UNIT – IV FAULT TRACING

Fault Tracing

Fault tracing is a sophisticated engineering methodology designed to systematically identify, analyse, and resolve equipment failures through comprehensive diagnostic techniques. Fault tracing is a systematic process that helps professionals understand the cause and effect relationship of equipment failures. It provides a structured approach to:

- Diagnose technical problems
- Identify root causes of malfunctions
- Develop preventive strategies
- Enhance organizational knowledge and reliability

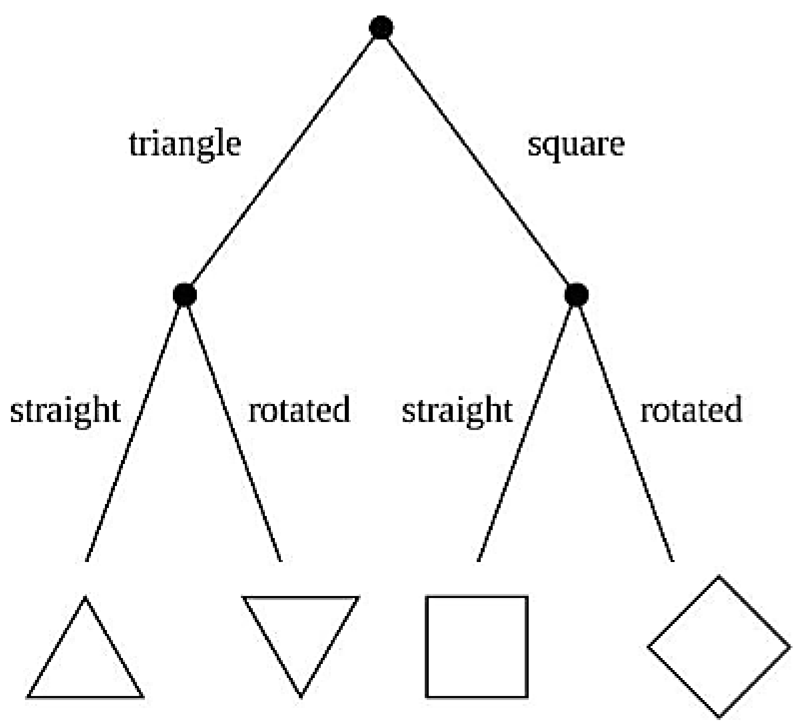
Fault tree analysis (FTA) is a type of failure analysis in which an undesired state of a system is examined. This analysis method is mainly used in safety engineering and reliability engineering to understand how systems can fail, to identify the best ways to reduce risk and to determine (or get a feeling for) event rates of a safety accident or a particular system level (functional) failure. FTA is used in the aerospace, nuclear power, chemical and process, pharmaceutical, petrochemical and other high-hazard industries; but is also used in fields as diverse as risk factor identification relating to social service system failure. FTA is also used in software engineering for debugging purposes and is closely related to cause-elimination technique used to detect bugs.

Importance of fault tracing

- Understand the logic leading to the top event / undesired state.
- Show compliance with the (input) system safety / reliability requirements.
- Prioritize the contributors leading to the top event- creating the critical equipment/parts/events lists for different importance measures.

Decision Tree

A decision tree is a tree-like model that acts as a decision support tool, visually displaying decisions and their potential outcomes, consequences, and costs. From there, the “branches” can easily be evaluated and compared in order to select the best courses of action. Decision tree analysis is helpful for solving problems, revealing potential opportunities, and making complex decisions regarding cost management, operations management, organization strategies, project selection, and production methods. Drawing a decision tree diagram starts from left to right and consists of “burst” nodes that split into different paths. Nodes are categorized as Root nodes, which compiles the whole sample and is then split into multiple sets; Decision nodes, typically represented by squares, are sub-nodes that diverge into further possibilities; and the Terminal node, typically represented by triangles, is the final node that shows the final outcome that cannot be further categorized.



The steps in decision tree analysis consist of:

1. Define the problem area for which decision making is necessary.

2. Draw a decision tree with all possible solutions and their consequences.

3. Input relevant variables with their respective probability values.

4. Determine and allocate payoffs for each possible outcome.

5. Calculate the Expected Monetary Value for every chance node in order to determine which solution is expected to provide the most value.

APPLICATIONS

- Decision tree analysis in risk management,
- Decision tree analysis in healthcare,
- Decision tree analysis in capital budgeting,
- Decision tree business analysis, and
- Decision tree analysis in finance

SEQUENCE INVOLVED IN FAULT FINDING ACTIVITIES

1. Collect the Evidence

All the evidence collected must be relevant to the problem at hand. If one is in doubt as to whether anything is relevant, then include it. Reject it afterwards at the first opportunity if it clearly is not relevant. The quantity of information collected is unimportant, what matters is that all information collected is relevant. Observe the system running, if you consider it safe to do so. Use all your senses: smell (burning), hearing (vibration), touch (temperature), sight (for unusual conditions). Refer to any relevant documentation.

2. Analyse the Evidence

Consider all the evidence collected and, if possible, reject any which after further careful consideration is not relevant Study the hardcore of relevant evidence and – through the process of careful, logical thinking –diagnose the likely fault or at least the area or region of the fault.

3. Locate the Fault

In a sense, this is a continuation of the process of analysis. The areas or regions are systematically reduced in size until a specific part can be identified as being faulty. For example, if a doorbell does not ring when it should, it is only by means of a systematic approach that one determines that the bell itself is faulty.

4. Determination and Removal of the Cause

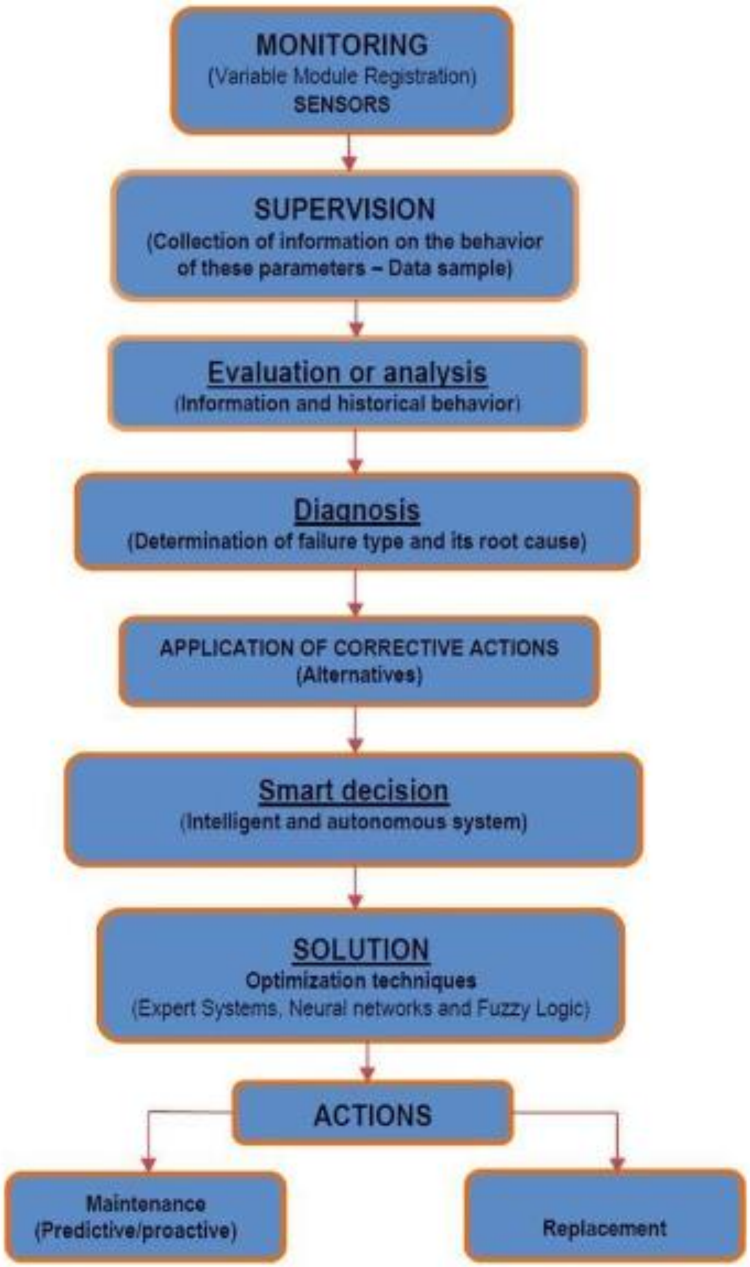
If the cause of a fault is not removed, the fault will recur even though the fault has been rectified. For instance, a flat bicycle tyre might be the result of a puncture (the fault) in the inner tube. If the puncture is repaired (i.e. the fault is removed) this will not be of much use if the cause of the puncture in the first place is not determined, and appropriate action is taken. The cause of the puncture may be a nail that has penetrated the outer cover. This must be removed.

5. Rectification of the Fault

This may be a simple task, as in the case referred to above, or it may be a much bigger one. Whatever is the case, it is a specific task based on earlier findings.

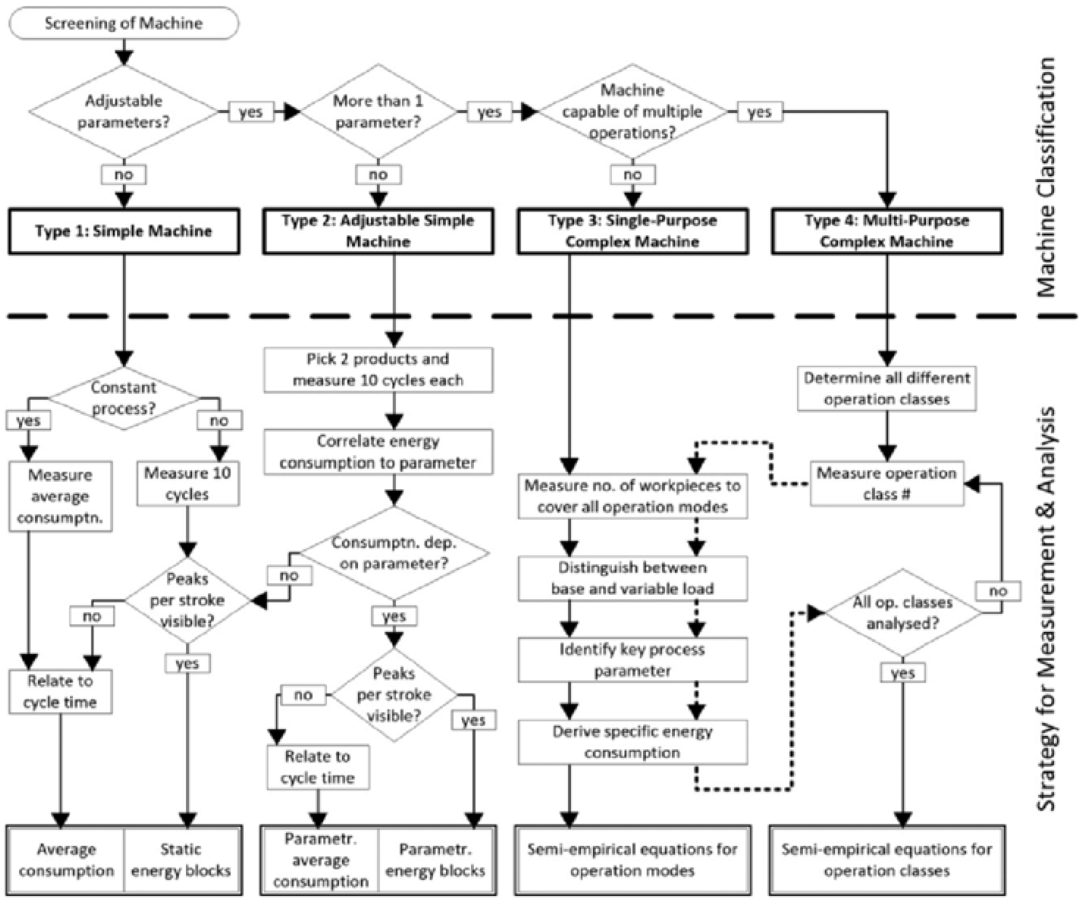
6. Check the System

It is important to ensure that the machine, equipment or system is functioning normally after the cause of the fault and the fault itself has been dealt with. In the case of the puncture, it is easy to confirm that the cause of the fault – and the fault itself – has indeed been dealt with satisfactorily, if the tyre remains inflated. With more sophisticated equipment or systems, it may be necessary to 'fine-tune' the system in order to return it to optimum working conditions.



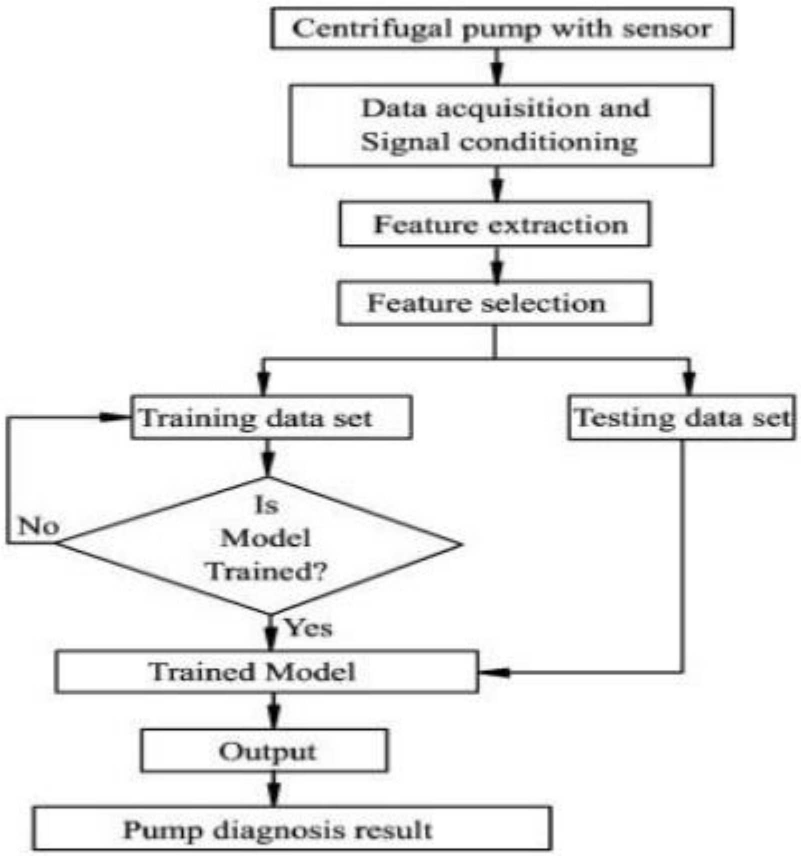
MONITORING
(Variable Module Registration)
SENSORS
SUPERVISION
(Collection of information on the behavior of these parameters – Data sample)
Evaluation or analysis
(Information and historical behavior)
Diagnosis
(Determination of failure type and its root cause)
APPLICATION OF CORRECTIVE ACTIONS
(Alternatives)
Smart decision
(Intelligent and autonomous system)
SOLUTION
Optimization techniques
(Expert Systems, Neural networks and Fuzzy Logic)
ACTIONS
Maintenance
(Predictive/proactive)
Replacement

Decision Tree for Problem in Machine Tool (Milling)

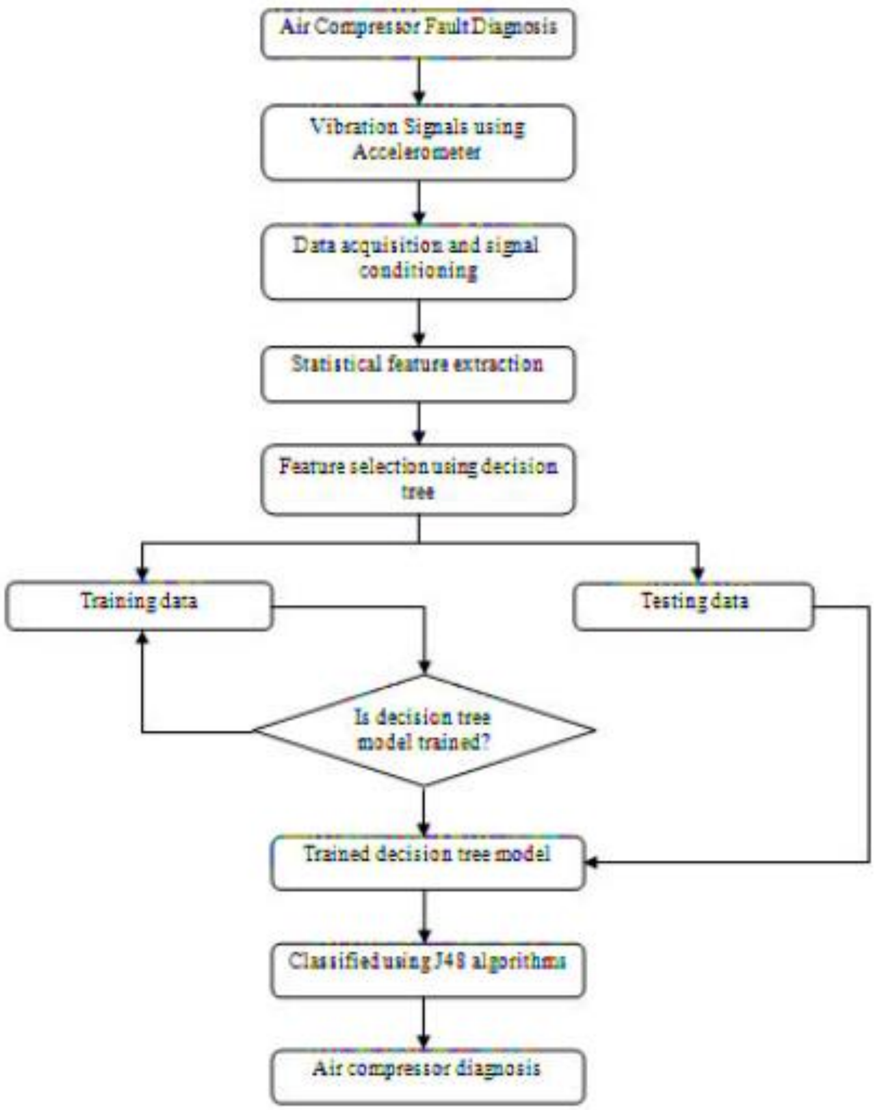


Decision Tree for Fault in Pump

A pump coupled with an electric motor is one of the most significant pieces of equipment within any industrial setting and is considered a high priority asset for failure analysis. Similar to an FMEA on pumps, FTA would also require the realization of interconnected subsystems that constitute a pump assembly. For example, any standard centrifugal pump would constitute the pump impeller, seal, suction and discharge nozzles, bearings, etc. Similarly, a coupled electric motor and its associated instrumentation and controls are also part of the pump-motor assembly and can trigger pump failure. Any single or combination of failures within each of these components can impact the pump operation and therefore need to be considered in the analysis. Due to a large number of components with various inter-dependencies, the pump FTA can become fairly complicated if the team is missing credible failure data or lacks experience on how to interpret fault trees correctly. The starting point to construct a fault tree for the pump would always be to define the top failure event and branch out further events that caused the top event. The top event can be as simple as the pump failing to operate.

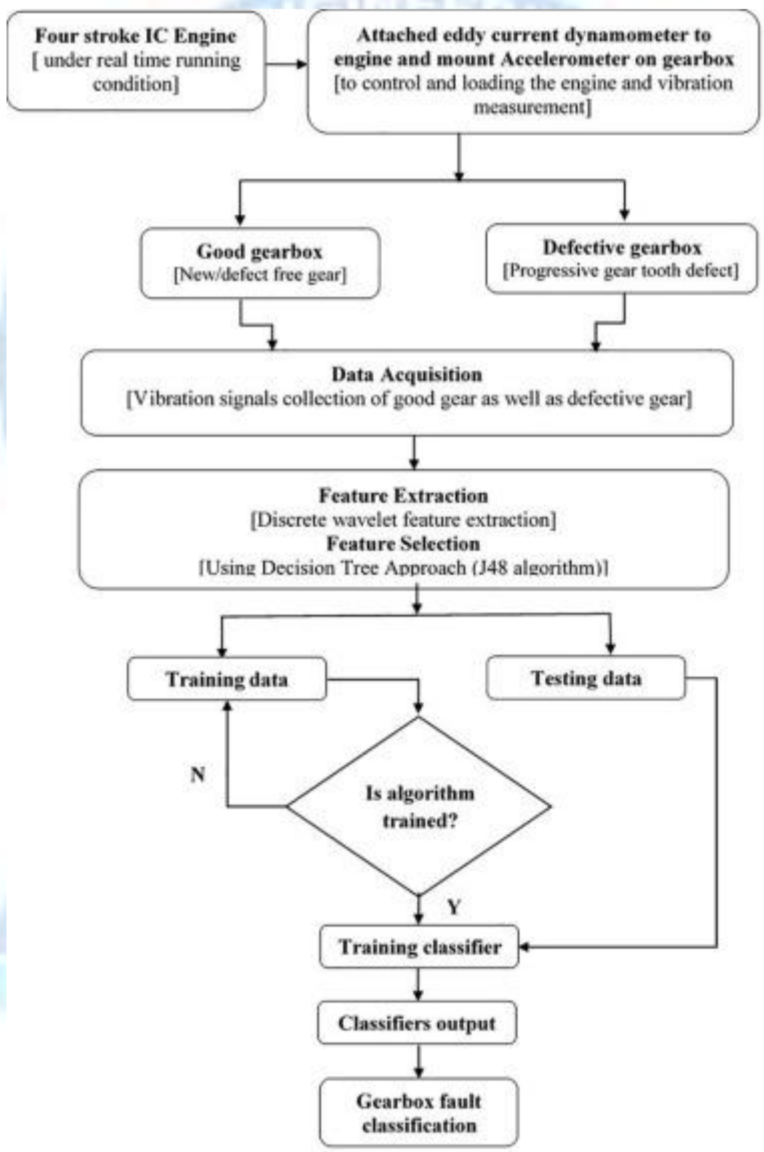


Decision Tree for Fault in Air Compressor

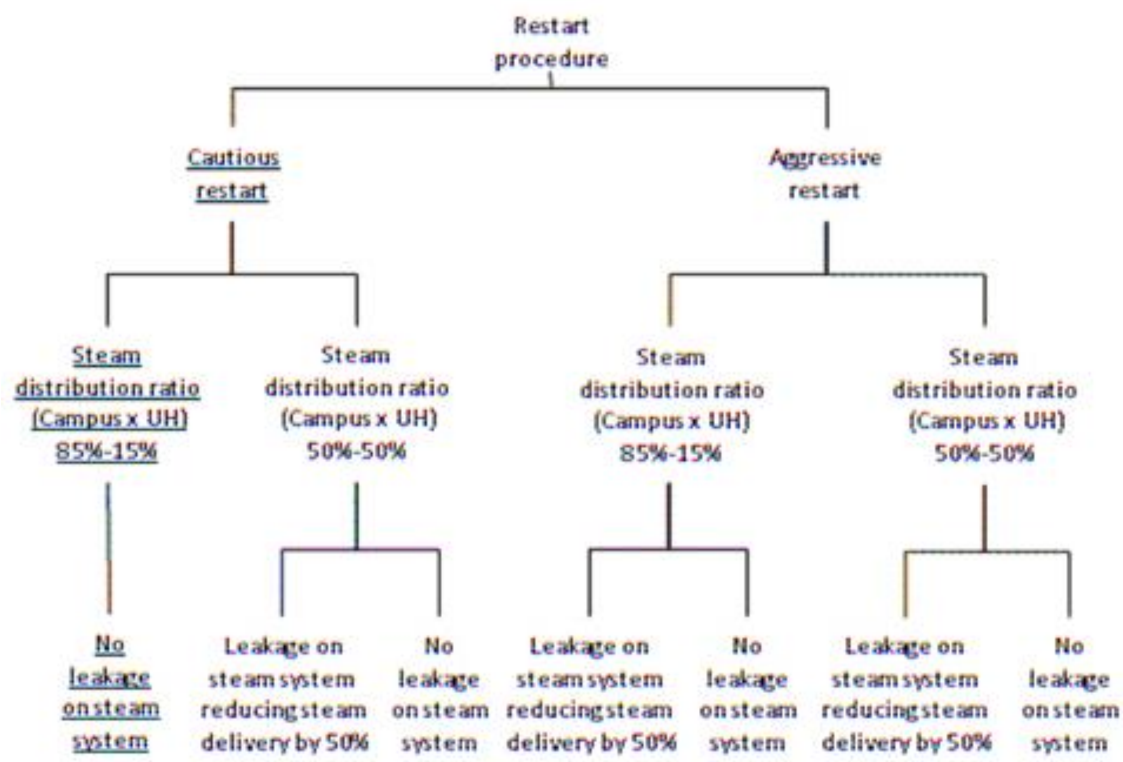


Since compressors work at high cycles, generated vibrations and fatigues are factors contributing to fracture and failure of these sets. In normal operating conditions, compressor has an allowed range of vibrations. If these vibrations exceed a definite limit, it suggests that compressor is no longer operating in normal conditions. On the other hand, each part or element of compressor runs at a certain frequency. If a failure occurs in this set, it is represented at a distinct frequency and range of vibrations. Therefore, the present study uses vibration signals for condition monitoring of compressors. Before analysis of signals in pre-processing step, samples were imported into MATLAB Software and wavelet transform of each sample which represents distinctive states of compressor was done. Signals collected by sensors in the first step were wholly at time domain. Although vibration data offers valuable information on condition of the machine, but such data does not include failure signal and there are numerous noises in them. The noises in time-domain signals problematize direct detection of failures.

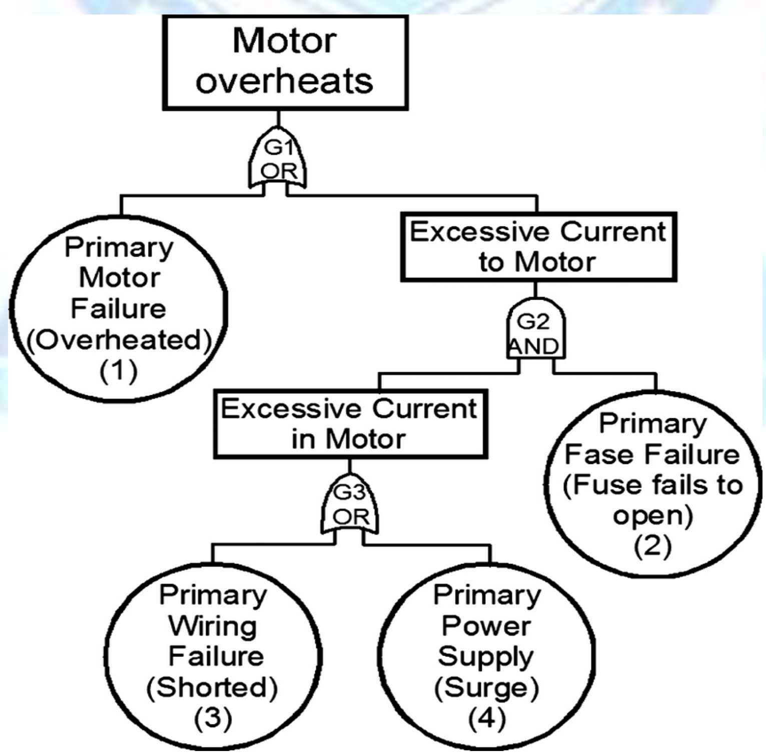
Decision Tree for Fault in an IC Engine



Decision Tree for Fault in a Boiler



Decision Tree for Fault in a Motor



Types of Machine Tool Faults.

Machine tools in the process of use, there are often some faults, such as not timely elimination, will directly affect the production, and will make the precision of the machine tool rapidly decline. Therefore, it is very important to summarize and analyze the fault causes of machine tools and explore the methods of troubleshooting. There are the following causes of failure:

- The machine itself of the mechanical parts, electrical components, hydraulic equipment and other work failure, or some parts wear badly, accuracy is out of tolerance and even damage.
- The machine tool is inaccurately installed.
- Improper daily maintenance.
- Unreasonable usage. The original design of the machine tool is imperfect or unreasonable.

1. Bearing Overheating

The shaft parts of machine tools, especially the spindle, are generally assembled into a rolling bearing or sliding bearing, and rotating at a very high speed sometimes will produce a high amount of heat. This phenomenon, if not eliminated in a timely manner, will lead to overheating of the bearing, and the corresponding part of the machine tool temperature and thermal deformation, which not only affects the accuracy of the machine tool itself and machining accuracy, and will burn out the bearing.

2. Machine tool vibration

Machine tool vibration in machining process, it is inevitable, but when the vibration will not only reduce the machining accuracy of work piece, affect productivity, aggravate wear of the machine tool friction pair, and the tool life, especially for cemented carbide, ceramics, such as brittleness tool material is particularly significant, cause vibration of the machine tool.

3. Noise

After the machine is started, due to the rotation between the motion pairs or reciprocating linear sliding, periodic contact and separation, between them due to mutual motion and produce a certain vibration. In addition, the entire transmission system of the machine will resonate. Therefore, no matter how reasonable the structure of any machine, how accurate assembly, how appropriate operation, once started will produce noise. If the sound is rhythmic and harmonious, it is normal; if the sound is too loud and harsh, it is abnormal. Noise is the forerunner of machine failure, so if abnormal phenomenon should be stopped immediately, troubleshooting before production.

4. Oil leak

Oil leakage of machine tools is a common fault in the daily work of machine tools. It not only wastes oil, directly causes economic losses, but also affects the working performance of the machine tool. Meanwhile, long-term oil leakage will also bring adverse consequences to the installation foundation of the machine tool. Therefore, we should attach importance to the "leakage control" work of machine tools. To carry out investigation and research, find out the oil leakage site, analyze the causes of oil leakage, and take measures to solve.