j^-)}\right] \quad (29)$$

where $\tilde{S}_i$ and $\tilde{R}_i$ represent the utility measure and regret measure, respectively, and $w_j$is weight of the jth criterion (Tong et al., 2005). In fact, $\tilde{S}_i$ is A_i with respect to all criteria calculated by the sum of the distance for the FBV, and $\tilde{R}_i$ is A_i with respect to the jth criterion, calculated by the maximum distance of FBV.

Step 7: Calculating the values of $\tilde{S}^*; \tilde{S}^-; \tilde{R}^*; \tilde{R}^-; \tilde{Q}_i$:

$$\tilde{S}^* = min_i \tilde{S}_i, \tilde{S}^- = max_i \tilde{S}_i \quad (30)$$

$$\tilde{R}^* = min_i \tilde{R}_i, \tilde{R}^- = max_i \tilde{R}_i \quad (31)$$

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$$\tilde{Q}_i = v\frac{(\tilde{S}_j - \tilde{S}^*)}{(\tilde{S}^- - \tilde{S}^*)} + (1-v)\frac{(\tilde{R}_j - \tilde{R}^*)}{(\tilde{R}^- - \tilde{R}^*)} \quad (32)$$

Here, ν means the weight of the strategy of maximum group utility (Wu et al., 2009). When ν>0.5, the decision tends toward maximum majority rule; if ν = 0.5, the decision tends toward the individual regret of the opponent. Hence, ν is introduced as the weight of the strategy of 'the majority of attributes'. Value of ν is usually taken as 0.5. However, ν can take any value from 0 to 1 Rank and improve the alternatives, sort them by values S, R, and Q, in a decreasing order, and reduce the gaps in the criteria and the best alternatives with the lowest value (Wu et al., 2009).

RESULTS

Data Collection

Research method of this study was performed in several steps. In the first step, different industries which had an occupational health and safety system (OHSAS18001) were primarily studied. This research was done on 4 companies in Mazandaran province, Iran, which had this system. In the second step, important indices of safety and accidents related to the industries were defined. The number of workers in each company and demographics of the studied companies are shown in Table 2.

Table2.Demographics of the studied companies

Company	Number of workers	Average age	Product rate (ton/day)	Implementation year
1	1500	22	875	2010
2	360	18	80	2011
3	50	18	10	2010
4	1000	22	800	2004

OSHAevaluation indices were defined based on the standard of performed risk, performed audition, employee safety training and personal protection equipment for evaluating the safety level of industries. Moreover, indices of frequency of accident, severity of accident, severity-frequency of accident, and repetition coefficient of occupational diseases were defined as accident indices. To collect the data required for these indices, fuzzy questionnaire and checklist of this standard were developed under the supervision of experts and inspectors of occupational health. The third step was the collection of data related to safety and accident indices based on the statistics derived from documents and archives of the unit of industrial health and safety and the defined indices were measured.

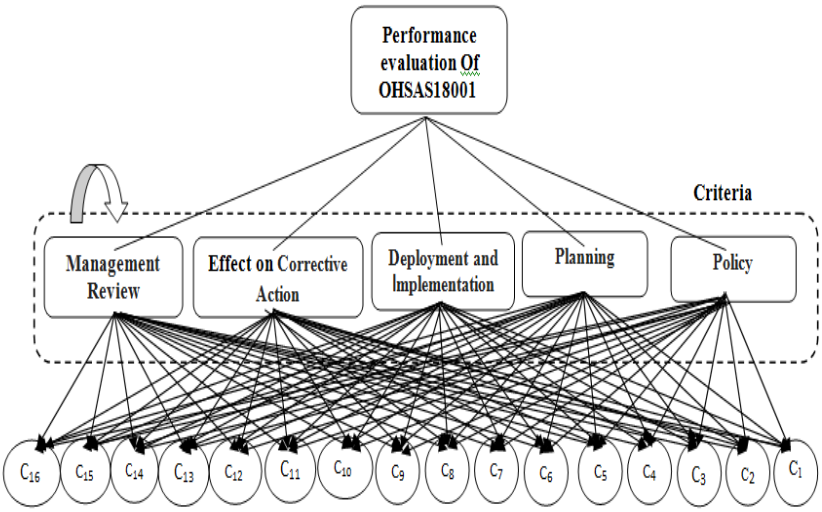

Fig.1 ANP Model

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In the fourth step, the indices defined by ANP fuzzy method were weighed. Finally, the companies which where using fuzzy VIKOR method were ranked in terms of evaluating the performance of these indices. In this paper, as shown in Figure 1, according to the safety experts, a one-way relationship existed between the criteria and options the criteria were inter-related.

Table 3. Criteria & indicators

Criteria	Indicators (sub- criteria)
Policy (A_1)	Proportionate amount of policy wit risk assessment conducted$[C_1]$
Planning (A_2)	The number of effective risk assessments$[C_2]$
	The amount of adaptation work areas, processes & … with OHSAS18001system$[C_3]$
Deployment and Implementation (A_3)	Employee safety training$[C_4]$
	The amount of employee contributions$[C_5]$
	Investment of personal protective equipment$[C_6]$
	The amount of exercises done$[C_7]$
Effect on Corrective Action (A_4)	Severity of accident$[C_8]$
	Frequency of accident$[C_9]$
	Repetition coefficient of diseases$[C_{10}]$
	Frequency-severity of accident$[C_{11}]$
	Control measures$[C_{12}]$
	Audition$[C_{13}]$
	Human efficiency$[C_{14}]$
Management Review (A_5)	Safety behavior change index$[C_{15}]$
	Changing Safety Culture Index$[C_{16}]$
	Periodicals evaluation$[C_{17}]$

Reliability and validity of the collected data

Validity refers to the measurement degree of what the researcher wants to measure (Diani, 2009). since the inventory was based on the identified factors in the research background and perspectives of safety provided by inspectors and teachers, its validity can be confirmed.

Another technical feature of data collection tool (questionnaire) is reliability. The mentioned concept means that to what extent the data collected in similar conditions would produce the same results. SPSS software is one of common application to determine the reliability using Cronbach's alpha method. in this study, a questionnaire was designed to be placed at the disposal of several safety experts. If alpha coefficient was 0.7 or more than it, The reliability of the questionnaire is desirable. the alpha coefficient of output software was 0.87 which represents the reliability of the questionnaire.

Computing consistency ratio for each pairwise comparison matrix

Consistency ratio has to be calculated after the construction of all pairwise comparison matrices. Consistency index that represents the deviation from consistency is calculated using the following equation:

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (33)$$

Consistency ratio is a direct measure of the consistency of pairwise comparisons and is calculated by dividing CI by random consistency index (RI).

$$CR = \frac{CI}{RI}$$

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(34)

In other words, compatibility rate (CR) can be used to obtain compatibility rate comparison of the measured parameters. If CR ≤ 0.1, the comparison can be accepted as a consistent one. After all the data collected from the questionnaire were acceptable, incompatibility rate (of less than 0.1) was calculated using geometric mean for each inventory of expert opinions.

After forming the paired comparisons of the tables, consistency rate of each paired comparison was calculated using Formulas 33 and 34. Consistency rate of each paired comparison is given in below

Table 4. consistency rate of each paired comparison

Paired Comparison Tables	consistency rate
paired comparison towards the goal	0.02
paired comparison towards the Policy Criteria	0.034
paired comparison towards the Planning Criteria	0.023
paired comparison towards the Deployment and Implementation Criteria	0.006
paired comparison towards the effect on Corrective Action Criteria	0.002
paired comparison towards the effect on Management Review Criteria	0.004

According to the ANP drawn diagrams, tables composed of paired comparisons. matrix geometric mean of questionnaires collected by experts (Table 5). paired comparisons to other criteria calculated such as this table.

Table 5. Paired Comparison of the Criteria relative to Goal

Goal	(A_1)			(A_2)			(A_3)			(A_4)			(A_5)		
(A_1)	1	1	1	0.33	0.55	1	1	1	1	0.55	0.77	1.28	0.33	0.55	1
(A_2)	1	1.8	3	1	1	1	1	1.8	3	0.77	1.4	3	1	1	1
(A_3)	1	1	1	0.33	0.55	1	1	1	1	0.55	0.77	1.28	0.33	0.55	1
(A_4)	0.77	1.2	1.8	0.3	0.55	1	0.77	1.2	1.8	1	1	1	0.33	0.55	1
(A_5)	1	1.8	3	1	1	1	1	1.8	3	0.77	1.4	3	1	1	1

Determining the relative weights of elements

After paired comparisons between criterias and options, For each of the cases according to the calculation methods of ANP and Chang have been obtained in the relative weight of the model. The relative weights are calculated using the method of Chang and the super matrix is calculated at MATLAB software. The results of the final weights of criteria and indicators are shown in Tables 5 and 6.

Table 5. The finall weights of criteria

The effect on Policy Criteria	The effect on Planning Criteria	The effect on Deployment and Implementation Criteria	Paired comparison towards the effect on Corrective Action Criteria	The effect on Management Review Criteria
0.19985	**0.1924**	**0.1925**	**0.2101**	**0.205**

As shown in Table 6, the proportion of risk assessments carried out with the policy of the highest rank and index Safety Culture is the lowest rank according to the weights obtained.

Decision matrix

After calculating weight indices, expert opinions about each company were separately collected using questionnaires and interviews. Afterwards, the geometric mean of opinions of experts was taken in each company.

Table 6. The final weights of Sub-criteria

Sub- criteria	weights
C_1	0.105
C_2	0.100
C_3	0.097
C_4	0.088
C_5	0.093
C_6	0.080
C_7	0.082
C_8	0.073
C_9	0.0601
C_{10}	0.0606
C_{11}	0.0547
C_{12}	0.038
C_{13}	0.031
C_{14}	0.0123
C_{15}	0.0126
C_{16}	0.0029
C_{17}	0.0049

Calculating the normalized values

After calculating the geometric mean of indices for each company, data normalization was done. as can be seen in the table of normalized data, the third triangular fuzzy number was greater than one.

Maximum average method was used to solve this problem so that the second triangular fuzzy numbers were applied for ranking the companies (Shavandi, 2006).

The best and worst values of all companies

To determine the best and worst values of Vikor method, the best and worst values for each of the indicators were obtained using geometric mean of expert opinions for all four companies.

In this section, Sj distance from option i with respect to the positive ideal solution (combining the best) and negative ideal solution was Rj interval option (the worst combination). Higher rankings on Sj and bad ratings would be based on Rj values (shown in Table 7 through 10).

Table 7. The best and worst values

value	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9
f^+	0.317	0.319	0.296	0.242	0.299	0.329	0.324	0.309	0.311
f^-	0.210	0.211	0.213	0.176	0.212	0.187	0.199	0.203	0.204
w	0.105	0.1	0.097	0.088	0.093	0.08	0.082	0.073	0.0601

Table 8. The best and worst values

value	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}
f^+	0.311	0.317	0.303	0.311	0.303	0.314	0.305	0.312
f^-	0.204	0.206	0.199	0.219	0.216	0.180	0.200	0.210
w	0.0606	0.0547	0.038	0.031	0.0123	0.0126	0.0029	0.0049

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Table 9.The calculated results of S_i

Companies	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8
Company 1	0.1012	0.09885	0.09644	0.083705	0.07471	0.060723	0.08148	0.0729
Company 2	0	0	0	0	0	0	0	0
Company 3	0.1048	0.09949	0.08697	0.087265	0.09231	0.079532	0.07651	0.0655
Company 4	0.0572	0.05766	0.03188	0.031157	0.04288	0.038322	0.03619	0.0245

Table 10.The calculated results of S_i

Companies	S_9	S_{10}	S_{11}	S_{12}	S_{13}	S_{14}	S_{15}	S_{16}	S_{17}
Company 1	0.0599	0.0604	0.053	0.0379	0.03096	0.0122	0.00685	0.002	0.004
Company 2	0	0	0	0	0	0	0	0	0
Company 3	0.0538	0.0542	0.0545	0.0341	0.03077	0.0111	0.01259	0.002	0.0048
Company 4	0.0236	0.0238	0.0248	0.0055	0.02076	0.0066	0.00465	0.0003	0.0027

Calculating Q_i value of Vikor method

In this section, the amount of Q_i was calculated to include v (strategy weight) or utility maximum with constant value of 0.5. When V was greater than 0.5, the Qi index was agreed on. When V was smaller than 0.5, the most negative attitudes were shown. In general, if V is equal to 0.5 is equal to the mean agreement (Rezaei & Abedini, 2013). to determine Q_i values, S *, S -, R *, and R– were calculated, the results of which are shown in Tables 11 and 13.

Table 11.The amount of Sj & Rj

S_j		R_j	
S_1	0.937218	R_1	**0.1012**
S_2	0	R_2	**0**
S_3	0.950237	R_3	**0.104**
S_4	0.432499	R_4	**0.0576**

Table 12.The results of S*, S -, R* & R–

S^*	S^-	R^*	R^-
0	0.950237	0	**0.104**

Table 13.The amount of Q_i

Company	Q_i	Ranking
Company 1	**0.979688**	**2**
Company 2	**0**	**4**
Company 3	**1**	**1**
Company 4	**0.504497**	**3**

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CONCLUSION

As noted previously, growth of industry and use of various types of equipment and materials have provided comfort for people. Industrial development in the industry and products has imposed accidents, occupational diseases and various environmental problems on employees and workers in the industry and many individuals also suffer from its adverse consequences. In recent years occupational health and safety system (OHSAS18001) as a management tool for controlling and improving problems have raised in all development projects and industries. In the present study, descriptive information was collected obtained using questionnaires and interviews. To study the issue and also consider its purpose of research, questionnaire was used as the main instrument for data collection. Most of the data required for the data analysis were collected from field questions from the participants using the questionnaire.

The study started by library research of past studies and evaluation and identification of safety measures were reviewed by the experts. Then, the questionnaire was completed by the Safety Committee. the results of which indicated that review and corrective action criteria had the highest level of priority among the defined criteria in this system. Also, according to the survey conducted on the index, employee safety training had the highest ranking among the 17 defined indicators. Excel and MATLAB software were used for the data analysis. Finally, the third company was selected as the top company.
According to the results and findings of the research the investigated case, some recommendations could be made for future research:

- The indicators can be combined with other models such as fuzzy AHP and fuzzy TOPSIS to solve or resolve VIKOR and TOPSIS models in order to analyze the data.
- Ranking corporate safety standards can be compared.

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