Maintenance Method
For
Critical Equipments
Of
Coal Handling Plant

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1.0 Abstract: -

Maintenance of Critical Equipments for Coal Handling Plants (CHP) of Thermal Power Stations is typical job. The failures of these equipments have led to high maintenance and operation costs. Coal handling plants of Thermal Power Generation House have focused on the key measures of Plant Availability. During study carried of maintenance of CHP, following major problems are encountered.

- Low levels of planned maintenance
- Advanced maintenance methods are not used.
- No measurement of equipment performance.

Developing a special method for maintenance of Critical Equipments is necessary for improving maintenance quality and reducing operating costs. The combination of corrective preventative and condition based maintenance will required to apply for Critical Equipments. This type of maintenance policy and strategy will improve performance of CHP through availability of Critical Equipment.

The concept of Maintenance Method for Critical Equipments (MMCE), discussed in this paper for Coal Handling Plant is to offer significant benefits. The major coverage on bearings and gearboxes of Critical Equipment condition monitoring is featured in this paper. Guidelines for implementation of MMCE in CHP are also discussed in this paper.

2.0 Introduction: -

To maintain an efficiently operating unit and avoid failure of critical equipment, it is necessary to maintain the critical parts of that equipment. The effect of planned maintenanence is depending upon the methods used for preventative maintenance. It is required to apply corrective preventative method for critical equipments. The approach to preventive maintenanence may become inefficient because of improper "Mean". Less mean is costly and more mean is harmful. So it is necessary to determine correct mean depending upon the condition of Critical Equipments. It is required to correct the "Mean" each time by applying predictive maintenance policy.

Continuous feedback is required for corrective preventive maintenance of Critical Equipment. It can be done only by measurement of Critical Equipment performance.

3.0 Critical Equipments Of CHP: -

In CHP the equipments which performance effect directly on plant operation and plant performance are known as Critical Equipment. It is important to identify the critical equipment of CHP. Crushers, Wagon Tippler, Bunker Feeding Conveyors and Feeders are critical equipments. To maintain an efficiently operating unit and avoid failure of critical equipment, it is necessary to maintain the critical parts of that equipment. So it is also important to identify the critical parts. The parts directly affect the performance of equipment performance and operations are known as critical parts of equipments. Each equipment overall performance depend upon the condition of bearings. So these bearings are treated critical parts.

3.1 Crushers: -

In CHP crusher work on principle of combination of impact and attrition crushing. In this type of crushing first coal is break due to impact and further scrub between two hard surfaces to get desired coal size. Some crushers are work only on principle of impact crushing. Generally these crushers are used before final crushers.

The output size of coal affects the performance of CHP. Naturally these two hard surfaces are critical parts. One of these surfaces are known as grinding plates and other may known as rings, hammers etc. The linkage between crusher rotor and drive assembly are also critical parts. As failure of these linkages will stop crushing.

3.2 <u>Wagon Tipplers</u>: -

In CHP generally there are two types of wagon tippler. They are known as rota type and rotary type. The main difference between these tipplers is that rotary type tippler is having floating barrel [1] and rota type tippler turns between two bearings.

The drive linkages are undergoing of cyclic loading and failure of these linkage stop the equipment operation. Due to this unloading affects, which drops the performance of CHP.

3.3 <u>Bunker - Feeding Conveyors</u>: -

CHP are having number of conveyors but bunker-feeding conveyors are playing vital role. The main of each CHP is to maintain bunker levels for smooth coal supply to boilers. As these conveyors feeds the bunker their performance affects CHP performance. The drive linkages consist of gearbox and couplings. Failure of any part of the linkage will stop operation of feeding bunker level. So these parts are critical parts of bunker feeding conveyors. The conveyor pulleys are also critical parts.

3.4 <u>Feeders</u>: -

The performance of feeders affects the efficiency of CHP. The feeders used in CHP are Apron Feeder, Vibrating Feeders, Roller Screens and Vibrating Screen Feeders etc. Generally vibrating feeders, which are used, are of electromagnetic type. The springs and coils and suspension rods are the critical parts. Weak coil springs that are not generating sufficient accelerating forces can also cause low speed and reduce the performance. In vibrating screen feeder have critical part like beam and its members, drive linkages etc. Apron Feeders is sturdy machine the main critical parts are pans, chain and rollers. The roller screens have critical parts in drive linkages.

4.0 <u>Life Cycle Of Critical Components</u>: -

The life cycle of critical component plays vital role in this type of maintenance. After fitting the new component it is required to place limits on component operation to get the desired performance for the maximum lifetime. It is required to maintain and operate the component as per manufacturer recommendation. Component is expected to degrade at some known controlled rate. This is to be verified by monitoring condition. The "condition" being measured can take a variety of forms. Any condition that shows a change, as the health of the spare deteriorates, can be used. It is require applying the preventive maintenance for component survival. The cycle of corrective maintenance is to be decided by checking continuously performance of the component. A time comes when survival of preventive maintenance is not useful then only solution is to replace the component by new one remains. Evidence can be found by monitoring the condition of failure process is under way; it may be possible to take action to prevent failure. This position is known as potential failure position. The time period between actual failure and potential failure is known as lead-time. The component should be change less than lead-time after knowing potential failure. It will allow planning shutdown before severe damage occurs. See Figure No 1.

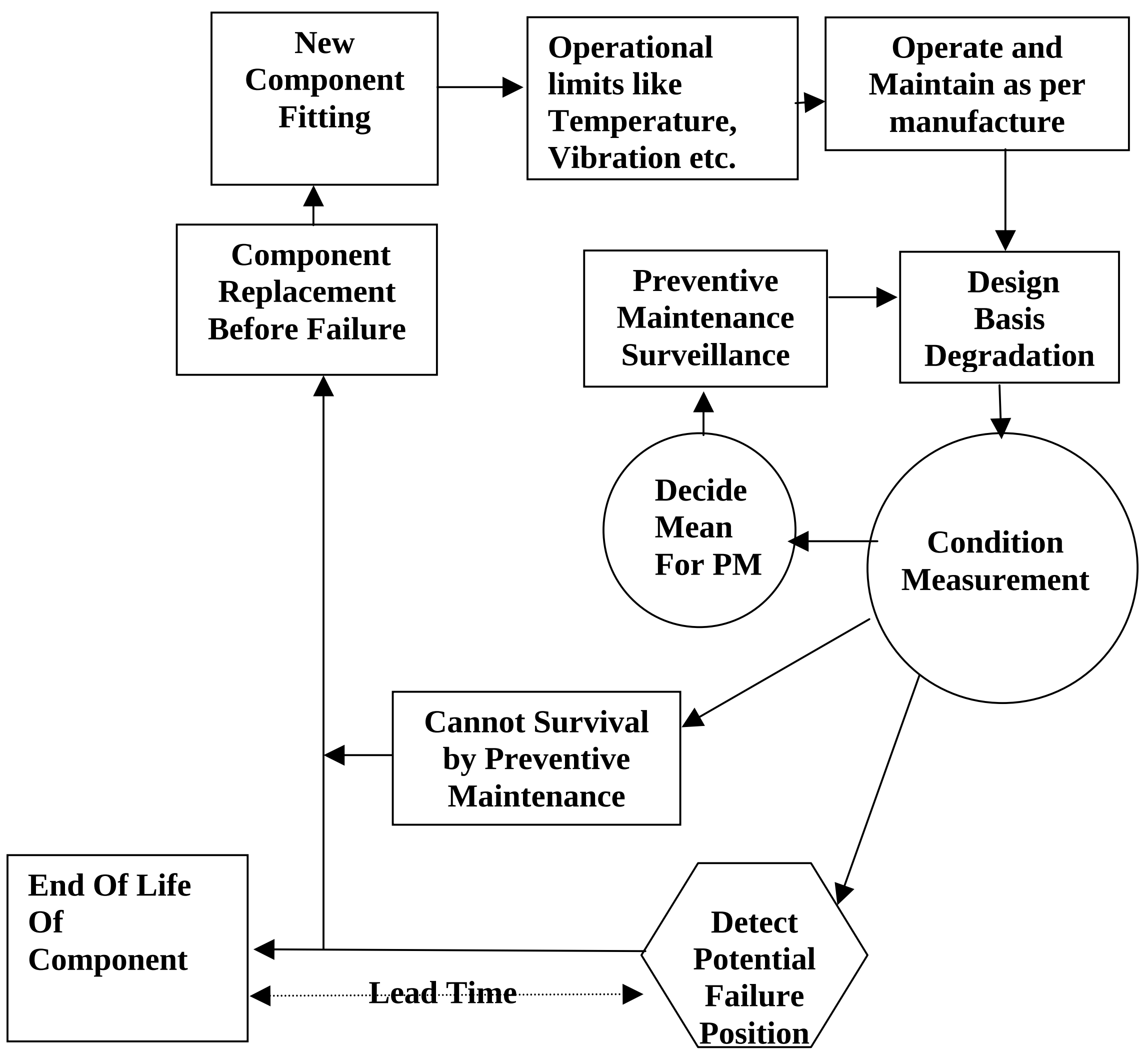

Figure No 1

5.0 <u>Bearings Of Critical Equipments</u>: -

All the critical equipments except Electromagnetic Vibrating feeders are having bearing arrangement. A bearing arrangement consist of rolling bearing associated with components like shafts, housing etc. a shaft or machine elements is generally supported in a locating and a non locating bearing. Locating bearing provides axial location for the machine element in both directions. Non-locating bearing must permit movement in the axial direction, so that bearings are not additionally stressed. The basic static load rating is defined in accordance with ISO 76-1987 as the static load, which corresponds to a calculated contact stress at the centre of the most heavily loaded rolling element/raceway. This stress produces a total permanently deformation of rolling element. The basic dynamic load rating of bearings generally determined in accordance with the methods prescribed by ISO 281/1-1990

5.1 Rated Life Of Bearings: -

The life of rolling bearing is defined as the number of revolutions, which the bearing is capable of enduring before the first sign of fatigue occurs on one of its rings or rolling elements. Service life of bearing is the actual life achieved by a specific bearing before it fails. Specification life is life specified by an authority and based on hypothetical load and speed data supplied by the same authority. It can be also known as a basic rating life. The simplest method for calculating basic rating life is to use ISO equation.

$L_{10} = (C/P)^p$

Where

L_{10} =Basic rating life in millions of revolutions

C= Basic dynamic load rating in N

P= Equivalent dynamic bearing load in N

p = 3 for ball bearing and 3.3333 for roller bearing

Basic rating life in running hours = $(C/P)^p$ X [1000000 ÷ (60 X RPM)]

The loads acting on the bearing can be calculated according to the law of mechanics if the external forces are known.

It also required to consider other factors which influences bearing life. These factors are considered for material, operating conditions etc. the equation introduced by ISO for this purpose is given below.

Adjusted rating life in millions of revolutions =$L_{na} = a_1 a_2 a_3 (C/P)^p$

a_1= Life adjustment factor for reliability =1 for 90% reliability, 0.62 for 95% reliability

a_2= Life adjustment factor for material

a_3= Life adjustment factor for operating conditions.

In CHP the life adjustment factor for operating conditions is very important, as the operating conditions are dusty, dirty and often wet conditions. So for 90% reliability it should be 0.9 for 95% reliability it should be 0.55 (self experience basic). The life adjustment factor can be kept as 1. The table no 1 gives the idea about the life of bearings of some of critical equipment in running hours.

Bearing Life	**Equipments**	
	Crushers	**Bunker Feeding Conveyors**
Rated Life (As per ISO) for 90% reliability	45000Hrs	50000Hrs
Rated Life (As per ISO) for 95% reliability	28000Hrs	31000Hrs
Rated Life (For CHP) for 90% reliability	40000Hrs	45000Hrs
Rated Life (For CHP) for 95% reliability	25000Hrs	27500Hrs

Table No 1

Actual service life of bearing is less than the rated life. So it is necessary for condition monitoring of bearings. Due to condition monitoring it is easy to identify potential failure of bearings. And before end of lead-time bearing can be replaced. To get maximum service life it is require preloading and re lubricating the bearings.

5.1.1 <u>Preloading Of Bearings</u>: -

Depending upon the type of bearing the preload may be either radial or axial. The axial displacement in the bearing arrangement under preload is smaller than bearing agreement without preloads. The main effects of preload are given below.

- Reduces noise.
- Enhance stiffness.
- Give long service life

When the preload exceeds a given optimum value, increases friction and consequently increase heat generation and result in sharp drop of bearing life. The Figure No 2 shows relationship between bearing life and preload /clearance

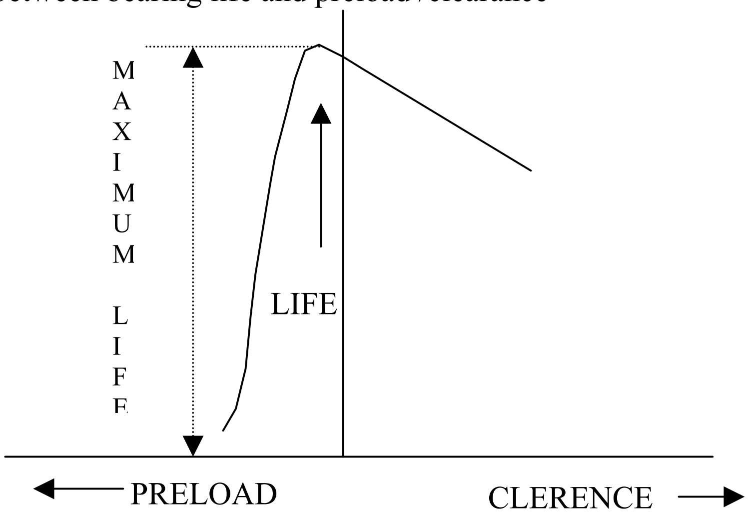

Figure No 2

5.1.2 <u>Bearing Lubrication</u>: -

The rolling element bearings are to be adequately lubricated to operate reliably. Generally in CHP bearings are grease lubricated. And this lubricant has additional task than of lubrication, such as sealing from dust, removal of heat etc. So the larger quantity of lubricant is required. The grease filled in bearing arrangement loses its lubricant properties during operation as result of mechanical work, ageing and build-up of contamination. It is there fore necessary for grease to be replenished or renewed from time to time. The re-lubrication interval is a function of bearing speed and bore diameter of a certain bearing type. See Figure No 3

These intervals are based upon the working condition of CHP. But as the more life past these interval are required to change. The most reason for re-lubrication is entry of fine dust, which is known as respirable dust in bearings. To avoid the entry of these dust it is required to clean are of bearing in each shift. Otherwise it will require increasing the frequency of re-lubrication.

5.2 <u>Effects Of Bearing Defects</u>: -

Different types of defects influence the bearing's residual service life differently. Defect identification and residual life prediction must begin with installation defects that increase loads applied to the rolling surfaces of a bearing and include all rolling surface

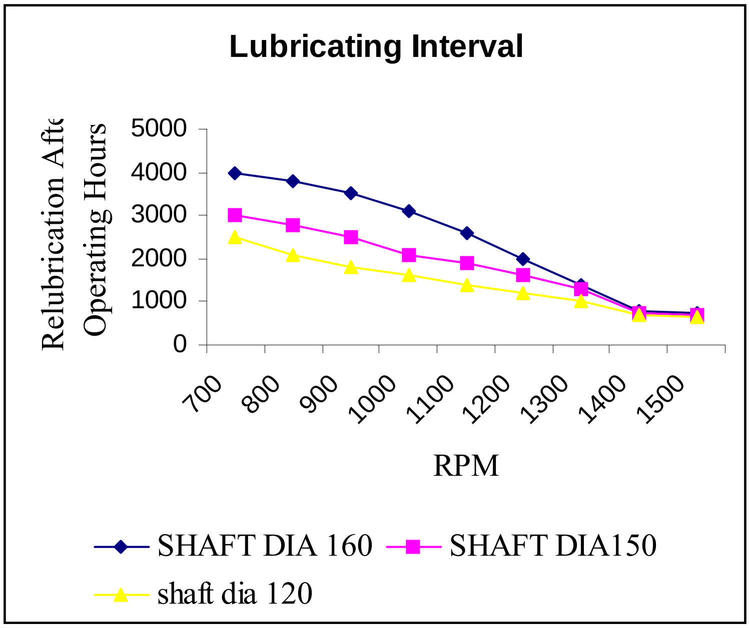

Figure No 3

wear defects. Due to [2] race misalignment, increased radial tension (tight fit), and the slip of bearing races in the mounting (loose fit). Angular misalignments between shaft and housing occur when shaft bends under the operating load or when the bearing seating in the housing are not machined at a single setting etc. Shaft misalignment that results [2] in increased static loads applied to the bearing and a bent shaft that produces rotating forces. Rotating loads can accelerate [2] wear on all the rolling surfaces, fixed and rotating races, rolling elements and the cage. Cavities (spalls) and cracks can appear on all the rolling surfaces. In addition to wear on the rolling surfaces, lubrication defects such as too little or too much, impurities and aging can appear. All contribute to accelerated bearing wear.

5.2.1 Vibration Monitoring Of Bearings: -

In rolling element bearings, vibration results from the impact generated by a ball rolling over a defect. Vibration excited by shock pulses can be used for detecting bearing defects [2]. It is possible to detect several types of rolling surface wear defects with shock pulse excitation at the beginning stage of their development. Measuring the level of high frequency vibration, excited by shock pulses, and the magnitude of the crest (peak) factor, are quite enough when detecting changes in rolling element-bearing condition with minimal expense. However, it must be recognized that overall measurements may not be sufficient to evaluate defect depth (severity) because the magnitude of high frequency vibration is much more dependent on the rise time of the leading edge of the shock pulse than the amplitude of the pulse. This dependency becomes much stronger with increasing frequency of the measured vibration. Faults in any of the four bearing components will generate specific frequencies dependent upon the bearing geometry and rotating speed. (BPFO =Ball Pass Frequency, Outer Race, BPFI =Ball Pass Frequency, Inner Race, BSF - Ball Spin Frequency, FTF - Fundamental Train Frequency or cage rotating frequency)

5.2.2 <u>Temperature Monitoring Of Bearings</u>: -

Higher than normal operating temperatures, whether caused by ambient conditions or generated within the bearing itself, have the potential to harm rolling bearings. Normal operating temperatures differ, depending on the application. Normal bearing operating temperatures in CHP range from 55^0 to 72^0C. Bearings in gear drives normally operate at range from 68^0 to 72^0C. Condition of bearing can be verified by monitoring temperature changes.

6.0 <u>Drive Gearbox of Critical Equipments</u>: -

All the critical equipments except Electromagnetic Vibrating feeders and some crushers are having gearboxes for drive systems. Generally in CHP critical equipments are equipped with worm, helical, helical & spiral gear units. In driving systems of belt conveyors there are mostly used two or three stage gearboxes.

6.1 <u>Effects Of Gearbox Defects</u>: -

Improper condition (damage, defect, failure) of a gearbox is caused by: improper positioning of an electric motor against a gearbox (misalignment) or with conveyor pulley. Tooth separation [3] caused by: bad machining (tooth errors), gear's wheels misalignment, pitting or flaking (all teeth). Failure caused by: fracture of a tooth, chipping of a tooth tip, whole or partly breakage of a tooth may also occur. This type of failure may be called the one tooth failure. Low backlash between two wheels will extra rub in teeth and more backlash will reduce less area of contact. This effect early failure of gear teeth and generate sound while in operation.

6.2 <u>Acoustic Monitoring Of Gearboxes</u>: -

Often the vibration spectra produced by gearboxes appears to be complicated, but they can generally [4] be broken down into:

1.Tooth meshing harmonics
2.Ghost components
3.Sidebands
4.Low harmonics of the shaft speed

For a well-meshed set of gears, only the fundamental gear meshing frequencies are likely to be measured, so once the ratios of the gear trains within the gearbox are known then the gear meshing frequencies can be identified. However, deviations from the ideal profile which are the same for each tooth-mesh and which therefore give a signal periodic at the tooth-meshing rate can be due to two main sources. Firstly, tooth deflection under load, which varies as the load is shared between different numbers of teeth during each mesh cycle. Secondly, situations in which the gear train may not mesh properly and deviations due to misalignment or uniform wear, producing harmonics at twice or even three times the gear meshing frequencies. These side bands are due to the modulation of the uniform tooth-meshing signal, representing slow changes (e.g. eccentricity) or sudden variations due to local faults.

6.3 Temperature Monitoring Of Gearboxes: -

The temperature of a gearbox in operation will increase until the heat balance of the internally generated heat plus the external imposed heat reaches equilibrium with the dissipated heat. Sources of internal heat generation are the power losses in the gearbox due to friction between the components in relative motion. There is friction in the gear mesh, in the bearings, at the seals and hydrodynamic friction between the lubricant and the moving components.

These frictions in normal condition develop heat, which is lesser than abnormal condition. On the same principal the condition of gearbox can monitor.

The system will require three or more permanently located infrared [5] thermometers accurately mounted in the gear guard door or at some other convenient location. The thermometers are located in the center and on either end of the gear tooth flank. The system can be provided with local and/or remote indication of temperature profile and absolute contact temperature together with alarms as required

6.4 Vibration Monitoring Of Gearboxes: -

Each machine in the best of operating condition will have some vibration, which may be regarded as normal or inherent. Whenever machinery vibration increases beyond safe limits, the usual reasons are unbalance, misalignment, worn gears or bearings, looseness, etc. In vibration monitoring of gearbox it is necessary to use tachometer-derived synchronizing trigger in the vibration analyzer to collect of series of waveform samples that are averaged together. The important part of this is that the beginning of each time record must occur at exactly the same time in the rotation of the gear in question. This allows the entire vibration signal [6] that comes from the gear to be emphasized in the time domain average, and all the vibration components from the other gears, shaft rpm, and bearing tones, etc. to be averaged out. This produces a time waveform that shows the individual teeth on the gear, with very little contamination from other components from the machine. When doing synchronous averaging, the analysis parameters of the analyzer are adjusted so the time record length spans a little more time than one revolution on the gear.

7.0 Conveyor Pulley Maintenance: -

The main conveyor component is pulley. There are two are more pulleys to conveyors. The drive pulley, which transfers the energy to conveyor and tail pulley to guide the conveyor at other end. Besides if it’s having the gravity take-up three more pulleys are required. If the gravity take up is having trolley then again two pulleys required. The number of pulleys required to conveyor is depending upon its application, location and type of conveyor. to prevent unneeded downtime and to promote efficient operation it is required timely maintenance and inspection and prevent many of the most common causes of pulley failure, thereby extending the life of components and keeping production prospering.

7.1 Effects Of Pulley Defects: - One of the most prevalent pulley [7] failure modes is end disc failure. End disc failure normally occurs through cyclic fatigue failure of the weld between the hub and the end disc in welded-in hub designs (see figure 4). Rim limitations are familiar cause of pulley failure. Two common types of rim failure include circumferential and longitudinal rim cracks. Lagging can help prevent wear on the pulley rim from abrasive or corrosive materials contacting the pulley. A pulley in an abrasive environment absent of lagging may promptly experience wear along the rim's outside diameter. As this wear increases, the thickness of the pulley rim decreases well below its intended design limits, and it will soon experience a full crack and/or catastrophic failure.

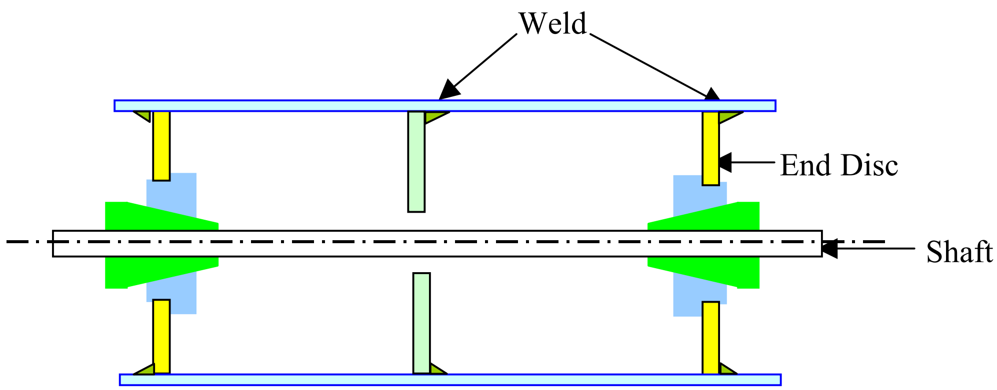

Figure No 4

Undersized shafting or excessive shaft deflection can easily cause tremendous stress levels within the end disc. For problematic pulleys with recurring end disc failures, it may be necessary to increase the shaft size of the pulley at the hub in order to minimize deflection and the bending stresses within the end disc. Additional failures can occur as a result of operating conditions, the most common of which may be tracking. Tracking may be adversely affected by such factors as alignment of the idler, pulley, or frame/structure. Tracking can also be influenced by build-up on pulleys or idlers, uneven loading, or belt/splice defects. Other common problems that can cause pulley failures include overloads/jam-ups, over-tight manual take-up, and excessive take-up weight or friction. Manual take-ups are commonly over tensioned, possibly causing problems to the pulley assemblies. Manual take-ups should be tightened through a trial and error process to provide just enough tension to prevent belt slip during start up.

8.0 <u>Implementation Of MMCE</u>: -

The combination of corrective preventative, condition based maintenance and proactive maintenance is required to implement for maintenance of CHP critical equipments. As this program [8] is based upon the combination of methods, it is desired to follow first preventive maintenance and then carry for predictive maintenance technology and then detect root cause of any failure.

8.1 <u>Condition Measurement Techniques</u>: -

The "condition" being measured can take a variety of forms. Any condition that shows a change, as the health of the spare deteriorates, can be used. Table No 1 will guide condition measurement for coal handling plant. SKF Copperhead systems are most suitable for monitoring condition of the Critical Equipment Of Coal Handling Plants.

Measurement		**Equipment**	
Parameter	**Instrumentation**	**Positions**	**Description**
Vibrations	Vibration analyzers/data collectors, hand held overall meters	Transducer placed in path of vibration transmission i.e. bearing housings	Crushers & Pulley Bearings, Gearbox, Crusher Rotors
Vibrations	Detection meters, Shock pulse etc.	As close to source of vibrations.	Crushers & Pulley Bearings, Gearbox, Crusher Rotors
Temperature (Contact)	Thermocouples, RTD	Surface or internally mounted	Crushers & Pulley Bearings, Gearbox
Temperature (Non-Contact)	Infra red cameras, Pyrometers, Laser Thermometer	Surface	Crushers & Pulley Bearings, Gearbox
Lubricants (Condition)	Analytical lab or Portable lab kit	Any lubrication sample	Gearbox, Fluid Couplings
Lubricants (Wear Debris)	Spectrographic analysis, On-line systems Ferrography	Wear Debris in lubricant used between wear surface via magnetic plugs	Gearbox, Fluid Couplings

Table No 1

8.1.2 <u>Fault Detection System</u>: -

A fault detection system is a device to detect problems, danger, or errors in a machine or process and alert or alarm the user or operator to the situation. The system should detect specific machinery and process faults and alerts the machine operator to problems. in the vibrating screen. The system virtually eliminates unplanned screen downtime and expensive repair costs. The system should use the latest technology in condition monitoring. The system should provide continuous automatic monitoring.

9.0 <u>Conclusion</u>: -

By applying maintenance methods suggested for Critical Equipment of CHP will allows:

- To plan shutdown before severe damage occurs and reduce reactive maintenance practice.
- Cause of failure can be analyzed
- Will benefits in Critical Equipment availability, optimized use of resources, reduced downtime, which increased availability of CHP

For applying these methods for Critical Equipment of CHP will require a substantial investment. The return on this investment will be dependent on the effectiveness of its implementation and the commitment of all personnel

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