Maintenance cost analysis of Hydraulic mobile crane

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Abstract - The aim of this work is to increase overall equipment effectiveness. Greater safety, longer equipment life and minimum life cycle cost with the help of failure analysis of critical items and its proper preventive maintenance. To ensure failure free operation of mobile cranes, it is necessary to design & develop planned maintenance system on the basis of failure analysis of critical items. This work covers failure analysis of under carriage parts of crane, such as boom bushes, pins, as well as super structure parts such as Boom & cylinder Attachment. On the basis of failure analysis of said parts, some recommendations are given to prevent their futuristic failure . This work also covers effective inspection methods, safe operating practices & preventive maintenance procedure to increases life cycle with least failures at minimum cost.

A case study is also discussed in which a problem of hydraulic mobile crane & its modification is covere The present work consists of failure analysis of some critical items of Mobile crane, their causes of failures & remedies. This work also covers as a systematic and collective approach to safe operation, Repair & maintenance procedure to Mobile crane operator to reduce maintenance cost, machine breakdown time & least rate of failures.

Introduction - Maintenance can be defined as those activities required to keep a facility in as-built condition, so that it continues to have its original productive capacity. And the responsibility of the maintenance function is to ensure that production plant and equipment is available for productive use at minimum cost, for the scheduled hours, operating at agreed standards with minimum waste.

OBJECTIVES OF MAINTENANCE

Operational Objectives

- To provide freedom from breakdowns during production operations
- To maximize the plant availability
- To ensure equipment operating at its maximum working efficiency
- To ensure longer service life or longevity of the plant equipment
- To maintain satisfactory working conditions for safety, psychological and psychological reasons etc.

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Cost Objectives

- To check maintenance expenditure through budgetary control.
- To minimize the maintenance cost
- To maximize the profitability

Types of Maintenance

Maintenance systems can be classified under following heads

1. Replacement instead of maintenance
2. Running Maintenance
3. Shutdown Maintenance
4. Emergency Maintenance
5. Break Down Maintenance
6. Planned Maintenance
7. Preventive Maintenance
8. Corrective Maintenance
9. Predictive Maintenance
10. Design-In maintenance

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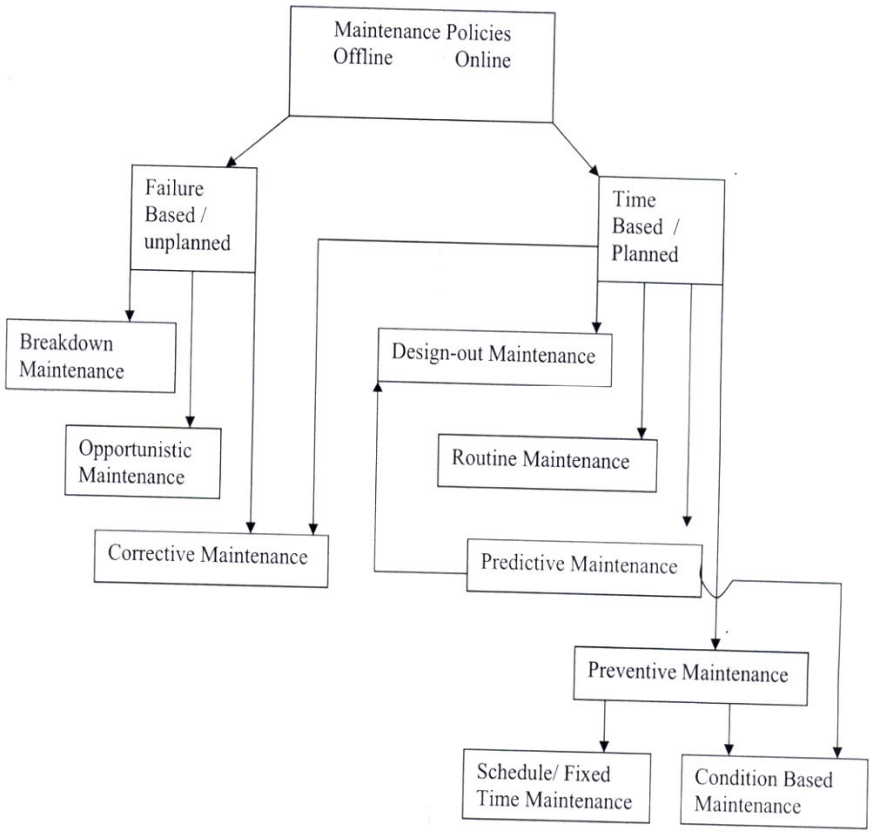
Block Diagram For Maintenance Policies



PREVENTIVE MAINTENANCE

This maintenance activity is well scheduled in advance and carried out as per schedule the is prepared based on the recommendation and prior experience of the planning engineer. And is modified either bi-annually with the requirements and the specific needs of the equipment as well as the plant. This maintenance includes lubrication fastening, measurements and adjustments of various related components. Though this practice is very much routine, it has greater importance is the availability of the equipment. Preventive maintenance combines time based &condition based methods to keep equipment functioning by controlling equipment, components, assemblies, accessories, attachment and prevents corrosion, fatigue or other forms of deterioration from working.

SHUTDOWN MAINTENANCE

Long duration jobs pending in the Excavator received through feedback from the preventive maintenance and inspection or from operation or from visual inspection including permanent rectification if any is done during such maintenance. This particular maintenance has the potential to remove the problems, specifically, breakdowns which are repetitive in nature. During shutdown each and every important part is checked and replaced if necessary. In preventive maintenance module of SAP all jobs resulted from various agencies are shown as pending and hence become the main reference for

planning shutdown activities.

BREAKDOWN MAINTENANCE

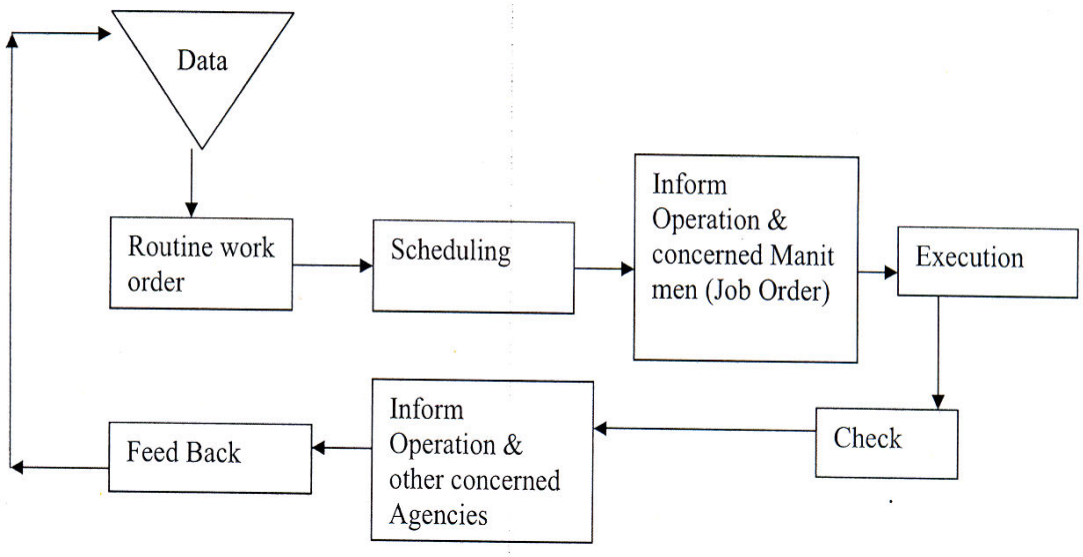
This activity is carried out on Excavator after breakdown of any of its components. The requisite spare tools and tackles are arranged with in the stipulated period and the job is attended with high devotion as otherwise this may hamper the production activities. Generally breakdown occurs by not following the maintenance schedule properly or by faulty operations.

Breakdown may be minor , major, complete stoppage of equipment. Breakdown maintenance is used when does not significantly affect operation or production or generate any financial losses other than repair costs.

B/D maintenance system involves

- Need smaller maintenance organization
- Lower skill levels
- Depends on high out side expertise
- Involve high cost of spares
- Builds up high level of uncertainties
- High loss of production opportunity and Quality

Block Diagram For Routine Maintenance:



Condition Monitoring-Condition Based Maintenance

Condition Based Maintenance

Condition Monitoring is perhaps the most misunderstood and misused of all the plant improvement programmed. Most users define it as:

A mean to prevent catastrophic failure of critical rotating machinery

Others define condition monitoring as:

A maintenance scheduling tool that uses vibration , infrared or lubricating analysis data to determine the need for corrective maintenance actions .

A few share the belief, precipitated by the vendors of monitoring systems that is :

The panacea for critically ill plant and machinery.

One common theme of all these definitions is that condition monitoring solely a maintenance management tool . Because of these misconception, the majority of established programmes have not been able to achieve a marked decrease in maintenance costs, or a measurable improvement in overall plant performance.

Condition monitoring is much more than a maintenance scheduling tool and accordingly it should not be restricted to maintenance management. As part of an integrated, total plant performance management programme, it can provide the means to improve the production capacity, product quality and overall effectiveness of our manufacturing and production plants. Condition monitoring is not panacea for all factors limiting total plant performance. Condition monitoring is thus a management technique that uses the regular evaluation of the actual operating condition of the plant equipment, production systems and plant management functions, to optimize total plant operation.

The output of the condition-monitoring programme is data. Until action is taken to resolve the deviations or problems revealed by the programme , plant performance cannot be improved.

As a maintenance tool, condition monitoring can provide the data required to schedule both preventive and corrective maintenance tasks on as-needed basis instead of relying on industrial average life statistics, such as mean time to failure (MTTF), to schedule maintenance activities. Condition monitoring uses direct monitoring of the operating condition , system efficiency and other indicators or to determine the actual MTTF or loss of efficiency for each machine train and system within the plant.

A condition monitoring programme can minimize unscheduled breakdowns of all mechanical equipments in the plant, and ensure that repaired equipment is an acceptable mechanical condition.

A condition monitoring programme cannot function in a void. To be an effective maintenance management tool, it must

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be combined with an viable maintenance planning function that will use the data generated to plan the appropriate repairs.

DATA COLLECTION & INVESTIGATIONS

7.1 Specifications of Tire Mounted Crane

Name of Machine:	Tire Mounted Crane
Maximum Load carrying capacity:	20 Tones
Make/ Model & HP of Engine:	MITSUBISHI,16DI4WT
Model& Serial No:	RK200/1036
Punj No. of Engine:	MC0010
Serial No. of Engine:	279589
Weight of Machine:	22.96 Tones
Length:	10.195 Meters
Width:	2.49 Meters
Height:	3.48 Meters

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Existing Maintenance Schedule

Oil Replacement Schedule

Oil Replacement Schedule No.	Assembly	Duration	Lubricant to be Used		Qty required per change in ltrs	Cost(Rs.)/ltr
			Grade	Brand		
1.	Engine Crank Case	250 hrs	SAE 30 pride	IOCL	20 ltrs	Rs. 240/-
2.	Hydraulic Oil tank	1000 hrs	Servo Premium XHP(CE)	IOCL	365 ltrs	Rs. 200/-
3.	Torque Converter & transmission case	1000 hrs	SAE10WS-3(API class DS)	Rimulaz oil 10W0	40 ltrs	Rs. 220/-
4.	Axle differential case	1000 hrs	Ultra 50	IOCL	30 ltrs (15ltrs*2 points)	Rs. 220/-
5.	Axle planetary hub case	1000 hrs	Ultra 50	IOCL	16 ltrs (4ltrs*4 points)	Rs. 220/-
6.	Winch Reducer	1000 hrs	Ultra 50	IOCL	8 ltrs	Rs. 220/-
7.	Swing reducer	1000 hrs	Ultra 50	IOCL	1.2 ltrs	Rs. 220/-
8.	Reservoir tank (Upper)(Main & auxiliary winch swing brake accelerator, propel brake	Check at every 8hrs & add	Ultra 50	IOCL	.18ltr* 2 points=.36ltr	Rs. 220/-
9.	Reservoir tank (lower)(for propel brake)	Check at every 8hrs & add	Ultra 50	IOCL	.8ltr	Rs. 220/-

7.2.2 Check Points/ Maintenance of Engine

1. Check the engine oil level before starting the engine.
2. Change engine oil & oil filter element every 250 hrs.
3. Check tightness of bolt & nuts & retighten if required.
4. Particular checks are required for mounting of air cleaner muffler.
5. Check electric wiring.
6. Check the following points carefully:- (a) Battery
   (b) Starting Motor
   (c) Alternator
7. Always fill radiator with soft water.
8. Check the level of electrolyte in the battery after every 50.
9. Check fuel level.
10. Check oil level in power steering pump, cylinders & Hoses.
11. Check dust indicator.

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12. Check brake pedal effectiveness & stroke in brake chamber (standard stroke 110mm).
13. Drain water & sediment from fuel tank.
14. Check for sediment & water in water separator.

1st 50 hrs Maintenance Schedule for New Machine:

i. Drain engine oil & refill to the correct fill mark, change oil filter element.
ii. Change the oil in the air cleaner.
iii. Flush out radiator and refill with soft water. Check all nuts & bolts for tightness.
iv. Check the condition for starter motor, alternator etc, for dust & rust.
v. Grease all the greasing points.
vi. Battery fluid level checks.
vii. Battery specific gravity check.
viii. Service lubrication points regularly.
ix. Change gear oil, hydraulic oil, Crankcase Oil.

250 running hrs maintenance Schedule

i. Change the engine oil & filter element.
ii. Change the oil in transmission case & clean strainer.
iii. Check oil in Travel Reduction Gear.
iv. Drain Hydraulic Oil tank Sump & change oil & replace element.
v. Check Hoses and Lines for cracks, bend etc.
vi. Check Fuel Hoses for cracks, bend etc.
vii. Cleaning Air Cleaner Outer Element.
viii. Check Tightening Torque of Bolts and Nuts.
ix. Adjust clutch &brake pedal free play.

500 running hrs maintenance schedule:

i. Grease Replacement of Swing Bearing &Swing Internal Gear.
ii. Replace Fuel Filter & Water Separator.
iii. Change feed Pump Separator.
iv. Clean Feed Pump Strainer.
v. Clean Radiator and Oil Cooler Core Outside.
vi. Clean Oil Cooler Front Screen.
vii. Clean Air Conditioner Condenser.
viii. Check Injection Nozzle.

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1000 running hrs Maintenance Schedule

i. Change the Oil of Swing reduction Gear & Travel reduction Gear.
ii. Inspect and Adjust Valve Clearance.
iii. Measure Engine Compression Pressure.
iv. Check Starter and Alternator.

Condition of Different parts after 1795 running hours

After taking data from log book it is found that there was no any major failures upto 1795 running hours. But after 1795 running hours some parts are failed before there life cycle. The condition of different parts are given below :

- Boom hoist clutch damaged
- Brake & Clutch drum lining damaged (Wear Out)
- Swing drum both (left & right) wear out
- Propel clutch & drum wear out
- Digging clutch & drum damaged

The maintenance department repaired the machine and the total breakdown time was 2 days.

Condition of different parts after 1896 running hours

- Boom Cylinder damaged
- Maintenance Department repaired the machine and the total breakdown time was 7 days. The failed component increases the maintenance cost. Hence, it is necessary to calculate maintenance cost at different running hours

DATA ANALYSIS

8.1 Calculation of Maintenance Cost

1. Every10 hrs Maintenance

	Amount (Rs.)
Grease used 5 Kg @ Rs. 250/ Kg	1250/-
Maintenance Hours = 2	
Two labour @ Rs400/8 hrs	200/-
Supervision Cost	400/-
Total	1850/-

2. First 60 hrs Maintenance Cost for new machine

Engine Oil : 20 ltrs @ Rs. 240/ltr	4800/-
Torque converter & transmission case Oil : 40 ltr @ Rs. 220/ltr	8800/-

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Axel differential & Planetary hub case Oil : 36 ltr @ Rs. 220/ltr	7920/-
Propel Brake 7 Resevoir tank Oil : 1.5 ltr @ Rs. 200/ltr	330/-
Hydraulic Oil : 10 ltr @ Rs.200/ltr	2000/-
Maintenance Man Hours :04	
One Forman @ Rs. 1600/8 hrs	800/-
Two labour @ Rs.400/8 hrs	400/-
Supervision Cost	600/-
Total Cost	Rs. 25,650 /-

3. 300 hrs Maintenance Cost :

Engine Oil : 20 ltr @ Rs. 240/ltr	4800/-
Fuel filter Element : 01 No.	500/-
Maintenance Man Hours =02	
One Foreman @ Rs.1600/8 hrs	400/-
Two labour @ Rs. 400/8 hrs	200/-
Supervision Cost	400/-
Total Cost	Rs. 6300/-

4. 600 hrs Maintenance Cost

Engine Oil : 20 ltr @ Rs. 240/ltr	4800/-
Fuel Filter Element : 01 No.	500/-
Hydraulic Filter element : 01 No.	700/-
Torque converter & transmission case Oil :40 ltr @ Rs. 220/ltr	8800/-
Axle differential & planetary hub case Oil : 36 ltr @ Rs.220/ltr	7920/-
Propel brake & reservoir tank Oil : 1.5 ltr @ Rs. 220/ltr	2070/-
Maintenance Man hours: 4hrs	
01 Foreman @ Rs. 1600/8 hrs	800/-
02 Labour @ Rs. 400/ 8 hrs	400/-
Supervision Cost	600/-
Total Cost	Rs.26,590/-

5. 800 hrs Maintenance Cost

Engine Oil: 20 ltr @ Rs. 240/ltr	4800/-
Fuel Filter Element: 01 No.	500/-
Maintenance Man hours: 2hrs	
01 Foreman @ Rs. 1600/8 hrs	400/-

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02 Labour @ Rs. 400/ 8 hrs	200/-
Supervision Cost	400/-
Total Cost	Rs.6300/-

6. 1000 hrs Maintenance Cost

Engine Oil: 20 ltr @ Rs. 240/ltr	4800/-
Fuel Filter Element: 01 No.	500/-
Hydraulic filter element: 01 No.	700/-
Torque converter & transmission case Oil :40 ltr @ Rs. 220/ltr	8800/-
Axle differential & planetary hub case Oil : 36 ltr @ Rs.220/ltr	7920/-
Propel brake & reservoir tank Oil : 1.5 ltr @ Rs. 220/ltr	330/-
Hydraulic Oil: 10 ltr @ Rs. 200/ltr	2000/-
Maintenance Man Hours: 08	
One Foreman: Rs. 1600/8 hrs	1600/-
Two Labour: Rs. 400/8 hrs	500/-
Supervision Cost	1200/-
Total Cost	Rs. 28350/

7. 1250 hrs Maintenance Cost

Engine Oil: 20 ltr @ Rs. 240/ltr	4800/-
Fuel Filter Element: 01 No.	500/-
Maintenance Man Hours: 08 hrs	
One Foreman: Rs. 1600/8 hrs	1600/-
Two Labour: Rs. 400/8 hrs	800/-
Supervision Cost	1200/-
Total Cost	Rs. 8900/-

8. 1500 hrs Maintenance Cost

Engine Oil: 20 ltr @ Rs. 240/ltr	4800/-
Fuel Filter Element: 01 No.	500/-
Hydraulic filter element: 01 No.	700/-
Torque converter & transmission case Oil :40 ltr @ Rs. 220/ltr	8800/-
Axle differential & planetary hub case Oil : 36 ltr @ Rs.220/ltr	7920/-
Propel brake & reservoir tank Oil : 1.5 ltr @ Rs. 220/ltr	330/-
Winch & swing reducer Oil: 10 ltr @ Rs. 220/ltr	2200/-

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Maintenance Man Hours: 04 hrs	
One Foreman: Rs. 1600/8 hrs	800/-
Two Labour: Rs. 400/8 hrs	400/-
Supervision Cost	600/-
Total Cost	Rs. 27050/-

9. 1750 hrs Maintenance Cost

Engine Oil : 20 ltr @ Rs. 240/ltr	4800/-
Fuel Filter Element : 01 No.	500/-
Maintenance Man Hours : 02 hrs	
One Foreman @ Rs. 1600/8 hrs	400/-
Two Labour @ Rs.400/8 hrs	200/-
Supervision Cost	300/-
Total Cost	Rs. 6200/-

Condition of Different Parts after 1850 hrs

The following Components failed:

- Boom hoist clutch damaged
- Brake & Clutch drum lining damaged (Wear Out)
- Swing drum both (left & right) wear out
- Swing clutch both (left & right) wear out
- Propel clutch & drum wear out
- Digging clutch & drum damaged
- Hydraulic hoses & oil seal replaced
- 'O' Ring changed

Total Cost of materials & Repair Rs. 50,000/-

Machine shut down: 2 days for maintenance

1 Foreman @ Rs.1600/-	Rs.3200/-
4 Labour @ Rs.400/-	Rs.3200/-
1 Engr. @ Rs. 1000/-	Rs.2000/-
Total Cost	Rs. 58400/-

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Condition of different parts after 1970 running hrs:

Tube Tyres replaced	
Boom Cylinder damaged	
Hydraulic hoses & oil seal replaced	
'O' Ring changed	
Head light assembly changed	
Halogen lamp, 25V& 12V	
Maintenance down time: 7 days	
Material Cost	Rs. 1,50,000/-
Labor Cost (1 Engr., 2 Foreman, 5 labour)	Rs. 53,450/-
Total Cost	Rs. 2,03,450/-

10. 2200 hrs Maintenance Cost

Engine Oil : 20 ltr @ Rs. 240/ltr	4800/-
Fuel Filter Element : 01 No.	500/-
Hydraulic filter element : 01 No.	700/-
Torque converter & transmission case Oil :40 ltr @ Rs. 220/ltr	8800/-
Axle differential & planetary hub case Oil : 36 ltr @ Rs.220/ltr	7920/-
Propel brake & reservoir tank Oil : 1.5 ltr @ Rs. 220/ltr	330/-
Winch & swing reducer Oil: 10 ltr @ Rs. 220/ltr	2200/-
Hydraulic Oil : 10 ltr @ Rs.200/ltr	2000/-
Maintenance Man Hours: 08 hrs	
One Foreman : Rs. 1600/8 hrs	1600/-
Two Labour : Rs. 400/8 hrs	800/-
Supervision Cost	1200/-
Total Cost	Rs. 30,850/-

11. 2400 hrs Maintenance Cost

Engine Oil : 20 ltr @ Rs. 240/ltr	4800/-
Fuel Filter Element : 01 No.	500/-
Maintenance Man Hours: 02 hrs	
One Foreman @ Rs. 1600/8 hrs	400/-
Two Labour @ Rs. 400/8 hrs	200/-
Supervision Cost	300/-
Total Cost	Rs. 6,200/-

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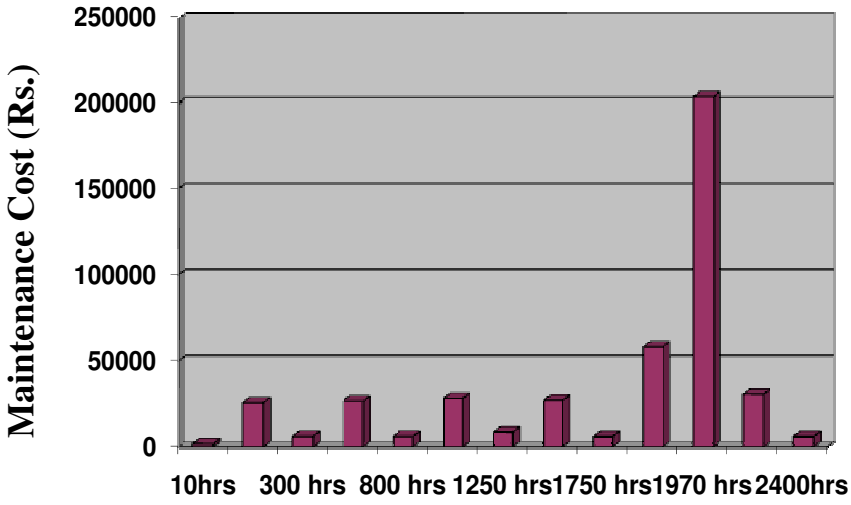
Analysis between Machine Running Hours, Maintenance Cost and Machine down Time

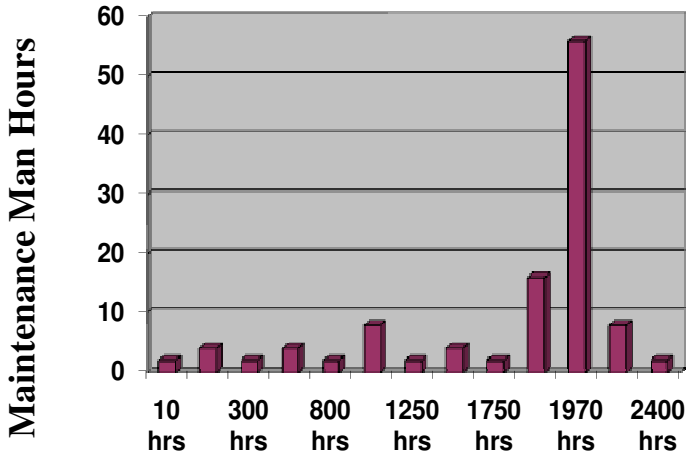
S.No.	Machine Running Hours	Maintenance cost in Rs.	Maintenance Man Hours (Machine Down Time)
1.	10 hrs	1850	2
2.	60 hrs	25650	4
3.	300 hrs	6300	2
4.	600 hrs	26590	4
5.	800 hrs	6300	2
6.	1000 hrs	28350	8
7.	1250 hrs	8900	2
8.	1500 hrs	27050	4
9.	1750 hrs	6200	2
10.	**1850 hrs**	**58400**	**16**
11.	**1970 hrs**	**203450**	**56**
12.	2200 hrs	30850	8
13.	2400 hrs	6200	2

Study between Maintenance Cost and Running Hours



Graphs between Maintenance Cost and Running Hours

Study between Maintenance Man Hours and Running Hours



Machine Running Hours

Graphs between Maintenance Man Hours and Running Hours

It is clear from above two graphs that the maintenance cost as well as machine Breakdown Time is very high due to failure of components. Hence, it is necessary to find the reasons of failure of these components.that the failure of future events can be minimized.

RESULTS:-

Results of Case Study

Money save	25 Thousand
Time Save	2 Days
Man Power Save	Welder(2), Fitter(1), Turner(2)
Bush replace	400 Rs. One
Change Bush time	2 hours
Man Power required to change the bushes	2
Man Power hours	4 hours

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Company not provide those Bushes

Unskilled Man Power required changing those Bushes. In the previous method firstly Welding rod used than turning takes place, than finishing this consumes more time & money &money power.

CONCLUSIONS & FUTURE SCOPE

As we know, nowadays competition is very high and also increasing day by day. Thus to survive in the market the machinery must be maintained safe, reliable & economic operation at minimum maintenance cost with least rate of failures.

Safe, reliable & economic operation of earthmoving equipment cannot be ensured without regular safety inspections and thorough preventive maintenance programs. A thorough inspection program can forecast maintenance needs or potential equipment failure or malfunctions. The lack of such a program could result in serious deterioration of the equipment, or repair charges as well as on increased potential for accidents.

In present work an effort has been done to reduce failure rates of critical items of Hydraulic Mobile crane. Because of failure of components does not only increase the maintenance cost but also increases breakdown time & decreases production.

The failure of above critical items of hydraulic mobile crane does not only increase maintenance cost but also losses production in large quantity, because machine breakdown time was 7 days when they failed.

After failure analysis of above critical items of Hydraulic Mobile crane it was found that the machine components was failed only due to lack of knowledge of maintenance plan to the operator. The operator was not so trained to maintain Hydraulic Mobile crane in safe condition.

In the present work a case study is discussed in which a problem of hydraulic mobile crane and its modification is covered.

For future work it is necessary to analysis failures of superstructure & attachment components of hydraulic Crane so that the mean time between failures can be increased with least maintenance cost & increases production.

For future scope, it is also essential that machinery problems be detected early enough to plan repair actions and to minimize machine breakdown time. The techniques involves for prediction of failures, called predictive maintenance. If it is possible to predict failure of components, the need of the breakdown and the emergency maintenance can be reduced to greater extent.

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