IMPROVING EFFICIENCY AND PERFORMANCE OF 5MN HYDRAULIC PRESS THROUGH EFFECTIVE PREVENTIVE MAINTENANCE ENGINEERING AND MANAGEMENT TECHNIQUES

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ABSTRACT

The capital cold of this research work is to access the availability of 5 MN hydraulic press and to abate its down time in order to ensure maximum plant production capacity rate and to implement an advance and modern preventive maintenance engineering management aliment schedule. This work is agitated out on hydraulic press installed and in working condition in Frontier Ceramics Ltd Peshawar - Pakistan where various undesired and performance gradated breakdowns were centrally focused and analyzed forth with the perilous components of machine, which were beneath breakdown action which were further determined and analyzed though various maintenance techniques. Considering the motives of research, these undesired failures have been scrutinized and reviewed using famous Cause and Effect Analysis with Fish Bone diagram and 5-why techniques and consequently the root cause of these potential failures were investigated. Following these valuable measures the existing machine availability has dramatically enhanced up to a convinced level that will also upturn the required scheduled plant production capacity leading to diminish all the undesired possible maintenance rates and decreases the frequency of machine down time. This in about-face facilitated to advance new-fangled preventive maintenance checklists of determined period for the betterment of machine performance and obviously helpful to avert the possible degrading of machine before it truly transpires. This research work is principally marking at plummeting abandoned spell like sudden failures and to enhance the plant current manufacturing capacities achievement through accretion machine availability, mean time between failures and mean time between failures of critical components of machine that need extensive maintenance techniques and skills. Obviously this work has been accomplished by optimum operation of time necessary for required maintenance, scrutiny regularity as recommended by plant stockholder and of course a considerable opportunity of prior professional practice.

Keywords: Availability of machine and equipment, Breakdown, Hydraulic press Preventive maintenance techniques, Root Cause analysis with Fish bone diagram and 5 -why analysis.

Introduction

Modern Machine Plant and Machinery Maintenance Techniques are of great concern in any manufacturing unit in order to meet the needs of intensification in reliability and the expected decline in production forfeiture due to various undesirable breakdowns. Considering the current scenario of contemporary diligences that emphasize on high level of process automation with complex machines while the function of process automation is to accomplish sophisticated production frequency with enhanced quality. Consequently machines maintenance techniques must be effective as well as properly managed so as the entire plant may persist in its full working and operating state in order to achieve the desired production goals/targets. Today a lot of cooperative extents are in progress so as to keep the entire plant or a certain machine in fully trouble free setting or even in better environment that is possible only through effective maintenance engineering and management. Modern and Effective Maintenance Techniques subsidize to plant and machine efficiency, customer service, better quality, security and safety and on time delivery. It has been observed that whenever annul planned breakdowns or astonishing machine or equipment failures are experienced, complete processing system and production line is disconnected as a consequence production stops spontaneously. Consequently it would be affluent to fetch the production system into running state under alternative condition. Considering some complex mechanical equipment and apparatus that consisting *n* units the prime model to preventive maintenance cycle strategy is planned to minimize the maintenance cost tariff, the model is focus to the availability and the reliability while the optimal variable is considered as preventive maintenance cycle.

Planned Preventive Maintenance (PPM) decreases the frequency of systematic breakdowns which further increases the equipment availability. In order to meritoriously forecast correctly equipment maintenance timing e.g. preventive maintenance (PM) requirements that not only supports optimizing plant/machine uptime but also try to minimize all the possible negative influences on manufacturing production efficiency. Hence it becomes a forceful need for any manufacturing units to minimize the rate of undesired plant and machinery breakdowns and an effective monitoring and encouraging maintenance operations with modern approach should be incorporated into production planning models. Functional availability of entire plant and machinery are taken care by Maintenance Engineering Department. As the maintenance perception was very deep-rooted and no proper attention was given to the working conditions of processing plant and machines, as a result due to normal breakdowns occurring these machines were rejected or refurbished. But living in present era, these extraordinary complex and capitalized machines need to be carefully scrutinized or maintained in order to maximize or increase the rate of their working availability.

I. 5MN HP Regular Inspection & Maintenance - A Basic Need

The common opponents of any type of hydraulic press are the possible existing of gravity, friction, fatigue, dirt and foreign matter. More likely the plane position requires special provision surfaces to withstand the entire weight of all associated components during the functional cycle. These supporting surfaces are subjected to mechanical wear from relentless friction and to damage from dirt and foreign matter that are common around the press as lubricants and hydraulic fluids very easily catch and assemble dirt onto these critical surfaces. The need of accurate alignment of the press stationary and moving parts is critical to minimizing wear, and also to diminishing intensities of various stresses induced on the press edifice and components. Though press mechanisms may be enormous for long life and a minor misalignment can very easily accelerates the rate of intensities of working stresses involved and result in impulsive failure. A common example of misalignment of the central crosshead may produce an unnecessary wear to the press main ram that further damage main cylinder packing. As per vendor recommendations the guide ways and crosshead must be endangered from dirt and foreign matter as well as misalignment as dirt is straightforwardly air-blown or tracked on the shoes of workers. Similarly careless handling of substantial tooling, bars, or hand tools may cause a permanent scratch or dimple to these critical surfaces. Beside these considerations Maintenance Engineering Department must recognize that effective maintenance must start with instructing all the entire maintenance workforces about these needs and the associated exposures along with their consequences, as well as proper maintenance techniques and preventive trials.

II. Basic Parameters & Specification

5MN hydraulic press is especially designed for semidry-pressing of ceramic tiles from slip powder with approximately 48% of humidity. The press can concurrently produce twelve 8 x12 cm, 12 x 12 cm and 20 x 12 cm ceramic tiles of various sizes. The total pressing area is 2700cm^2. Power source for vertical, four-column down stroke press is provided from hydraulic pump-accumulation station. The press comprises of two inactive irritable portions – a frame and an architrave which are further interlocked by stakes over which a movable crosshead travels. The press sorts a green tile ejector with automatic regulating and slip powder filling mechanism for powder blends, as well as an automated control system.

The press is equipped complete with:

- hydraulic operating drive and automatic control system;
- slip powder filling system;
- tile ejector and die cleaning apparatus;
- tile turn-over system for green pressed tiles;
- essential electric equipment;
- Operating manual/documentation.

Specifications:

Initial Pressing Force, (MN)	**1.5**
Final Pressing Force, (MN)	5
Maximum Distance of movable crosshead, (mm)	150
Maximum transference of movable crosshead from vertical axis per travel length, (mm)	+/-0.5
Maximum dimension in span width, (mm)	1500
Tile thickness, (mm)	5
Under floor close, (mm)	1380
Above floor close, (mm)	4145
Press working fluid	Hydraulic oil

Figure 1: 5MN Hydraulic Press

III.Problem Statement

A 5MN hydraulic press for the production of green ceramic tiles is a perilous machine. Even though the company is subsequently performing the present preventive maintenance schedule but more focus is concern on Run to Failure (RTF) maintenance concept. It is clear that by implementing this strategy, plant and machinery is intentionally allowed to operate until an unexpected breakdown occurs, at which point reactive maintenance is performed. It means no maintenance, as well as preventative maintenance, is accomplished up until the occurrence failure event. Conversely experience shows that Run to Failure (RTF) maintenance is inappropriate for uses where machine failure develops a safety risk (oil pipes bursting) or where equipment availability is obligatory as each minute of downtime costs many thousands of investment. On the other hand it is also undesirable for plant operation where total maintenance costs might be abridged with an extra proactive attitude to maintenance such as preventive or predictive maintenance stratagems. However Run to Failure (RTF) maintenance concept devours some serious drawbacks like:

- **Unpredictable** – Because most of machines and equipment failures are unpredictable so it is very challenging to anticipate.
- **Inconsistent** – The irregular flora of failures means proficient forecasting of staff and resources can be difficult.
- **Costly** – All of the associated costs of this strategy need to be reviewed at the time of its implemented. Such costs include production costs, breakdown costs, and additional direct parts along with labor costs connected with execution of the maintenance activities.
- **Inventory costs** – Maintenance Engineering Department will need to hold necessary spare parts in inventory in order to lodge for intermittent failures.

Consequently using this type of maintenance strategy/schedule is over surpassing the minimum acceptable level of unexpected failures and breakdowns and due to these repeated failures in various mechanisms, there is a considerable decline in production schedule and volume. On the other side it also affects Mean Time between Failure (MTBF) Program which further also decreases machine availability. Thus through this research work an endeavor with maintenance engineering management approach has been made in order to overwhelmed those traditional ways of press maintenance activities through integrating modern Preventive Maintenance (PM) schedule rather than Run To Failure maintenance approach .

IV.Research Methodology

A. Data Assortment

Investigating the required data is vital for examining the analysis of Root Cause of existing problem. The purpose of data assortment is to review the data in order to explore the hidden facts, the ways it occurred.

B. Maintenance History Database

Maintenance Engineering Department must have precise maintenance history of entire plant in order to properly plan repairs. As a minimum, the concern maintenance engineer must know the standard mean-time-to-repair (MTTR) for every recurring repair, rebuild, and maintenance task necessary to keep optimum operating condition of critical plant machinery. Without this knowledge, he cannot plan an effective repair. Moreover the concern should have at least knowledge regarding explicit tackles, parts necessary for replacement, supporting kits, and most important the professional skills of concern maintenance personnel necessary to accomplish the given maintenance activity successfully. This information, in conjunction with proper repair sequence, is an absolute requirement of a viable repair plan. This type of information requires a comprehensive maintenance database that compiles actual mean-time-to-repair, standard repair procedures, and the myriad of other information required for proper maintenance planning. In addition, by adding data on repairs and maintenance, this same database could provide a complete machine history with information on the frequency, timing, and cost of maintenance. As this research work is concerned with improving the current efficiency and performance of 5 MN Hydraulic press that has been installed and in its full working condition at FCL since 2003, therefore the past failure data assortment is necessary to analyze the necessary strategies for better performance.

Table 1 - Maintenance History Data Base

S. No	Problem	No. B/D	Corrective Measures	Preventive Measures
1	System hydraulic oil temperature is high	9	Temperature gauges replacement and cooling fan at cooling tower belt replacement.	No Measures
2	Main pump motors does not start	11	E-Stop re allocated that has the control circuit locked out	No Measures

3	Loud noise around the pre-fill valve.	10	Dampening controls on pre fill valve properly adjustment.	No Measures
4	Maximum pressure cannot be reached	10	Solenoid valve replaced.	No Measures
5	Main Ram Advancing Slow	12	Calibration between pump stroke command and pump stroke position conducted.	No Measures
6	Die housing cooling not taking place	16	Water jacket was cleaned by acid	No Measures
7	Billet loader will not raise	7	Hydraulic auxiliary circuit pressure adjusted.	No Measures
8	The die or tool stack rotates during the shear cycle	13	key stock replaces	No Measures
Reminder: - The frequent failure occurs must be treated for at least acceptable level i.e. above 3 Spells of failures				

The past failure data of hydraulic press with sufficient information is available in maintenance data log books in equipment past history database with information like:

- The possible causes of breakdown;
- Down Time/Breakdown;
- Restoration time, scrutiny time and recommendation For maintenance action taken;
- Details of Spare Parts replaced ;
- Additional failure information and reasons associated to machine components, quality report of slip powder, hydraulic oil standard, process detail, shift details, operator description etc. This information is helpful in future analysis that could be helpful in there designing of machine throughout the availability improvement attempt.

V. Analysis of Failure/Problems and Counter Trials

A. Considering Root Cause Analysis (RCA):

Root Cause Analysis is a technique applicable to discourse a given problem or non-conformity, in order to investigate the root cause of the problem. It is used to precise the cause, and further preclude the failure from recurring. Or, in other words a technique that helps to answer the questions of what is the cause of the problem occurred in the first place. It pursues to identify the basis of a problem and using a definite set of phases, with supplementary tools, to find the principal cause of the problem, so that we can:

- Decide what transpired.
- Define why it happened.
- Decide what to do to diminish the likelihood that it will happen again.

RCA undertakes that systems and events are interconnected. An act in one area generates an action in extra, and extra, and so on. Through sketching back these actions, we may ascertain where the problem originated and how it propagated into the symptom we are now fronting.

B. Need for Root Cause Analysis (RCA) for this research work:

The Root Cause Analysis will reveal:

- ➢ Why the machine or machine components failure or breakdown occurred;
- ➢ How these failures or breakdowns can be eradicated in future by implementing:
- ➢ Any possible alteration to processes
- ➢ Modifications to machine operation
- ➢ Educating and Training of machine operating personnel

- Adaptive Machine Design
- Verification that new or rebuilt equipment is free of defects which may shorten life:

C. Tools of Root Cause Analysis:

1. Cause and Effect Diagram (*Fish Bone Diagram)*:

Focus on to :

- Explore the root cause of a problem.
- Discover bottlenecks in processes.
- Identify where and why a process isn't working.
- Identify the cause of repeated problem occurring of a certain system.

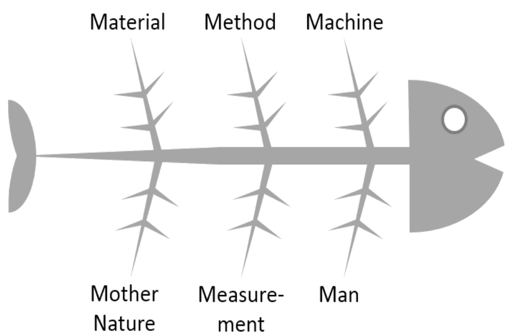

Figure 2: Fish bone diagram

Components include:

- Man–Concern Person implicated with the practice.
- Machine–The desired machine, apparatus, equipment etc. necessary for performing a specific work.
- Method-The procedure and guideline determining how the progression is performed based on necessary recommendations and requirements like policies, rules, regulations and laws.
- Measurement –The required statistical data gathered during various intervals from the process that is helpful in quality and performance evaluation stages.
- Material –It include raw materials, spare parts, packing material etc. used to manufacture the ending product.
- Mother Nature-It includes environmental conditions, geographical location, local timing, temperature and culture in which the process operates.

2. 5- Why Analysis:

This technique is based on repeatedly asking the question "Why" (five is a good rule of thumb), we may easily peel away the layers of symptoms which can lead to the root cause of a problem. It helps to identify the cause-effect inter action of a given problem or a certain failure event. It may also be helpful when the factual cause of a problem is uncertain. As compare to other tools this method is straight forward which tries to solve a stated problem without a large comprehensive exploration which requires many resources.

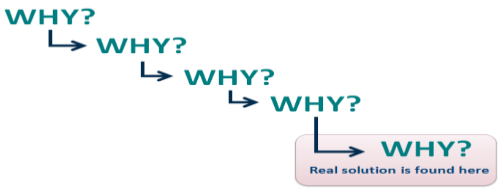

Figure 3: 5 Why Analysis

Table 2 Repeated breakdowns Analysis

S. No	Problem	Problem Locality	Purpose
1	System hydraulic oil temperature is high	Heat exchanger	To un block the heat exchanger on water side.
2	Main pump motors does not start	Hydraulic Pump	To Start auxiliary pump first.
3	Loud noise around the pre-fill valve.	Pre fill valve	Correct Pressure Setting.
4	Maximum pressure cannot be reached	Relieve Valve	To control system Relief valve bypassing.
5	Main Ram Advancing Slow	Main System	To accommodate required pressure
6	Die covering cooling not sufficient	Die Frame	To deliver the required cooling rate
7	Billet loader will not raise	Loading Arm	Ram proper position
8	The die or tool stack rotates during the shear cycle	Frame key stock	System lower portion equilibrium

D. Root Cause Analysis execution:
1. Problem proclamation:

System hydraulic oil temperature is high

- ✓ Problem locality: Heat Exchanger
- ✓ Purpose: To un block the heat exchanger on water side.
- ✓ Customer: Frontier Ceramics Ltd – Peshawar.

a) Short-term control –Oil Pump replacement.
b) Cause and Effect analysis (Fish bone diagram

Figure 4: Fish bone diagram for System hydraulic oil high temperature

c) 5-Why Root – Cause Analysis:

Table 3 5- Why Root Cause Analysis

Problem Title: System hydraulic oil Temperature is high			
Why	**Why the problem did occur?**	**Why it was not detected?**	**Why it was not prevented?**
1Why	Hot water flow through heat exchanger	Temperature gauge has Not been calibrated.	Only Run To Failure Maintenance Concept is applicable in plant.
2 Why	Water pump carries hot water	No maintenance personal is available at pump station.	No Preventive Maintenance Policies
3 Why	Hot Water supply from Cooling tower	Only casual and visual inspection is carried out almost once in a month.	Only Run To Failure Maintenance Concept is applicable in plant.
4 Why	Cooling fan is out of order	As only one maintenance personal is available and further the event did occur during night shift and hence the problem took a considerable long time for detection.	No proper maintenance planning for night shifts
5 Why	Fan belt is broken	The belt was replaced only at morning shift as the spare parts store remained closed during night shift.	No reserve/spare belts available at cooling tower station.

d) Routine Corrective Counter Measures:

- ✓ Temperature gauges monitoring during press working Hours.
- ✓ Temperature gauges calibration time period.
- ✓ Assigning a skilled maintenance operator for pump Station.
- ✓ Cooling tower daily monitoring, inspection, cleaning etc.
- ✓ Appropriate Maintenance Planning for night shifts.
- ✓ Arrangement of spare parts necessary in case of break down for pump station and cooling tower.

NOTE: Likewise supplementary problems can be analyzed via these techniques that would identify the possible root causes in order to obtain the corrective counter measures and to prevent them in future.

Table 4 Execution of Preventive Maintenance Program Checklist
(After conducting Root Cause Analysis)

S.No	Problem	Corrective Measures	Preventive Measures
1	System hydraulic oil temperature is high	Temperature gauges replace and cooling fan at cooling tower belt replaced.	Temperature gauges and cooling tower daily Monitoring.
2	Main pump motors does not start	E-Stop re allocated that has the control circuit locked out	Start auxiliary pump first and Investigate overload cause.
3	Loud noise around thepre-fill valve.	Dampening controls on prefill valve properly adjustment.	At the start of the press always check dampening controls on pre fill valve for proper adjustment.
4	Maximum pressure cannot bereached	Solenoid valve replaced.	At the end of each production shift always check for any possible contamination in valve. Clean or replace if needed. At the start of press machine always check for proper pressure setting. Adjust if necessary.
5	Main Ram Advancing Slow	Calibration between pump stroke command and pump stroke position conducted.	Confirm calibration between pump stroke commands and pump stroke position feedback position.
6	Die housing cooling not taking place	Water jacket was cleaned by acid	Periodic checking of scale formation.
7	Billet loader will not raise	Hydraulic auxiliary circuit pressure adjusted.	Check hydraulic auxiliary circuit for proper pressure on daily base. Inspect the ram position for proper feedback position at every operating cycle.
8	The die or tool stack rotates during the shear cycle	key stock replaces	Sufficient amount of required key availability at press section.

VI. Preventive Maintenance Management Program

As already discussed that the company typically relies on run-to-failure maintenance but unfortunately it does not fully facilitate the availability of hydraulic press therefore the need of an effective preventive maintenance management for the press is the only solution. In preventive maintenance management, machine repairs or rebuilds are scheduled based on the mean-time-to-failure (MTTF) statistic. As most of the maintenance tasks are based on elapsed time or hours of operation. The mean-time-to-failure (MTTF) or bathtub curve represents that a installing a perfect new equipment will always posses a relatively considerably great chances to breakdowns because of installation difficulties during the start of scarce time of function however passing some normal operations the likelihood of functions failure becomes relatively low for a protracted passé. After this equipment normal function and the likelihood of sudden failures dramatically enhances with intervened time.

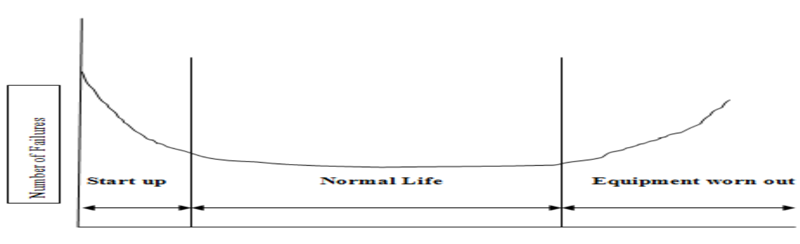

Figure 5: MTTF or Bathtub curve

Preventive Maintenance Management Advantages:

1. Management control.

- Dissimilar repair maintenance that would react to some failures, preventive maintenance may be planned.
- Assignments are easily scheduled so that equipment is available for preventive maintenance activities at equitable times.

2. Overtime.

- Overtime can be condensed or eradicated.
- Surprises are eliminated.
- Work can be done when appropriate;

3. Spare Parts inventories.

- A smaller stock of parts is necessary in industry that accentuates preventive tasks associated to the stocks necessary to accommodate breakdowns that would happen whenever preventive maintenance is not implemented.

4. Backup equipment.

- Due to strict production demand and low equipment availability, backup or standby equipment is needed in case of undesired breakdowns.
- A sufficient amount of backup may be required during preventive maintenance, but on the other hand investment will certainly be abridged.

5. Quality.

- Effective preventive maintenance helps confirm quality yield. Tolerances are maintained within control limits. Naturally, productivity is improved and the investment in preventive maintenance pays off with increased revenues.

6. Support to users.

- If properly revealed, preventive tasks help show equipment operators, production managers, and other equipment users that the maintenance function is striving to provide a high level of support.

7. Cost–benefit relationship.

- Too often, organizations consider only costs without recognizing the benefit and profits that are the real goal.

VII. Hydraulic Press Preventive Maintenance: Establishing a Program

A necessary basic strategy to conduct appropriate maintenance on a hydraulic system two specific areas of great concern. The first strategy is concern with Preventive Maintenance which is the key to the achievement of any maintenance schedule whether in hydraulics system but also for any processing plant need for appropriate reliability. The second strategy is connected with corrective maintenance, that initially responsible for extra hydraulic components breakdowns especially when it is not performed according to required standard. Preventive Maintenance strategy of a hydraulic system is basically simple and if shadowed accurately can eliminate most hydraulic component failure. We must view a PM program as a performance oriented and not activity oriented. In order to develop a preventive maintenance program for hydraulic press installed at FCL Peshawar the following tasks/strategies are considered and each task is properly tabulated separately to achieve best results:

The PM program consists of:

I. Equipment Daily

II. Weekly Check Sheets

III. Equipment Monthly PM Task List

IV. Equipment Semi-Annual PM Task List

V. Equipment Yearly Major Maintenance Task List

I - Maintenance Daily Check Sheet

The Daily Check Sheets contain simple checks that are designed to have someone from the maintenance department do a brief scan around the equipment every day while the equipment is in operation. Any assignments listed that are to be carried out while the equipment in operation should be identified and approval granted by a qualified member of management that the inspections can be done safely. The inspection task should have the following objectives:

Table 5 Daily Maintenance Checklist

Daily Maintenance Check List		
Machine Name: 5MN Hydraulic Press		
Dated:		
Mechanics Name:		
Time Used:		
S. No	**Description**	**Frequency Daily based**
1	Check cleanliness and general conditions around press area.	D
2	Monitor two cycles of operations and note any abnormal status	D
3	Grease Container, Press& Die slide ways	----
4	Check Hydraulic oil temperature and record	D
5	Check for any high volume or high pressure leaks	D
6	Check hold down bar for damage or looseness	----
7	Check slide ways lubrication conditions	------
8	Check pilot pressure 120 to 170 kg/cm^2.	D
9	Check loader for proper operation and alignment	----
10	Check electrical supply system of motor	----
11	Check hydraulic pump for any unusual sound or vibration and note it.	----
12	Check the oiling level for v notch of chain conveyor system	----
13	Check press pit for hydraulic oil level.	----
14	Check water temperature for 25-35 ^{0}C	D
15	Check and record the Servo Pressure (<550 psi)	D
16	Check and record the auxiliary Pressure (<500 psi)	D
17	Check and record the pilot Pressure (<150 psi)	D

II - Maintenance Weekly Check Sheet

The Weekly Check Sheets contain items that are not as critical and would require excess time if they were on the Daily Check Sheets. These items should be picked based on the severity of the outcome if there is a failure, available spare parts, time required for change out, etc., and even though they may not be checked every day, they do not need to go an entire month before they are checked. All the same objectives as the daily checks should apply, only the frequency is changed.

Table 6 Weekly Maintenance Checklist

Weekly Maintenance Check List		
Machine Name: 5MN Hydraulic Press		
Dated:		
Mechanics Name:		
Time Used:		
S. No	**Description**	**Frequency Daily based**
1	Check cleanliness and general conditions around press area.	---
2	Monitor two cycles of operations and note any abnormal status	---
3	Grease Container, Press& Die slide ways	W
4	Check Hydraulic oil temperature and record	---
5	Check for any high volume or high pressure leaks	---
6	Check hold down bar for damage or looseness	W
7	Check slide ways lubrication conditions	W
8	Check pilot pressure 120 to 170 kg/cm^2.	---
9	Check loader for proper operation and alignment	W
10	Check electrical supply system of motor	W
11	Check hydraulic pump for any unusual sound or vibration and note it.	W
12	Check the oiling level for v notch of chain conveyor system	W
13	Check press pit for hydraulic oil level.	W
14	Check water temperature for 25-35 ^{0}C	---
15	Check and record the Servo Pressure (<550 psi)	---
16	Check and record the auxiliary Pressure (<500 psi)	----
17	Check and record the pilot Pressure (<150 psi)	----

III - Monthly Preventative Maintenance Task List

The Monthly PM task list should be designed for duties that generally require planned down time. All tasks that are performed during this time should be items that have been identified as critical areas of the process that require attention every month, and cannot normally be accessed during production time. These tasks should have the following types of work:

IV - Semi-Annual (SA) Preventive Maintenance Task List

The Semi-Annual PM task should be items that are identified as jobs that require more time that has been allotted for the monthly PM. Some tasks may include:

Table 7 Monthly Maintenance Checklists

Monthly Maintenance Check List		
Machine Name: 5MN Hydraulic Press		
Dated:		
Mechanics Name:		
Time Used:		
S. No	**Description**	**Conducted By (Deptt)**

1	Inspection of entire unit for unusual noise and/or vibration.	Mechanical
2	Inspection of pipes/fittings for leaks.	Mechanical
3	Inspection of rubber gaskets.	Mechanical
4	In case various problems are identified and unit requires serious servicing, then perform all Non-Critical Tasks for the Problematic components.	Electrical/ Mechanical
5	Observation of entire unit in operation and note any unusual noises and/or vibrations.	Electrical/ Mechanical
6	Inspection for possible leaks and/or parts corrosion/erosion.	Mechanical
7	Inspection all electric wiring for deterioration and tighten electrical contacts Also check for corrosion and cleanliness.	Electrical
8	Checking mechanical operation at the top of the press.	Mechanical
9	Inspection and replace oil filters if necessary also. Write down installation date on the filter.	Mechanical
10	Observation of cooling tower to ensure proper operation. Inspect for unusual noise or vibration.	Mechanical
11	Inspection and cleaning of louvers.	Mechanical
12	Checking operation of make-up water valve	Mechanical
13	Visually checking of fan.	Mechanical
14	Checking oil level in gear reducer.	Mechanical
15	Provide Water Treatment if necessary	Mechanical
16	During winter ensure proper operation of basin heaters, if present.	Mechanical
17	Cleaning of condenser water strainers/sand filters.	Mechanical
18	Air pressure limit switches replacement if necessary	Electrical/ Mechanical
19	Inspection of brake adjustments	Mechanical
20	Checking rotary limit switches condition	Electrical
21	All Solenoid valves operation monitoring	Electrical
22	Checking of calibration of sensors and instrumentation	Electrical
27	Alignment of motor/pump combinations, moving assemblies, mounted switches and sensors, cameras, etc.	Electrical

V - Yearly Major Maintenance Task

The yearly major maintenance tasks should include items reserved for a low production time of the year and planned-for tasks that are not emergency items, but take more than one day to complete. However, there are some tasks that may take longer to complete but can't be postponed until the yearly shut down as there would be a risk of more lost production time waiting for this date to arrive.

Examples of yearly maintenance jobs:

1) **Wear and Tear Items** – Certain wear and tear items can last a year or years before replacement. These tasks need to be identified and planned for replacement at this time.
2) **Special Projects** – New equipment, equipment upgrades and enhancements
3) **Equipment Rebuilds** – Complete refurbishment for better reliability throughout the year.
4) **Major Component Replacement –** For some components it is more economical to replace before a failure occurs, but it takes more than a day for replacement.

Table 8 Semi Annual (SA) Maintenance Checklist

Semi Annual (SA) Maintenance Check List

Machine Name: 5MN Hydraulic Press		
Dated:		
Mechanics Name:		
Time Used:		
S. No	**Description**	**Conducted By (Deptt)**
1	Inspection of all linkages and ensure proper positioning.	Mechanical
2	Cleaning and re-installing permanent filters or replace disposable filters.	Mechanical
3	Provision of lubrication, if necessary.	Mechanical
4	Checking operation and condition of pressure relief valve.	Mechanical
5	With unit under load, inspect for leaks and any signs of abnormal operation.	Mechanical
6	Draining of until all sediment and discolored water is expelled.	Mechanical
7	Inspection of tank exterior, fittings and hand-holes for signs of corrosion.	Electrical
8	Operation and inspection of all control linkages. Adjust and lubricate linkages as necessary.	Mechanical
9	Checking electrical wiring connections on controls and switches.	Electrical

VIII. Analyzing Data Calculations and Results:

1. Equipment Availability:
An equipment availability is the total available time of utilization of a machine.

$$Availability = \frac{Total\ available\ time - Total\ breakdown\ time}{Total\ available\ time}\ x\ 100$$

2. Mean Time Between Failures: (MTBF)
MTBF is the time between two failures. When failure rate is constant, the mean time between failures is the reciprocal of the constant failure rate or the ratio of the test time to the number of failures.

$$\text{MTBF} = \frac{Total\ available\ time\ - Total\ breakdown\ time}{No\ of\ breakdowns}$$

3. Mean Time To Repair: (MTTR)
MTTR is the average time that it takes to repair something after a failure.

$$MTTR = \frac{Total\ breakdown\ \ time}{No\ of\ breakdowns}$$

Table 9 Machine performance statistical analysis data before hand root cause analysis and present maintenance management schedule:

Monthly Downtime Statistical Data

Production Month	Total Available Time (hrs)	Total b/d Time (hrs)	Total Productive Time (hrs)	Total No of b/d
September	684	100	584	11
October	720	90	630	10

A. Conducting Analysis before RCA:

<u>1. September</u>:

$$Availability = \frac{684 - 100}{684} x\ 100 = \mathbf{85.38}\ \%$$

$$\text{MTBF} = \frac{684\ - 100}{11} = \mathbf{53.09}\ \boldsymbol{hrs}$$

$$MTTR = \frac{100}{11} = \mathbf{9.09}\ \boldsymbol{hrs}$$

<u>2. October</u>:

$$Availability = \frac{720 - 90}{720} x\ 100 = \mathbf{87.50}\ \%$$

$$\text{MTBF} = \frac{720\ - 90}{10} = \mathbf{63.00}\ \boldsymbol{hrs}$$

$$MTTR = \frac{90}{10} = \mathbf{9.0}\ \boldsymbol{hrs}$$

Table 10 Machine performance statistical analysis data after root cause analysis and establishing Maintenance management system

Monthly Downtime Statistical Data				
Production Month	**Total Available Time (hrs)**	**Total b/d Time (hrs)**	**Total productive Time (hrs)**	**Total No of b/d**
September	684	28	565	8
October	720	25	677	8

B. Conducting Analysis after RCA:

<u>1. November</u>:

$$Availability = \frac{684 - 28}{684} x\ 100 = \mathbf{95.91}\ \%$$

$$\text{MTBF} = \frac{684\ - 28}{8} = \mathbf{82.00}\ \boldsymbol{hrs}$$

$$MTTR = \frac{28}{8} = \mathbf{3.50}\ \boldsymbol{hrs}$$

2. December:

$$Availability = \frac{702 - 25}{702} x\ 100 = \mathbf{96.44}\ \%$$

$$\text{MTBF} = \frac{702\ - 25}{8} = \mathbf{84.63}\ \boldsymbol{hrs}$$

$$MTTR = \frac{25}{8} = \mathbf{3.13}\ \boldsymbol{hrs}$$

Table 10 Summary of results comparing the statistical data of availability, MTBF and MTTR before conducting RCA for the months of May 2012 to October 2012. It may also be noted that the results of months of May to August are being calculated through same techniques as for the consecutive months of September and October 2012 respectively.

Monthly Downtime Statistical Data							
S.No	**Month**	**Machine Availability %**	**Product. Target %**	**MTBF (hrs)**	**Target (hrs)**	**MTTR (hrs)**	**Target (hrs)**
1	May	87.96	95	69.00	80	9.44	7
2	June	83.02	95	48.91	80	10.00	7
3	July	79.85	95	35.67	80	9.00	7
4	Aug	81.48	95	36.67	80	8.33	7
5	Sep	85.38	95	53.09	80	9.09	7
6	Oct	87.50	95	63.00	80	9.00	7

Table 11 Summary of results for comparing the statistical data of availability, MTBF and MTTR after conducting RCA for the months of November and December 2012 respectively.

Monthly Downtime Statistical Data							
S.No	**Month**	**Machine Availability %**	**Product. Target %**	**MTBF (hrs)**	**Target (hrs)**	**MTTR (hrs)**	**Target (hrs)**
7	Nov	95.91	95	82.00	80	3.5	7
8	Dec	96.44	95	84.63	80	3.13	7

Figure 6: Graphical Comparison of Availability (%) before and after conducting RCA

Subsequently analyzing the statistical data graphically, we come to the conclusion that machine availability after conducting root cause analysis dramatically encountered the production target values and considerably enhanced than the machine availability before conducting root cause analysis.

Figure 7: Graphical Comparison of MTBF before and after conducting RCA

Subsequently analyzing the statistical data graphically, we come to the conclusion that machine Mean Time between Failure (MTBF) after conducting root cause analysis dramatically encountered the production target values and considerably enhanced as observed before conducting root cause analysis.

Figure 8: Graphical Comparison of MTTR before and after conducting RCA

Here we can come to the conclusion that MTTR after root cause analysis couldn‘t come across the target values and it has been decreased considerably than the MTTR before root cause analysis. Therefore the graphical interpretation shows the mean time to repair (MTTR) diminished from the actual MTTR to planned MTTR. However it has been enhanced considerably after conducting root cause analysis.

C. Analyzing average values of Availability %, MTBF and MTTR before and after conducting root cause analysis RCA for the given period (May to December 2012)

Before Conducting RCA Analysis			**After Conducting RCA Analysis**		
Average Value of Machine Availability (%)	Average value of MTBF (Hrs)	Average value of MTTR (Hrs)	Average Value of Machine Availability (%)	Average value of MTBF (Hrs)	Average value of MTTR (Hrs)
84.20	51.06	9.14	96.17	83.31	3.31

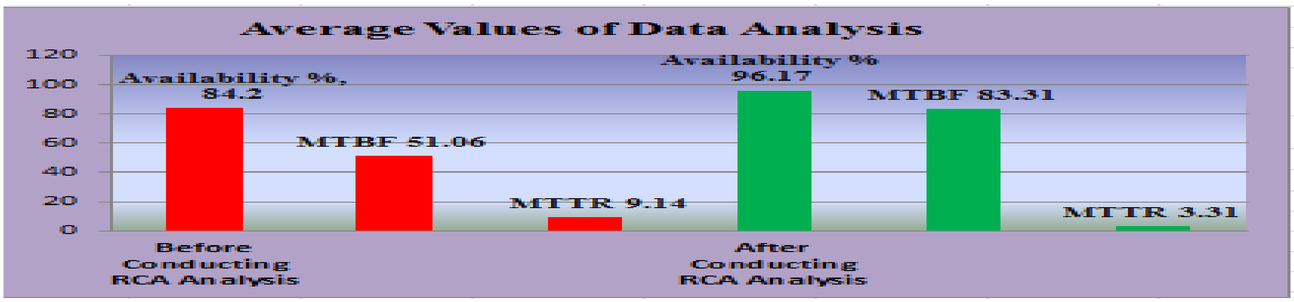

Figure 9: Graphical Presentation of Comparison of Analysis Values

D. Finally analyzing the improvement carried out within Machine Availability %, MTBF and MTTR respectively.

1. % Incremental Performance Regarding Machine Availability:

$$\frac{Final\ Average\ Availability\ after\ RCA - Initial\ Average\ Availability\ before\ RCA}{Initial\ Average\ Availability\ before\ RCA}\ x\ 100$$

$$\frac{96.17 - 84.20}{84.20}\ x\ 100 = 14.21\ \%$$

2. % Incremental Performance regarding Machine MTBF:

$$\frac{Final\ Average\ MTBF\ after\ RCA - Initial\ Average\ MTBF\ before\ RCA}{Initial\ Average\ MTBF\ before\ RCA}\ x\ 100$$

$$\frac{83.31 - 51.06}{51.06}\ x\ 100 = 63.16\ \%$$

3. % Incremental Performance regarding Machine MTTR:

$$\frac{Initial\ Average\ MTTR\ before\ RCA - Final\ Average\ MTTR\ after\ RCA}{Initial\ Average\ MTTR\ before\ RCA}\ x\ 100$$

$$\frac{9.14-3.31}{9.14}\ x\ 100 = 63.78\ \%$$

IX. Conclusion

This research work has been carried out for improving Efficiency and Performance of 5 MN Hydraulic Press for Ceramics Tiles through Effective Maintenance Engineering and Management Techniques where all the associated undesired and recurring process interruptions failures were basically considered and were the center of analysis during research work. Also those perilous components that were responsible for repeated breakdowns occurring were also acknowledged and treated further for analysis. Correspondingly the causes for the various breakdowns have also been investigated using the famous tackles of Root Cause Analysis like 5-why analysis as well as Fish Bone Diagram are also instigated in order to determine those actual critical causes that influence on the efficiency of press. This methodology of course not only helped to improve and develop some new preventive maintenance checklists for the machine life betterment but also helped to avert the failure of press before it actually occurs. Working with various performance enhancement calculations that were based on previously available statistical history database which actually led the work to Average availability of critical machine after conducting Root Cause Analysis is increased to 14.21%, Average MTBF of machine after Root Cause Analysis enhanced to 63.16 % and MTTR that basically diminished to 63.78 % respectively. Consequently after conducting Root Cause Analysis a considerable improvement in the intensification of planned productivity is observed through graphical representation of data analysis. This is true through careful investigations of the existing working conditions and maintenance procedures and by implementing modern preventive maintenance engineering and management approach and schedule.

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