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The role of expert system and fuzzy logic for risk assessment in the areas of, Health, Safety, and Environment (HSE) (Case Study in Assaluyeh Pars Oil and Gas Company)

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Abstract: *Recognizing different types of risks in development of oil and gas industry can help investors and companies that wish to be active in this area. The main reason for lack of success of many investing companies in the development of oil and gas fields is lack of proper and correct understanding of risks classification and rate of their importance. Due to the wide range of input data of different risks and diversity of inputs, fuzzy logic and functions should be used in an expert system. Therefore, a comprehensive model was introduced in this study for risk assessment in health, safety, and environment (HSE) area in Pars oil and gas company through an extensive literature review and asking question from experts in this area. In this regard, after the identification of the relevant dimensions and indices, since the traditional scales cannot provide accurate and proper assessment of quality in uncertainty conditions, we made these indices fuzzy. Finally, the fuzzy expert system was designed by MATLAB software.*
Keywords: *expert system, risk assessment, Pars Oil and Gas Company, MATLAB, HSE*

INTRODUCTION

Fortunately, during the past few years, many efforts have been made in the oil and gas industry to strengthen the contracting companies in promoting national technology and localization. Establishment of Pars oil and Gas Company as a contractor and assignment of gas phases development plans for South Pars was in line with fulfilling this objective. With the increasing growth of technology in the oil and gas industry, we are always faced with the increasing risks arising from work. The control of these risks requires a management system that will lead to the reduction of these risks, increased safety, well-being of employees, and protected environment. Therefore, it is rational that the management of the organization to consider safety, health, and the environment aspects, because the improvement in the overall performance of the organization will not be possible without considering these aspects (Dana, et al., 2001). Introducing and classifying a variety of risks in the development of oil and gas industry in this study, we tried to examine risks available in this industry, since costs of investment in this area are very high and lack of familiarity with a variety of risks can impose irreparable losses on investors. Therefore, due to wide range of input data of types of risks, fuzzy logic and functions should be used in an expert system. In this study, to evaluate the risk and different costs, we introduce an expert system for risk assessment in Pars Oil and Gas Company.

2. Review of literature

A study was conducted entitled fuzzy modeling of explosion consequences in drilling operations of Iran considering HSE. The project was dedicated to risk model and assessing the outcome for some aspects of the blowout (Atallahi et al., 2015). In another study entitled environmental risk assessment of gas power plant in southern Iran, TOP-EFMEA technique was used. In general, this study suggests that the use of multi-criteria decision-making model has potential impact on management policies (Josie et al., 2013). A study entitled designing and implementation of an expert system and fuzzy logic used William Fine method for the assessment and management of risk of safety, health, and environment in Ahwaz Pipe manufacturing company (KaabZadeh et al., 2015).

3-Methodology

Current research is applied in terms of objective, since its results can be used practically to facilitate executive operations or to solve the problems. It is also descriptive in terms of data collection method. In this study, in order to collect the data, a combination of a library and survey method was used. In this study, MATLAB software was used to design expert system. We tried to design a system that can improve the flexibility and function of the system due to having appropriate graphical user interface and using fuzzy logic Toolbox. To design this system, 5 fuzzy modules were created. Figure 1 illustrates this issue.

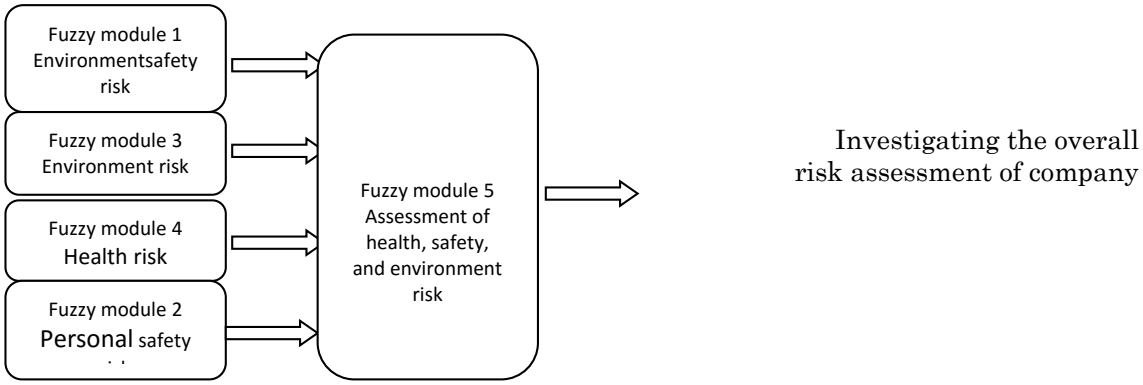

Figure 1- Fuzzy modules

Modeling algorithm description

In this study, triangular and trapezoidal functions and Mamdani fuzzy inference method was used for fuzzification and centroid method was used for defuzzification. Mathematical operations were performed by MATLAB software. After developing the model, the model testing was carried out on the developed model. If the error is he acceptable level, the process of modeling is completed, otherwise, previous steps should be reviewed and required reforms should be applied.

First step: Initial design of system

In this part, input variables and output variables of system are defined. Input variables were obtained by studying different studies conducted in HSE risks area.

Second step: Fuzzification

Triangularand trapezoidal functions were used for fuzzification of the variables (Khan Mohammadi, 2013). For fuzzification of input variables and fuzzification of sub-indices of each of the dimensions, 3-option and 5-option range was used, shown In Tables 1 and 2 and Figures 2 and 3.

Table 1 – 3-option range

3-option range	
Variable	Fuzzy number
Low	(502000)
Medium	(805020)
High	(1001008050)

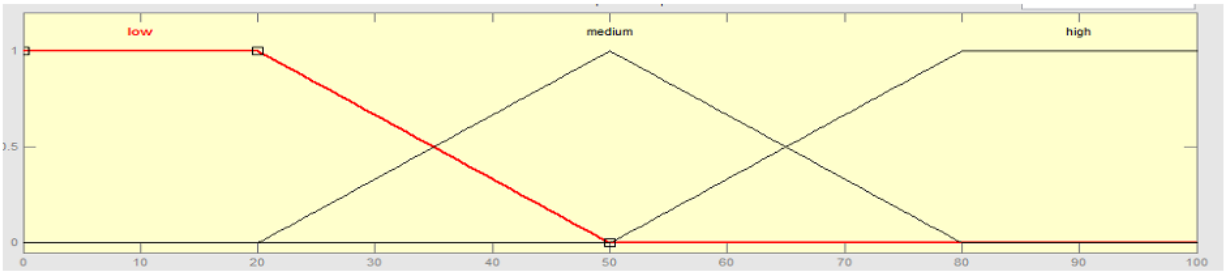

Figure 2- membership functions of 3-option range fuzzy sets

Table 2- 5-option range

5-option range	
Variable	Fuzzy number
Very low	(301000)
Low	(503010)
Medium	(705030)
High	(907050)
Very high	(1001009070)

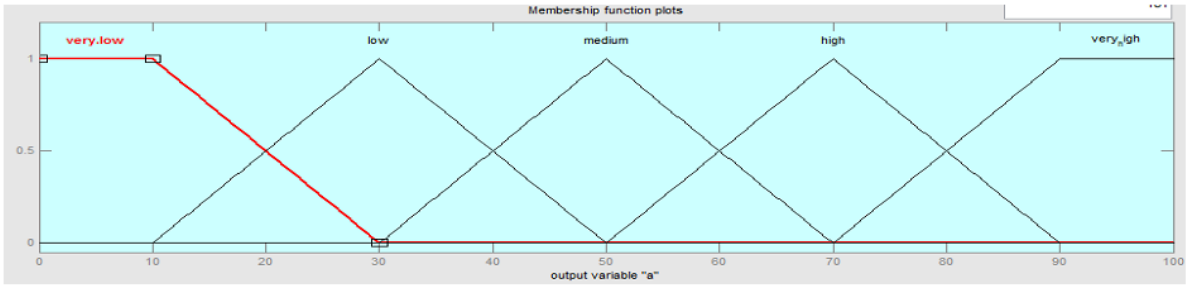

Figure 3- membership functions of 5-option range fuzzy sets

Table 3 and Figure 4 represent personal safety risk modules

Table 3- personal safety risk modules

Output variable	Risk input variables			
personal safety risk	Respiratory devices for emergencies	personal H2S detection	personal protective equipment	Rescue equipment
low	low	low	low	low
Medium	Medium	Medium	Medium	Medium
High	High	High	High	High

Tables 4 to 7 show 2 to 5 modules.

Table 4- environmental safety risk module

Output variable	Risk input variables			
Risk possibility	Compressed gas cylinder	Safety with cranes	Scaffolding	Safety Showers
Very low	Low	Low	Low	Low
Low				
Medium	Medium	Medium	Medium	Medium
High				
Very high	High	High	High	High

Table 5- health risk module

Output variable	Risk input variables		
personal safety risk	Residential Environmental Health	Food health	Work environment health
low	low	low	low
Medium	Medium	Medium	Medium
High	High	High	High

Table 6- environment risk module

Output variable	Risk input variables			
Environment risk	Industrial waste collection	Environmental Protection	Emergency evacuation routes	Food waste collection
low	low	low	low	low
Medium	Medium	Medium	Medium	Medium
High	High	High	High	High

Table 7- Fuzzy Inference System of HSE risk assessment (fuzzy module 5)

Output variable	Risk input variables			
Assessment score of HSE risk	Environment risk	Health risk	Environmental Safety Risk	Personal safety risk
Very low	Low	Low	Very low	Low
low			Low	
Medium	Medium	Medium	Medium	Medium
High			High	
Very high	high	high	Very high	high

Third step: Inference Rule development

To complete fuzzy inference system, it is requited that fuzzy logic rules to be defined. Figures 4 to 6 represent the number of fuzzy modules rules

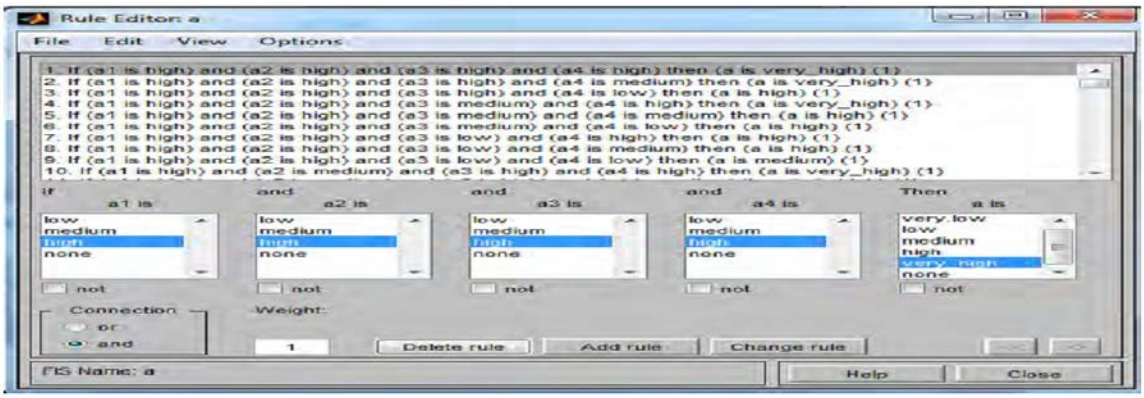

Figure 4- overall view of fuzzy module 1 rules

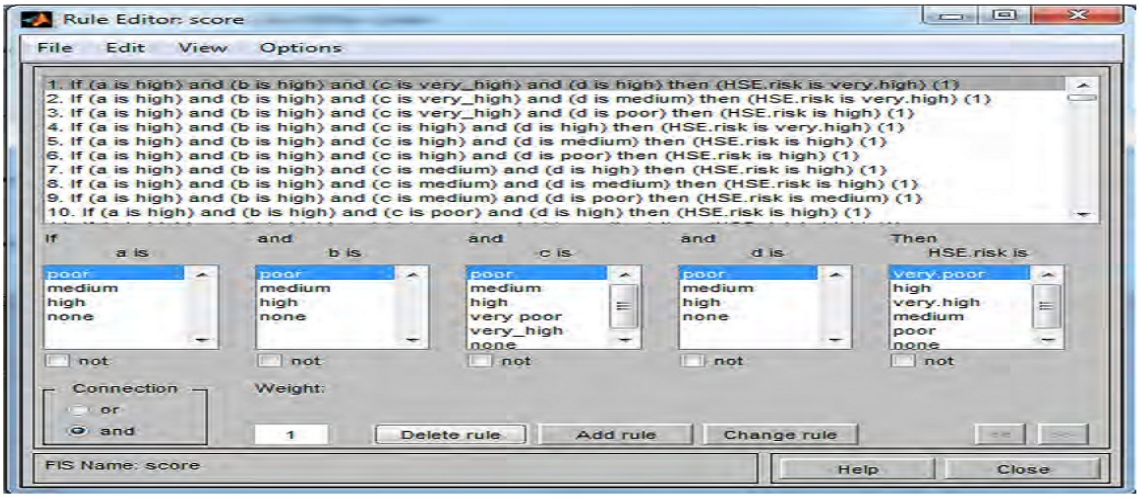

Figure 5- overall view of fuzzy module 2 rules

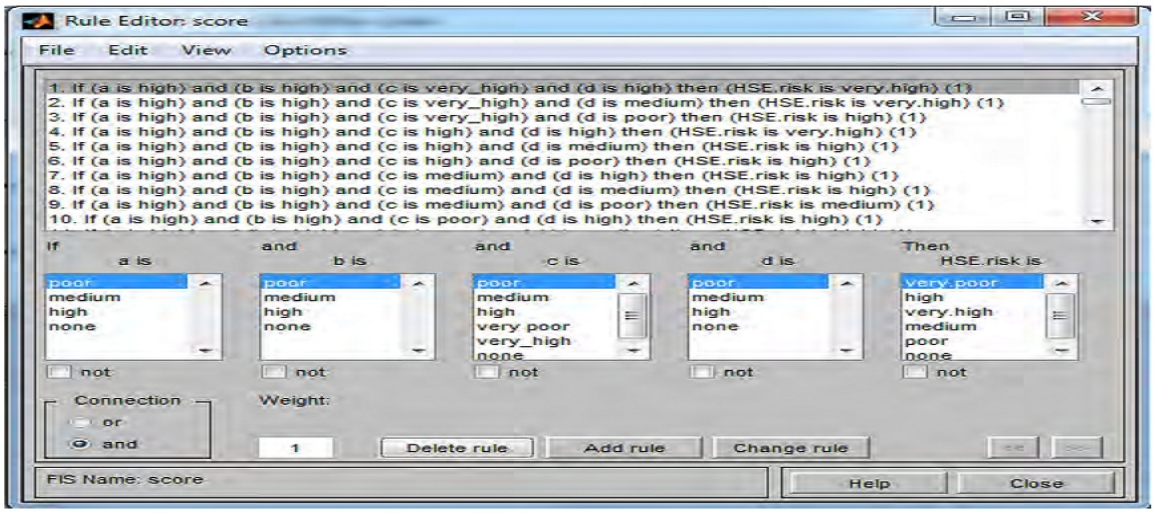

Figure 6- overall view of fuzzy module 5 rules

Fourth step: defuzzification
The value of outputs obtained in the earlier steps is fuzzy. To simplify the analysis, fuzzy numbers should be converted to ordinary numbers. In other words, the value of output s is defuzzified

Fifth step: model testing
To test the model, output behavior analysis method is used. Outputs equivalent to each combination are calculated using MATLAB software. Figure 7 shows the behavior of system output variable that is assessment score of HSE risk, environmental safety risk, and personal safety risk.

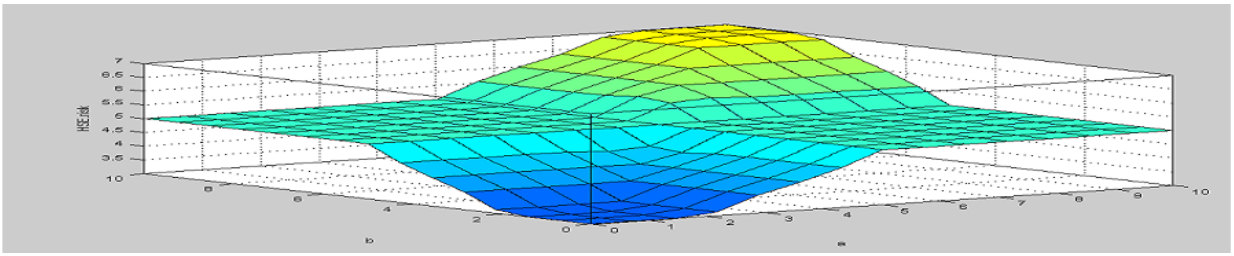

Figure 7- the behavior of HSE risk assessment score variable

4. Results of study

The research examines fuzzy expert system in the Pars oil and gas company. In this system, there are 4 main dimensions that each of these dimensions has sub-indices. In this section, the inputs of fuzzy expert system were determined by distributing questionnaire among 15 Pars gas oil company managers. Each one of them was asked to give score from 0 to 100 for each of the sub-indices of system. In addition, the severity of risk was determined according to interval of 0 to 1 by view of experts. Given verbal variables ranges assigned and type of partitioning of research sub-indices (3-option and 5-option verbal variable), the corresponding verbal variable was also determined. Then, the mean of all inputs was calculated and entered to system. As a result, each of modules was entered to output variable column in the last cell of table. For example, Table 8 indicates the issue.
Fuzzy module 1 consists of 4 inputs of compressed gas cylinder, safety of working with cranes, scaffolding, and safety of showers. In this module, with the severity of the risk 0.2, the overall risk of environmental safety will be equal to 12.2529.

Table 8 - Input variables Module 1

Output variable	Risk input variables				
Risk probability	compressed gas cylinder	safety of working with cranes	scaffolding	safety of showers	
61.2646	77.0925	59.0308	29.0749	57.7093	Mean
0.2					
12.2529	Overall environmental safety risk				

Figure 8 shows the output of this fuzzy module

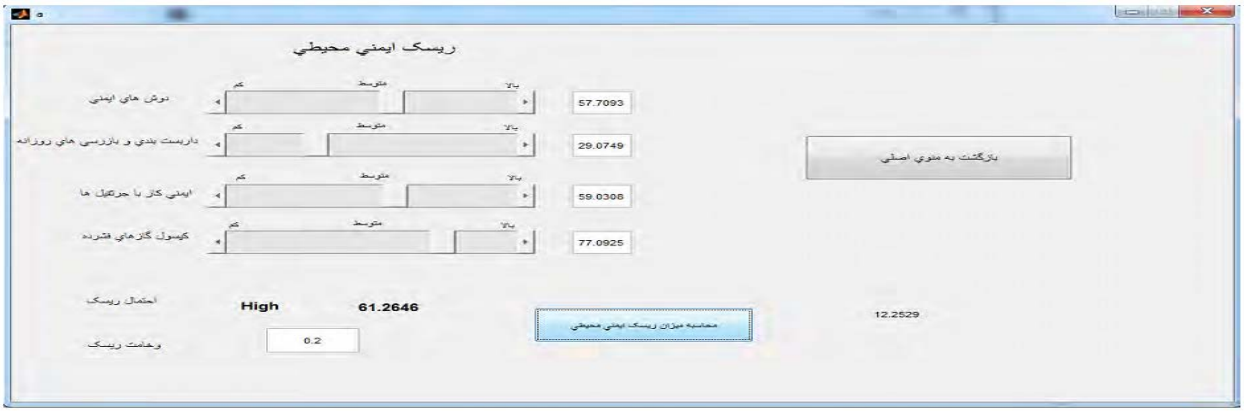

Figure 8- level of environmental safety risk

Similarly, input and output of subsystem of (fuzzy module 2), and (fuzzy module 3) and (fuzzy module 4), like (fuzzy module 1), were obtained. Therefore, the overall risk of personal safety in fuzzy module 2 with the severity of 0.2 is equal to 8.0278. In fuzzy module 3, the overall risk of environmental with severity of 0.3 is equal to 10.8451. In the Fuzzy module 4, the overall risk of health with severity of 0.2 is 8.9944
Finally, risk assessment of fuzzy module 5 is in accordance with Figure 9 shows the company's risk assessment score. Thus, the overall HSE risk of Pars Company is 10.9172.

Figure 9- risk assessment score

5- Conclusion

This main objective of the study was to present a comprehensive model of fuzzy expert system to help users of the company to facilitate HSE risk assessment process. Using this system and by changing the dimensions affecting risk reassessment, the risk available in the organization can be easily assessed. This model is considered as a comprehensive model since it covers most of the risk assessment models.
Limitations of this study include lack of infrastructures required in the country for risk assessment, as well as access to a limited number of experts in the areas of safety, health, and environment .By conducting this study and obtaining its results, the way was paved for future studies, which includes providing an expert system for management of risk in manufacturing and service companies.
Results of this study are as follows:

1. The dimension of environmental safety has high risk and may create problem for Petro Pars Company. All 4 existing factors (safety of showers, scaffolding, safety of working with cranes, compressed gas cylinders) have high probability of occurrence. As a result, overall risk of environmental safety is high. To reduce the risk, HSE manager of the company should pay much attention and take steps to reduce them.
2. The dimension of personal safety has medium risk. All 4 existing factors of personal safety risk (respiratory devices failure during emergency, failure of personal H2S detection, damage to personal protective equipment, and rescue equipment) had medium probability of occurrence and organization manager should pay attention for them and take necessary actions to reduce the probability of incidence of the event and to reduce the risk.
3- The environmental dimension has medium risk. All fourth factors of environmental risk assessment (environmental protection, emergency evacuation routes, places to accumulate food wastes, and places to accumulate industrial wastes) had medium probability of occurrence. Therefore, organization manager should pay attention for them and take necessary actions to reduce the probability of incidence of the event and to reduce the risk.
4- The health dimension has medium risk, and companies must take steps to reduce this risk. Thus, indices of health risk assessment in oil and gas projects include work and offices environment health, food health, residential environment health, and welfare of employees.

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