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Application of PERT Network to Improve the Availability Through Reduction in Maintenance Downtime of Blast Furnace Capital Repair at BSP Bhilai

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Abstract: Continuous production rate of any industry or plant depends on its all components & their functioning. The time for which the component or unit is not working is called DOWNTIME. From the production point of view DOWNTIME is not desirable. To avoid downtime modern maintenance techniques can be applied. In planning any project network analysis plays very important role. With the help of PERT network each and every activity can be identified individually and then it can be observed in the whole system. By the identification of activity duration we can calculate the total time for the completion of the project and then we can minimize that time with help of crashing. The same thing has been done here, the system taken is BLAST FURNACE, and the network analysis has been applied to the Category-2 repair cycle which has to be done in every 5-8 years. By identification of the activities the time study has been done and then though mathematical calculations the repair time for which the system has been stopped has been minimized. This will help in the saving of the time for production as well as the saving of the money which is being lost because of the stoppage of the system. The data collected are factual and they have been keen observed to make improvements. This project will be very helpful for the maintenance department.

Keywords: Blast furnace, PERT network.

I. Introduction

In today's competitive world the success of a manufacturing company depends on the continuous safe and economical operation of its plant and equipments. This calls for a very systematic and pro-active approach to a maintenance whereby the health of all critical equipments of a plant is continuously planned and preventive action is taken in time to avoid the equipment failures. Significant improvements in the effectiveness of maintenance function can be achieved by implementing different programs for reduction of downtime due to maintenance.

Whenever any machine in the production line of system fails, a full or partial failure of system takes place. Delay occurs while carrying out remedial action. To keep the delay cost at a manageable level downtime of the system is to be kept low and availability of the system has to be improved. Under the circumstances different parameters like maintenance, manpower, tools/spares, and diagnostic equipment should be available at right time, gaining a lot of importance while implementing maintenance function.

The modern production systems are becoming more and more specialized, automatic and highly capital intensive. The overhead cost or delay cost (cost for attending it) is very heavy, which needs to be minimized [1].

II. Methodology

A. Programme Evaluation Review Technique (PERT)

PERT was first used in 1957 as a method of planning and controlling the Polaris missiles Program by Booz, Allen and Hamilton together with U.S. Naval department. The aim was to finish the project two years in advance. PERT describes basic network technique, which includes planning, monitoring and control of projects. PERT finds applications in planning control of complex set of tasks, functions and relationships. It is a very important technique in the field of project management. PERT is commonly employed for conducting the initial review of a project. PERT is a very useful device for planning the time and resources. It represents an important step in the development of managerial science. It points out potentially troublesome areas (which may disrupt program objectives) against which a timely action can be taken to prevent their occurrences. PERT helps in decision-making [4].

B. PERT Planning Techniques

The PERT planning technique consists of the following steps:

- The project is broken into different activities systematically.

- Activities are arranged in logical sequence.
- The network diagram is drawn. Events and activities are numbered.
- Using three times estimate, the expected time for each activity is computed.
- Standard deviation and variance for each activity are computed.
- Earliest starting times and latest finishing times are calculated.
- Expected time, earliest starting time, and the latest finishing times are marked on the network diagram.
- Slack is calculated.
- Critical path(s) are identified and marked on the network diagram.
- Length of critical path or total project duration is found out.
- Lastly, the probability that the project will finish at due date is calculated.

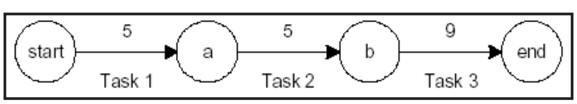
C. Estimation of Activity Time

For dealing with uncertainties associated with different activities, PERT approach computes expected time for each activity from the following three time estimates:

1. Optimistic time: It is the shortest possible time in which an activity can be completed if everything goes exceptionally well.
2. Most likely time: It is the time in which the activity is normally expected to complete under normal contingencies.
3. Pessimistic time: It is the time, which an activity will take to complete in case of difficulty, i.e., if mostly things go wrong. It is the longest of all three estimates.

III. CPM Theory

One of the more common project estimation schemes is Critical Path Method or CPM. Project managers who use CPM ignore the probabilities and use only nominal case estimates.



Following this approach would lead us to commit to finishing the project in 19 days.

IV. CPM Technique

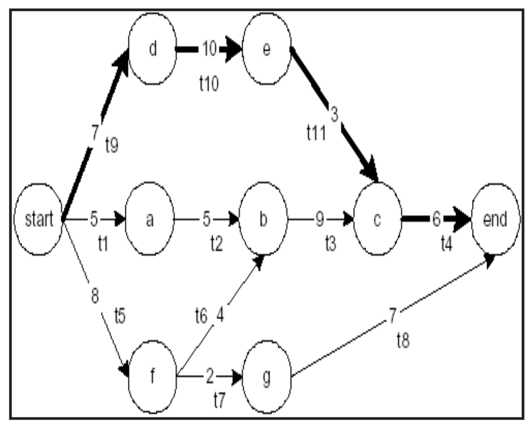
CPM employs the following steps for accomplishing a project planning;

- Break down the project into various activities systematically.
- Label all activities.
- Arrange all the activities in the logical sequence.
- Construct the arrow diagram.
- Number all the nodes (events) and activities.
- Find the time for each activity.
- Mark the activity times on the arrow diagram.
- Calculate early and late, start and finish times.
- Tabulate various times and mark EST and LFT on the arrow diagram.
- Calculate total float for each activity.
- Identify the critical activities and mark the critical path on the arrow diagram.
- Calculate the total project duration.
- If it is intended to reduce the total project duration, crash the critical activities of the network.
- Optimize the cost.
- Update the network.
- Smooth the network resources.

A. Dependencies

Both PERT and CPM represent the project with a diagram that shows the tasks and their dependencies. The simple diagrams above show three tasks that have sequential dependencies. The arrow from Task 1 to Task 2 indicates that the start of Task 2 depends on the end of Task 1. Task 2 cannot start until Task 1 finishes.

In larger projects these charts can get fairly complex.



The chart above shows a project with many tasks and dependencies. At the start of the project three tasks (t1, t9, and t5) begin concurrently. Other tasks start as these tasks end. Notice that t6 and t7 cannot begin until t5 completes. Notice also that t3 cannot start until t2 and t6 both complete.

The longest path through this network is known as the *Critical Path*, from which CPM gets its name. The critical path is shown in bold. This path through the project tells us that the *end* event is 26 days from the *start* event.

If we were using PERT, then the date of the end event would be a random variable based upon the μ and s of each of the tasks on the critical path. We would also be able to calculate the probabilities of other paths going critical.

B. Repair Description Schedule

Blowing out: -

After the furnace is stopped, the inside metal deposits (in molten state) are blown out. This also called as SALAMANDAR TAPPING. The furnace is slowly cooled. The salamander tapping constitutes molten metal slag and the residue up to hearth level.

Once the salamander tapping is done the furnace is ready for Capital repair.

Since furnace is hollow as shown in figure refractory lining throughout the walls (shell) becomes impossible to reach all heights. 3 nos. hanging platforms are inserted through electric winches and chained to fixed structure at the top. The three number platforms are suspended at different levels, so that work and refractory lining can be simultaneously done during repair.

For mega repair like this many agencies are called. It is mandatory to have discussions and repair meetings to start at least 6-months in advance so that agencies are booked, spare parts procurement and fabrication (internally) to be started. At least 4-5 meetings are held before any capital repair of category-2. There is a separate group from the shop floor aside for this capital repair. They make the plans.

The likely agencies, which are invited to help in this repair, are:-

- Central heavy maintenance,
- Capital repair Modification group,
- General maintenance group,
- Project department,
- Pipe line erection and maintenance,
- Water supply department,
- Refractory Engineering department,
- Safety Engineering department,
- Civil engineering department,
- Building and structural inspection,
- Equipment inspection department,
- Instrumentation department,
- Energy management department,
- Transport and diesel (traffic) department,
- Materials recovery department,
- Central machine shops,
- HSCL contract civil jobs,
- HSCL contract mechanical jobs,
- Central technical services,
- Bhilai Engineering design bureau,
- Design and drawing department,
- Hydraulics and lubrication department,
- Bearing Engineering department,

And many other departments, as per the necessity. Every day morning and evening there would be meetings during the period of repair to discuss the problems and progress of the repair.

C. Data Collection, Formulation and Calculations

From blast furnace plant the following data have been collected:-

Total time being taken for repair = 90 days

Activities involved with the repair cycle:-

- Preparatory jobs, dismantling of charging appliances, lowering of hanging platforms (HPs)
- Dismantling of Shaft refractory lining up to Bosh(10)
- Dismantling of Bosh & Mantle ring (MR) coolers(12)
- Dismantling of TZ refractory lining(1)
- Dismantling of TA & TZ coolers(2)
- Erection of Bosh & MR coolers and sealing of Hanging platforms(4)
- Dismantling of refractory lining up to Iron notch(4)
- Dismantling of refractory lining up to Upper Hearth Bottom (UHB)(18)
- Changing of UHB coolers(3)
- Refractory building of hearth bottom first 9 layers(14)
- Erection of Hearth & TZ coolers(4)
- Removal of protection platform
- Refractory rebuilding of hearth up to TZ(7)
- Relining of TZ area(2)
- Relining of Bosh area & cleaning(2)
- Lowering, cutting & removal of all hanging platforms(2)
- Pressure testing & rectification(2)
- Shell charging at bosh area, mantle ring area, shaft zone area, Erection of shaft coolers, Replacement of protective segments, dome lining plates and uptake pipes repair(9)
- Repair work in Hoist house where skip winches, SLI (stock level indicator) winches, Hydraulic oil pumps etc, Repair work in cast house viz., Blow pipe assembly changing, cast house crane repair, rocking runner, cast house runner repair, Repair work in stove house viz., Hot blast, cold blast valve repair, stove shell repair, rebuilding, chimney valves and pipes repair etc(4)
- Skip buckets changing, skip track repair, Cooling pipes and Air conditioning & ventilation system jobs(4)
- Dust catcher, bunkers and gates repair, Blowers repair(4)
- Bleeders repair at the furnace top, Slag granulation plant repair(4)
- Drilling machine and Mud gun replacement, Cast house crane complete over-hauling, Skip winch pulley, at the top and middle platform complete over-hauling(8)
- Blast furnace foundation columns repair civil work, Root repair at cast house, hoist house and stove platform(16)
- Stock house all bunkers ore & coke their screens and hopper repair(9)
- Skip track below ground, gates weighing screens repair, Complete conveyor system of stock repair(8)

All activities are shown here with their time duration.

For these activities to be performed contractual labors are hired.

The cost over 1 labor per shift is about Rs. 500/-

(This cost includes labor cost, tools cost power cost, and all miscellaneous costs).

D. Formulation and Computation

Observing the activities of the repair cycle a pert network had been formed the network has been shown on the next page.

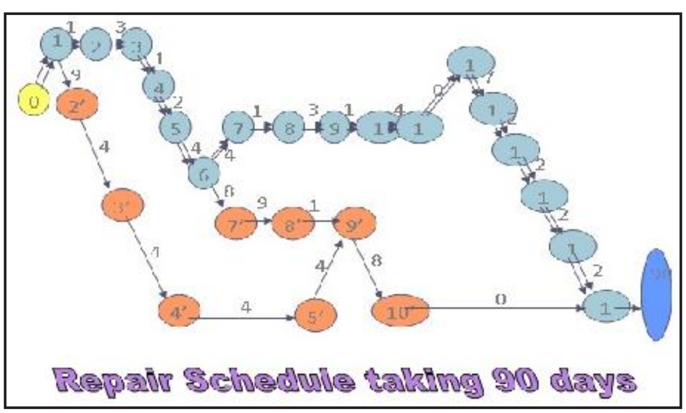
Taking this network as a reference, the PERT chart calculations have been done.

Through these calculations slacks have been calculated and then through this critical activities have been identified.

After identifying critical activities crashing has been done to reduce the time taken by the path.

After crashing a new network has been drawn.

S.no.	Activity	Earliest Starting Time	Latest Comple-tion Time	Slack
01.	0-1	0	0	0
02.	1-2	10	10	0
03.	1-2’	10	10	0
04	2-3	22	22	0
05	2’-3’	10	66	56
06.	3-4	25	25	0
07.	3’-4’	14	70	56
08.	4-5	26	26	0
09.	4’-5’	18	74	56
10.	5-6	28	28	0
11.	6-7	32	32	0
12.	6-7’	32	32	0
13.	7-8	36	36	0
14.	7’-8’	40	57	17
15.	8-9	54	54	0
16.	8’-9’	49	66	17
17.	9-10	57	57	0
18.	5’-9’	22	78	56
19.	10-11	71	71	0
20.	9’-10’	65	82	17
21.	11-12	75	75	0
22.	10’-17	73	90	17
23.	13-14	82	82	0
24.	14-15	84	84	0
25.	15-16	86	86	0
26.	16-17	88	88	0



E. Critical Activities before Improvement

S.no.	Job Description	No. of Days
01.	Preparatory jobs, dismantling of charg-ing appliances, lowering of hanging plat-forms (HPs)	10
02.	Dismantling of Shaft refractory lining up to Bosh	12
03.	Dismantling of Bosh & Mantle ring (MR) coolers	3
04.	Dismantling of TZ refractory lining	1
05.	Dismantling of TA & TZ coolers	2
06.	Erection of Bosh & MR coolers and seal-ing of HP	4
07.	Dismantling of refractory lining up to Iron notch	4
08.	Dismantling of refractory lining up to Upper Hearth Bottom (UHB)	18
09.	Changing of UHB coolers	3
10.	Refractory building of hearth bottom first 9 layers	14
11.	Erection of Hearth & TZ coolers	4
12.	Removal of protection platform	1
13.	Refractory rebuilding of hearth up to TZ	7
14.	Relining of TZ area	2
15.	Relining of Bosh area & cleaning	2
16.	Lowering, cutting & removal of all hang-ing plat forms	2
17.	Pressure testing & rectification.	2
	Total	90 days

F. Critical Activities after Improvement (Crashing)

S.no.	Job Description	No. of Days
01.	Preparatory jobs, dismantling of charging appliances, lowering of hanging platforms (HPs)	7
02.	Dismantling of Shaft refractory lining up to Bosh	8
03.	Dismantling of Bosh & Mantle ring (MR) coolers	3
04.	Dismantling of TZ refractory lining	1
05.	Dismantling of TA & TZ coolers	1
06.	Erection of Bosh & MR coolers and seal-ing of HP	3
07.	Dismantling of refractory lining up to Iron notch	3

S.no.	Job Description	No. of Days
08.	Dismantling of refractory lining up to Upper Hearth Bottom (UHB)	14
09.	Changing of UHB coolers	3
10.	Refractory building of hearth bottom first 9 layers	9
11.	Erection of Hearth & TZ coolers	4
12.	Removal of protection platform	1
13.	Refractory rebuilding of hearth up to TZ	5
14.	Relining of TZ area	2
15.	Relining of Bosh area & cleaning	2
16.	Lowering, cutting & removal of all hanging plat forms	2
17.	Pressure testing & rectification.	2
	Total	70 days

After crashing the critical activities this network has been drawn which shows the reduction in project duration i.e. from 90 to 70 days.

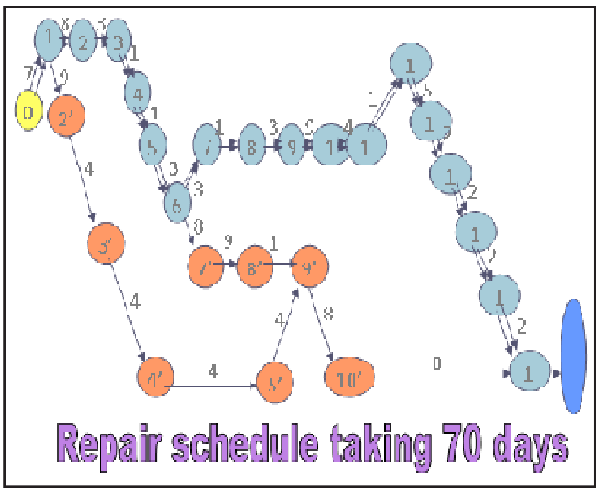
Availability before improvement = 0.95300

Availability after improvement = 0.9630

Reduction in downtime = 20 days

V. Discussions

We see here the availability has been improved to a great extent this improvement will make the system more economic. By reducing these 20 days from the repair/downtime we can reduce the cost also, let us sees how it can be done. The cost of 1 person per shift is about Rs.500 (it includes the labor coast cost of tools & tackles, power utilization and all miscellaneous costs. Keeping that in mind let us compare the cost in two conditions.



A. Cost Comparison (Comparison between Normal and Crash Costs of Repair)

S. no.	Activity	Normal Duration	Crash Duration	Persons Required (Normal)	Personas Required (Crash)	Normal Cost (Rs.)	Crash Cost (Rs.)
01.	Preparatory jobs, dismantling of charging appliances, lowering of hanging platforms (HPs)	10	07	14	20	210000	210000
02.	Dismantling of Shaft refractory lining up to Bosh	12	08	15	23	270000	276000
03.	Dismantling of Bosh & Mantle ring (MR) coolers	03	03	14	14	63000	63000
04.	Dismantling of TZ refractory lining	01	01	15	15	22500	22500
05.	Dismantling of TA & TZ coolers	02	01	14	28	42000	42000
06.	Erection of Bosh & MR coolers and sealing of HP	04	03	14	20	84000	45000
07.	Dismantling of refractory lining up to Iron notch	04	03	15	20	90000	90000

S. no.	Activity	Normal Duration	Crash Duration	Persons Required (Normal)	Personas Required (Crash)	Normal Cost (Rs.)	Crash Cost (Rs.)
08.	Dismantling of refractory lining up to Upper Hearth Bottom (UHB	18	14	15	20	405000	420000
09.	Changing of UHB coolers	03	03	14	14	63000	63000
10.	Refractory building of hearth bottom first 9 layers	14	09	14	22	294000	297000
11.	Erection of Hearth & TZ coolers	04	04	14	14	84000	84000
12.	Removal of protection platform	00	01	14	14	-------	21000
13.	Refractory rebuilding of hearth up to TZ	07	05				
14.	Relining of TZ area	02	02	20	25	180000	337500
15.	Relining of Bosh area & cleaning	02	02				
16.	Lowering, cutting & removal of all hanging plat forms	02	02	14	14	42000	42000
17.	Pressure testing & rectification.	02	02	28	28	84000	84000
	Total	90	70	219	281	1933500	2051500

1. Total normal cost = direct cost + indirect cost
   --- Direct cost = cost of repair = Rs. 1933500
   --- Indirect Cost = loss due to stoppage of furnace = Rs. 537600000
   Total Normal Cost = Rs. (1933500+537600000) = Rs. 539533500
2. Total crash cost = cost of repair = Rs. 2051500
   Loss due to delay in repair time (delay by 20 days)
   Total Normal cost – Total Crash cost
   = Rs. (539533500 – 2051500) = Rs. 537482000/-
   So here we see that there is a saving of about Rs. 53 crores by this modification in the cycle, so the results we have found are logistic also.
   This saving in cost can be used to motivate the employees & workers by providing them some extra incentives or some rewards so that good human relations can also be maintained which is very important in any organization, it is a part of employee satisfaction.

So we have seen that this early completion can help in so many ways like

- Improved availability of the system,
- Reduction in losses due to delay,
- Reduction in production cost,
- Employee satisfaction.

VI. Future Scope

- In the upcoming research Parameters like Inventory like control, ABC analysis will be included it is being done taking this project as a reference.
- For future studies and modifications this project can be very helpful.
- Alike this project some other fields can also be taken for the modifications in the same way.
- This project can be a basic tool for problems like this in some other systems.

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