Analysis of failure in manufacturing machinery

S. Sulaiman* and N. Abidin Ismail
Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Putra Malaysia, 43400 UPM, Serdang, Selangor, Malaysia, Phone: +603-98466336; Fax: +603-86567122
E-mail: *suddin@eng.upm.edu.my

Abstract. This paper presents information about how to interpret the machine failure in suitable ways. The concept in this paper focuses on the methodology and creates active thinking with positive attitude to solve the machine failure. It is also described few topic on elaborate the technique towards investigate and develop a better understanding of using this concept in manufacturing industry. Failure analysis (FA) in manufacturing has its own value for each characteristic and to communicate, it needs specific data. Two methods were discussed to perform FA i.e. Why-why analysis and PM analysis (is a philosophy which aims to clarify the mechanism behind the chronically defective phenomena by analyzing the phenomena in terms of physical principle). For Why-why analysis, it is mainly effective in preventing the recurrence of failures that occur at the initial period. Whereas PM analysis is mainly effective for resolving on a fundamental problem that occur in the accidental period.

1. Introduction
The purpose of FA is entirely positive; to prevent further failures. Failures occur when some system or part of a system fails to perform up to the expectations for which it was created such as a transmission fails, a pipeline leaks or a cell phone explodes. The concept of failure is easy to understand intuitively. But underneath that intuitive understandings are important conceptual principles which are commonly either misunderstood or not considered at all [1-3].

Failure itself is a human impression. Materials do not fall through in and of themselves. They follow the laws of nature faultlessly. If a part is loaded beyond its tensile strength, it wills breakdowns. While waiting for that pressure level is reached, it does not break. When a part fails in service, it was under-designed or poorly mass-produced for the situations in which it was used [4].

1.1 Ideas behind Equipment Failure Reductions
Nowadays in manufacturing, the failure is repeating and mostly it is happens due to many factor such as modification of equipment (planning and implementation), feed back to similar equipment and equipment of the next generation, daily maintenance (add or review the contents of daily maintenance, lubrication and cleaning such as parts and frequency) or periodical inspection/service (adds or reviews the contents such as parts and frequency).
In cases same breakdown occurs, the routine or method that being carried out to reduce breakdown is usually done by disassembly and service manual (disassembling procedures, check points etc. The thing needs to keep towards this activity is spare parts development (keep parts as spare parts).

Therefore, FA has being created as a method to pursue the true cause abnormality and prevent recurrence as an improvement after the current practise which is only restore the parts after detect an abnormal part at an early stage. The purpose of FA being implemented is described as in table 1.

| Division      | Purpose of FA                                      |
|---------------|---------------------------------------------------|
| Company       | Product quality, delivery and price that meet customer’s request. |
| Plant         | Improve productivity and zero defect delivery     |
| Maintenance   | Stable operation of equipment (produce no defects) and increase efficiency. |

In general, failures of machine come from two main types which is functionality stops failure and decline in functionality failure. Functionality stops failure occur when the operation of equipment is totally stop due to breakdown while decline in functionality failure occur when the equipment function shows in decline of speed, accuracy or short stoppage.

The causes include mistakes in the planning stage or manufacturing stage, wrong way to use; wrong way to conduct daily maintenance, negligence of maintenance group and repair mistakes as illustrated in Figure 1.

**Figure 1.** Summary of machine life cycle

**Figure 2.** Three main reason of breakdown
Failure is happen due to many reasons. Generally it can be divided to three main reasons as illustrated in Figure 2.

Like human beings, equipment is constantly under stress whether it is operated or left unattended and its life comes to an end in due course as shown in Figure 3. Therefore, health maintenance and physical strength enhancement (Kaizen) are important for the equipment.

2. Failure Analysis
Failure of a component indicates it has become completely or partially ineffectual or has deteriorated to the point that it is unreliable or unsafe for normal sustained service. FA is an engineering methodology to determining how and why equipment or a component has failed. The goal of a FA is to understand the root cause of the failure so as to avoid similar failures in the future. In addition to confirming the failure mode it is important to determine the factors that explain the how and why of the failure event. By recognising the roots cause of the failure occurrence, how and why of failure can be clarifying [5-7].

It is not always necessary to prevent the first, or root cause, from happening. It is merely necessary to break the chain of events at any point and the final failure will not occur. Frequently the root cause analysis identifies an initial design problem. Then a redesign is commonly enacted. Where the root cause analysis leads back to a failure of procedures it is necessary to either address the procedural weakness or to develop an approach to prevent the damage caused by the procedural failure.

2.1 WHY-WHY Analysis
The answers to the “Why” questions form a chain of causes leading to the root cause. The answer to the first Why is the direct cause. The logical end of each chain is a root cause (each chain will have its own root) and the causes in between the direct cause and the root cause are contributing causes. There
may be no contributing causes, but there is always a root cause – the best and logical place to stop as identified by the team. This place is where continuing to ask Why adds no value to prevention of repetition, inconsistency reduction, or cost savings [8].

When the problem is identified, and preliminary data has been gathered and verified, the analysis can begin. This process uses the Why-Why analysis method to build a cause chain because it is a natural, logical progression for thinking through a problem as described in Figure 4. Using the 5-Why approach provides a structured approach to corrective action and can form the basis for a broad-based continual improvement and preventive action plan. This formal process should capture and prioritize causes and address them as the basis for continual improvement efforts. The issues acknowledged through this process are difficulties within the organization that are costing time, money, and frustration [9]. This cause identification process, coupled with a structured prioritization process will also satisfy the requirements for:

- Corrective action to a degree appropriate to the magnitude of the problems and commensurate with the risks encountered
- Effective handling of customer complaints and reports of product nonconformities
- Investigation of the cause of nonconformities relating to product, process and quality system, and recording the results of the investigation.

2.2 PM Analysis
PM Analysis is a ‘Philosophy’ which aims to clarify the mechanisms behind the chronically defective phenomena by analyzing the phenomena in terms of physical principles. This can be done by using 5 M’s, which are the first physical principles is to analyze and understand the mechanism of a machine.
Then analyze how the machines, man, materials and method are interrelated with the phenomena. This is the main ideas behind analyzing the factors of failure.

PM Analysis also can be described as chronic problems are physically analysed based on principles and laws to clarify the mechanism for the phenomenon. PM Analysis is suitable for problems with clear causes and non-effective counter-measures. Through PM analysis process, confidence is build up and “Kaizen” abilities and techniques improve as described in table 2. Table 3 shows the method on how to perform PM analysis.

**Table 2. Differential between Conventional Kaizen and Kaizen for Zero Defects (PM Analysis)**

|                      | Conventional Kaizen                              | Kaizen for zero defects |
|----------------------|--------------------------------------------------|-------------------------|
| **Goal**             | ½ Substantial reduction                          | As close to ) as possible |
| **Ways of thinking** | 1. Focus on priority thinking                    | 1. Cannot focus on priority thinking |
|                      | 2. Resolve issues that have a substantial effect from the biggest point | 2. Think rationally and list up all possible factors which may have had an effect |
|                      | 3. Carry out counter measures on a limited number of factors | 3. Thoroughly investigate each factor |
|                      |                                                  | 4. Fix all defects |
|                      |                                                  | 5. When possible, fixes together |
|                      |                                                  | 6. Implement intensively |
| **Approach**         | Fishbone diagram (factors and effects)           | PM analysis |
| **Other**            | When problem rates are high                      | When problems rates are low; |
|                      |                                                  | When problems are chronic |

**Table 3. Step to perform PM Analysis**

| Step 1               | Clarify the phenomena                           |
|----------------------|------------------------------------------------|
| Step 2               | Understand the structure/composition            |
| Step 3               | Physical analysis of the phenomenon             |
| Step 4               | Review the conditions that lead to the phenomenon |
| Step 5               | Review the 5 Ms and correlations                |
| Step 6               | Review the investigation methods                |
| Step 7               | Determine the problem                           |
| Step 8               | Restoration and Kaizen                          |
| Step 9               | Maintenance Control                             |

Figure 5 shows of example by using CAD; the mechanism of the structural drawing can easily being understood. This is described as in step 2 in Table 3.
3. **Summary of Why-why analysis and PM analysis.**

Why-why analysis is used to respond to sudden failures and to reviews how to prevent their recurrence. It’s mainly effective in preventing the recurrence of failures that occur during the initial failure period. The analysis of true cause of the problem is by repeating the question “Why”. It’s also needed to understand the fact of what is happening, and repeatedly analyse why this fact is occurring.

PM analysis is used to reduce chronic losses, especially when reducing defects and short-period stops to “zero”. It’s mainly effective for resolving on a fundamental level the problems that occur in the accidental failure period. The analysis is by grasp the problem as a “physical phenomenon” and analyzes the factors that lead to the phenomenon. It can be done by list the factors that may affect the occurrence of the problem from the point of view of man, machine, materials and methods.

4. **Conclusion**

When a new case of machine failure keeps happening, truly reducing the failure in true sense means digging down to its root cause and answering the question,” What really must be stopped?” Before digging into the search for a root cause, organizational Kaizens can often be devised for problem arising from how daily maintenance & periodic machine adjustments are performed, or problems from design (how safety factors are calculated, how devices are used.

Failures will return and countermeasures will need to be repeated without doing failure analysis to this extent. For these reasons, while digging down in the search for root causes is important, the series of motions presented here cannot be performed by the Maintenance Department alone, and will require the cooperation of all related departments.

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