Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(6):2044-2048

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Natural gas pipeline repairing methods adaptability analysis

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ABSTRACT

During the natural gas flowing in the pipeline, all kinds of accidents may occur inevitably. Due to the continuous technological development of emergency repairing, there may be more than one feasible repairing scheme for the same natural gas pipeline accident. Therefore, it is very important to determine the optimum repairing scheme scientifically among others. In this paper, we use the rescue time, accident loss, rescue cost and social influence as the indexes; construct the repairing scheme decision-making model based on the Analytic Hierarchy Process. Lastly take the repairing scheme decision-making process of one natural gas pipeline accident as an example.

Key words: Natural gas pipeline; repairing method; analytic hierarchy process (AHP)

INTRODUCTION

During the flowing process, the gas pipeline accidents sometimes happen due to corrosion、pipeline defects、third-party damage and other factors. With the continuous technological development of emergency repairing, there may be more than one feasible scheme for the same gas pipeline accident. If we can use a certain method to ensure the optimum repairing scheme, we can not only complete the emergency rescue mission safely and reliably, but also save the cost of repairing. It will bring great economic benefits and social benefits undoubtedly. Unfortunately, we often use qualitative analysis with a larger subjectivity when we were having the comprehensive evaluation of the repairing plan in the past.

This paper analyzes the adaptability of natural gas pipeline repairing scheme evaluation problem based on the Analytic Hierarchy Process (AHP), which is a kind of practical combination method of quantitative and qualitative analysis in the system engineering, it will provide policymakers with complex systems thinking process mathematically. The AHP has been applied to numerous practical problems in the last few decades [1] [2]. The basic idea is to decompose complex problems into several layers and elements by the decision makers, and make comparison judgment and calculation among those elements in order to get different elements and proposed weight of scheme, the idea will provide decision basis to seize the best scheme. The key of the AHP is to construct judgment matrix [3]. We use a 9-point scale method to construct judgment matrix for comparison of the importance of two elements [4].

1. THE ANALYTIC HIERARCHY PROCESS

2.1 Constructing the AHP model

It includes decomposition of the decision problem into elements according to their common characteristics and the formation of a hierarchical model having different levels[5]. Each level in the hierarchy corresponds to the common characteristic of the elements in that level[6]. The top most level is the focuses of the problem. The intermediate levels correspond to criteria and sub criteria, while the lowest level contains the ‘decision alternatives’.

2.2 Obtain the judgmental matrix
In this step, the elements of a particular level are compared pairwise, with respect to a specific element in the immediate upper level. A judgmental matrix is formed and used for computing the priorities of the corresponding elements.

First, criteria are compared pairwise with respect to the goal. A judgmental matrix, denoted as A, will be formed using the comparisons. Each entry a_{ij} of the judgmental matrix is formed comparing the row element A_i with the column element A_j :

$$\mathrm{A}=\begin{bmatrix} a_{11} & \dots & a_{1n} \\ & & \\ a_{n1} & \dots & a_{nn} \end{bmatrix} = A(a_{ij}) \tag{1}$$

The comparison of any two criteria C_i and C_j (example: rescue time and rescue cost) with respect to the goal is made using questions of this type: in the two criteria C_i and C_j, which is more important with respect to a best repairing scheme and how much more?

The use of a 9-point scale to transform the verbal judgments into numerical quantities representing the values of a_{ij}. The scale is explained in Table 1.

Table 1: The semantic scale

Intensity of importance	Definition	Description
1	Equal importance	Elements A_i and A_j are equally important
3	Weak importance of A_i over A_j	Experience and judgment slightly favor A_i over A_j
5	Essential or strong importance	Experience and judgment strongly favor A_i over A_j
7	Demonstrated importance	A_i is very strongly favored over A_j
9	Absolute importance	The evidence favoring A_i over A_j is of the highest possible order of affirmation
2、4、6、8	Intermediate	Values between two adjacent judgments are used

The entries a_{ij} are governed by the following rules:

$$a_{ij} > 1, a_{ij} = 1/a_{ji}, a_{ii} = 1 \tag{2}$$

2.3 Local priorities and consistency of comparisons
Once the judgmental matrix of comparisons of criteria with respect to the goal is available, the local priorities of criteria is obtained and the consistency of the judgments is determined. It has been generally agreed that priorities of criteria can be estimated by finding the principal eigenvector ω of the matrix A. That is:

$$AW = \lambda_{\max}\omega \tag{3}$$

When the vector w is normalized, it becomes the vector of priorities of the criteria with respect to the goal. $\lambda_{\max}$ is the largest eigenvalue of the matrix A and the corresponding eigenvector w contains only positive entries.

The consistency of the judgmental matrix can be determined by a measure called the consistency ratio (*CR*), defined as:

$$CR=\frac{CI}{RI} \tag{4}$$

In which
CI= the consistency index
RI= the Random Index

CI is defined as:

$$CI = \frac{1}{n-1}(\lambda_{max} - n) \quad (5)$$

RI is the consistency index of a randomly generated reciprocal matrix from the 9-point scale, with reciprocals forced. Saaty has provided average consistencies (RI values) of randomly generated matrices (up to size 11×11) for a sample size of 500. The RI values for matrices of different sizes are shown in Table 2.

Table 2: 1~9order matrix RI value

n	1	2	3	4	5	6	7	8	9
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45

When the consistency ratio CR=CI/RI<0.10, think the judgment matrix is with satisfied consistency. Otherwise, we think the first established judgment matrix is not satisfying, it need to be adjusted its elements scale value again until it reaches the satisfying consistency.

2. APPLICATION

There is a natural gas pipeline; the traffic condition is good along the pipeline. Due to the corrosion, a gas leakage accident happened about 91km far away from the initial station, preliminarily we can ensure three feasible methods including fixture repair、carbon fiber reinforcing repair and sleeve.

3.1 Constructing the AHP model

The repairing scheme decision-making model is constructed based on the analytic hierarchy process, which is shown in Fig.1.

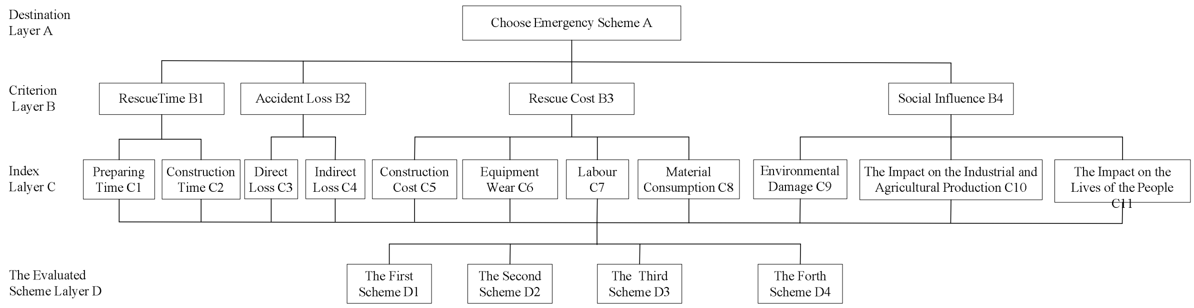

Fig.1: The AHP model for emergency scheme

3.2 Obtain the judgmental matrix and consistency of comparisons

In this paper, the focus of the problem is the optimum repairing scheme. The rescue time, accident loss, rescue cost and social influence are compared pairwise with respect to the goal. The comparison of criteria with respect to the overall objective is shown in table 3. The consistency ratio is acceptable.

Table 3: Comparison of criteria with respect to the overall objective

	Rescue time	Accident loss	Rescue cost	Social influence	w_i
Rrescue time	1	1/4	1/3	1/4	0.0830
Accident loss	4	1	1	2/3	0.2791
Rescue cost	3	1	1	2/3	0.2597
Social influence	4	3/2	3/2	1	0.3782
λ_{max} =4.0163，CI=0.0054，CR＝0.0061<0.1					

For the rescue time, the preparing time and the construction time are compared each other, the comparison of the three repairing methods with respect to the rescue time is shown in table4, and the second-order matrix is always consistent.

Table 4: Comparison of the three repairing methods with respect to the rescue time (B_1- C)

B_1	C_1	C_2	Wj
C_1	1	3/2	0.6000
C_2	2/3	1	0.4000

For the accident loss, the direct loss and the indirect loss are compared , the comparison of the three repairing methods with respect to the accident loss is shown in Table 4. And the second-order matrix is always consistent.

Table 5: Comparison of the three repairing methods with respect to the accident loss (B2- C)

B_2	C_3	C_4	W_j
C_3	1	3/2	0.6000
C_4	2/3	1	0.4000

For the rescue cost, the construction cost, equipment wear, labor and the material consumption are compared pairwise; the judgmental matrix is shown in table 6. And the consistency ratio is acceptable.

Table6. Comparison of the three repairing methods with respect to the rescue cost (B3- C)

B_3	C_5	C_6	C_7	C_8	w_j
C_5	1	4	4/3	2	0.4000
C_6	1/4	1	1/3	1/2	0.1000
C_7	3/4	3	1	3/2	0.3000
C_8	1/2	2	2/3	1	0.2000
λ_{max} =4.000，CI＝0，CR＝0<0.1					

For the social influence, the environmental damage, the impact on the industrial and agricultural production, the impact on the lives of the people are compared pairwise, the judgmental matrix is shown in table7.

Table7. Comparison of the three repairing methods with respect to the social influence (B4- C)

B_4	C_9	C_{10}	C_{11}	W_j
C_9	1	3/2	3/2	0.4274
C_{10}	2/3	1	4/3	0.3136
C_{11}	2/3	3/4	1	0.2590
λ_{max} =3.0091，CI＝0.0046，CR＝0.0088<0.1				

The combining weights of C_1～C_{11} are shown in table 8.

Table8. Comparison of the three repairing methods with respect to the optimum repairing scheme (A- C)

A	B_1	B_2	B_3	B_4	Combining weights W_j
	0.0830	0.2791	0.2597	0.3782	
C_1	0.6				0.0498
C_2	0.4				0.0332
C_3		0.6			0.1675
C_4		0.4			0.1116
C_5			0.4		0.1039
C_6			0.1		0.0260
C_7			0.3		0.0780
C_8			0.2		0.0520
C_9				0.4274	0.1616
C_{10}				0.3136	0.1186
C_{11}				0.2590	0.0978

Table 9. All index data dimensionless value and comprehensive evaluation score

Repairing scheme	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	Y_i	sorting
Fixture	0	0	1	0	0.46	0	0.33	0.21	0	1	1	0.37	3
Carbon fiber reinforcing repair	1	1	0	1	1	0.25	0	1	0.5	0	1	0.54	1
Sleeve	0	0.67	0.38	0.2	0	1	1	0	1	0.49	0.52	0.48	2

Calculation results show that y_i is the biggest in the carbon fiber reinforcing repair method, so we judge the carbon fiber reinforcing repair method is the best scheme

CONCLUSION

This paper studied comprehensively about the adaptability of the analytic hierarchy process for the determination of natural gas pipeline optimal repairing scheme. A practical application of AHP has been discussed. In this application, AHP has been used for capturing the perceptions of stakeholders on the rescue time, accident loss, rescue cost and social influence, which will help the authorities in prioritizing their repairing schemes.

Acknowledgments
The authors wish to thank the special fund of China's central government for the development of local colleges and universities—the project of national first-level discipline in Oil and Gas Engineering, and a sub-project of the National science and technology major project of China (No. 2011ZX05054), under which the present work was possible.

REFERENCES

[1] Muerza, Victoria, De Arcocha, Daniel; Larrode, Emilio. *Production Planning & Control*, vol.25(8), pp715-728,**2014.**
[2] R. Ramanathan. *Journal of Environmental Management*, vol.11, pp.27–35, **2001**.
[3] Yunfang Zhu, Zhaohua Dai. *Machine*. vol.4, pp.39–43, **2003**.
[4] Hui Pan, Junming Dai, Jinsong Shi. *Journal of Hydraulic Engineering*. vol.6, **1997**.
[5] Weiping Shu, Yuanlai Cui. *China Rural Water and Hydropower*. vol.6, **2005**.
[6] Zhongfeng Li, Shunli He, Xiangguang Zhou . *Natural Gas Industry*. vol.25(7), pp. 131~133, **2005**.