

## **Assignment 1, 14<sup>th</sup> February 2008**

On the background of

### **USING FAULT TREES TO DETERMINE THE ROOT CAUSE OF ROTATING EQUIPMENT FAILURES**

Discussion about the content of the paper and try to relate it to condition monitoring

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Studies have shown repeatedly nearly 80% of production losses are caused by only 20% of the failures. That sentence i got at first time when i surfed on the internet, looking for RFCA term definition. In facts, an industry survey has shown that premature failures are responsible for: Up to 30% of maintenance time, Up to 25% restriction in equipment lifetime, An increase in production unit cost by up to 5%, and also lost time injuries and even fatalities. Continuous reliability improvement of plant reliability by optimizing predictive maintenance for rotating equipment is one of the most important challenges plants face today. To know how to effectively prevent equipment failures, conduct a successful root cause failure analysis and improve condition monitoring for pumps, turbines and compressors are continuing challenges for engineers. Proper analysis and solving of chronic problems at the source saves time and money.

Today, to solve its problem more comprehensively, reliability engineers use Fault tree method which gives analysis a step by step approach that leads to the identification of a fault's first or root cause. Benefit of using fault tree such as we can maximized uptime, minimized unplanned downtime, improved process control, enhanced quality, minimized maintenance costs, and improved supply-chain performance. Reliability engineering and predictive maintenance in this case have two major objectives, that is preventing catastrophic failures of critical plant production systems and avoiding deviations from acceptable performance levels that result in personal injury, environmental impact, capacity loss, or poor product quality. As it definition, A fault tree represent a graphical of the top event, known as final events, and all possible events believed to have caused the top event. The fault tree should include all machine failures as well as human faults that may have led to the top event.

Root Cause Failure Analysis is a structured methodology for truly understanding what went wrong when failures or incidents occur. When applied to problem equipment or incidents on a regular basis, this methodology will help to eliminate the causes of these problems and allow us to put controls in place to prevent them from ever happening again. Root Cause Failure Analysis also provides the concepts needed to effectively perform industrial troubleshooting investigations. It describes the methodology to perform Root Cause Failure Analysis (RCFA), which is one of the hottest topics currently in maintenance engineering. It also includes detailed equipment design and troubleshooting guidelines, which are needed to perform RCFA on rotating machinery in most production facilities. RCFA method offers its users a structured means of achieving continuous plant reliability improvements by targeting mechanical and organizational deficiencies in a process facility.

Summarizing from the Paper, we get some information that the significant undesired events are the result of a series of events. For example, Six major events leading to the secondary compressor damage are : No procedure; The improper installation; A spare part is not available; Wrong specifications (decision to make rod); Fails after operation; and The

broken causes extensive damage (extensive secondary damage). The reliability engineers should be able to investigate step by step, starting from investigate the vestiges of the failure, after that examine fatigue failure of the machine, followed by conclude the Improper thread design. Improper thread design initiates the physical root of rod failures. This is the basic event for hidden root of failure.

RCFA is a detailed analysis of a complex or we can call it as multi event failure. The initiating event is called the root cause, and factors that contributed to the harshness of the failure or perpetuated the events leading to the failure are called contributing events. The goal of the RCFA is to find out the hidden or latent root(s) of the failure and not to attach the blame on individuals involved in the series of events leading to the failure. In the rotating equipment, failure of a high speed compressor rotor, could be called as rare event (sometime also called sporadic events), because of it may take place only once every hundred years while a more common failure, such as a mechanical seal failure, may occur several times a year, the author said in his paper.

Taken from the paper, the author tries to explain us how to construct a Fault Tree in a better way. He said that fault trees can be utilized as explanatory or exploratory tools. Explanatory fault trees work as a visual explanation of the obvious, map the investigate course. Exploratory fault trees assist the investigate team determine any possibilities that they may have overlooked. Before to do any RFCA investigation, Plant management has to determine the maximum acceptable economic risk (MAR) level for plant equipment . It can be a initial benchmark for analysis any acceptance criteria for the equipment. An interdisciplinary investigation team consisting of mechanical, process, purchasing, safety, and operations personel, to investigate elusive and costly failures, factors contributing to the failure and so on. The RCFA investigation team must have the support from management. To conduct an RCFA investigation, the author follows the six basic steps as shown below :

1. Organize an investigative team; which is the model of an interdisciplinay team is utilized
2. Schedule meetings and assign tasks; during in this step the investigation team also construct a system of root cause failure investigation procedures, which cover the following stage :
  - a. Organize a review team
  - b. Preserve the data (people, position, parts, paper data)
  - c. Analyze data
  - d. Conclude the investigation
3. Select information/develop a fault tree; in this step, the objective of the team is to review all the information result which to focusing the groups attention, selecting unnecessary data, eliminating personal assumptions. In this step fault tree also modeled
4. Advise management of initial findings; always keep confidential all of investigation until the final decision announced by the management. Keep progress of the investigation and open feedback (with plant personnel)
5. Issue a report and conduct a review meeting; Latent roots or causes of the failure should be addressed firstly, preparing for draft a report in this step. Several purposes of a review meeting are :
  - present the team findings to management
  - provide an opportunity to answer questions
  - present the team's recommendations
6. Assign responsibility and track the completion of report recommendations; provide the necessary support/documentation to assure that tasks are completed by maintenance, project engineering, or operations.

The top event is the failure of interest. So, we should be able to list all the possible methods of verifying the root cause or initiating event which provide hierarchic information. Data supporting for an initial event can be visual inspection, testing of systems, component analysis, process data, theoretical verification, and so on. In this paper also explain some example which the author describe they can be representative of rotating equipment failure cases. Next, will be shown some examples of it.

### **Sample of Fault Tree Case and Its Analysis**

#### **Example 1: Slurry Pump Fire**

In the example 1, the author try to explain about investigate in the slurry pump. Before a fault tree was built, most of operation personnel believe that the cause of the failure was the pump design. However, using the fault tree guided the team to the conclusion that the product release was a consequence of a thrust bearing failure. Since that, the process unit changed their tower operating procedure.

#### **Example 2: Fluidic Catalyst Cracking Unit (FCCU) Steam Turbine Failure**

This is an example where a fault tree analysis was used on actual unscheduled unit outage. An RFCA was performed to know what caused the initial shutdown of the power recovery train and the start up steam turbine failure. Assumptions were quickly formed in the plant, there were train shutdown was caused by personnel working in the logic panel and Turbine failure was due to loss of lube oil and steam deposits. In addition, inspection of the equipment in the field yielded information that instrumentation for wind milling steam was not in service, the low point drain in the turbine exhaust muffler was plugged and also deposits were also run into low points in the turbine exhaust.

#### **Example 3: Heater Failure due to Coking**

In this case, we be able to see that sometimes, incidences involving rotating equipment failures can actually be initiated by non rotating equipment malfunctions. In this incident, an extended outage happened in a process unit because of loss of emergency steam flow to one of the heater passes and flow from the heater charge pumps.

#### **Example 4 : Contamination of The Plant Amine System**

In this example, the RCFA investigation conducted a shorten process hazards review of the lean and rich DEA systems and discovered these potential accidents waiting to happen. This case illustrates another valuable secondary benefit of RCFA method. As a result of the investigation, some recommendation implemented on the system which is change some procedures of the operation and maintenance.

To get better finding the true cause of the problem, suggestion is to teach the all people from operation and maintenance component by RFCA training, that in the following time can make a qualified multidisciplinary team members. In the organization should have an updated system which accepted by all of those in the organization. And then also the full support from the management to conduct and make penetrated a good regulation into their department. Structured system will get to root cause failure analysis (RCFA) higher of the success with less of the effort a takes. Sounds like a good deal, it is!

We know that, the main cause an accident happen or occur is a human error. So, if we are working as management, we should manage our team in a good way of knowledge, for example better understanding of fault tree analysis. A small changing in the maintenance and condition monitoring custom, could save a lot of money.

References :

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