UNIT –II

L1 – CLASSIFICATION OF MAINTENANCE APPROACH

Maintenance Approach

Breakdown maintenance planned maintenance Preventive corrective predictive condition Reliability control Maintenance maintenance maintenance based maintenance control maintenance

Breakdown Maintenance

in this system the equipment is allowed to function / operate till no failure occurs ie no maintenance work is carried out in advance to prevent the failure.As long as the equipment is functioning at a minimum acceptable level, it is assumed to be effective. This means the people wait till the equipment fails and repaisir. This approach of maintenance is ineffective and extremely expensive. The following factors contribute to high maintenance costs.

- Poor planning
- Incomplete repair

Limitations:

Most repairs are poorly planned due to time constraint caused by production and plant management . this will cost three to four times than thesame reapir when it is well planned.

This approach focus only on repair or the symptoms of failure and not on the root cause of failure. This results only in increase in the frequency of reapir and correspondingly the maintenance costs.

For example when a bearing fails, it leads to production stop. By this approach only the bearing will be replaced with a nw one, but no attempt will be made to study the cause of failure or to present a recurrence of this failure. This may seriously affect the relaiability of the system.

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Breakdown of an equipment or machine or station in a system will have a significant effect on the production cost, quality and schedules. For each break down, one or more operatious that are to be performed by that particular machine/ equipment are idled, which in there delays the completion time of the job. Mean while, parts waiting for this equipment / machine are to be diverted and assigned to other competing machines. are to be diverted and assigned to other competing machines. because of this the cost of manufacturing goes up.

Corrective Maintenance

Corrective maintenance is the progress focused on regular planned tasks that will maintain all critical machinery and system in optimum operating condtions. The effectiveness of this program is judged on life cycle cost of critical equipment rather than on how quickly the broken machines are restored to working conditions. It is proactive approach towards maintenance management.

The main objectives of this program are to

- Eliminate breakdowns
- Eliminate deviations from optimum operating conditious
- Eliminate unnecessary repair
- Optimize all critical plant systems.

Presentive Maintenance

It is a maintenance program which Is committed to the elimination or prevention of corrective and breakdown maintenance. A comprehensive preventive maintenance program involves periodical edvaluation of critical equipment, machinery to delteet problem and schedule maintenance task toavoid degradation in operating conditions.

Benefits of Preventive Maintenance

In general the cost incurred towards breakdown maintenance is usually higher than the cost incurred on preventive maintenance.

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It maintains the equipment in good condition to preventing them from bigger problems Prolongs the effective life of the equipments. Detects the problem at earlier stages. Minimizes / eliminates the rewash/ scrap and help in reducing the process variability. Significantly reduces unplanned downtime.

Predictive Maintenance

Predictive maintenance is a management technique that uses regular evaluation of the actual operating conditions of plant equipment, production systems and plant management functions to optimize total plant operation. It is not a solution for all the factors that limit total plant performance.

CONDITION BASED MAINTENANCE TECHNIQUES

- Vibration Monitoring – determins the actual condition of equipments / machines by studying the noise or vibration produced during functioning.
- Thermography – determines the condition of plant machinery systems etcby studying the emission of infra red energy ie temperature.
- Tribology – determines the dynamic condition of bearing lubrication, rotol support structure of machinery etc by adlopting any one of the techniques like lubricating oil analysis, spectra graphic analysis, fesso graphy and wearparticle analysis.
- Electrical Motor Analysis – determines the problem within motors andother electrical equipments.
- Visual inspection - determines the condtions of working elements visuallybased on the experience.

Realibility Centered Maintenance (RCM)

It is one of the well- established systematic and a step by step instructional tool for selecting applicable and appropriate maintenance

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operation types. It helps in hw to analyze all failure modes in a system and define how to prevent or find those failures early. The rough process of a CM is as follows.

Target products or systems of maintenance should be clearly identified, and necessary data should be collected.

All possible failures and their effect on target produced or systems are systematically analyzed.

Preventive or corrective maintenance operation are considered selection of operations is done based on rational calculation of effectiveness of such operations for achieving required maintenance quality, such as reliability, costetc.

Applications of RCM

When designing, selecting and installing new systems in a plant.

When setting up preventive maintenance for complex equipment andsystems for which we are not clear on how they work.

When teaching people the basics of reliability it helps to explain thematters in a detailed fashion using RCM.

Total Productive Maintenance

The goal of TPM program is to significant increase the production, at thesame time increasing employee morale and job satisfaction.

The aim of total production maintenance was to maximize plant andequipment effectiveness to achieve optimum life cycle cost of equipment.

Implementation of TPM

To implement an effective TPM is an organization there are certain stagesto be planned and executed.

Stage I	-	initialization
Stage II	-	Introduction on TPM
Stage III	-	Implementation of TPM
Stage IV	-	Institutionalization

Stage I

Announcement by management about TPM. Joe level management people should attend awareness programs on TPM to have proper understanding, commitment and active involvement. Then all matters about TPM should be communicated to all others in the company.

- Initial education
- Setting up TPM departmental committees.
- Establishing TPM working system and target
- A plan for institutionalizing.

Stage II Introduction Stage

A grand ceremony is to be arranged inviting our customers, affiliated companies, sister concerns and communicating them that we care for quality.

Stage III – Implementation Stage

There are certain activities which are performed and known as pillars of TPM are carried out.

Stage IV Institutionalizing stage

Once the action are familiar with the TPM process and have experienced success with small level problems and then with high and complicated problems, the company can apply for PM award.

PILLARS OF TPM

TPM starts with 5, s principle. Problems cannot be clearly seen when the workplace is unorganized. Cleaning and organizing the workplace helps the tem to uncover problems.

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5S SEIRI – Sort out.

This means sorting and organizing the items as critical, important,frequently used items, useless, or ileins that are not need as of now.

SEITON – Organize

Each item has a place and only one place.. the items can be identifiedearly by writing name plates and coloured tags.

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SEISO – SHINE

Their involve cleaning the workplace free of turss, grease, oil, waste,scrap etc. no loosely hanging wires or oil leakage from machines.

SEIKETSU – Standardization

Employees have to discuss together and decide on standards for keeping the workplace/ machines/ pathways neat and clean. These standards are implemented for whole organization and are inspected randomly.

SHIFTSUKE – Self Discipline

This is to bring about self discipline among employees of the organization. This includes weaving badges, following work procedures, punctuality, dedication to the organization etc.

Pillar 2 – JISHU HOZEN

Also known as autonomous maintenance.

The pillar aims at developing operators capable of taking care of small maintenance tasks themselves, thus freeing up the skilled maintenance people to expend time on more value added activity and technical repairs

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Pillar 3 – KAIGEN

"Kai" means change "Zen means good. Means a continuous improvement will be there.

The above graph shows the continuous improvement.

Pillar 4 – PLANNED MAINTENANCE

It is aimed to have trouble free machines and equipments producing defect free products for total customer satisfaction. This maintenance classified into four "families or groups" which were dfined earlier.

Pillar 5 – QUALITY MAINTENANCE

It is aimed towards customer delight by getting them from the highest quality through defect free manufacturing. Focus is on eliminating non- conformances in a systematic manner. We gain understanding of what parts of the equipment affect product quality and being to eliminate current quality concerns and then more to poleintial quality concerns.

Pillar 6 – Training

It is aimed to have multi-skilled employees whose morale is high and who are eager to work and perform all the required functions independentl and effectively.

Pillar 7 – Office TPM

It must be followed to improve, productivity, efficiency in the administrative functions and identify and eliminate losses. This includes analyzing processes and procedures towards increased office automation. Office TPM addressestwelve major losses.

Pillar 8 – Safety Health and Environment

This pillar aims at achieving

- Zero accident
- Zero health damage
- Zero fires.

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TPM & TQM

Similarities

In many of the aspects, TPM is found to have similarity with the total quality management (TQM) program. The following are the similarities between them.

Empowerment of employees to initiate corrective action, bench markingand documentation.

Top level management committed to the program.Long range outlook perspective.

Dissimilarities

The main objectives are to achieving zero defects zero accidents and zero breakdowns in all functional areas of an organization. Also the objectives include to create different team of people to have active participation aiming at minimization of defects and to inculcate autonomous policy.

Maintenance scheduling

It is a joint maintenance operations acitivity in which maintenance agress to make the resources available at a specific time when the unit can also be made available by operations. Resources include manpower, materials, tools and any special equipment.The work scheduling should be aimed at to have least adverse effect on normal operating schedule while optimizing the use of maintenance resources – especially labours.

The success of any maintenance schedule depends on two basic elements.

- Work should not be schedules which is not completely ready forscheduling, regardless of pressure.
- People from other operating units should be involved while creatingthe schedule.

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Communication is the main key to establish successful maintenance scheduling.

This involves everyone from planners, schedulers, maintenance supervisor, craftsman, store room personnel. Any discontinuity in communication with heavily influence and drag down the success rate.

State holders and their role

In maintenance scheduling, the state holders belong to various departs, sections of the company. For the scheduling to be effective, it is essential to ensure a sound communication among the state holders. Each one of the state holders in the communication chain has a role to play, which are to be clearly defined and the should be made aware of it.

1. Planner

The work is property planned with respect to customer requirements, shores material \, directly purchased material and special service mentioned on work order. Also the work to be carried out with the time of safety requirements should be described.

2. Schedules

He should ensure that

- Trades are available to conduct the work during the schedule duration.
- Materials and / or service availability
- Communicating the details of the above to person involved in maintenance and operations.

Maintenance Scheduling Principles

3. Maintenance Supervisor

He / She will be responsible for the day to day activities comprised in weekly schedule and also determines the business availability. They attend to specific such as to who- what – where – when.

4. Craft Man

She executes the assigned task and keep informing the

maintenanceteam, the outcome as well as any practical difficulty in their part, for any further analysis.

5. Storeroom personnel

They maintain the records of receipt of goods and notify if any damage exists.

6. Operations Superintendent

He must be kept informed in advance about the equipment condition. Since he is well aware of production schedule, should determine the opportune time with maintenance to release the equipment.

7. Operator

He is the person responsible for securing the equipment and report back to maintenance personnel if any elevation is observed.

- Job plans providing number of person, required, lowest required craft skill level, craft work hours per skill and job duration information and necessary for advanced scheduling.
- Weekly and daily schedules must be adhered to as closely as possible. Proper priorities must be placed on new work orders to prevent interssuption of these schedules.
- A scheduler develops a one – week schedules for each crew based on craft hours available, forecast that shows the highest skill available.

- The one – week schedule assigns work for every available work hour.

  The schedule allows for emergencies and high priority, reactive jobs byscheduling a significant amount of work on the easy interrupted tasks.

- The crew supervisor develops a daily schedule one day in advance using current job progress, the one-week schedule and new high priority reactive job as a guide.

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- Wrench time is the primary measure of work force efficiency and of planning and scheduling effectiveness. Work that is planned before assignment reduces unnecessary delays during jobs and work that is scheduled reduces delays between jobs.

- Schedule compliance is the measure of adherence to the one – week schedule and tis effectiveness.

REPAIR

Generally, the maintenance scheduling embraces the following activities.

- Inspection
- Repair
- Overhauling

Hence the term repair does not reflect the actual but only the time duration consumed to perform the corrective action. Based on the time the repair may be minor one like adjustment of fasters, adjustment of belt tension, etc, or major one like un conditioning the bed surfaces, guide ways and cleaning of bearings etc.

To create maintenance scheduling program, the various maintenanceactivities may be classified into four categories which are as follows.

- Inspection (I)
- Minor Repair (R)
- Medium or major (R2) and
- Overhauling (O)

Repair cycle

The repeated performance of all/ some of the above mentioned activitiesin sequence between successive overhauling is termed as Repair cycle”

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The figure shown below shows the activities to be carried out duringoverhauling of equipments.

It is clear that first an inspection activity is scheduled followed by minor/ major repair activities. Then an inspection takes place followed by a major reapir.

Again a second inspection is followed by major repair. Like this is goes and completes one reapir cycle. The set of there activities between two conseeutive. Overhauling is defined as a repair cycle. This typical repair cycle covers three inspection and two minor and major repair activities. This can be representedo1 – I1 – R11 – R21 – I 2 – R1 – I3 R2

From the above it is understood that the repair cycle is mainly time dependent between activities

An index number generally known as repair completely number is used to devote the complecity repairing equipments. More the complexity number more will be the activities involved and in turn more staffing requires to complete the repair cycle.

LUBRICATION

In industrial equipments / machineries, the surface of the mechanical parts will have physical contact on the neighbouring parts to establish a relative motion between them.

During the operation of the equipments, those contacting surfaces are subjected to friction which depends on the are a of material, properties of material etc which in undesirable. This leads to progressive damage resulting in material loss which is defined as wear. Friction and wear also generate heat and responsible for the overall loss in system efficiency. All these contribute to significant economic costs due to equipment failure, cost for replacement and downtime.

The primary objective of lubrication is to reduce wear and heat between contacting surfaces in relative motion. By means of lubrication co efficient of friction (which depends on area of contact and amount of load acting). Could be reduced and intern heat and wear of the surfaces.

Lubrication also aids to

- Reduction of rust formation
- Reduce oxidation
- Transmit mechanical power into hydro fluid power systems
- Seal against clust, dirt and water.

Selecting the light and right lubricant, the sight amount of lubricant and the correct application of the lubricant are essential to the successful performance of any bearing, because bearing lubricants serve three purposes.

Reducting friction by separating mating surfaces.]To transfer heat (with oil lubrication)

To protect from correction and with grease lubrication, dirt ingress.

The success of there three factors depend heavily on the film thicknesson the raceway and at the sit / roller end contact.

LUBRICANTS

Any method or material used to reduce friction with high coefficient of friction, by establishing low- discus film are called lubricants. Lubricants are available in liquid, solid and gaseous forms. Solid lubricants (soap, mica, molybdenum disulfide etc) are used for industrial applications when oil or greaseare not suitable. Graphite is used when the loading at contact points is heavy.

Methods of Lubrication

The following are the various methods of lubrication normally used forindustrial applications.

- Hydrostatic lubrication
- Hydrodynamic or Fluid film lubrication
- Boundary Lubrication
- Elasts hydrodynamic Lubrication (Ehd)
- Extreme pressure (EP) lubrication.

In general, the method of lubrication is characterized by the friction

and wears characteristics of wearing surface. Based on the value of "R" which is defined as follows, the method of lubrication is chosen.

R = Mean Fluid Film thickness/ surface roughness (CLA) Where R is less then or equal to 1 for Boundary lubrication R is inbetween 5 and less than or equal to 100 for fluid film lubrication. R is between 1 and 5 for mixed lubrication.

Lubricamts are available in liquid, solid and gaseous forms. Graphite isused when the loading at the contract points in heavy.

HYDROSTATIC LUBRICATION

In hydrostatic lubrication systems, a their film of lubrication is created between the journal and the bearing by supplying lubricant under pressure with an external source like pump. Since the lubricant is suppolied under pressure, this type of bearing is called externally pressurized bearing

Compared to Hydrostatic bearing, hydrodynamic bearings are simple in construction, easy to maintain and lower in initial as well as maintenance.

2. Hydrodynamic or Fluid film lubrication

In heavily loaded bearings such a thrust bearings and horizontal journal pressure is also required to support the load until the film is \established.

If the pressure is generated externally is called as hydrostatic lubrication and if generated internally in within the bearing by dynamic action, it is referred to as hydrodynamic lubrication. In this type of lubrication, a fluid wedge is formed by the relative surface motion of the journals or the thrust runners over their bearing surfaces.

a. Thrust Bearings

* in hydrodynamic lubrication, the wearing surfaces are completely separated by a film of oil. This type lf lubrication is similar to moharized speed moving on water.

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When not moving the boat begains to move, it experiences a resistance due to the iscosity of water.

This cause a slight life of leading edge of the boat and allows a small amount of water between it and supporting water surface.

As the velocity of boat increases, the wedge shaped water film increases until a constant velocity is reached.

When the velocity is constant the amount of water entering the leading edge equal the amount passing outward from the trailing edge.

For the beat to emain above the supporting surface there should exist a upward pressure equalists the laod. The same principle can be applied to sliding surface. The operation of thrust bearing is an example of hydrodynamic lubrication. Thrust bearing assembly used in hydropower industries are alsocalled ltilt pad barings.

The pads of these bearings are designed to lift and to tilt to provide enough area for lifting the load of generator. As the thrust runner moues over the thrust shoe, fluid adhering to the runner is drawn between the runner and shoe forming a wedge of oil.

As the velocity of thrust runner, increases the pressure of oil wedge and the runner is lifted as full fluid film lubrication takes place. When the loadhigh the pressure pupms are used to provide initial oil film.

Extreme Pressure Lubrication

Antiwear agents (chemicals) which are normally used in boundary lubrication will not be effective beyond certain temperature (250 degree Celsius). In heavy loading applications oil temperature raises beyond the anti-wearprotection.

Under this situation lubricants containing additincs that protect againstextreme pressure called EP lubricants are used.

EP lubrication can be adchieved by chemical compounds of phosphorus, sulplur, chloride or combination of these.

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JOURNAL BEARING

The operation of a journal or sleeve bearing is also an example of hydrodynamic lubrication when the journal is at rest its weight squeezes out the oil film so that the journal directly rests on the bearing surface. During operation, the journal has the tendaency rollup the side of bearing. So the fluid adhering to the journal is drawn into contact area and when the speed increases an oil wedge is formed, which is shown in the drawing shown above.

The pressure of the oil wedge increase until the journal is lifted up vertically but also pushed to the side by pressure of oil wedge.

Then the journal is rotating at a constant velocity, film thickness will exist only at the left counter and not at the bottom of the bearing.

Elasto – hydrodynamic (EHD lubrication)

The lubrication principle is applicable to rolling bodies such as tail or roller bearings, is known as EHD lubrication.

The formation of the lubricant film between mating bearing surfaces is called elasto – hydrodynamic mechanism of lubrication.

The two major considerations in EHD lubrication are the elastic deformation of the contacting bodies under load and the hydrodynamic effects forcing the lubricant to separate the contracting surfaces while the pressure ofthe load is deforming them.

The contact between the large end of the roller and the inner race it is called elasto – hydrodynamic contact or a hydrodynamic contract. As the rit / roller loads are much lower than the roller / race loads, the film at the rit/ rollerand contract is usually twice as thick on the roller / race contact

However, scoring and welding amy still occur in severe conditions, including high speeds, viscosity, load or inadequate lubrication, in there conditions, a lubricant with extreme (EP) pressure additines is to be used to prevent bearing damage.Even though the lubrication principle of rolling object is different from lsiding objects, the principle of hydrodynamic lubrication can be applied upto limits.

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edge of beaing. Adhersion of oil to the sliding element and support surfaces increases pressure and creates an oil film between two surfaces.

Since the area of contract is extremely small in a roller bearing or ball bearing , the force per unit area will be extremely high. Under this pressure, it would appear that the oil could be squeezed from between the surfaces. The viscosity increase and prevents the oil from being entire squeezed out.

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