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14944

RESTRICTED

September 1985

ENGLISH

Pakistan.

PREVENTIVE MAINTENANCE DEVELOPMENT CENTRE, PMDC, LAHORE,

DP/PAK/83/002

PAKISTAN

Technical Report *

Mission 24 March to 7 May 1985

Prepared for the Government of Pakistan

by the United Nations Industrial Development Organization,

acting as executing agency for United Nations Development Programme

Based on the work of Richard Vogl

Consultant on non-destructive testing methods

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United Nations Industrial Development Organization

Vienna

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1. INTRODUCTION

Following a request from the Goverment of Pakistan to UNIDO for technical advisory services in establishing a Preventive Maintenance Developement Center (PMDC) at Lahore, Kala Shah Kaku, Ravi Rayon Ltd. of the Federal Chemical and Ceramics Corporation LTD (FCCCL) Karachi - an UNIDO Consultant on non-destructive testing methods Mr. R.F.Vogl untertook a one month and fourtenn day mission to the Centre from March 24 to May 7, 1985 - in accordance with the UNIDO job-description DP/PAK/83/oo2/11-52/32.1.E.

Upon his arrival the expert was introduced to Mr.Sarfraz, Head of the PMDC and his staff and with Dr.A.Banescu, Chief Technical Advicer CTA of the Projekt.

2. EXPERT'S ACTIVITIES AT THE PMDC

2.1 Training and advice

- Theory an practice of vibration analysies, balancing with the help of vibration analyser, and recommend test programme for various low and high speed machines.
- Introduction of the principle of ultrasonic thickness tester and practise of its usage.
- Practical training on the usage of Dye penetrant testing kit.
- Practical Training Magnetic particle flaw Detector. Non destructive testing of alloys for detection of its constituents.

2.2 Proposals of equipment

The expert suggested some of the necessary equipment for non-destructive testing (NDT) for chemical plant maintenance in corrpondens with the before mentioned expert activities an in accordance with the Head of the PMDC and the CTA of the projekt.

2.3 Preparation of lectures

A) A lecture was prepared especially in vibration analysing and balancing, explanation of vibration. what is vibration, explanation of instruments for vibration measurements, how vibration is measured, where to measure, what measurements to make, interpretation of vibration measurements, correction of the most common mechanical problems uncovered through vibration analysis especially unbalance misalignment, defective bearings, defective gear teeth and so on.

B) An other lection has been prepared which deals with the topic "maintenance by aids of non-destructive testing" especially with periodically wall-thickness measurement on chemical plants by the ultrasonic methode and some aspects regarding material testing by the Dye penetrant methode as well as inspection with optical devices like endoscope and fiberscope.
Periodical wall-thickness measurements on chemical plants by the ultrasonic method are very common. A ultrasonic measuring method has been described and prepared which permits the determination of actual corrosion und wearrates in containers and piping in the chemical industries.

Usually from a good knowlegde and experience with fractures and accidents the zones of max. stress to carry out wall-Thickness testing are known.

C) A further lection dealt with the use of industrial radiagraphy. The sources of radiation, X-ray tube and artifical radioactive sources, (radio-isotopes) like iridium, cobalt and so on, some explanation of advances and disadvances of radio-isotopes against a X-ray-tube, further explanation has been made in regard of the inverse square law; exposure factors of X-ray films, darkroom layout and film processing equipment etc.

Attention must be paid to the radiation protection rules, dose rate measuring device, pocket dosimeter for direct reading of the radiation dose. A further chapter dealt with the interpretation of exposed X-ray films, respective radiagraphs, defects in welding joints and castings, cracks, lack of fusion, inclusions, undercut, etc..

2.4 Industrial visit

The PMDC intend to improve the maintenance laboratories of the different FCCCL units in order to maximise the productivity of its units.

A visit was paid to the FCCCL Head quater in Karachi, to discuss the already existing instrumentation and equipment and there further need.

It was known that national fibres LTD at Korangi, Karachi is well equiped with experienced laboratory people regarding vibration measurement instrumentation. During the visit in the factory and after a disscussion with Mr. Baitullah it was foand that the laboratory is in posess of different testing instruments including vibration meter, vibration analyser.
The plant facilities an components become checked periodically.
It has been agreed that other FCCCL units should be brought to the same level.

3. MEETING AT P M D C

A meeting was held an the April 22, 1985 in the PMDC at Kala Shah Kaku in order to introduce to Centre to the local industries.

Participants were Heads and Engineers of maintenance Departements of FCCCL units. Among many other things including demonstrations, a fruitfull discussion took place regarding NDT in the field of preventive maintenance, implementation of periodically inspection by application of ultrasonic equipment industrial radiography and vibration analyser as well as DYe penetrant testing in order to minimize plant shut down.

4. RECOMMENDATIONS

4.1 Further technical assistance

Further technical assistance, after the ordered equipment is supplied could be very usefull for the PMDC at the first to setting up the whole equipment and X-ray unit,and the second the give practical training "on the Job-training" especially for the interpretation of radiographs on welds and castings.

4.2 Get in touch with local industries

In a further stage the PMDC should utilize all possibilities to get in touch with the local industry - also with the local private industry in order to offer inspection and maintenance services.

4.3 Darkroom facilities

A small darkroom must be installed in order to use the equipment which is ordered. A double door system, one door after the other, -so no light can be entering.

4.4 A mobile testing laboratory

A non-destructive testing laboratory can be mobile so that inspections of weld and materials can be made on-site for instance during the construction of a building, the laying of pipelines and the installation of heavy machinery components.

5. A C K N O W L E D G E M E N T

The expert wishes to acknowledge the considerable help of Mr. Sarfraz, Head of the PMDC, and Mr. Irfran and Mr. Idrees.

The expert also wishes to express his appreciation to Mr. Siddiqi, Manager Production & Planning at FCCCL and to Mr. Naushad Ali, Assistant Manager in regard to the arrangement of an industrial visit at National Fibres LTD.

Mr. Baitullah, Sr.Manager Engg. at National Fibres LTD, has provided very valued activities not only during the visit, but also during the meeting at PMDC.

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Many thanks should be given to Mr. Rana, UNDP Resident Representative in Pakistan and to Dr. K.S.Stephens, UNIDO/SIDFA in Islamabad, to Mr. Engineer in Lahore, as well as to other members of the UN-family.

The author is especially indepted to Dr. A. Banescu, CTA of the project, for his support and his assistance rendered throughout the whole period of the assignment.

Before concluding the expert would like to thank all those who offered their co-operation to him in carrying out his task during the past six weeks.

Annex I :

Recommended list of instruments an equipment for non-destructive testing of materials

1. Ultrasonic thickness gauge
thickness range 1,2 MM to 300 MM

2. Industrial radiography unit 200/8
with accessories radiation protection
instruments und darkroom facilities

3. Dye penetrant crack - detecting agents

4. Vibration analyser
with vibration/sound level meter
for noise analyses.
range 50 - 50.000 CPM
amplitude 0 - 100 mils peak to peak or in/sec peak.

5. Vibration - meter portable frequency:
600 - 60.000 CPM amplitude :
vibration 0 - 100 mils peak to peak.

Annex II

Vibration Analysis

Vibration analysis is a non-destructive testing method in which the mechanical and operating conditions of machines are checked. There are a number of ways where vibration analysis can be used, especially for periodic routine vibration measurements of machines to check their mechanical conditions. Furthermore vibration analysis is used for postoverhaul or repair check to ascertain that machines have been returned to good operating conditions, and check of machines prior to plant shutdown for annual maintenance as an aid to planning overhaul work.

Explanation of vibration

If a mass is set in motion,it will move back and forth between some upper and lower limits. This movement of a mass through all its positions is defined as one cycle of vibration.
The number of these cycles in a certain time is the frequenz of vibration,-as one of the basic characteristics.
Cycles per minute (cpm), cycles per second (cps)

There are some other characteristics like displacement,velocity and acceleration,where measurement of vibration severity can be taken.
Displacement is generally the best parameter to use for low frequency measurements,say less than 600 cpm-it indicates how much the object is vibrating.
Velocity is usually the best parameter for machinery-vibration analysis for a frequency rate say 600 to 60,000cpm. Velocity indicates how fast the object is vibrating.
Acceleration is best when it is known that all the trouble some vibration occur at high frequencies, that is, above 60,000 cpm. The acceleration of the object which is vibrating is related to the forces which are causing the vibration.

Portable instruments for vibration measurement.

a, Vibration meter
A number of different portable instruments are available for making vibration measurements. The basic instrument for a machinery-vibration preventive-maintenance program, however,is a small hand-held vibration meter,which measures overall displacement or overall velocity. A vibration meter is used for checking the mechanical conditions of machines at periodic intervals,it can also be used for noise measurement. A vibration meter consists of an amplitude-range selector,a displacement/velocity/noise (A,B,C) selector, and a meter for reading the amplitude. A velocity pickup is connected to it by a cable.

b, Vibration analyzer
When a mechanical defect is detected,however the vibration meter is not capable of pinpointing the specific cause. This is the purpose of the vibration analyzer.
There are many different types of vibration analyser available.

The largest number in use are the tunable filter type with vibration pickup and strobe light. A vibration analyser have the capability to measure vibration amplitude, frequency and phase, the three characteristics needed to describe and identify any vibration. The tunable filter is a device to separate many individual vibrations at different frequencies as shown at most machinery vibrations so that an individual amplitude,frequency,and phase can be measured.

Points of measurements.

The bearing caps of machinery are usually the best locations for vibration measurements, since these are the points through which the forces of vibration are transmitted,-and they are accessible for measurements.
For periodic vibration checks a single measurement in the horizontal or vertical direction is often sufficient,but a complete analysis should include horizontal,vertical,and axial measurements at each bearing cap. Periodic vibration checks are carried out at regular intervals.

Interpretation.

Interpretation of measurements depends upon comparisons of amplitudes,frequencies,and phase. For example,a high-level vibration at a frequency of 1.800 cpm in a machine running at 1.800 rpm is indicative of unbalance,misalignment,or bent shaft.
If the vibration in the axial direction at this frequency is more than half as large as the radial vibration indicates either misaligned coupling or bearings. If a further check indicates unchanging phase readings in the axial direction around the bearing housing,it confirms that the problem is misalignment.

Common causes of vibration:

unbalance is the most common cause of vibration. Unbalance is recognized by vibration occurring at rotational frequency whose amplitude in the radial direction is more than twice the axial amplitude. When power is cut,the amplitude drops off gradually.
Misalignment on shafts,couplings,sleeve bearings is the second largest cause of vibration even when self-aligning bearings and flexible couplings are used.
Further common causes of vibration are bent shaft,defective anti-friction bearings,eccentric rotors,defective gear teeth, mechanical looseness on sleeve bearings, bearing pedestals,foundations etc.

Correction.

The most important common mechanical problems uncovered through vibration analysis is the correction of mechanical unbalance.
Unbalance is the unequal distribution of the weight of a part about its rotating centerline.
The more unbalance present- the greater the force, and therefore the greater the vibration. The amount of vibration indicates how much unbalance is present. An equal amount of weight at the same radius but opposite the heavy spot will balance the rotor.

Annex III

Maintenance by aids of non-destructive testing

Much of the work of preventive maintenance consists primarily of NDT examinations to ensure that certain components and assemblies are fit for further operational service. Even if it is found that their condition is satisfactory and there is no need for corrective action, considerable time is often spent shutting down, opening up for NDT inspection and boxing up again afterwards. Inspection can be time-consuming and expensive in terms of both - lost production and labor costs. Costs can often be reducted by the use of non-destructive testing instruments or other diagnostic aids which make it possible to examine the parts or machinery without dismantling and, in some cases, while the plant is actually in operation. Such devices can be used also to monitor plant operation and give early warning of deterioration or faults before they dead to extended damage. Some of these aids like ultrasonic wall-thickness measurement, Dye Penetrant testing etc. are described below.

Periodically wall-thickness measurement on chemical plants by the ultrasonic methode.

An ultrasonic wall thickness gauge is a small portable digital ultrasonic unit designed for making rapid non-destructive thickness measurements. Ultrasonic wall thickness gauges are used mainly where it is impossible to use conventional mechanical gauges or where such gauges los their accuracy owing to extend length of caliber arms etc. As is requires access to only one side of the material being measured it is ideal for site work.
Chemical plants, petroleum plant, boilers, pipes, ship-huls, and the like, can be checked periodically in service in order to make preventive maintenance to determine the amount of corrosion which has taken place

As before mentiomed, plant need not be taken out of service while measurements are being made even if the temperature of the measured surface is as low as - 1o° C or as high as 5oo° C.
The instrument will measure thicknesses from 1.2 mm to 3oo mm with an accuracy of ± o,1 mm over its whole range- even on depth eroded or correded positions and spots where pitting-corrosion has taken place.
From a good local knowledge and experience with fractures and accidents, the zones of maximum stress are known in many case.
Positions where wall-thickness reduction, wear rates of corrosion and flows normally occur:

Elbows on piping systems, pipe narrowing, inlet-and outlet nozzles on high-pressure boilers, fittings fabricated by grey-casting especially in contact with etching liquids, all high pressure and high temperature piping systems, welded joints and so on.
If it is known, e.g. in a high-pressure steam pipe, where the flows normally occur, the-possible dangerous wall thickness reduction can be recognized in time, and their magnitude and dangerous character assessed and prevented.
From the economical point of view it is very neccesary to detect dangerous wall-thickness reduction in time, in order to prefabricate spares, respective replacement pieces. This has the effect of minimizing the interruption to production respective to attain a decrease of downtime in a chemical plant.

Material testing by Dye Penetrant method.

Dye penetrant methode is applicable on all solid materials, such as cast steel, grey cast, alloyed or non-alloyed steel, aluminium, copper etc. for detecting cracks, pores and overlaps and it is free from chlorine and sulphur.

Applications:

1, Test parts to be degreased and cleaned as well as other impurities removed by special cleaner.

2, Penetrant Dye to be applied. Time of reaction depends on material, temperature etc. and ranges on the average between 1o- 2o min.

3, Work piece to be cleaned from penetrant dye by special cleaner or water and to be dried.

4, Developer to be applied in the thinnest possible manner. After short drying period penetrant dye penetrates on the defective spots showing a red contrast. Depth and width of crack may be taken from width of colour mark in the white developer coat.

5, Inspection- red lines in the white developer field show cracks and overlaps if present. Pores appear as red dots.
It should not be smoked nearby and open fire should be avoided.
When working in closed rooms you should care for proper aeration.

Working Process of red/white procedure.

a, work pieces to be cleaed by spec. cleaner.

b, penetrant dye to be applied by plunging, brushing or spraying.

c, time of reaction 15 min.

d, penetrant dye to be washed off by spec. cleaner by means of spraying. The cleaner will vaporize. Drying.

e, developer to be applied by spraying.

f, inspection.

Temperature indicating stickers.

Flexible self adhesive strips which, when the temperature of the surface to which they are attached reaches a specified level an indicating panel on the strips turn black. Strips can be obtained to indicate one particular temperature or different temperatures within a set range.
Uses:-to provide proof of excessive temperature exposures.
-to dedect temperature anomalies.
-to measure temperature gradients.

Optical inspection devices.

Bore viewers. These are simple, robust instruments for viewing the inside of small bores, tubes and holes. They can be used to inspect bores with diameters of 5 to 32 mm and up to a length of 2oo mm .
A bore viewer consists of a small light probe and magnifier. At the end of the probe is a miniature lamp powered from the battery handle.

A separate sleeve with a 45° mirror fits over the light.

Endoscopes. Endoscopes are slim tubular optical instruments that enable the user to look inside cylinders,tubes and similar hollow parts, particularly when the access to the hole is small. The diameter of endoscopes range from 5 to 45 mm with length varying from 1oo mm to 1o m according to diameter. Endoscopes over 1 to 1.2 m in length are normally made in sections for ease of handling and transport.

Inspection mirrors. Inspection mirrors are used for the internal inspection of larger hollow components and for viewing normally inaccessible parts of all kinds of plant, machines and equipment.

Fibrescopes. Fibrescopes are portable flexible inspection instruments for the internal inspection of curved pipes, shaped hollow components and machinery. They consist of a vinyl-covered,fully flexible metal tube containing two glass fibre bundles,one for image transmission and the other for lighting. There are optical systems at both ends of the image bundle, a variable focus objective system at the distal end, and a focusing magnifier at the eyepiece end. The remote focus control for the objective lens focus is next to the eyepiece.

Annex IV

INDUSTRIAL RADIOGRAPHY

SOURCES OF RADIATION

A: The X-ray tube

The X-ray tube consists of a glass bulb under vacuum enclosing a positive electrode or anode and a negative electrode or cathode. The cathode comprises a filament which, when brought to incandescence by a current or a few amperes, emits ~~electrical~~ electrons. Under the effect of the electrical tension set up between the anode and cathode (the voltage on the tube)these electrons from the cathode are attracted to the anode. This stream of electrons is cencentrated in a beam by a cylinder or facusing cup.

B:

Articicial radioactive sources (isotopes) Artificial radioactive substances are obtained by fission or irradiation in a nuclear reactor. It is possible in this way to obtain several isotopes in relatively large quantities and in a reasonably pure state. Among the factors deciding their value for the non-destructive testing of materials are the hardness and intensity or their radiation, their half-life and their specific activity.

Radio-isotopes in common use are iridium, caesium and cobalt.

SOME ADVANCES AND DISADVANCES OF ISOTOPES AGAINST THE X-RAY TUBE

1: They need no electic power supply and no cooling system , so that they are very easy to use on a worksite.
2: Since they give a generally harder radiation than that from on X-ray tube , they give less contrasty images; this means that the radiographs are less easy to interpret.
3: At it is impossible to swith off the radiation emitted by radio-active sources, they have to be effectively shielded. With sources whose radiation is very penetrating or intense, the shielding needed may be quite heavy .
4: The radiotion from radioactive sources cannot be adjusted.

THE INVERSE - SQUARE LAW

The intensity of the radiation per unit area of the film is inversely proportional to the square of the a facus - to - film distances. This means, a certain distance from a radiation source is the best protection against radiation.

FILM EXPOSURE FOCTORS

- The type of x-ray tube
- The radiation source
- The facus film distance
- The material and its thickness
- The type of film
- The precessing

Continue See P: 2

HE DARKROOM

For practical reasons the darkroom needs to be as close as possible to the place where the exposures are made, although naturally out of reach of radioactive radiation.

The darkroom must be completely lightproof, so the entrance will usually be in the form of a light-trap, two doors, one after the other a revoling door or a labyrinth .
In practice the labyrinth is found to be the best arrangement.
The films must be handled by inactinic light, and films can be processed under the normal orange-red or green darkroom safelights for x-ray films.
The darkroom layout should preferably be divided into a dry side and a wet side. The dry side will be used for loading and emptying film cassettes, fitting films into developing frames and so on. C the wet side the films will be processed in the various tanks of chemical solution. The tanks can be made of stainless steel or plastic bins.
The wet side of the dardroom will have five tanks, arranged in the following sequence: developer tank/bin, rinse tank, fixer tank, final wash tank for wetting solution.

INTERPRETATION OF RADIOGRAPHS

The defects found in welded joints fall naturally into several groups, especially chracks, lack of fusion, inclusions and so on. Cracks may occur in any location of the weld or in the heat - affected zone. They may be transverse to the weld or longitudinal.
They may be found along the line of fusion to the parent metal and in such instances are often difficult to interpret and to identify on a radiograph. It should be borne in mind that NDT of welds is a secondary problem the primary objective is of course to obtain high quality welds, and to avoid faults in welding, and castings.

RADIATION PROTECTION:

Persons using X-ray or gamma-ray equipment must always wear a film badge and carry a pocket dosimeter. The rooms in which the radiation work is done as well as the adjacent rooms must be constantly monitored with a radiation dose rate measuring device.

WATTO

The end