1.What is CM ?

- **Condition monitoring** (or, colloquially, **CM**) is the process of monitoring a parameter of condition in machinery, such that a significant change is indicative of a developing failure.it is a major component of Predictive Maintenance. The use of CM allows maintenance to be scheduled, or other action to be taken to avoid the consequences of failure, before the failure occurs.

  CM UR PLANT-Vibration Analysis, Thermal Analysis, Oil Analysis, Ultrasound Analysis

- Condition monitoring has a unique benefit in that conditions that would shorten normal lifespan can be addressed before they develop into a major failure.

- Condition monitoring techniques are normally used on rotating equipment and other machinery (pumps, electric motors, internal combustion engines, presses).

2. Different CM Technique ?

The following list includes the main condition monitoring techniques applied in the industrial and transportation sectors:

- Vibration Analysis and diagnostics
- Lubricant analysis
- Acoustic emission (Airborne Ultrasound)
- Infrared thermography
- Ultrasound testing (Material Thickness/Flaw Testing)
- Motor Condition Monitoring and Motor current signature analysis (MCSA)
- Model-based voltage and current systems (MBVI systems)

Most CM technologies are being slowly standardized by ASTM and ISO.

ASTM- American Society for Testing and Materials.

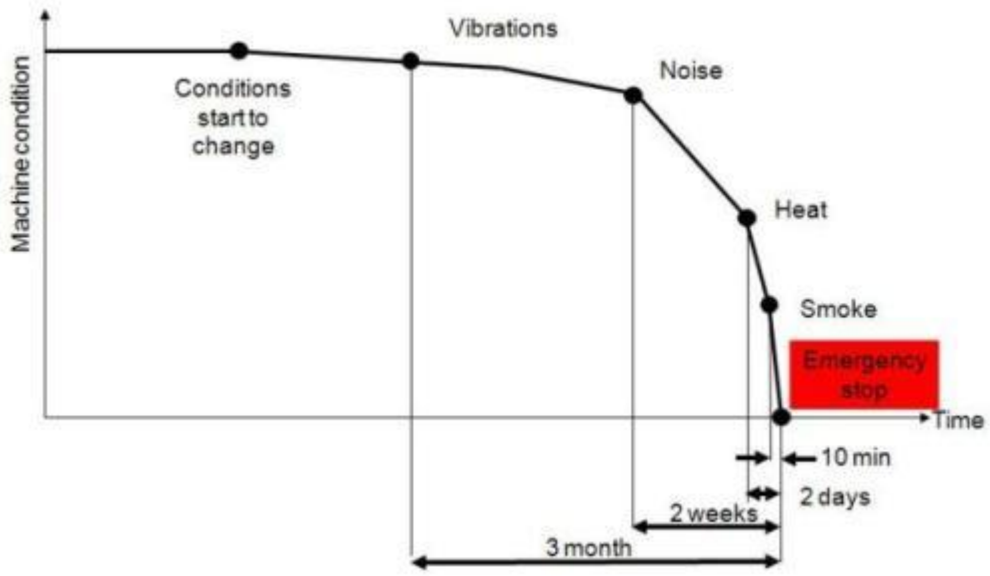
ISO- International Organization for Standardization

Acoustic emission (AE) is the phenomenon of radiation of acoustic (elastic) waves in solids that occurs when a material undergoes irreversible changes in its internal structure, for example as a result of crack formation or plastic deformation due to aging, temperature gradients or external mechanical forces.

Infrared thermography is equipment or method, which detects **infrared** energy emitted from object, converts it to temperature, and displays image of temperature distribution.

3. Objective of CM

Machine **condition monitoring is important** because it provides information about the health of a machine. You can use this information to detect warning signs early and help your organization stop unscheduled outages, optimize machine performance, and reduce repair time and maintenance costs.



4. Briefly introduction for Ferrography and thermography

- **Ferrography** is a specialized type of oil analysis used to study particle wear on machine components through analysis of contaminants in lubricating oil. It can be used to predict and diagnose errors occurring on machinery. Ferrography is related to tribology, which is the study of friction between interacting surfaces.
- **History-** Ferrography was pioneered in the 1970s by the late Vernon C. Westcott to help the United States military diagnose problems related to bearing failure before the issues became deadly.At the time, the best method of analysis could not detect small particles, so by the time the military found problems it was too late to find solutions. The military reached out to Mr. Westcott to find a way to solve this problem and from that Mr. Westcott developed the first ferrograph. The ferrograph first saw major use by the United Kingdom to detect helicopter failure in the Falklands War.

- **Purpose and uses-** Ferrography is a staple in failure prevention maintenance. Continuous monitoring of the lubricating oil allows a change from expensive and often unnecessary preplanned maintenance to the more cost-effective failure prevention. Ferrography is unique because it can deliver information about enclosed parts as lubricating oil circulates through these areas and is still accessible. Rinsing vital components with particle free lubricant and analyzing the output can offer a detailed report of machine wear without disassembling anything.

Since its initial application in the military, ferrography has been found to be helpful in

- ships
- coal mining
- diesel engines
- gas turbines in the aerospace industry
- agricultural industry
- naval aircraft

- **Further applications-** Applying the idea of ferrography in other fields, techniques have been found to analyze wear outside of lubricating oil and of particles that do not carry magnetic properties. These uses have been found in processing grease samples, gas emissions; and in examining wear on arthritic joints.In arthritic joints, residue from bone-on-bone contact can be found in fluid near the joint and analyzed using direct-reading ferrography which can give information regarding rate of decline in the joint. As of November 2016, minimal information is available regarding further uses of ferrography.

Type-

1.**Analytical ferrography**

2.**Direct-reading ferrography**

Analytical ferrography-

Analytical ferrography works through magnetic separation of contaminant particles and a professional analysis of the particles. A sample of the machine's lubricating oil is taken and diluted, then run across a glass slide. This glass slide is then placed on a magnetic cylinder that attracts the contaminants. Non-magnetic contaminants remain distributed across the slide from the wash. These contaminants are then washed, to remove excess oil, heated to 600 °F for two minutes, and the slide is analyzed under a microscope. After analysis, the particles will be ranked according to size. Particles over 30 microns in size are considered "abnormal" and indicate severe wear.

Particles are divided into six categories, with an additional five subcategories under ferrous wear.

- copper
- white nonferrous: usually aluminum or chromium
- babbitt: particles containing tin and lead
- contaminants: do not change appearance after heating, usually dirt
- fibers: typically from filters
- ferrous wear: magnetic particles that are attracted to the magnetic cylinder
  - high alloy: rarely found on ferrograms
  - low alloy
  - cast iron
  - dark metallic oxides: darkness indicates oxidation
  - red oxides

Being able to identify different particles can prove to be invaluable, because the prominence of certain particles can point to specific locations of wear. Furthermore, the presence of particles that do not make contact with the lubricating oil can uncover contamination. This kind of analysis required a trained professional and can be prohibitively expensive for smaller operations.

Direct-reading ferrography

Direct-reading ferrography is a more mathematical approach to ferrography. Essentially, the buildup on the glass slide is measured by shining a light across the slide. The blockage of the light by the buildup of particles is then used, over time, to calculate an average. An increase in blockage indicates higher amounts of machine wear. This method is less expensive, as expert analysis is not required, and can be automated. However, once an issue is identified, less information is available to diagnose the problem.

Limitations-

While ferrography is an effective tool for wear analysis, it does come with several limitations. Ferrography is a very expensive procedure because of the specialized and sophisticated instruments required. Ferrography stands out among oil analysis methods because of the magnetic element involved. This allows for a more detailed report that similar methods cannot produce. Additionally, for the qualitative approach that is analytical ferrography, experts are needed to make sense of the raw output. Furthermore, ferrography cannot solve problems, only bring attention to them. These issues then need to be dealt with on their own.

THERMOGRAPHY

- **Infrared thermography** (**IRT**), **thermal imaging**, and **thermal video** are examples of infrared imaging science. Thermographic camerasusually detect radiation in the long-infrared range of the electromagnetic spectrum (roughly 9,000–14,000 nanometers or 9–14 µm) and produce images of that radiation, called **thermograms**.
- Since infrared radiation is emitted by all objects with a temperature above absolute zero according to the black body radiation law, thermography makes it possible to see one's environment with or without visible illumination. The amount of radiation emitted by an object increases with temperature; therefore, thermography allows one to see variations in temperature.
- When viewed through a thermal imaging camera, warm objects stand out well against cooler backgrounds; humans and other warm-blooded animals become easily visible against the environment, day or night. As a result, thermography is particularly useful to the military and other users of surveillance cameras.

Different between Infrared and Thermography

IR film is sensitive to infrared (IR) radiation in the 250 to 500 °C (482 to 932 °F) range, while the range of thermography is approximately −50 to 2,000 °C (−58 to 3,632 °F). So, for an IR film to work thermographically, it must be over 250 °C (482 °F) or be reflecting infrared radiation from something that is at least that hot.

Night vision infrared devices image in the near-infrared, just beyond the visual spectrum, and can see emitted or reflected near-infrared in complete visual darkness. However, again, these are not usually used for thermography due to the high temperature requirements, but are instead used with active near-IR sources. Starlight-type night vision devices generally only magnify ambient light.

Advantages

- It shows a visual picture so temperatures over a large area can be compared
- It is capable of catching moving targets in real time
- It is able to find deterioration, i.e., higher temperature components prior to their failure
- It can be used to measure or observe in areas inaccessible or hazardous for other methods
- It is a non-destructive test method
- It can be used to find defects in shafts, pipes, and other metal or plastic parts
- It can be used to detect objects in dark areas
- It has some medical application, essentially in physiotherapy

Limitations and Disadvantages

- Quality cameras often have a high price range (often US$3,000 or more) due to the expense of the larger pixel array (state of the art 1024X720), while less expensive models (with pixel arrays of 40x40 up to 160x120 pixels) are also available. Fewer pixels reduce the image quality making it more difficult to distinguish proximate targets within the same field of view.
- Many models do not provide the irradiance measurements used to construct the output image; the loss of this information without a correct calibration for emissivity, distance, and ambient temperature and relative humidity entails that the resultant images are inherently incorrect measurements of temperature.
- Images can be difficult to interpret accurately when based upon certain objects, specifically objects with erratic temperatures, although this problem is reduced in active thermal imaging.

- Accurate temperature measurements are hindered by differing emissivities and reflections from other surfaces.
- Most cameras have ±2% accuracy or worse in measurement of temperature and are not as accurate as contact methods.
- Methods and instruments are limited to directly detecting surface temperatures.

What is vibration in CM?

Techniques collectively referred to as Vibration Condition Monitoring have a common objective of indicating early signs of deterioration, or malfunction in plant machinery through surveillance testing and analysis. Vibration Condition Monitoring helps reduce the possibility of catastrophic failures, increasing safety and machine performance. Through Vibration Condition Monitoring machinery operation can be improved to an optimum level that can often exceed original equipment manufacturers specifications. There are many faults that cause machine failure, all are detectable and most are preventable. The most common causes of failure which can be identified are:

- Bearing Failure
- Unbalance
- Misalignment
- Looseness - Mechanical/Structural
- Drive Belts - Pulleys
- Gearbox Faults
- Electrical Ã¢â‚¬â€œ Supply & Motor faults
- Resonance