Salt Rock Underground Gas Caverns Risk Assessment Based on Fuzzy Math

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Abstract: Use salt rock underground caverns to store gas is an important storage mode in China, effective risk management is the key to the success of this method. Aimed to risk management, the foundation work is risk assessment. Fuzzy math is an effective method for solve uncertainty problem just like risk assessment. In this article, a salt rock underground gas caverns risk assessment model based Fuzzy Math was built, with this model, the risk level of salt rock underground gas caverns can be quantitatively evaluated, and the evaluation results can be used as a reference for risk rescue decision.

Keywords: Salt rock, Gas storage, Risk assessment, Fuzzy math

1. Introduction

Natural gas is becoming more and more important type of energy, according to statistics, it accounting for 25% of the global energy market, compared with the traditional forms of energy, such as coal, natural gas has the advantages of environmental protection and high efficiency. But, the storage of natural gas is a challenging problem, in many countries, such as China, many salt rock underground caverns were used to store natural gas, and then, the risk monitor and management became one problem. As the first step of risk management, risk assessment is an important problem, cause assessment results is the key accordance of risk rescue.

2. Risk identification

First step of risk assessment is risk sources identification. Through field surveying and analysis literature, the salt rock underground gas caverns accident type including three: caverns destroy, gas leakage, surface subsidence. And the cause of the accident comes from three aspects: geological conditions, design scheme, process equipment. According to this, risk factors table can be expressed as Table1:

Table 1 Risk factors table

Accident Type	Aspects	Risk factors
caverns destroy	geological conditions	Low rock strength, rock creep, lots of rock layers,large local temperature difference, etc
	design scheme	Pillar failure, small pillar space, roof flex,etc
	process equipment	Low gas pressure, pressure different, openration frequently, etc.

	geological conditions	Casting damage, binding surface slip, binding surface gap, etc.
gas leakage	design scheme	Gas pressure high, low casting, equipment fatigue, etc.
	process equipment	Valve damage, wellhead pressure improper, equipment corrosion damage,ect.
	geological conditions	Thin top layer, rock creep, etc.
surface subsidence	design scheme	Gas pressure low, roof flex, etc.
	process equipment	Long time in low pressure, pressure different, etc.

After risk factors were collected, with the experts scoring method, the grade of every factor can be quantified, and risk identification was finished.

3. Risk assessment based on Fuzzy Math

After risk identification, the risk assessment model can be built, in this article, this model was built based on Fuzzy Math, concrete method is analytic hierarchy process. The first step of the model is build analytic hierarchy process diagram. According to the results of risk identification, three diagrams were created as Figure1, Figure2 and Figure3:
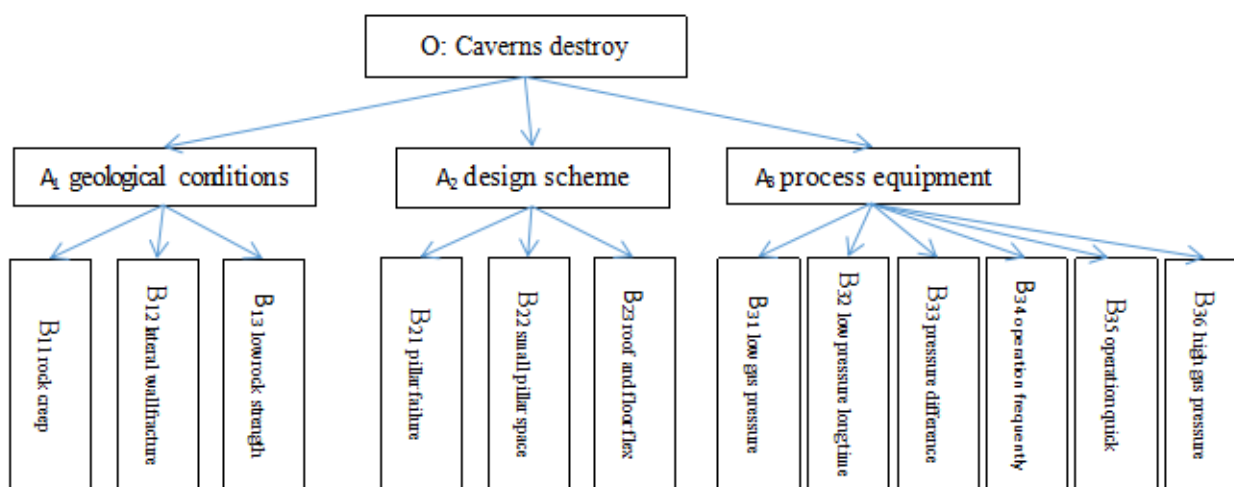

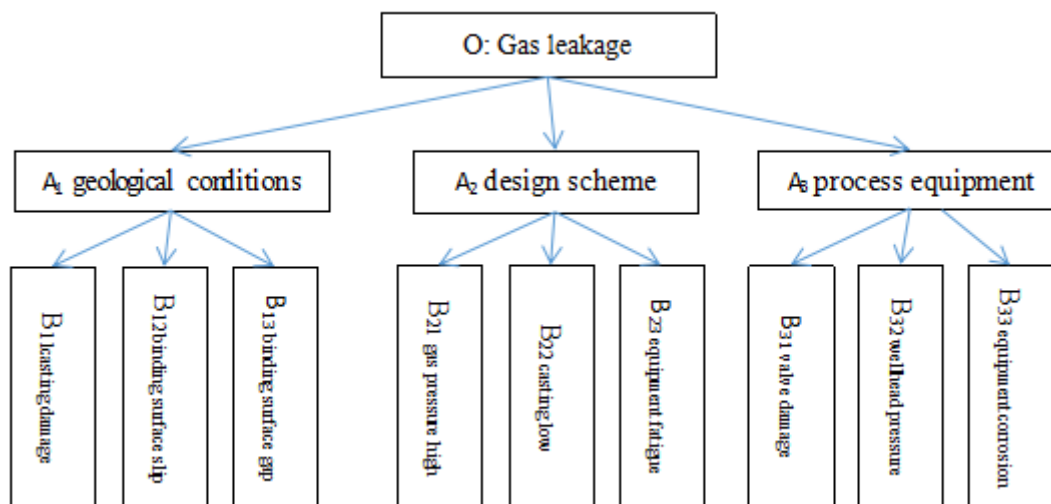Fig.1 Analytic hierarchy diagram of caverns destroy
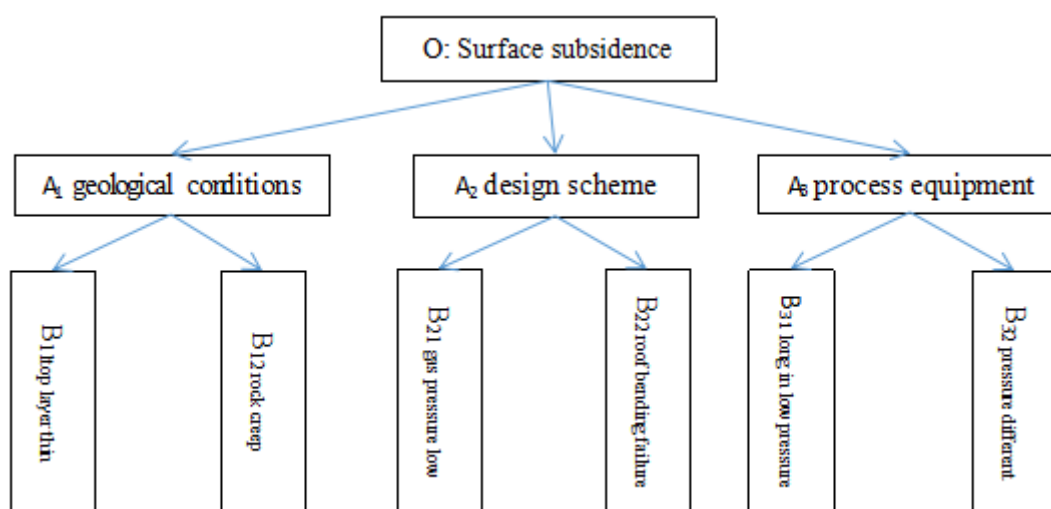
Fig.2 Analytic hierarchy diagram of gas leakage

Fig.3 Analytic hierarchy diagram of surface subsidence

The second step of model is establish hierarchy judgment matrix.According to the analytic hierarchy diagram, set the up layer factor as standard, compared each two factors in lower layer effect to up layer factor, the results are expressed in digital form, so as to form a judgment matrix.

The third step of model is analytic hierarchy process calculation and consistency check. According to judgment matrix, calculate the low layer influence on up layer. And the consistency check is to verify whether the results of the level of consistency of the consistency of the results.

The last step of model is determination of risk level. The final calculated results of three risks are distributed between 0 to 1. The risk level can be confirmed by the calculate results and Table2.

Table 2 Evaluation criterion of three risks

Risk level	Index range	Risk state
Very low risk	(0,0.13)	Very low disk, can negligible
Low risk	[0.13,0.29)	Low risk, in acceptable range
Medium risk	[0.29,0.48)	Must pay attention
High risk	[0.48,0.71)	Need to take measures
Very high risk	[0.71,1)	Unacceptable

4. Conclusion

With the Fuzzy Math method, a risk assessment model for salt rock underground gas caverns can be built, use this model, after the steps of risk identification and risk assessment, the risk level can be quantitatively evaluated, and the evaluation results is the key for risk rescue decision. This work can greatly improve the scientific and accuracy of risk management level, reduce the loss of risk.

5. Reference

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