

Research on FTA in Blasting Accident of Coal Mine

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Abstract

Through carrying out the fault tree analysis to the blasting accident of coal mine, this paper seeks 14 basic events of causing the blasting accident of coal mine. It adopts Boolean calculation to obtain 11 minimum cut sets and 5 minimal path sets for causing the blasting accident of coal mine. This paper raises the measures of preventing the occurrence of blasting accident through sequencing the importance for the various basic reason events of causing the blasting accident.

Keywords

Safety Evaluation; Fault Tree; Minimum Cut Set; Minimum Path Set.

1. Introduction

In order to implement the principle of “Safety First, Prevention First”, this paper provides the basis for safety facility design of coal mine so as to enhance the intrinsic safety degree of coal mine construction, as well as create the conditions for the standardization and scientization of safety management and safety equipment of coal mine. It also provides the basis for the safety supervision management department to perform the inspection and management so as to reduce and control the danger and hazardous factor in the coal mine construction project and coal mine production, reduce the safety risk in the coal mine production, prevent the occurrence of accident, as well as protect the property safety, personal health and life safety for the construction entity and coal mine.

Blasting is one important procedure of safety production, and it plays an important role. Even though it is not as serious as causing one gas or coal dust explosion accident, its frequency of occurrence is far more than the times of causing gas or coal dust explosion. In addition, the vibration, noise and dust caused from the blasting will bring certain damage to the stability of roadway support, roof, and the personal health, it is required to further resolve from the perspective of science and technology. Thus it is required to carry out the reasonable safety evaluation, which has an important realistic significance to guide the safety production of coal mine.

2. Principle of Fault Tree Analysis Method

Fault Tree Analysis (FAT) Method should start from the specific accident or fault that needs to be analyzed (top event), and analyze the occurrence reason layer by layer until seeking the basic reason of accident (bottom event). In which, the bottom event is also called as the basic event, their data has been known or there have been statistics or experimental results. Fault Tree is one logic tree diagram of being connected with the logic gate, and it demonstrates the occurrence reason and its logic relation of accident. Analyzing from the main reason of accident will promote the improvement for scientificity of analyzing results.

3. Engineering Application

The evaluation object is one coal mine enterprise with the designed production capacity is 450,000 t/a. It applies the fully-mechanized blasting process. This paper performs the analysis and evaluation for the main hazard types existing in the field e.g. gas, dust, fire, flood, roof, geological disaster,

mechanical and electric etc., As well as the analysis and pre-evaluation for the safety of main production procedures of mine e.g. ventilation system, hoisting system, transportation system etc.

3.1 Analysis of Hazard Source

The blasting is one main method of developing and driving the coal mine, which is also the main means for most small-scaled coal mine at present. The explosive and detonator used for the blasting are the flammable and explosive articles, and their hazards are mainly sourced from:

The explosion caused by the falling and collision due to violating the safety procedure regulations e.g. handling and storage of explosive materials, package of transportation vehicle, crane (or hoisting) speed etc. in the course of transportation.

The main storage location of storing the explosive materials is improper or the design has a major defect, the storage quantity and storage method of explosive and detonator violate the safety procedure regulations, the regulations of explosive materials e.g. issuance and return regulation, detonator numbering system, loss handling method of explosive materials etc. can't be implemented properly.

The issuance management regulation of explosive materials is disordered, the safety management measures can't be put into place or implemented improperly.

3.2 Establishment of Fault Tree Model

The completion of blasting includes the construction of blast-hole, loading, hole sealing, connection and detonation etc. Through a large number of analysis to the blasting injury accident, this paper will apply the fault tree analysis method to perform the qualitative and quantitative analysis to the casualty accident of normal blasting so as to seek the possibility of causing accident and the preventative measures.

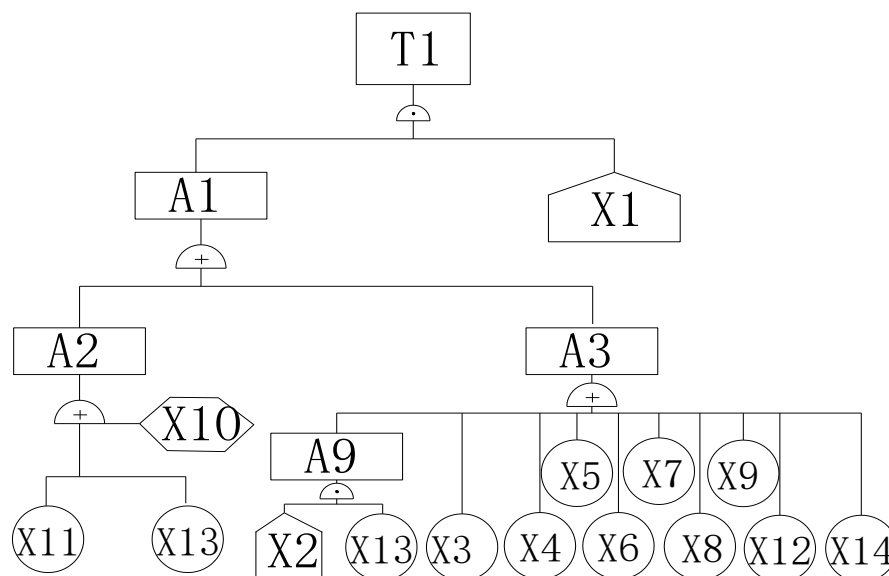


Figure 1. Blasting Casualty Accident Analysis Diagram

x₁——Normal shooting;

x₂——The space between blasting location and other roadway is too small;

x₃——Fail to set up guard if the distance from cut-through location is 20m during the single-head driving and blasting;

x₄——Not send signal before blasting;

x₅——Send the incorrect signal before blasting;

- x₆——No designated person and guard during blasting;
 x₇——Set up the incomplete guard during blasting;
 x₈——Guard person is not responsible;
 x₉——Guard safety distance is short;
 x₁₀——Fail to count the number of person before blasting;
 x₁₁——No notice before shooting;
 x₁₂——The notice before shooting was incomplete;
 x₁₃——Person accidentally enters another space;
 x₁₄——Not stop the work on one end if the distance is 20m during two run-through.

3.3 Fault Tree Analysis

3.3.1. Minimum Cut Set

In the fault tree, the basic event set of causing the top accident is the cut set. It is able to obtain 11 minimum cut sets of fault tree with Boolean algebra algorithm as below:

$$K1=(X1,X10,X11); K2=(X1,X10,X12)$$

$$K3=(X1,X2,X13); K4=(X1,X3)$$

$$K5=(X1,X4); K6=(X1,X5)$$

$$K7=(X1,X6); K8=(X1,X7)$$

$$K9=(X1,X8); K10=(X1,X9)$$

$$K11=(X1,X14).$$

3.3.2. Minimum Path Set

Due to path set is the basic event set of causing the non-occurrence of top event, it is able to obtain 5 minimum path sets with Boolean algebra algorithm according to the method of solving the minimum path set as below:

$$P_1=\{x_1\}$$

$$P_2=\{x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{14}\}$$

$$P_3=\{x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{13}, x_{14}\}$$

$$P_4=\{x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{11}, x_{12}, x_{14}\}$$

$$P_5=\{x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}\}$$

3.3.3. Structural Importance

As for the minimum path set, it is able to obtain the importance sequence for all basic events with the calculation formula of structural importance:

$$I_{\Phi}(1) > I_{\Phi}(3) = I_{\Phi}(4) = I_{\Phi}(5) = I_{\Phi}(6) = I_{\Phi}(7) = I_{\Phi}(8) = I_{\Phi}(9) \\ = I_{\Phi}(14) > I_{\Phi}(10) > I_{\Phi}(2) = I_{\Phi}(13) > I_{\Phi}(11) = I_{\Phi}(12)$$

4. Evaluation Result Analysis and Preventative Measure

4.1 Evaluation Result Analysis

If taking measures from the arrangement of minimum path set and the possibility of combining implementation, it is appropriate to select P3 as the control object so as to take the measures and control:

- x₁₀——Fail to count the number of person before blasting;
 x₁₃——Person accidentally enters another space;
 x₃——Fail to set up guard if the distance from cut-through location is 20m during the single-head driving and blasting;
 x₄——Not send signal before blasting;

- x₅——Send the incorrect signal before blasting;
- x₆——No designated person and guard during blasting;
- x₇——Set up the incomplete guard during blasting;
- x₈——Guard person is not responsible;
- x₉——Guard safety distance is short;
- x₁₄——Not stop the work on one end if the distance is 20m during two run-through.

It can be analyzed from the blasting casualty accident diagram that the initial reason event that will possibly cause the top event should be prevented and prohibited. However, in order to prevent more effectively, it is able to solve through the minimum cut (path) set. It can be known that the focus of prevention in the normal blasting casualty accident is to mainly control x₁₀ etc. 10 basic events.

4.2 Preventative Measure

- (1) Through analysis, it is able to indicate that x₁₀ etc. 10 basic events are the events of causing the blasting casualty accident, which should be prevented as the key points. Only if controlling these basic events in a pragmatic manner, the rate of accident will be reduced. As for the other relevant regulations of explosives with respect to the transportation and storage, which still need to be implemented as per the “procedure” regulations.
- (2) In terms of the accident occurrence, the unsafe factor of person and unsafe status of object are indispensable. It is required to strictly comply with the system of “One Blasting and Three Inspections”, as well as use the qualified explosives and electric detonator for the mine license, Adhere to “People-Oriented”, implement the safety production responsibility system and safety education training system.
- (3) Develop the safety management measure of blasting, as well as implement the various management regulation of explosive materials e.g. transportation, use, storage and return etc.

5. Conclusion

It can be seen from the structure of fault tree that there are 14 basic events of causing the blasting accident. Through the analysis to the importance of basic events, it is easy to analyze the complex blasting injury accident layer by layer until the bottom event, Determine the main reasons of affecting the top event of accident, analyze the logic relation among all events, it is required to prevent the combination of all basic events if preventing the occurrence of accident so as to predict the accident and unsafe factor, estimate the possible consequence of accident, as well as seek the most economic preventative means and method.

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