# UNIT - III CONDITION MONITORING.

## Condition Monitoring (CM):

Condition monitoring (CM) is one of the maintenance methods which are used to access the health and condition of equipments, machines, systems or process by absorbing, checking, measuring and monitoring several parameters. This technique is called as Equipment health monitoring.

The concept of condition monitoring is to monitor the several performance parameters such as vibration, temperature, noise etc and study their characteristics. Once an abnormality is encountered, the system is then generated an alarm, the system is then investigated and problems are rectified.



## Demand for Condition monitoring.

i) Increased quality expectations reflected in produces liability legislation.

ii) Increased automation to improve profitability and maintain competitiveness.

iv) Increased safety and reliability expectations.

v) Increased cost of maintenance due to labour and material cost.

## Key features of Condition monitoring

i) Links between Cause and effect

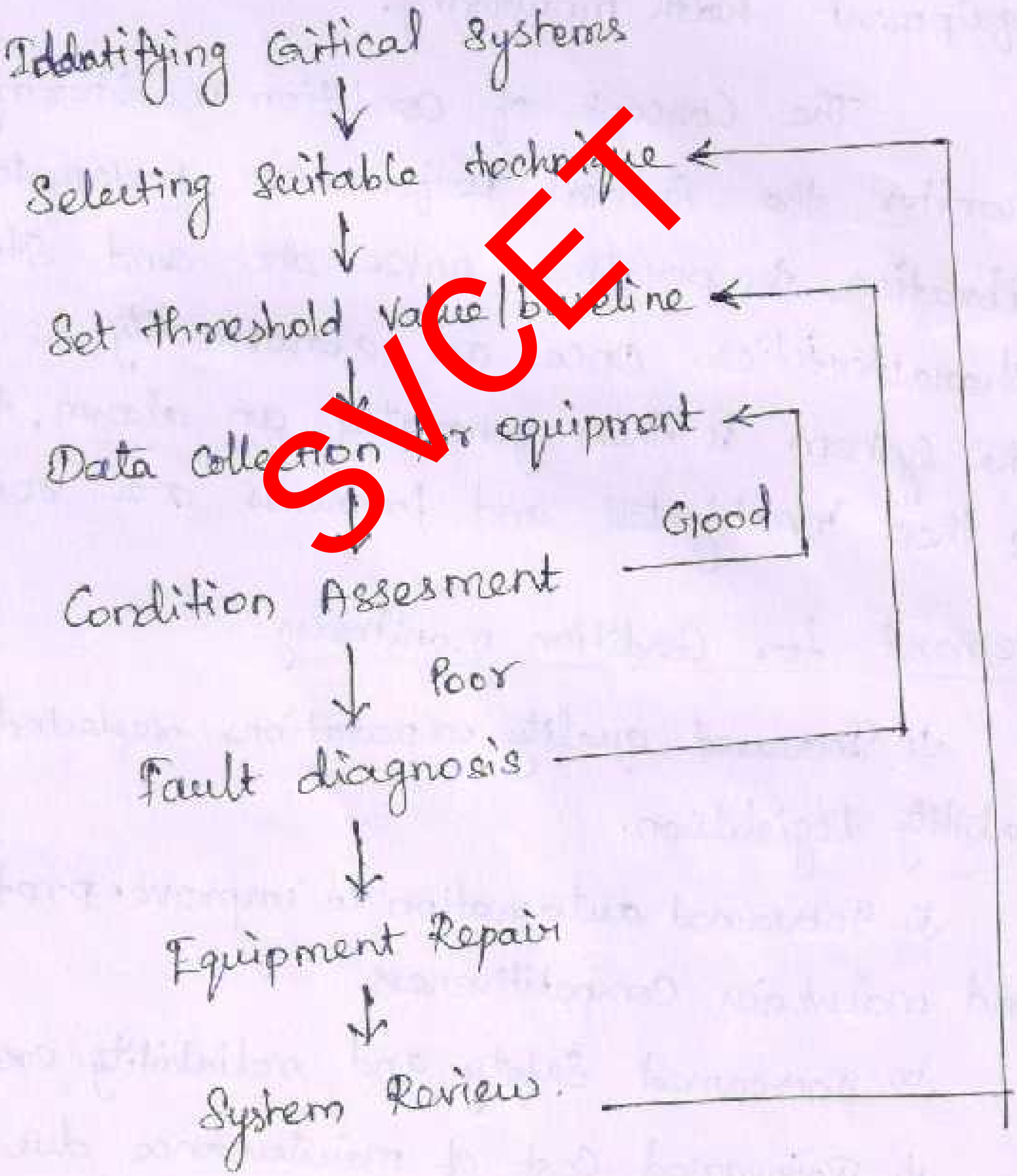
ii) Systems with Sufficient response

iii) Mechanisms for objective data assessment.

iv) Benefits outweighing Cost

v) Data storage and review facilities.

## Fundamental steps in Condition Monitoring



## Types of Condition monitoring.

i) Subjective Condition monitoring
ii) Aided Subjective Condition monitoring
iii) Objective Condition monitoring.

### i) Subjective Condition monitoring.

* Here, the monitoring Personnel use their perception of Senses and judgment to note any change of the Condition.

* The four senses, a man is bestowed with, like Seeing (Smoke), hearing (Roaring noise), Smelling (Burning of oil) feeling (excessive heat) are used.

### ii) Aided Subjective or Condition monitoring with Simple gadgets

* Here the monitoring Personnel use simple gadgets to add to their ability to perceive Conditions better.

### iii) Objective Condition monitoring

* In this type, different instruments and facilities are used for obtaining data giving direct measure of the Parametric Condition of the Components, even while the M/c is working.

## Levels of Condition monitoring.

Visual Inspections. (level 1) → { Seeing, Hearing, Touching, Smelling }

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Sensor assisted Inspections. (level 2) → { Different Instruments (Pistol thermometer, Tachometer, voltmeter, Ammeter,) }

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Indicator Analysis (level 3) → { Lubricant Analysis, Wear debris analysis. }

↓

Integrated monitoring application. (level 4) → { Remote sensors and alarm systems, microprocessor based instruments.etc. }



## Advantages of Condition monitoring.

i) Improved availability of equipement

ii) Minimized breakdown costs.

iii) Improved morality of the operating Personnel and Safety.

iv) Improved reliability.

v) Improved planning.

## Disadvantages of Condition monitoring

i. Gives only marginal benefits
ii. Increased running cost
iii. Sometimes difficult to organise.

## Cost Comparison with and without Condition monitoring.

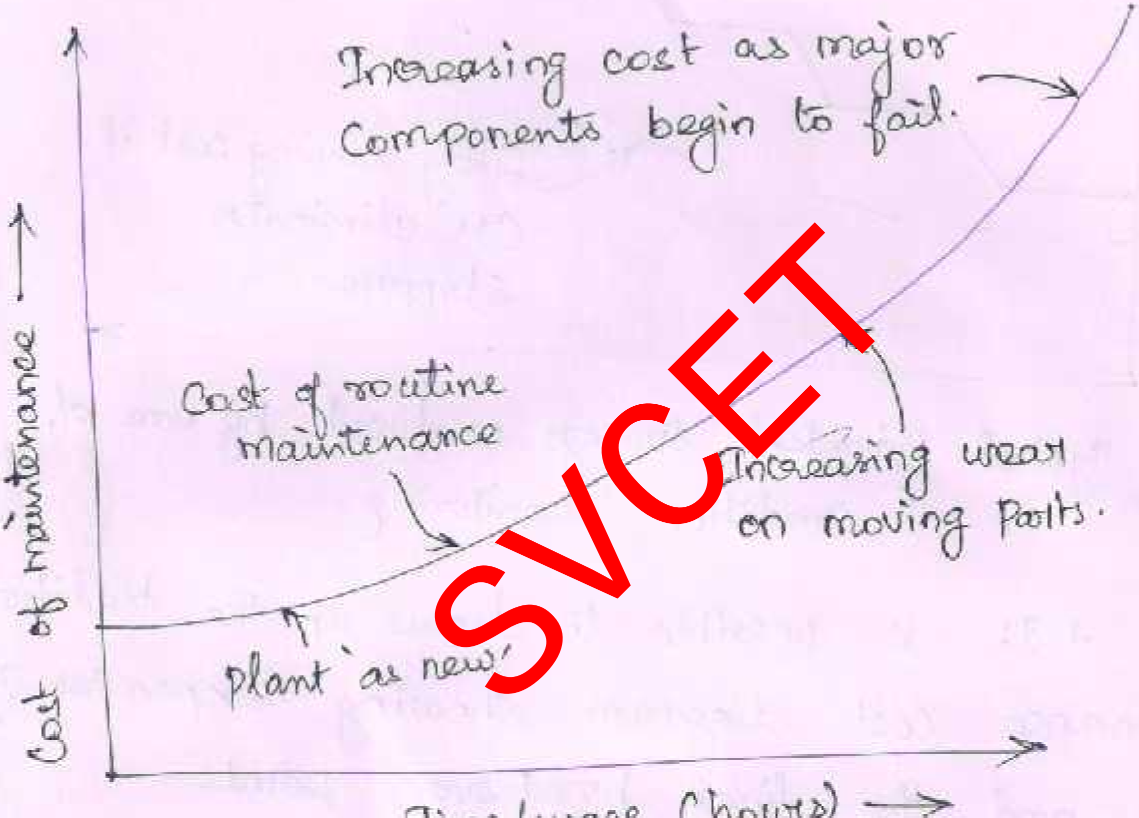





Fig. Typical Cost of a Current preventive maintenance.

* The Cost of maintenance Engineering department should be fairly clearly documented. This should include wages, Spares, overheads, instruments. etc.

* Curve Shows that there is a steady Increase in maintenance cost

for labour and spares as the plant usage time increases.

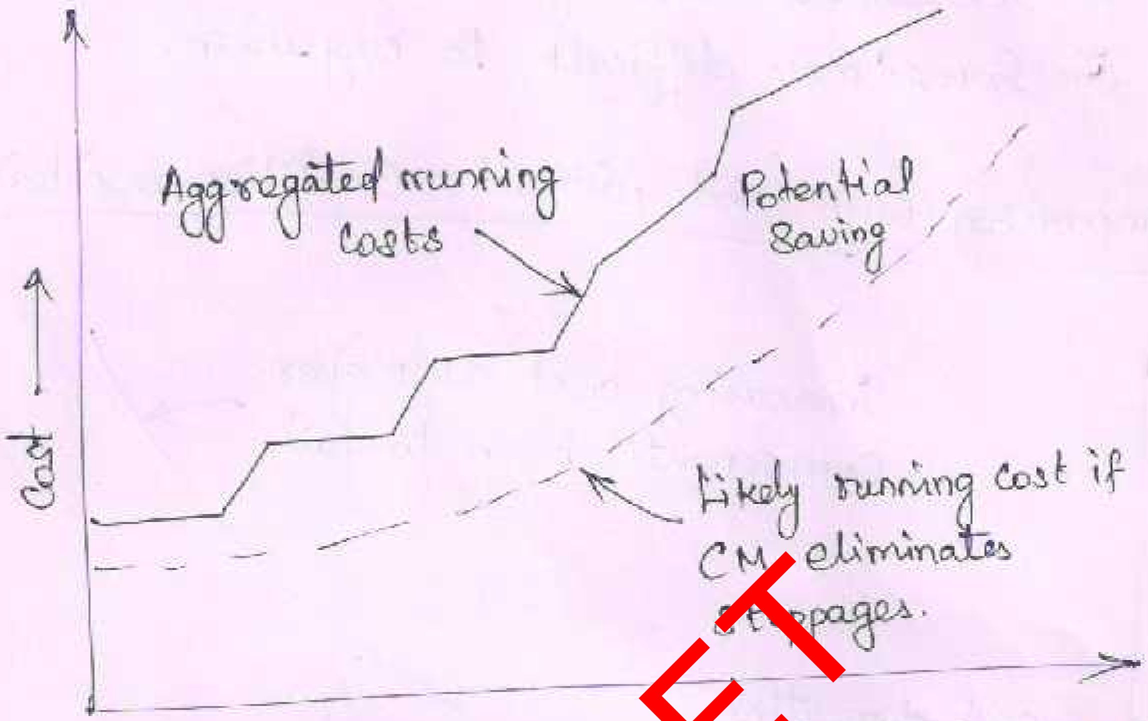



Fig: Typical Potential Savings produced by use of Condition monitoring.



* It is possible to draw up the traditional maintenance cost diagram showing expenses against savings and the final breakeven point.

* If we aggregate the graphs for the cost of the current maintenance situations and plot that alongside the expected costs after installing condition monitoring as shown in fig. then the area between the two represents the potential savings.

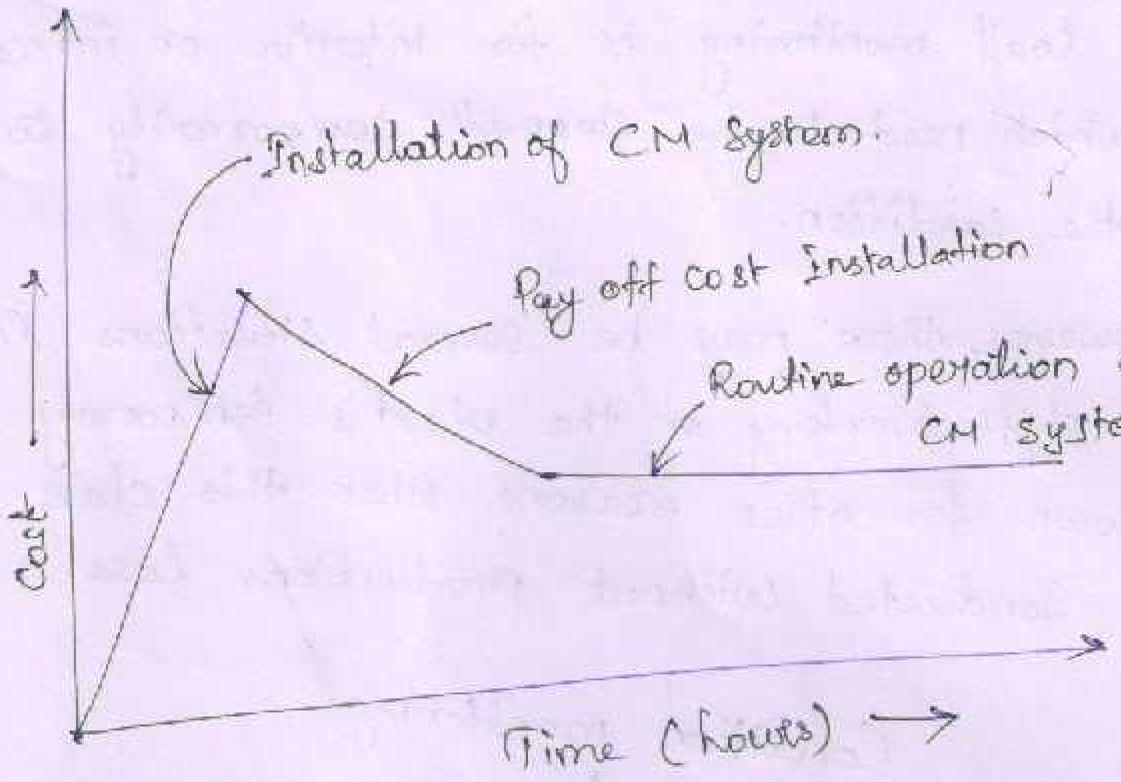



Fig: Typical cost of condition monitoring installation and operation.

Fig. shows how the cost of installing condition monitoring equipment is high at first, until the capital has been paid and then the operating cost becoming fairly low, but steady during the life of the condition monitoring equipment.



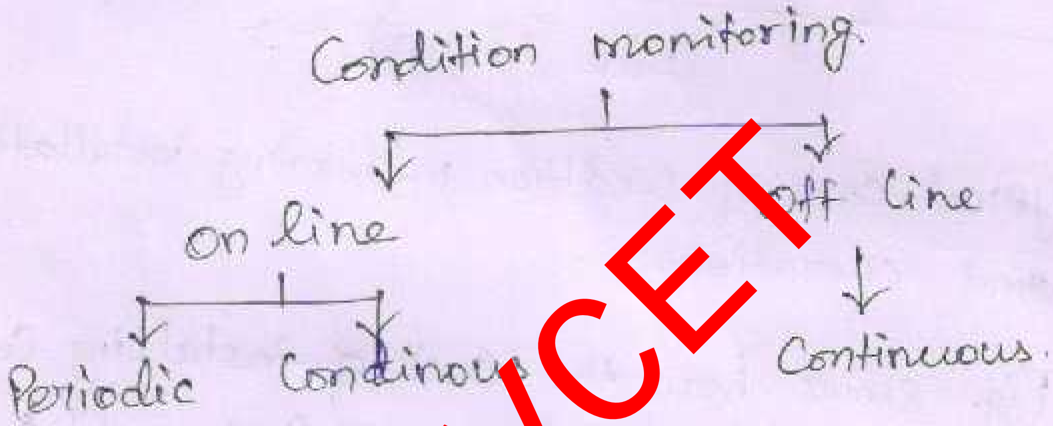
## ON Load and OFF Load Testing.

* Condition monitoring can be done in two methods viz, 'off-line' or 'on-line'.

* In off line condition monitoring, the m/c is withdrawn from service and disconnected from its normal supply.

* Off load monitoring is for interior or inaccessible parts which need to be stopped temporarily to check the condition.

* However, there may be several situations like the two shift working or the plant's temporary shut down for other reasons, when this class can be conducted without productions loss.






off-line monitoring systems can be peridic or continous. In periodic system, monitoring equipements are connected during the time of monitoring or taking data or reading and then removed. In continous monitoring, the monitoring equipments operate.

On load monitoring means monitoring or adjusting the parameters while the machine or equipment is running.

Thus, it is done for superficial, easily accessible and non interfering parts of the equipment which can be carried out without interruption to the operation.

On line continuous monitoring techniques allow developing faults to be detected before they lead to a catastrophic failure. It allows the change in maintenance programs from 'periodic' to 'condition' based leading to be more effective and reduced maintenance costs.



## Methods and Instruments for Condition Monitoring.

Various condition monitoring methods/techniques have been developed for the past 35 years and are in use. The success of condition monitoring depends in the efficiency of identifying the deteriorating trend in the machine components. For this purpose, it is essential to recognize the source or cause of failure. There is variety of technologies that can and should be used as part of a condition monitoring program.

| Type | method | on/off line | Comments. |
|---|---|---|---|
| 1. Visual Inspection. | Human Eye. | on/off | Covers a wide range of highly effective Condition checking and surface inspection methods. |
| | | off | Can be used for internal inspection of machines, good for detecting surface corrosion, wear and severe defects like cracks. |
| 2. Vibration monitoring | Frequency (Spectrum) analysis. | on | Represents the vibration of a rotating or reciprocating machine as a frequency spectrum which reveals the discrete frequency component content of the vibration. Provides the basis for fault detection, diagnosis and severity assesment. |

| | | | |
|---|---|---|---|
| | Shock pluse monitoring (or) spike energy and kurtosis. | on. | All of these techniques use high frequency vibration signals to detect and diagnosis a range of faults including rolling element bearing damage, lubrication failure and leak detection. |
| 3. Lubrication Analysis | magnetic plugs and filters | on/off | Analysis of debris picked up by plugs or filter in an oil washed systems. mainly large debris picked up, 100 - 1000 microns. |
| | Spectroscopy | N/A | Analytical technique is used to determine the chemical composition of the oil and debris. Generally, for small debris, size 0-10 microns. A contract service usually available. |

| | | | | |
|---|---|---|---|---|
| 4. | Crack monitoring | Dye Penetrant | on/off | Detects cracks which break the surface of the material. |
| | | Magnetic flux | on/off | Detects cracks at/near the surface of ferrous materials. |
| | | Electrical Resistance | on/off | Detects cracks at/near the surface and can be used to estimate depth of crack. |
| 5. | Corrosion monitoring | weight loss Coupons | off | Coupons are weighed and weight loss is equated to material thickness loss due to corrosion. |
| | | Polarization Resistance | on | A good indicator of corrosion but is unreliable as a means of estimating material loss rate. |

## Temperature Monitoring.

Temperature is defined as a measure of velocity of fluid Particles. It is a property which is used to determine the degree of hotness or Coldness or the level of heat intensity of a body.

* Instruments for measuring ordinary temperature are known as thermometers and those measuring high temperatures are known as pyrometers.

Since Pressure, Volume, Electrical resistance, expansion Co efficient, etc. are all related to temperature through the fundamental molecular structure, they change with temperature and these changes can be used to measure temperature.

The techniques used in such monitoring may be one or more of the following.

i. Temperature Crayons and Taps
ii. Thermometers and optical pyrometers.
iii. Softening Cones/wax/Paints.
iv. Bimetallic strips.
v. Thermo couples and fusible plugs.
vi. Thermistors.

vii) Thermo diodes and thermo transistors

viii) Infrared Thermography etc.

## Temperature Crayons and Taps.

* Temperature monitoring by feel of hand or by simple measuring items/ instruments, like thermometers, temperature crayons and taps. etc. is an old practice of finding out defects or defective components.

* The subjective of temperature monitoring is touching the motor. etc and assessing if over heated. Also temperature sensitive stickers are the most common and cost effective.

* A sticker having four of five 20 mm diameter dots of special paints, each of which changes its colour at a particular temperature is stuck to heat prone parts of the equipment.

* The operators or supervisor can identify its temperature range by looking at the stickers from a distance itself during their periodic patrol rounds. Temperature sensitive chalks, thermal paints with which

larger part of the heat prone body is painted fall under this Category.

The main objective of temperature monitoring is pyrometers, thermometers, pistol thermometers.etc. Depending of Convenience and need, there instruments Can be of thermostat type or Connected to Some Sort of warning system in Case of over heating.

Thermometers and optical Pyrometers.

Thermometers are use to measure the temperature of smaller ranges. The range of thermometers is increased to Certain limits by using infrared thermometers.



Pistol thermometers:-

* Ideal as Professional diagnostic tool for maintenance Professionals, the high end fluke 57E non Contact, pistol grip thermometer enables the Capture of a Simultaneous, time stamped digital photographic image as a temperature reading is taken. The logged results and Images from up to 100 locations can be uploaded via

a USB Connection to a PC using the windows based software that comes with the thermometer.

Thus, the temperatures can be stored, presented graphically and analysed, and the photographic images can be displayed on screen for improved documentation and maintenance follow-up.

The fluke 576 measures surface temperatures helping to quickly locate lubrication problems, overloads, short circuits or misaligned and overheated equipment, reducing work and follow up time and improving performance.



The fluke 576 Precision IR Thermometer, featuring a true dimension laser sighting system for precise targeting, is one of the most advanced of its type on the market for accurate condition monitoring and analysis.

It measures temperatures b/w −30 and +900 C to a 0.1C resolution with a very fast response time and a distance upto spot ratio of 60:1

Features include max/min readings, difference and average readings and audible alarms for high and low readings in comparison to 30 preset levels. A bargraph on the backlit LCD screen displays the last 10 readings.

## Wear Debris Analysis. (WDA).

* Wear Debris analysis (WDA) is related to oil analysis only in that the particles to be studied are collected through drawing a sample of lubricating oil.

* Wear debris analysis provides direct information about the wearing condition of the machine train, where as the lubricating oil analysis determines the actual condition of the oil sample.

* Particles in the lubricant of a machine can provide significant information about the condition of the machine. This information about the condition of the machine is obtained from the study of particle shape, composition, size and quantity.

* Wear debris analysis is normally conducted in two stages. The first method is routine monitoring and trending of the solid content

of the machine lubricant.

In simple terms, the quantity, composition, and size of particulate matter in the lubricating oil are indicative of the mechanical condition of the machine.

The second method involves analysis of the particulate matter in each lubricating oil sample. In this test the lubricant sample is run through a particle counter. The counter passes the lubricant stream through a beam that measures the number and sizes of the solid particle contained in the fluid.

If the wear debris concentration indicates that are too many particles in a given size range, then further investigation is required.



| S.No. | Type of wear | Descriptions. |
| --- | --- | --- |
| 1. | Rubbing wear | Particles $< 20\mu$ chord dimension and $\approx 1\mu$ thick. Results from flaking of pieces from mixed shear layer mainly benign. |
| 2. | Cutting wear | Swarf like chips of fine wire coils caused by abrasive cutting tool action. |

| | | |
|---|---|---|
| 3. | Rolling fatigue | Chunky, several μ thick from. (eg) Gear wear, 20-50μ chord width, Primary result of rolling contact bearing failure. |
| 4. | Combined Rolling and sliding wear | Typically ferrous 1 to > 10 μ dia. generated when micro cracks occurs under rolling contact fatigue condition. |
| 5. | Severe sliding wear. | Large > 50μ chord width, Several μ thick, Surfaces heavily striated with long straight edges. Typically found in gear wear. Caused by excessive loads or heat in the gear system. |



Examples of typical wear debris produced by specific machine components are given in Table below.

| Component | Contact situation | Type of debris. |
|---|---|---|
| Rolling Bearing<br>Gear teeth<br>Cam/Tappets | Non conformal rolling - Sliding. | Ferrous particles<br>Varying shape<br>Size range 10 - 1000 μm. |
| Piston rings, Cylinder<br>Splines and gear Couplings. | Load Concentrated in Small area | Ferrous particles<br>Iron oxide particles<br>Size < 150 μm. |

| | | |
|---|---|---|
| plain bearings Piston cylinder | Load distributed over a large area | Small ferrous and/or non ferrous Particles. |

## Wear debris Analysis Methods.

(a) Optical methods
- Light of obstruction technique
- Time of transition technique
- Forward reflectance technique

(b) Filter blockage:

(c) Magnetic Attraction

(d) Wear

(e) Ultra Sound

(f) Radioactivity

(g) Electrical Conductance

(h) Image Analysis.