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The Lifetime Reliability Solutions
Certificate Course in Maintenance and Reliability
Module 4 – Precision Maintenance Techniques for Machinery

Session 15
Creative Disassembly Root Cause Analysis

1. Introduction

It would be rare for a machine to fail and not give some material or historical evidence of why it has failed. Unfortunately much of this, particularly the material evidence, is not looked at and some experiential opinion will be offered for the cause. Consequently many of the failures, machines and systems, repeat themselves, possibly until in desperation the consultants are brought in. So often the answers are already there. While RCA within a plant maintenance function is the primary focus of this session remember that the process has an infinitely wide application and many of the principles are generic.

All of us are problem solvers and, although we may be reluctant to see it as such, we are root cause analysts. Root cause analysis is seen as a different thing by different people. There are numerous methods from the quite simplistic to powerful software packages, but at the end of the day they are all about **preventing a repetition of the problem being addressed.**

The collecting of information for analysis does not start with the stripping of the machine; it begins once the need for repair is identified and advances along two fronts, the historical and the operational or running characteristics.
Further evidence is collected once the machine is stopped and before stripping.

This Session will look at this process.

2. Root Cause Analysis

Regardless of the method applied, Root Cause analysis is essentially problem solving, but

- using the available evidence
- to identify the basic and underlying, or Root, cause
- from management, operational, design, maintenance or assembly shortcomings
- to provide solutions to prevent repetition.

To prevent repetition is the key phrase here, prevention in the future, not making corrections in the here and now.

Fixing things, reworking, cleaning up, modifying and fortifying are **corrective** steps.
Prevention has to do with **Why**

- Why the design is inadequate
- Why the machine needs repair

For instance, how did a deficient design get into service? – were the Quality Management Procedures deficient?

With job experience it is possible to see immediately something that we believe will solve the problem. There is a great danger of root cause analysis becoming subjective and highly prone to error. It is important to keep focus upon the whole causal system and to recognise there may well be more than one issue to be dealt with.

Potential pitfalls that can occur include;

- selecting a root cause from a list. This seems delightfully simple but may involve picking the most nearly correct cause and can produce inconsistent, inaccurate and confounding results.
- offering a personal opinion of what the root causes are and what is the best solution. At each step comes personal opinion and consequently any two persons will come up with entirely different analysis and recommendations.
- decision trees can be used to produce one, and only one, right answer. Judgement, experience and bias can degrade the information such that management is denied the possibilities that fall through the cracks.
- there is rarely only one root cause to an event
- even when you find the truth people don't always want to hear it.
- the true root cause(s) may lie within the fundamental structure or culture and effecting a change may be quite incomprehensible to those ultimately responsible.
- do not let blame get in the way of cause.

Two very basic truths;

- All adverse events are the result of human errors that queue up in a particular sequence.
- Errors must be accepted as system flaws, not character flaws.

If RCA is deemed as important, don't leave it to the person who found the problem or who has to fix it, appoint an RCA Facilitator and an RCA Team Leader. The RCA Facilitator is in charge and is the process expert. The RCA Team Leader is the content expert.

When an RCA is to be conducted

- Establish what criteria is required, from history, pre-shut checks, strip down etc
- Who is to be on the team. Be overly inclusive -
  .everyone learns the process, - some of
  the best ideas come from those not directly involved
- Each is to bring a full record/sequence of what they observed and every idea that has occurred.

There are numerous methods, ranging from the simplistic to the quite sophisticated software, and the choice is bound up in the level of criticality of the problem. There is no point in applying a major software package to establishing why the toilet vent fan failed, but it is important to be aware of the pitfalls listed above and to maintain some objectivity.

3. Creative Disassembly

A machine is overhauled or repaired because it is no longer servicable, it cannot perform the duties for which it is intended.

To be confident that when the machine is returned to service it will do so reliably, it is necessary to identify the causes for the failure. All the evidence that is needed to achieve this will be present – the challenge is to obtain it and analyse it.

Where there is pressure for a machine to be returned to service with minimal delay – or sooner, there may not be adequate opportunity for this process. The options in such a circumstance may be:

- for maintenance to negotiate with production for the time needed, bearing in mind the repair may have many of the same problems returned with it and there is a high probability of further premature failures,
- to accept a temporary repair subject to a scheduled proper repair. When stripped for the second repair the machine is likely to have some very useful evidence available, especially if not run to destruction.
- To apply additional resources aimed at gathering the evidence and analysing it as quickly as possible parallel to the repair process. It is possible to address many of the causes in this way. Others may be recorded for later correction.

The three phases of collecting evidence are

- Prior to shutdown
- Shutdown, but prior to strip down
- Strip down

3.1 Pre-Shut Down

This is the time to gather to gather historical and background data from CMMS, operators and those who have worked on the machine previously.

There is certain data that can only be obtained whilst the machine is still in service;

- Vibration and Bearing characteristics, thermographic and oil wear debris data for diagnostic purposes. Operating conditions need to be correlated with this. This can have a considerable bearing upon identifying the defect processes that are present. There may be an opportunity to change some process variables which may give further insights to what is taking place.
- Checks for running softfoot. Each hold down bolt is eased in turn and the change in vibration observed.
  Note that running softfoot is different to static softfoot; it occurs because of the thermal condition and /or the dynamic forces present
- Identify the presence of resonance in the machine, its base and supporting structure, and the pipework or other attachments.

3.2 At Shutdown, but before Strip Down

Before strip down begins there is valuable information that can be obtained;

- Where thermal growth may be an important factor for alignment considerations obtain a set of hot alignment readings. These are important not only for possible implication in RCA but for ensuring the data is used for future alignments in the cold condition.
- Look for witness marks such as cracked paint or shaft marks to indicate where there may have been relative movement taking place during operation.
- Check for static soft foot.
- Sample lubricants prior to removal

3.3 Strip Down

- Look for witness marks, evidence of fretting etc
- Disassemble in clean and well lit areas
- Photograph damage if applicable
- Avoid damaging during removal
- Mark the relative locations of bearings in housings, top and side, inboard and outboard
- Inspection of bearings - when removed, prior to cutting,
  - cut the cage/retainer rather than springing it
  - cut outer race from top centre to bottom centre
  - reinspect prior to cleaning
  - filter solvents to see what is in the bearing
  - analyse bearing and ball path patterns
  - spalling patterns revealing poor fitting
  - fitted surfaces revealing fretting, out of roundness etc
- Gearing wear patterns - eccentricity, backlash, misalignment etc

If time does not permit a proper examination of the bearings and other components prior to reassembly it is likely that the machine will return to service with the same problems still present. Ensure that these components are retained for later examination so that the problems may be recorded for future correction. A good practice is to have a table set aside in the workshop with plastic bags and labels where removed bearings and other components may be retained for examination. The bearing should be placed in the box of the new bearing, and labelled with machine and location, so that the CM technician is aware of the make of the replacement item – this is critical for diagnostic purposes.