Development of Maintenance Strategy to Improve Performance of Induce Draft Wet Cooling Tower

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Abstract- Throughout the years, the importance of the maintenance management system and their functions has grown rapidly. Cooling towers are used in many process applications in the various industries. Reliability of these towers is crucial. In many cases, redundant towers are installed to ensure a process will not have to be stopped due to a cooling tower failure. The most prevalent cause of cooling tower downtime is failure of bearings, improper water distribution by the nozzles, fan unbalance, failure of the gearbox or associated mechanical components, such as the driveshaft or disc couplings etc. Further, the elimination of these components reduces the losses in the drive system and offers the possibility for improved overall system efficiency. To succeed in the ever-growing competitive global marketplace, it is vital for modem industries to reduce costs related to asset maintenance, repair and replacement, which directly affects the cost of manufactured products. Unplanned downtime results in high maintenance costs. Consequently, improving maintenance efficiency provides substantial benefits to equipments. Cooling tower maintenance considering future uncertainties could improve the efficiencies of the heat transfer processes and as a result, improve the performance of the cooling tower. As a step towards incorporating uncertainties in the cooling tower consideration, this paper presents a cooling tower maintenance methodology including cooling tower trouble shooting with their causes and remedies, preventive maintenance schedule for cooling tower, optimization of cooling tower overhauling activity in maintenance and monitoring technologies. The methodology has been presented, allows the easy maintenance and monitoring of cooling tower with the use of new technology in drive assembly. In this present work we have prepare a preventive maintenance schedule on the basis of their failure and causes. This increases the utilization of the cooling tower and reduces the uneven breakdown maintenance.

Index Terms- cooling tower, maintenance, optimization

I. Introduction

A cooling tower extracts heat from water by evaporation. Small portion of the water being cooled is allowed to evaporate into a moving air stream in an evaporative cooling tower which provides significant cooling to the rest of that water stream. Evaporative cooling towers are relatively inexpensive and very dependable means of removing low grade heat from your process.

In various industries there is a use of cooling tower in which various cells are grouped together in serial lines. Well organized of these cooling tower maintenance structure will ensure the effectiveness of the entire production lines. In order to increase the effectiveness of the cooling tower in the production lines, we have studied some advance technologies which ensure the well maintenance and easy survival of cooling tower. Improved reliability of cooling tower is now possible due to advancements in technology. Maintenance of instruments and equipment is a continuous process: once the equipment has been inventoried, the program must continue. Continuous monitoring and maintenance of cooling tower must be done in order to get the better performance of the cooling tower. Cooling tower suffers the many problems in their operation. Proper identification and implementation of corrective action is possible by preparing the scheduled maintenance of cooling tower.

In a cooling tower, cool water is pumped away from the cooling tower and is circulated through hot equipment. The cool water absorbs heat from the equipment and becomes warmer. The warmed water is returns back to the cooling tower. In the cooling tower the warmed water is sprayed downward, and air is blown upward with a fan. As the warm water droplets contact the air, some of the water droplets evaporate, and the air absorbs the heat released from this evaporation and thus lowering the temperature of the remaining water. This cooling effect of the remaining water is called the latent heat of evaporation. During this process, some water is lost to the air from evaporation and some water is lost by the misting effect (called “drift”) into the air.

The basic way to distinguish between cooling towers is how the air and water interact, open cooling towers or closed cooling towers. Open cooling towers are also known as direct cooling towers; allow the water to come into contact with outside air. If cooled water is returned from the cooling tower to be used again, some water must be added to replace the water that has been lost. Pollutants are able to enter into the water used in these processes and must be filtered out. Cooling technology, inc provides all open water cooling towers with sand and gravel filters to help combat this issue. Another method of combating the excess minerals and pollutants is some means of a dissolved solid control, such as a blow down. With this, you drain off a small percentage of the flow to aid in the removal of these contaminants. This is fairly effective, but not as efficient as filtration.

Closed loop cooling towers is also known as indirect cooling tower which does not allow the water to come into contact with any outside substance, therefore keeping the water more pure due to the lack of foreign particles introduced.

II. OBJECTIVE

In this study we find out all aspect of cooling tower failure and their causes which degrades the efficiency of the heat transfer processes. In our study on the basis of past data recorded and by proper observation of cooling tower our aim is to prepare the maintenance schedule of the cooling tower. This maintenance schedule reduces the uneven failure of the cooling tower. Proper monitoring and use of advanced technologies in cooling tower operation also reduces the maintenance task associates with the cooling tower. By proper monitoring we can find out the fault at primary stage so that we can reduces the major breakdown.

The primary goal of maintenance is to avoid the consequences of failure of equipment. This may be by preventing the actually occurrence of the failure, which Planned Maintenance and Condition Based Maintenance help to achieve. It is designed to preserve and restore equipment reliability by replacing worn components before they actually fail. Preventive maintenance activities include partial or complete overhauls at specified periods, oil changes, lubrication and so on. In addition, workers can record equipment deterioration so they know to replace or repair worn parts before they cause system failure. The ideal preventive maintenance program would prevent all equipment failure before it occurs.

III. PROBLEM IDENTIFICATION

Breakdown based maintenance strategy is used in existing cooling tower with most of the parts (nozzles, fills, drift eliminator). The most critical failures occur in the drive assembly which is mostly responsible for the fan unbalance.

In absence of advancement of technologies, the cooling tower monitoring and maintenance becomes difficult. Treated water is not used in some cooling tower. Proper maintenance department not included with the cooling tower.

I. Causes of Poor Performance:

The performance of a cooling tower degrades when the efficiency of the heat transfer process declines. Some of the common causes of this degradation include: Scale Deposits, Clogged Spray Nozzles, Poor Air Flow, Poor Pump Performance.

A. Scale Deposition

When water evaporates from the cooling tower, it leaves scale deposits on the surface of the fill from the minerals that were dissolved in the water. Scale build-up acts as a barrier to heat transfer from the water to the air. Excessive scale build-up is a sign of water treatment problems.

B. Clogged Spray Nozzles

Algae and sediment that collect in the water basin as well as excessive solids get into the cooling water and can clog the spray nozzles. This causes uneven water distribution over the fill, result in uneven air flow through the fill and reduced heat transfer surface area. This problem is a sign of water treatment problems and clogged strainers.

C. Poor Air Flow

Poor air flow through the tower reduces the amount of heat transfer from the water to the air. Poor air flow can be caused by debris at the inlets or outlets of the tower or in the fill. Other causes of poor air flow are loose fan and motor mountings, poor motor and fan alignment, poor gear box maintenance, improper fan pitch, damage to fan blades, or excessive vibration. Reduced air flow due to poor fan performance can ultimately lead to motor or fan failure.

D. Poor pump performance

An indirect cooling tower uses a cooling tower pump. Proper water flow is important to achieve optimum heat transfer. Loose connections, failing bearings, cavitations, clogged strainers, excessive vibration, and non-design operating conditions result in reduced water flow, reduced efficiency, and premature equipment failure.

IV. DESCRIPTION OF PROBLEM

In operation of cooling tower various types of problems offered, which affects the performance of cooling tower. The problems occur in cooling towers are of many types and various causes are responsible for the same failure.

A. Cooling Tower Trouble Shooting

Cooling Towers are categorized under critical equipment in our plant. A catastrophic failure of a cooling tower has the potential to partially shut a major portion of the site down, costing thousands of dollars in lost production. It is very important that we know the mechanical condition of our cooling towers at all times.

B. Cooling tower trouble shooting description

Gearbox overheating: At one station, over half the gearboxes experienced failures of the output shaft bottom bearing. One of the root causes of failure was oxidation of the oil at the elevated temperatures at which the gearbox was running. The gearbox did not have a cooling fan mounted on the input shaft and the result was a “dead space” in the airflow around the gearbox. Oil analysis detected the oxidation and the grade of oil was changed.

Shaft bearing failure: A number of different failure mechanisms are responsible for output shaft bearing failures. Possible causes of bearing failure are solid or water ingress via a shaft seal, poor lubrication or contamination of oil. Some designs of gearbox are prone to oil starvation of the top output shaft bearing when the fan rotates in reverse. This has been addressed by the fitting of anti-reverse rotation devices. If the fans are left stationary false brinnelling damage can take place. Over long periods (>3 weeks) the thickness of the oil film reduces to the point where fretting corrosion can occur if water ingress occurs via the shaft seal. Such damage can occur during commissioning, when some fans run but others are left stationary for long periods.

Gear teeth failures: Some gearboxes experienced single teeth failures on the intermediate shaft bevel gear. Metallurgical analysis of the damaged teeth suggested a manufacturing defect or a transient overload on the gear, possibly when the motor was started. The defect was detected using Enveloped Signal Processing of the signal from the accelerometer mounted at the output shaft.

Fan unbalance: Water logging of fan blades can cause fan unbalance. Porous GRP material delaminates and small pieces break off inside the hollow fan blade, lodging at the end of the blades and blocking the water drain holes.

The most common Cooling Tower Fan failure involves the gearbox or fan blades and are catastrophic in nature. Cooling Tower Fans have applications in many industries, and in most of these cooling is a reasonably critical process and warrants monitoring. The mechanical components of a Cooling Tower Fan are made up of, Motor, Jackshaft (Optional), Gearbox, and Fan Blades.

Make-up water system: Cooling tower is supplied with a mechanical ball & float valve in the basin for automatic addition of system makeup water. The valves are field adjusted during start-up. By piping directly to each basin on multiple tower installations, the rate of makeup is maximized. Make-up water supply pressure should be according to the design level to prevent valve failure. If supply pressure exceeds, the owner should supply a pressure-regulating valve.

Balancing water flow: On single inlet towers, there is no need to balance the flow. The system pressure drops insure uniform flow to each of the spray nozzles. On multiple inlet towers, if the piping to the tower is symmetrical, there will not be a need to balance flow between cells. On non-symmetrical inlet piping, you may need to balance the water flow between cells. The easiest way to accomplish this is to remove the drift eliminators (with fans off) and to observe the water distribution pattern over the fill on each cell. The water to individual cells can be adjusted by throttling the valve on the riser feeding each cell until the nozzle spray patters are consistent and the resulting flow patterns over the fill on each cell are similar. This balancing should be performed at the anticipated/design flow to the tower.

Impact of air and water distribution on performance: Uniform air and water distribution in the cooling tower is needed to optimize interaction of air and water within the fill material. When either the air or water distribution becomes less than optimum, the tower thermal performance drops off. Significant variations in the water flow rate to your tower can reduce the spray pattern achieved by your nozzle spray header. Consequently, flow is concentrated within the fill and may locally exceed the liquid loading rate (m3/hr) capacity of the fill. Excess loading will reduce heat transfer performance. In addition, such concentration of flow resulting from poor nozzle distribution leaves un-wetted pathways through the fill. Airflow intended for cooling the water moves to these dry, less obstructed pathways, effectively bypassing the hot water.

C. Problem caused by Improper Water Treatment

Corrosion: Corrosion of condenser system components such as circulating pumps, condenser tube sheets and cooling towers can be very costly in terms of service disruption, loss of production, increased maintenance and capital equipment replacement. Implementing a properly designed chemical water treatment program is the simplest method of preventing these corrosion problems.

Scale: Formation of scale deposits will result in a loss of cooling transfer efficiency, translating directly into increased cooling costs. Raw water contains varying amounts of mineral salts such as calcium, magnesium, iron and silica. When these minerals exceed their solubility point due to increased cycles of concentration, the minerals precipitate out of solution and produce scale forming salts. It is essential to maintain a proper bleed-off schedule to prevent excessive over cycling.

Fouling: Air contains particles of dust and dirt of various kinds, (depending upon the local environment), causing recirculating water to become contaminated with a variety of materials. This creates fouling on the inside surfaces of condenser systems which can lead to under-deposit corrosion and loss of cooling transfer efficiency.

D. Safe Level of Water Constituent in Cooling Water

Tower water must also be evaluated for solids and mineral content. Minerals can form deposits or scale on the tower materials. As with biological growth, sedimentation and scaling of tower surfaces reduce the overall heat transfer coefficient and the cooling capability of the tower.

As material (biological, mineral, or particulate) is deposited within the fill, the overall tower effectiveness is lowered, and the weight of the fill increases substantially. This added loading can lead to structural failure of the fill and its support system. Clearly, the need for proper treatment, and its value, cannot be overstated.

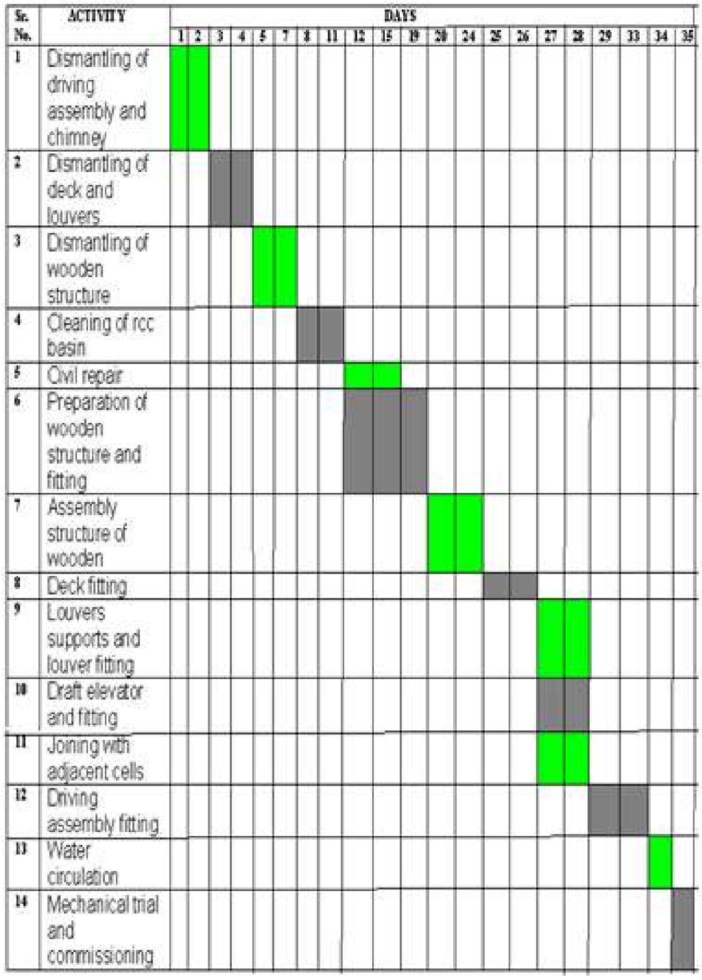
The most obvious indicator that the fill is becoming contaminated is the loss of performance from the tower. This may be seen as an increase in the Cold Water Temperature (CWT) or an increase in fan power. Periodic visual inspection of the fill media is the most practical way to monitor water treatment effectiveness.

E. Optimization of Cooling Tower Overhauling Activity

Dismantling of cooling tower is very complex and time consuming. This problem is occurs when proper sequencing procedure is not used in overhauling. This overhauling of cooling tower is occurs when we required the breakdown maintenance of cooling tower or when we needs the scheduled maintenance. When we use the proper sequence of overhauling activity then we can reduce the complexity in overhauling activity and achieves the less time with minimum labour. When this overhauling activity is unplanned then it increases the overhauling cost of a cooling tower in terms of labour cost and time consumption.

Overhauling Chart for Cooling Tower in Industry:

Table 1 Cooling tower overhauling activity Chart



Cooling Tower Overhauling Activity Details in Industry: In an industry various types of activity are involve in the overhauling of cooling tower. Labour required in overhauling activity are depends upon the type of activity is to be done. The cost of labour is depends upon the number of labour and their skills. Skilled labour performs their task more efficiently with minimum time.

Labour Cost (skilled labour) = 200 Rs

Labour Cost (Semi Skilled Labour) = 150 Rs

The table shows the activity i.e. number of activity which is to be performed in the industry, day shows the number of says required to do a certain activity, labour shows the number of labour involve to complete the activity, cost of labour shows the labour cost associates with particular activity and types of labour shows the which type of labour is involve in the activity i.e. skill or semi skill.

This overhauling activity charts represents the cost and activity of a cooling tower overhauling. Chart shows the hw much cost is associates with a particular activity involve in overhauling of a cooling tower used in the industry.

Activity	Day	Labour Required	Labour Cost	Types of Labour
1	2	5	2000	skilled
2	2	5	2000	Skilled
3	3	6	3600	Skilled
4	4	4	2400	Semi Skilled
5	4	5	3000	Semi Skilled
6	8	4	6400	Skilled
7	5	6	6000	Skilled
8	2	4	1200	Semi Skilled
9	2	4	1200	Semi Skilled
10	2	4	1200	Semi Skilled
11	2	4	1200	Semi Skilled
12	5	4	3000	Semi Skilled
13	1	3	450	Semi Skilled
14	1	2	300	Semi skilled

Table 2 Cost and Labour Involve in Cooling Tower Overhauling.

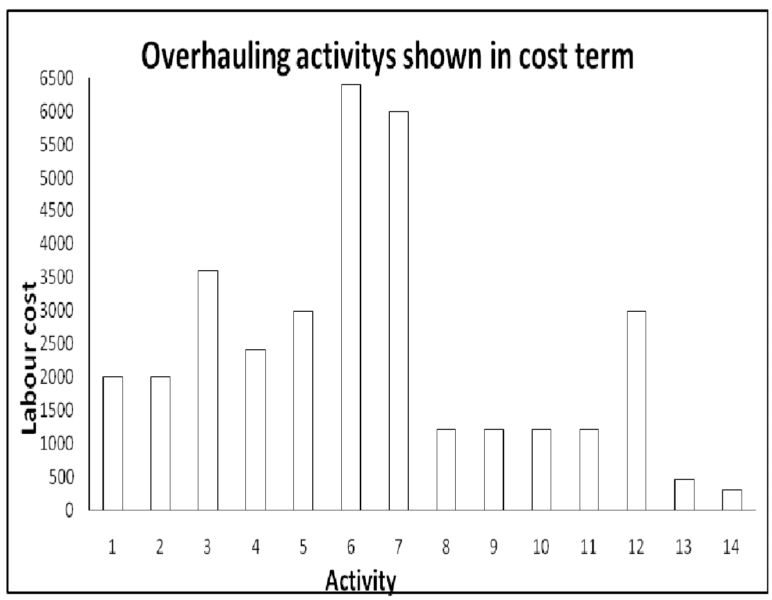


Chart 1 Cost Vs Activity of Cooling Tower Overhauling

F. Optimization of Cooling Tower Overhauling Activity

Optimization of cooling tower activity can be achieve by starting those activity together whose assembling or disassembling does not affect the one another. When we start these activities together then it saves the time in terms of lost in

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production and cost in terms of labour. This table shows the reduced time of overhauling activity thus saves the time and labour cost.

Table 3 Optimization of Cooling Tower Overhauling Activity Chart

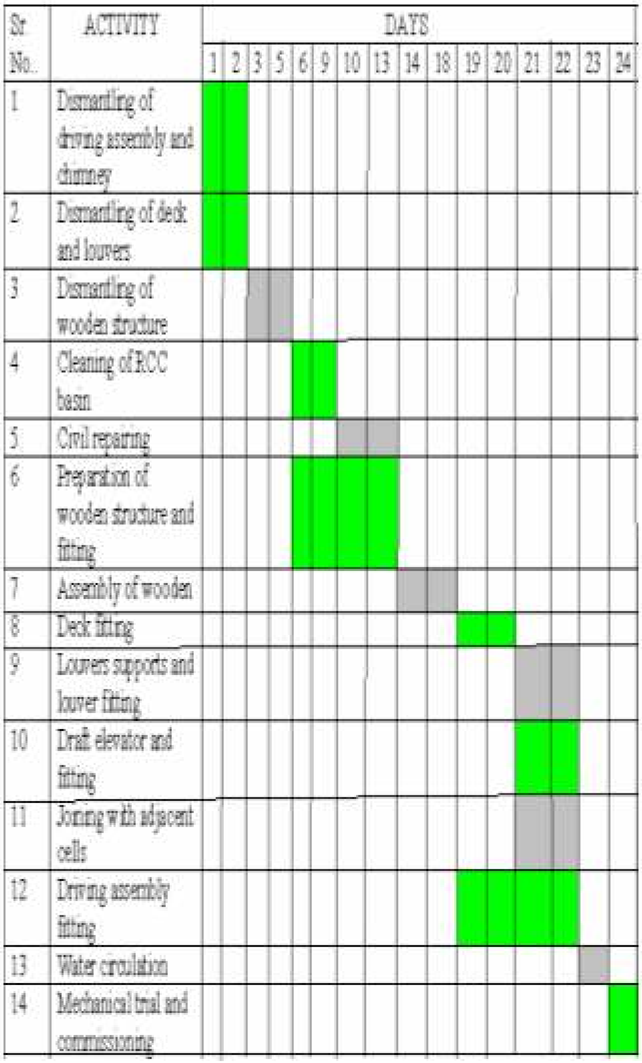

Table 4 Optimum Cost and Labour Involve in Cooling Tower Overhauling

Activity	Day	Labour Required	Labour Cost	Types of Labour
1 – 2	2	6	2400	Skilled
3	3	6	3600	Skilled
4 -6	8	7	11200	Skilled
7	5	6	6000	Skilled
8 – 12	4	7	5600	Skilled
13	1	3	450	Semi Skilled
14	1	2	300	Semi skilled

This chart represents the cost and activity of a optimize overhauling of cooling tower. The activity 1 -2 shows in the bar represents that these activity is started simultaneously. Simultaneous starting of this activity overcomes the time to complete the overhauling and save the cost in terms of labour and time.

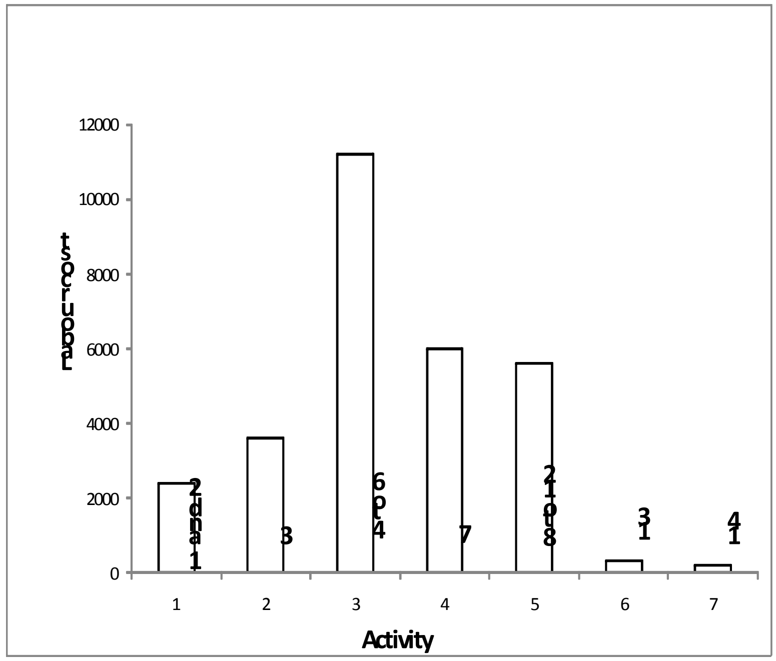

Chart 2 Cost Vs Activity, Optimization of Cooling Tower Overhauling

Cooling tower overhauling Cost Saving: This chart shows the save in cost of cooling tower overhauling activity. The previous cost of overhauling of cooling tower is 33150 and optimum cost is 29300.

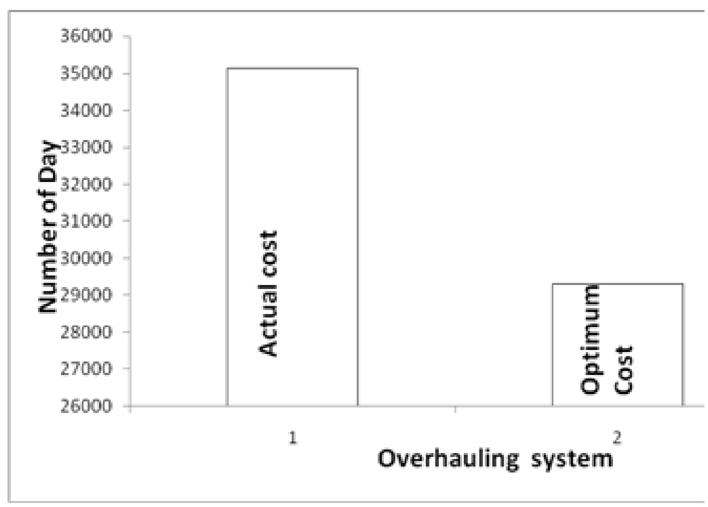

Chart 3 Cooling tower overhauling Cost Saving

Cost Saving = (Actual Cost - Optimum Cost) * 100 / Actual Cost
= (33150 – 29300) * 100 / 33150
= 11.62 %

Hence we can save the cost up to 3850 i.e. 11.62 %.

Cooling tower overhauling Time Saving: This chart shows the save in time of cooling tower overhauling activity. The previous time of overhauling of cooling tower is 35 days and optimum cost is 24 days.

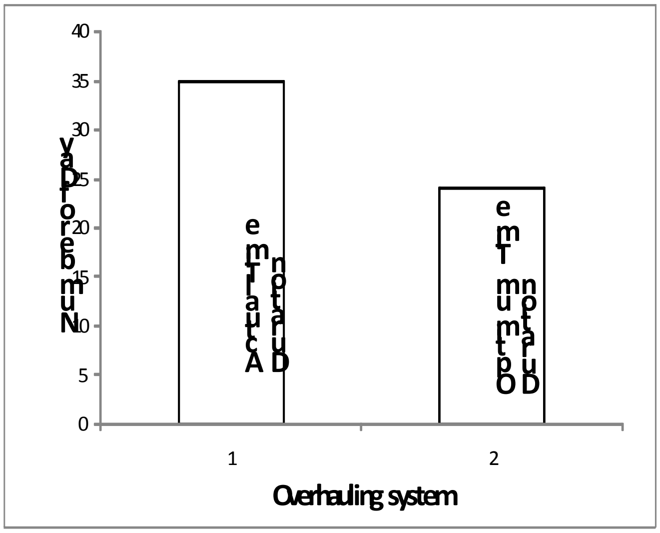

Chart 4 Cooling tower overhauling Time Saving

Time Saving = (Actual Time - Optimum Time) * 100 / Actual Time

= (35 – 24) * 100 / 35

= 31.43 %

Hence we save the 11 days thus save in time up to 31.43 %.

V. CONCLUSION

1. The most important part of the cooling tower is the mechanical equipment, to which the operator must devote the most attention in order to maintain optimum cooling tower production. Downtime and associated losses can be prevented by proper operation and maintenance. Preparation of preventive maintenance schedule makes the proper inspection of cooling tower. This preventive maintenance schedule reduces the instant failure of the cooling tower thus enhances the life of cooling tower components. Proper water treatment of cooling tower as per scheduled maintenance also reduces the uneven biological growth, scaling and corrosion.

2. A well planed sequencing of cooling tower overhauling activity reduces the cost in terms of labour saving and time in terms of lost in production. This overhauling can be achieved by starting that activity together which does not affect the one another and also addition of some labour. This saves the cooling tower overhauling cost up to 11.62% and time (days) up to 31.43 %.

3. Failures of the gearbox, driveshaft, or disc couplings have been the biggest reliability issue facing tower manufacturers and end users. Many of the problems associated with cooling tower maintenance and reliability are solved with a direct drive, low speed, pm motor. The relatively high speed induction motor has been eliminated. The motor itself has not historically been a problem, but the associated resonances and potential vibration concerns have been an issue. The driveshaft and associated disc couplings have been removed, thus eliminating problems associated with misalignment, improper lubrication, natural frequencies, or delaminating of the driveshaft itself. Eliminating the troublesome gearbox maintenance issues with a simplified direct-drive motor is just the beginning. The permanent magnet motor and drive package provides high system efficiency. The variable speed control allows the tower to operate at optimum performance, which results in a considerable amount of energy being saved. When gearboxes run at these high speeds they generate a lot of heat and that's energy being lost.

4. Continuous monitoring of the processes in the operating machinery has always been considered as one of the most efficient methods for machine condition assessment. Recently, a major step forward in the development of microprocessor and signal analysis technology has occurred that allows the development of powerful, efficient, and, at the same time relatively in-expensive systems for continuous condition monitoring of different machine parameters.

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