NDE2002 predict. assure. improve.
National Seminar of ISNT
Chennai, 5. – 7. 12. 2002
www.nde2002.org

SIMPLE INSTRUMENTS USED IN CONDITION MONITORING

Prof. D.R.KIRAN
Head, department of production Engineering,
St.Peter's Engineering College

ABSTRACT

Condition monitoring is a system of assessing the service condition or the change of service condition of any component or a part of an equipment or a system. Considerable research has been done in this direction leading to development of several electrical and electronic monitoring instruments. These, when connected to strategic locations of the systems measure and indicate certain parameters enabling us to monitor the condition and take vital decisions on a continuous basis.

Nevertheless the high cost of these instruments prevent their use in all required locations. On the other hand traditionally used simple mechanical gadgets are being used by the maintenance personnel of today's industry all over the world. These have the advantages of being portable, simple, easy to use and economical. More significantly they can be used to check any location or component suspected to be functioning abnormally. This paper discusses some of such instruments used and could be used for condition monitoring of industrial machines as well as process equipment like pressure vessels and heat exchangers

1. What is Condition monitoring

Condition monitoring is that type of planned maintenance wherein the actual working conditions of major components of an equipment are constantly monitored to give an indication of which parts should be replaced and which need not in the near future. In other words the preventive maintenance with condition monitoring is a system in which, in addition to the programmed stoppages for maintenance work, an assessment is made on the condition of all major parts of an equipment while in operation, even when a preventive maintenance schedule is on. If by assessment, the condition of the part is satisfactory, the schedule of stopping the machine or scrapping the part etc. is reviewed and deferred . Similarly if the condition monitoring finds a certain part may fail in a short time, it is replaced even before its PM schedule and prevent unexpected breakdowns.

2. On-load vs off load condition monitoring

On load monitoring means monitoring or adjusting the parameters while the machine or equipment is running. Thus it is done for superficial, easily accessible & non interfering parts of the equipment which can be carried out without interruption to the operation.

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.

3. Subjective, aided subjective or objective condition monitoring

i) Subjective condition monitoring :

Here the monitoring personnel use their perception of senses and judgement to note any change of the condition. The four senses a man is bestowed with, like seeing (emanation of smoke), hearing (bearing noise), smelling (burning of oil or rubber components due to excessive heat), feeling (touching the motor to feel the excessive heating or touching the housing to feel a vibrating shaft) are used. It is important that the person carrying out subjective condition monitoring has an adequate qualifications and skills as the result depends on their judgement and experience. In subjective condition monitoring it is also possible to use instructions, guidelines or hints where to look for leakage, bearing play etc. Posters or figures illustrating different conditions of components may also be helpful

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. These gadgets are discussed more in detail in the following paragraphs.

iii) Objective condition monitoring :

In objective condition monitoring different instruments and facilities are used for obtaining data giving direct measure of the parametric condition of the components even while the machine is working. In many cases these simple mechanical or complex electronic measuring devices can be mounted on convenient locations for better monitoring and control.

A doctor feeling the pulse (subjective), his using a stethoscope to determine any abnormal heart beat (aided subjective) or looking into the ECG monitor (objective) form the examples of the above three categories.

4. Some of the gadgets and simple instruments used for condition monitoring

a) Monitoring of visual condition of inaccessible parts/locations

Quite often the visual condition of the components located at inaccessible locations are to be monitored, may be with respect to corrosion or fatigue cracking or even dust/ sediment collection that is deleterious to the functioning of the component. Simple gadgets are being used either on-line or off-line, to aid the perception of the condition. Depending upon the extent of change as perceived, the equipment can be stopped for detailed check and/or rectification. Some of the gadgets are illustrated below:

i) *Inspection mirrors* used to inspect crevices, dark spots , inside of narrow mouthed cylinders, or the pipes of heat exchangers or boilers. These mirrors can be simple like that of a dentist or

a) with adjustable mirror angle controlled by a wire running along the holding rod or

b) illuminated with a light bulb near the mirror of special use in dark spots, inside cylinders or inside heat exchanger pipes.

c) with telescopic rod, for adjusting the length of the gadget.

d) mirrors fitted inside a small tube rather than on a rod to prevent damage to the mirror during insertion or other operation. These are also called as *borescopes*.

e) periscopic, for specialised applications or to assist the viewer et. Etc.

fig. 1 a) a collection of inspection mirrors. b) inspection of crevices and c) inspecting the inside of as cylinder

Of specific interest to the NDE practitioners is their versatility to inspect the inside of the boiler pipes or heat exchanger pipes, which can tell a lot about the working condition of the inside of the tubes about the rusting, cracking, sedimentation etc. enabling an early preventive action.

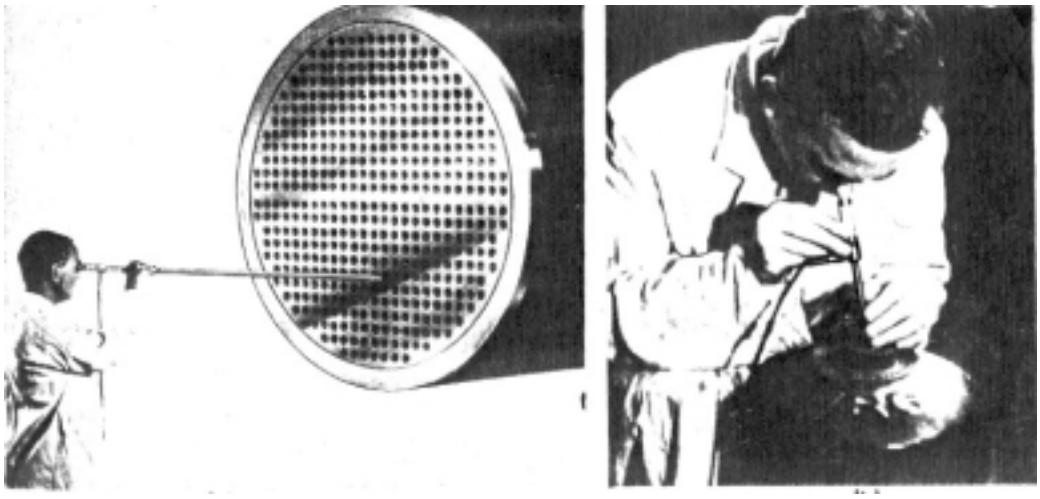

Fig. 2. Use of borescopes to inspect heat exchanger pipes.

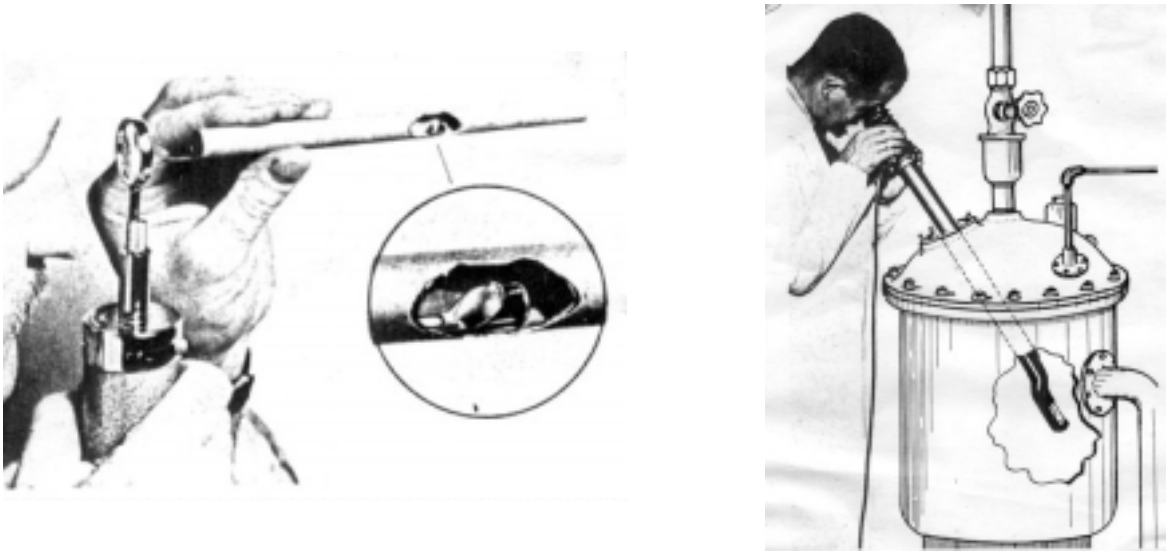

Fig. 3 borescopes and periscopes

ii) *Endoscopes:* These are like borescopes, but are flexible. They work on the principle of image transfer by total internal reflection in a bundle of glass fibres. They are more popular with gastroenterologists for diagnosing ulcers in stomachs. Also called optical fibroscopes, they are flexible ands are more versatile in several applications illustrated below. Some times they are permanently fixed for constant monitoring of critical components are inserted when needed into pre-fixed tubular guides leading to the location to be monitored.

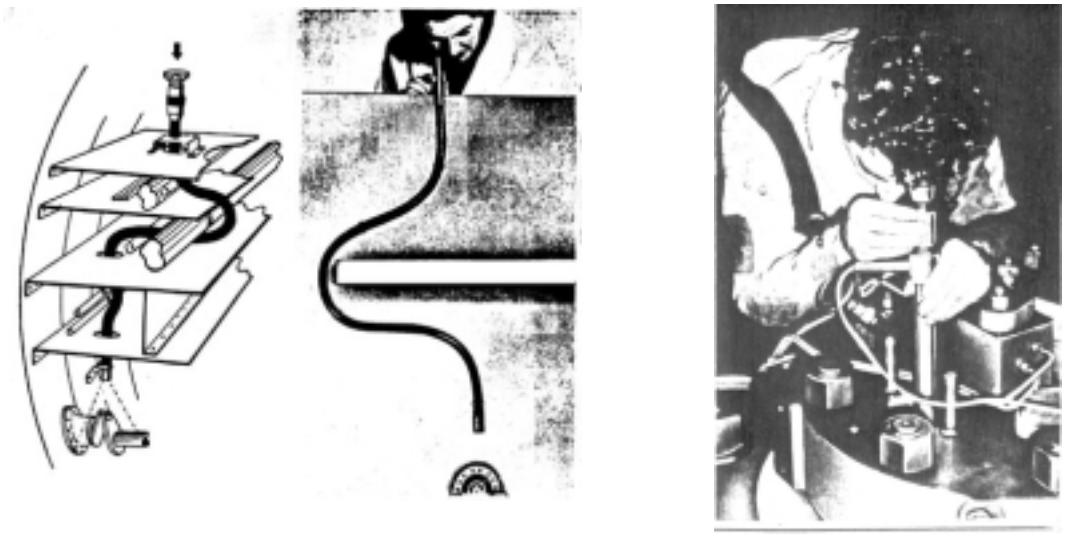

Fig. 4. The application of endoscopes in industrial equipment

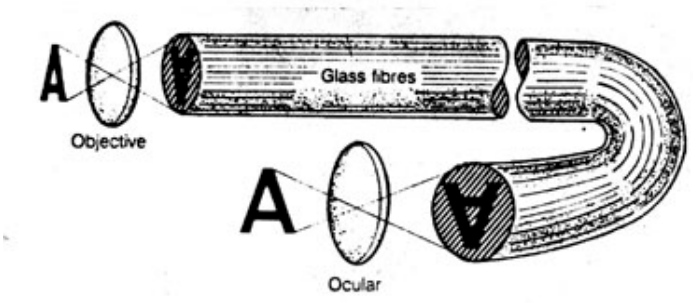

Fig. 5. The principle of endoscope

Having illustrated the gadgets for visual perception as above, some of them used in other monitoring functions may be cited as below, classified into the three categories.

b) Temperature monitoring

Subjective -

Touching the motor etc. and assessing if over heated.

Aided subjective -

Temperature sensitive stickers are the most common ands 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 the heat prone parts of the equipment. The operatives 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 -

Objective -

Pyrometers, thermometers, pistol thermometers etc. Depending of convenience and need, these instruments can be of thermostat type or connected to some sort of warning system in case of overheating.

c) Vibration monitoring

Subjective

By touching and feeling the vibrations in a rotating body or by listening to vibrating sounds.

Aided subjective

Stethoscopes, use of screw driver ends by expert foremen etc.

Objective -

Shock pulse meters (SPM), vibration measuring instruments etc.

Vibration measurements made near the source of vibration might indicate the following:

- imbalance
- shaft misalignment
- damaged bearings (worn or chipped balls or races)
- damaged gears another transmission components
- mechanical looseness
- cavitation and stall etc.

d) Leak Monitoring

Subjective -

Listening to and identifying any hissing sound near hydraulic or pneumatic circuits.

Aided subjective -

A number of leak detecting techniques are available, including the soap and water methods. Use of proprietary preparations can make this method more effective, capable of detecting leaks as low as 1 m1/s.

Objective -

One powerful technique is ultrasonic detection. When a fluid is forced through a leak under internal or external pressure, sound is generated in the frequency range 40-80 Khz. The ultrasonic leak detector identifies this very high frequency which is easily separated from the lower frequencies of ordinary machine noise.

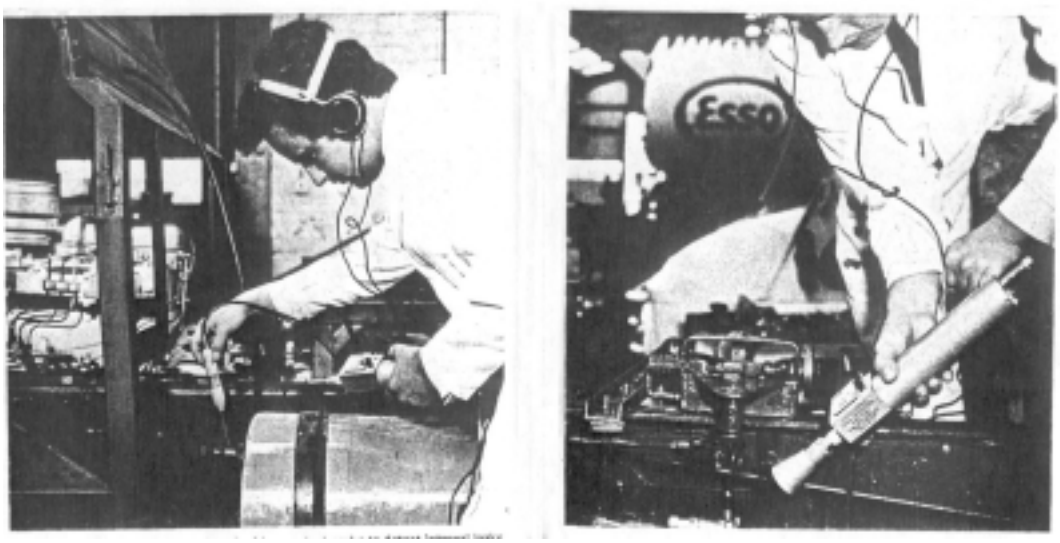

Fig. 6. Ultrasonic leak detector to detect internal & external leaks

e) Corrosion Monitoring

Subjective -

Corrosion cannot be generally judged visually and is not as effective as those discussed below.

Aided subjective -

Corrosion coupons, which are small pieces say 1 square inch, of the same material as the base, are pasted at locations suspected to be highly corrosive, and analysed once in a month or as required. The corrosion characteristics of the coupon are expected to be same as the base metal to which they are pasted, and hence give an indirect measurement the corrosion of the body.

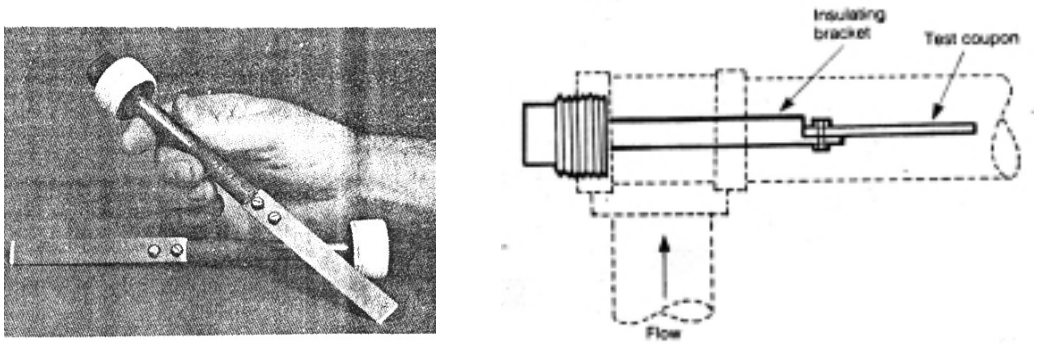

Fig. 7.a) A view of the corrosion coupon. b)The coupon mounted in tubes carrying chemicals

Objective -

Electrical and electronic devises can be developed to measure the corrosion characteristics based on the following principles, the details of which are beyond the scope of this paper.

- The basic principle in Corrosion Monitoring is the change in the resistance of special electrical elements in corrosion environment.
- The potential difference between the reference electrode and the system will indicate the presence and the extent of corrosion.
- The polarisation resistance of the special designed probe indicate the rate of corrosion.
- Hydrogen gas formation during corrosion can be detected with a thin walled blind tube which can be analysed to determine the corrosion.

f) Belt tension monitoring:

subjective -

Slightly pressing down the V-belt

Aided subjective -

Pen type tension gage as illustrated below is a simple and handy one. Depending upon belt looseness, the inner part of the gage telescopes into the upper part, leaving the rubber ring stuck on to the lower part at the lowest point of insertion. On removing the gage, the position of the rubber ring on the graduated scale of the lower part indicates the belt looseness, that can be corrected if necessary.

Objective -

Strain gages or other electronic instruments are used to measure the stresses in metallic parts or components.

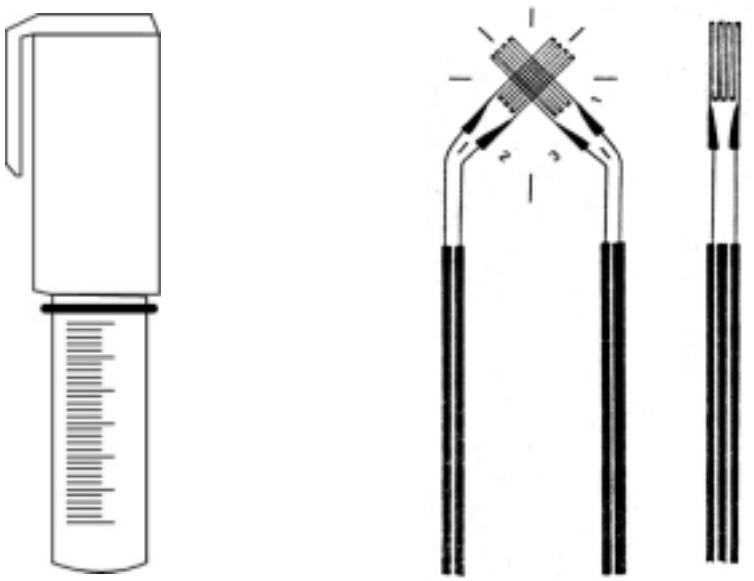

Fig. 8. a) pen type tension gage and b) strain gage for bi-directional measurement

g) Shaft run-out monitoring:

When a lathe is being tested for accuracy, a mandrel is fixed in the spindle and rotated and checked for the run-out.

Subjective -

If the run-out is high, it can be visually seen.

Aided subjective -

By use of dial gages fixed on to the bodies, the amount of run-out can be measured. But this can be done by turning the spindle by hand or at low speeds.

Objective -

Optical sensors as illustrated below can be used to check the run-out even at high speeds.

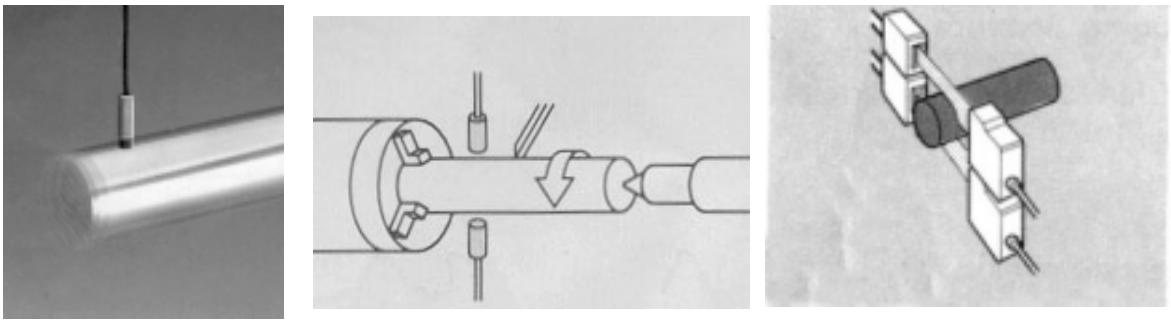

Fig. 9 Run-out checking by optical sensor

h) Crack detection

This is mostly off-line monitoring and most tests under this category form NDE tests, the primary function of ISNT specialists. Most serious failures are preceded by crack growth from a point of stress concentration or from a material defect at the surface of the component. A number of crack detection techniques have been developed to a great degree of advancement, like dye penetration test (PT), magnetic particle test (MT). Electrical resistance or eddy current test (ET), Ultrasonic Testing (UT) and Radiographic test (RT).

While the first two of the following can be classified as aided subjective, the latter can be categorised as objective Since the purpose of this paragraph is to highlight crack detection as a condition monitoring techniques, these NDE methods are only cited but not discussed further.

5. Conclusion

While only few types of monitoring namely, visual, temperature, vibration, leak, corrosion, run-out, belt tension, and crack monitoring are discussed, a host of simple gadgets are being developed according to their specific use for many other monitoring functions that are not discussed here.

****