Case Studies in Engineering Failure Analysis 2 (2014) 33–38

Contents lists available at ScienceDirect

Case Studies in Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/csefa

Case study

Fault tree analysis of failure cause of crushing plant and mixing bed hall at Khoy cement factory in Iran

Ali Nouri.Gharahasanlou *, Ashkan Mokhtarei, Aliasqar Khodayarei, Mohammad Ataei

Mining Engineering, Faculty of Mining, Petroleum & Geophysics, Shahrood University of Technology, Shahrood, Iran

ARTICLE INFO

Article history:
Received 31 August 2013
Received in revised form 12 October 2013
Accepted 5 December 2013
Available online 23 January 2014

Keywords:
Fault tree analysis (FTA)
Crushing department
Mixing bed hall
Failure
Mining industry
Maintenance

ABSTRACT

Evaluating and analyzing the risk in the mining industry is a new approach for improving the machinery performance. Reliability, safety, and maintenance management based on the risk analysis can enhance the overall availability and utilization of the mining technological systems. This study investigates the failure occurrence probability of the crushing and mixing bed hall department at Azarabadegan Khoy cement plant by using fault tree analysis (FTA) method. The results of the analysis in 200 h operating interval show that the probability of failure occurrence for crushing, conveyor systems, crushing and mixing bed hall department is 73, 64, and 95 percent respectively and the conveyor belt subsystem found as the most probable system for failure. Finally, maintenance as a method of control and prevent the occurrence of failure is proposed.

1. Introduction

Completing planned activities in the mining industry is meant to provide complex demands of reliability and safety of both parts of the system as well as the technological processes. This is of great importance for developing companies. In addition, it will increase liability for such companies. Therefore, focusing on risk management to accurately identify the problems and failures of complex technological mining systems is an urgent need [1].

Fault tree analysis is one of the many systematic safety analysis methods developed in the last 40 years to promote the safety of complex technical systems. Bell Telephone Laboratories first used fault tree analysis in 1962 to study the safety of the launch control system for Minuteman missiles [2]. Faisal I. Khan used quantitative approaches based on risk analysis consisting of three major modules: risk estimation module, maintenance planning module and evaluation module for scheduled maintenance and inspection. Furthermore, he tried to minimize the probability and consequences of failure in relation to safety, economy, and environment [3]. Also M.J. Little, in the western wall of the PPRUST open pit mine analyzed slope stability [4]. In 2010, different applications of this technique in analysis of coal spontaneous combustion, reliability assessment of rock slope failure, and the prediction of the risk of potential coal and gas outburst were used [5–7]. In 2012 and 2013 this method was used in the analysis of failure rate and safety diagnosis on coal mine production systems, roof fall

* Corresponding author.
E-mail addresses: ali_nouri@alumni.ut.ac.ir, Alinoorimine@gmail.com (A. Nouri.Gharahasanlou).

2213-2902
http://dx.doi.org/10.1016/j.csefa.2013.12.006

accidents in coal mines, main causes of accidents due to gas outburst in mines, safety of rail transport systems in coal mine, effect of operating environment conditions on LHD, and radiation hazards in uranium mine [8–14]. In this study, fault tree analysis (FTA) method was chosen from various risk assessment techniques (e.g. informal risk assessment, event tree analysis, failure modes, effects and criticality analysis). After consideration of its applications in the mining industry over the past two decades, a case study was conducted at Azarabadegan Khoy cement factory.

2. Fault tree analysis

Fault tree analysis is a systematic safety analysis tool that proceeds deductively from the occurrence of an undesired event (accident) to the identification of the root causes of that event [15].

Fault tree analysis starts with a "top event" that generally display with rectangular and related events based on logical relations with the top event that are drown below, branching downward as in a tree [16]. In most cases, the top event is chosen based on its criticality. In addition, intermediate events based on the reasons for their occurrence are divided into the following branches. The analysis continues at each level, until basic causes or the analysis boundary conditions are reached. Branches of failure that require no further development are known as basic event, which are shown with a circle. If the failure data is not available, they event is called an "undeveloped event" and a diamond symbol is used to represent it. These events reflect the initial conditions, which are cause the main accident. Also a triangle symbol is used to show "transfer" in FTA which indicates the tree is developed further at other trees [17].

Fault-tree diagrams use logical operators, principally the "OR" and "AND" gates. In AND gate the output event occurs if any of the input events occur. This describes the intersection of the sets containing all input events to that gate. The output from an OR gate occurs if one of the input events occurs. This describes the union of the sets containing all input events to the gate [17]. Fig. 1 shows the logic symbols used in FTA.

Six basic steps used to develop a fault tree analysis [2]:

I. System configuration understanding
II. Logic model generation
III. Qualitative evaluation of the logic model
IV. Equipment failure analysis and obtain basic data
V. Quantitative evaluation of the logic model
VI. Recommended appropriate corrective actions

2.1. Probability of occurrence of the logic gates

In order to estimate the probability of occurrence of the top event, it is essential to estimate the probability of occurrence of the logic gates' output fault events. Thus, equations to estimate the probability of occurrence of "OR" and "AND" logic gates' output fault events are presented below [18]:

- OR gate

$$P(X_0) = 1 - \prod_{j=1}^{m}(1 - P(X_j)) \tag{1}$$

where m is the number of input fault events, $P(X_0)$ is the probability of occurrence of OR gate's output fault event Xo, $P(X_j)$ is the probability of occurrence of input fault event X_j, for $j = 1, 2, 3, \ldots, m$.

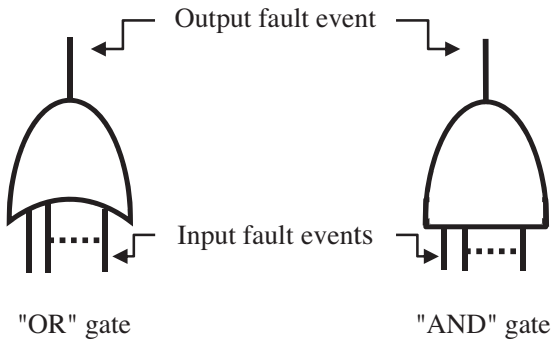

Fig. 1. Logic symbols used in FTA [17].