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Identification of Bottleneck and Reducing Cycle Time of an Industrial Oven by Using Project Management Techniques

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Abstract - *The present work was carried in a oven industry. In order to reduce the manufacturing time of Industrial Oven. a process oriented crashing approach to project management is proposed which gives information about total project data and about individual activities as a function of contractual. The decision to reduce the project duration must be based on the analysis of trade off between time and cost. In current method the assembly of industrial oven is done in 2041minutes i.e. 34.01hours and within 4.3 working days critical path method is the proposed method to carry out the assembly operation in parallel way so that the assembly of the complete oven can be completed in 1694minutes i.e. 28.23hours therefore saving 5.78hours i.e. (347 minutes) reduced cycle time by 17% of initial cycle time.*

Keywords: industrial oven machine, Product Breakdown Structure, Network Techniques, Critical Path Method and crashing technique, Project management.

1. INTRODUCTION

The aim of the paper is to reduce the cycle time of Industrial Oven machines by Identifying the bottleneck and reducing cycle time of activities. This is done by using the industrial engineering techniques such as,
Critical Path Method (CPM)

CPM and PERT are network based methods to assist in the planning, scheduling and control of projects. A project is defined as a collection of interrelated activities with each activity consuming time and resources. Both the methods are basically time oriented methods in the sense that they both lead to the determination of a time schedule for a project.

1.1 PROBLEM STATEMENT

After studying the problem Earlier the oven industry used to take 2041 minutes i.e. 34.01hours and within 4.3 working days this is because of using the same resources to carry out the other subassemblies

1.2 OBJECTIVES

The objective of the project is to identify the location of Bottleneck in the existing process, determine the project critical path duration, reduce the cycle time of project and decrease the production cost by applying the project management techniques.

2 LITERATURE REVIEW

Komesh Sahu and Meenu Sahu[1]. "Minimizing Cost and Time of Project using Crashing" this paper tells about the crashing in project management. Crashing is reducing project time by expending additional resources. Crashing the network is nothing but contracting or compressing the network that means to reduce the project duration at minimum cost with minimum project duration. Naveen Kumar and Dalgobind Mahto[2] "Assembly Line Balancing", here the authors said that Assembly line balancing is to know how tasks are to be assigned to individual work stations, so that the predetermined goal is achieved. Minimization of number of work stations and maximization of the production rate are the most common goals. Peter Shelth Professor Guy Le Roy[3] "Project Analysis Through CPM Critical path method" here he said that CPM is a technique for analyzing projects by determining the longest sequence of tasks (or the sequence of task with the least slack) through a project network. The CPM and the CCPM (Critical chain project management) are both valuable tools that any organization can use successfully to manage their projects. "Scope management, cost management, and time management" are important variables for projects. Concepts like network diagram (PERT and CPM),learnt how to draw the CPM network, precedence diagram and management engineering were more useful in this project.

3 METHODOLOGY

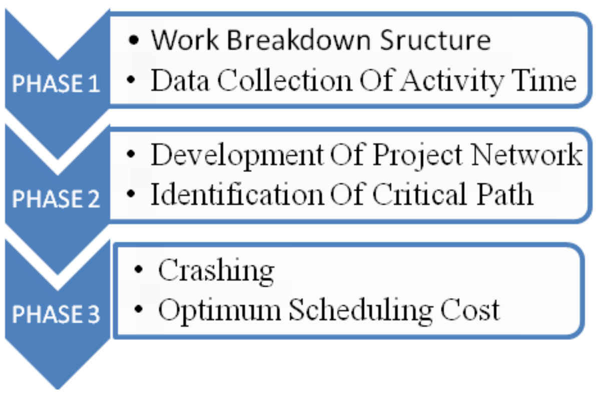

Figure-1

3.1 WORK BREAKDOWN STRUCTURE

The product breakdown structure in project management and systems engineering is a deliverable oriented decomposition of a project into smaller components. A work breakdown structure element may be a product, a service, or any combination. A work breakdown structure. The product breakdown structure of an industrial oven manufacturing.

Work Breakdown Structure

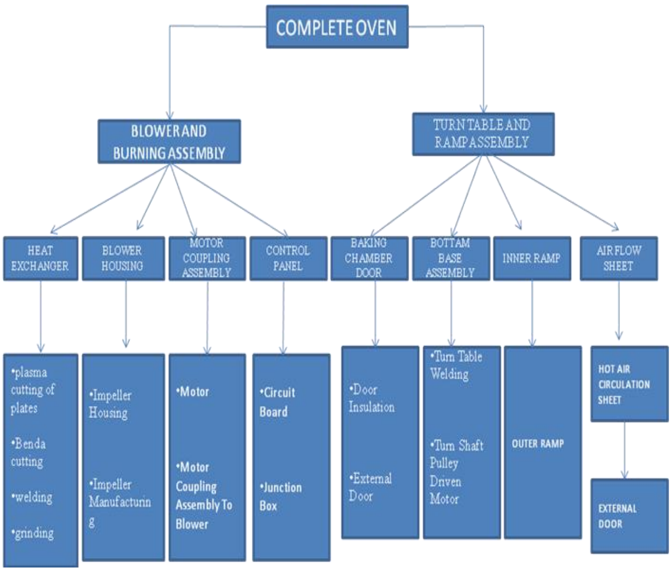

Figure- 2 Work Breakdown Structure

It can be seen in above figure that the industrial oven is divided in main two component i.e. 1)Blower and burning assembly 2) Turn table ,ramp assembly than further again divided in to their subassemblies such as heat exchanger, blower housing, motor coupling assembly and control panel. The another main assembly separated by their subassemblies like Baking chamber door, bottom base assembly, inner ramp, air flow sheet. The manufacturing time and operations of subassemblies are given tables at different work stations. The subassemblies like heat exchanger, blower housing. Baking chamber door and bottom base all are manufactured parallel at different workstations.

3.2 ACTIVITY RELATIONSHIP TABLE

In the process of manufacturing industrial oven there are number of activities which needs to perform and the sequence of operation, operation time and the total number of activities are tabulated in table 1.

Activity	DESCRIPTION	Duration	NO OF WORKERS
1 to 2	Cutting	395	2
2 to 3	Bending	240	2
3 to 4	Marking & Punching	166	2
4 to 5	Plasma Cutting	45	1
4 to 6	Benza cutting	75	1
4 to 7	Spot welding	90	2
4 to 8	Cutting plates	30	1
4 to 9	Cutting squire blocks	60	2
4 to 10	Motor coupling assembly	100	2
6 t0 11	Welding	185	1
7 to 12	Base table welding	20	2
8 to 13	Plate welding	50	1
9 to 13	Squire block welding	120	2
10 to 14	Fixing impeller	50	2
11 to 15	Grinding	40	2
12 to 16	Yoke Arrangement	60	2
13 to 17	Making insulation cover	128	2
14 to 18	Impeller housing	60	2
15 to 19	Outer cover welding	35	2
16 to 20	Yoke welding	15	2
17 to 21	External door	60	2
18 to 22	Blower housing	25	2
19 to 23	Burner assembly	30	2
20 to 24	Shaft welding	120	1
20 to 25	Shaft and motor assembly	145	2
21 to 26	Door assembly	30	2
22 to 28	Shifting to work station	5	2
23 to 28	Shifting to work station	5	2
25 to 27	Assembly bottom base	95	2
26 to 28	Shifting to work station	5	2
27 to 28	Shifting to work station	5	2
28 to 29	Final assembly	645	4
29 to 30	Painting	135	3
30 to 31	Inspection	25	1

Table – 1 Activity Relationship Table

3.3 DEVELOPMENT OF PROJECT NETWORK

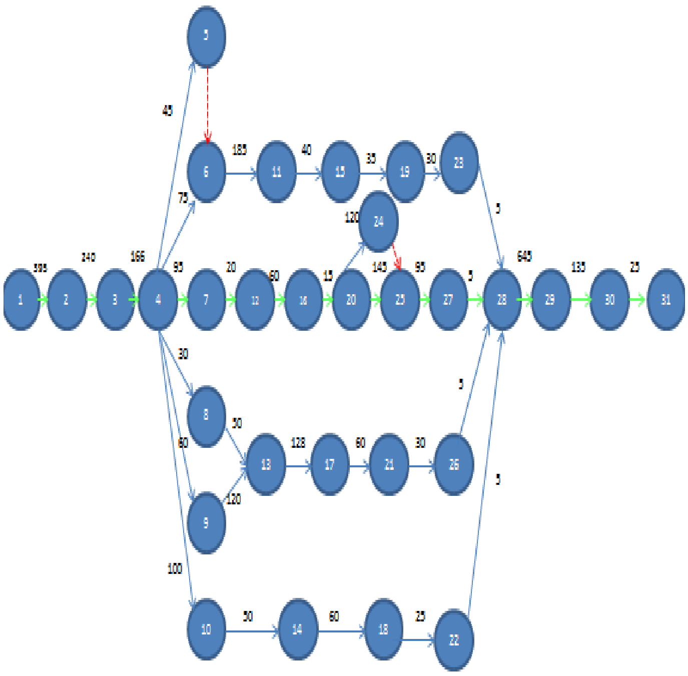

Figure – 3 Precedence Network

3.4 IDENTIFICATION OF CRITICAL PATH

The path which has highest duration

The critical Path Is

1-2-3-4-7-12-16-20-25-27-28-29-30-31
And critical path duration is = 2041 minutes (34.01 hours)
The total Indirect cost 4800/shift = 600/hour

3.5 CRASHING

Crashing the project refers to reduce crashing a number of activities to reduce the duration of project below normal value.

The special measures might include using overtime, hiring additional temporary help, using special time saving materials, obtaining special equipment.

Critical path method of Time Cost Trade Offs is concerned with how much (if any) to crash each of the activities to anticipated duration of the project down to a desired value. The data required for determining how much to crash a particular activity is calculated by the time cost trade for the activities.

Cost Scheduling Computations:

Let
NT= Normal time: - completion of an activity with allocation of resources
NC= Normal cost: - cost associated with normal time
CT=Crash time: - shortest completion time of an activity with extra resources
CC= Crash cost: - cost associated with crash time
Cost Slope = change in cost/change in time
= (Normal cost - crash cost) / (crash time - normal time)

CRASH TIME AND CRASH COST

Activity	DESCRIPTION	Duration	ND	NC	CC	CD	SLOPE
1 to 2	Cutting	395	6.58	987.5	1645.83	4	254.84*
2 to 3	Bending	240	4	600	800	2.5	133.33*
3 to 4	Marking & Punching	166	2.77	276	553.33	1.25	182.86*
4 to 5	Plasma Cutting	45	0.75	75	112.5	0.5	150
4 to 6	Benza cutting	75	1.25	62.5	187.5	0.5	166.67
4 to 7	Spot welding	105	1.75	175	350	0.9	205.88*
4 to 8	Cutting plates	30	0.5	50	75	0.25	100
4 to 9	Cutting squire blocks	40	0.67	66.67	100	0.5	200
4 to 10	Motor coupling assembly	100	1.67	166.67	333.33	0.9	217.39
6 t0 11	Welding	185	3.08	308.33	616.67	1.5	194.74
7 to 12	Base table welding	70	1.17	116.67	175	0.15	57.3770*
8 to 13	Plate welding	50	0.83	83.33	125	0.6	178.5714
9 to 13	Squire block welding	120	2	200	400	1	200
10 to 14	Fixing impeller	50	0.83	83.33	125	0.7	312.5
11 to 15	Grinding	40	0.67	66.67	100	0.5	200
12 to 16	Yoke Arrangement	60	1	100	150	0.75	200
13 to 17	Making insulation cover	128	2.13	213.33	320	1.8	320
14 to 18	Impeller housing	60	1	100	150	0.75	200
15 to 19	Outer cover welding	35	0.58	58.33	87.5	0.3	102.94
16 to 20	Yoke welding	15	0.25	25	37.5	0.1	83.33
17 to 21	External door	60	1	100	150	0.45	90.91
18 to 22	Blower housing	25	0.42	41.67	62.5	0.2	96.15
19 to 23	Burner assembly	30	0.5	50	75	0.2	83.33
20 to 24	Shaft welding	120	2	100	300	1.5	400
20 to 25	Shaft and motor assembly	150	2.5	250	500	1.5	250
21 to 26	Door assembly	30	0.5	50	75	0.2	83.33
22 to 28	Shifting to work station	10	0.17	16.6	16.6	0.17	0
23 to 28	Shifting to work station	10	0.17	16.6	16.6	0.17	0
25 to 27	Assembly bottom base	100	1.67	166.7	333.33	0.6	156.25
26 to 28	Shifting to work station	10	0.17	16.6	16.6	0.17	0

27 to 28	Shifting to work station	10	0.17	16.6	16.6	0.17	0 *
28 to 29	Final assembly	645	10.75	2150	3225	7	286.7 *
29 to 30	Painting	135	2.25	337.5	450	1.75	225 *
30 to 31	Inspection	25	0.42	20.83	41.67	0.15	78.125 *
			TOTAL DC	7147.4			

Table 2

Total direct cost (TDC) – it is the one in which we can allocate the cost of the job directly

Example: Raw material cost, labor cost
Total indirect cost (TIC) – in which not possible to allocate the cost of job directly
TIC = 600/hour
Slope of each activity can be calculated as
Slope = CC-NC /ND-CD

Crashing along this critical path and looking into their minimum slope the crashing can be start on activity which has lower slope and its ascending order along the critical path and Δt value which is found (0.15). The activity "16 to 20" has lower Δt value can be crashed by 0.15hours (9minutes)

Crashing table

Augmentable steps	Duration	Total Direct Cost	Total Indirect Cost	Total Cost	Activity crashed
	34.01	7064.06	20406	27470.06	–
step 1	33.86	7076.56	20316	27392.56	16 to 20 ↓ (0.15)
step 2	33.71	7093.23	20226	27319.23	7 to 12 ↓ (0.15)
step 3	33.56	7113.36	20136	27249.36	30 to31 ↓ (0.15)
step 4	33.41	7313.4	20046	27359.4	2 to 3 ↓ (0.15)
step 5	33.26	7471.73	19956	27427.73	25 to 27 ↓ (0.15)
step 6	33.11	7749.06	19866	27615.06	3 to 4 ↓ (0.15)
step 7	32.96	7799.06	19776	27575.06	12 to 16 ↓ (0.15)
step 8	32.81	7957.39	19686	27643.39	4 to 7 ↓ (0.15)
step 9	32.66	8069.89	19596	27665.89	29 to 30 ↓ (0.15)
step 10	32.51	8728.22	19506	28234.22	1 to 2 ↓ (0.15)
step 11	32.36	9803.22	19416	29219.22	28 to 29 ↓ (0.15)
step 12	32.21	10044.89	19326	29370.89	20 to 25 ↓ (0.15)

Table 3 Crashing Critical Path 1

After crashing along the critical path the duration of project is reduced from 34.01hours to 32.21hours
Similarly further crashing can done to another critical Path and so on.

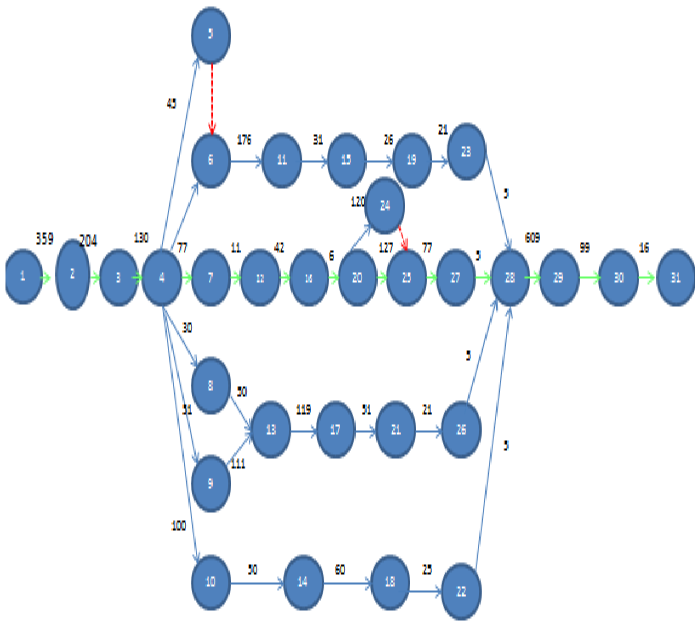

Figure – 4 Final Precedence Network

Critical path 2 is

1-2-3-4-9-13-16-20-25-27-28-29-30-31
=1775minutes (29.58 hours)

Augmented steps	Duration	Total Direct Cost	Total Indirect Cost	Total Cost	Activity crashed
	29.58	15620	17748	33368	
step1	29.43	15645	17648	33293	21 to 26 ↓ (0.15)
step2	29.28	15751	17558	33309	13 to 17 ↓ (0.15)
step3	29.13	15801	17468	33269	4 to 9 ↓ (0.15) 29 TO 30 ↓ (0.15)
step4	28.98	15851	17378	33229	17 to 21 ↓ (0.15)
step5	28.83	16001	17288	33289	9 to 13 ↓ (0.15)
step6	28.68	16201	17198	33399	2 to 3 ↓ (0.15)
step7	28.53	16478	17108	33586	3 to 4 ↓ (0.15)
step8	28.38	17136	17018	34154	1 to 2 ↓ (0.15)
step9	28.23	18211	16928	35139	28 to 29 ↓ (0.15)

Table- 4 Crashing Critical Path 4

In above table 4 it can seen that after crashing the critical path 4 the duration of the project reduced from 34.01hours to 28.23hours which is 5.78hours has been saved and hence the minimum duration of the project is 28.23hours which in terms of 3.5days.

4 OPTIMUM SCHEDULE COST

Determining Time estimation for all activities

- EST- Earliest start time: the earliest time at which the activity can start given that its precedent activities must be completed first.
- EFT-Earliest finish time: equals to the earliest start time for the activity plus the time required to complete the activity.
- LFT- Latest finish time: the latest time in which the activity can be completed without delaying the project.
- LST- Latest start time: equal to the latest finish time minus the time required to complete the activity.
- TF- total float = LFT – EFT

Activity	Duration	EST	EFT	LST	LFT	TF=LFT-EFT
1 to 2	395	0	395	0	395	0
2 to 3	240	395	635	395	635	0
3 to 4	166	635	801	635	801	0
4 to 5	45	801	846	801	846	0
4 to 6	75	801	876	801	961	85
4 to 7	105	801	906	801	906	0
4 to 8	30	801	831	801	983	152
4 to 9	40	801	841	801	913	72
4 to 10	100	801	901	801	1116	215
6 t0 11	185	876	1061	961	1146	85
11 to 15	40	1061	1101	1146	1186	85
15 to 19	35	1101	1136	1186	1221	85
19 to 23	30	1136	1166	1221	1251	85
23 to 28	5	1166	1171	1251	1256	85
7 to 12	70	906	926	906	926	0
12 to 16	60	926	986	926	986	0
16 to 20	15	986	1001	986	1001	0
20 to 24	120	1001	1121	1031	1151	30
20 to 25	150	1001	1151	1001	1151	0
25 to 27	100	1151	1251	1151	1251	0
27 to 28	5	1251	1256	1251	1256	0
8 to 13	50	831	881	983	1033	152
9 to 13	120	841	961	913	1033	72
13 to 17	128	961	1089	1033	1161	72
21 to 26	30	1149	1179	1221	1251	72
26 to 28	5	1251	1256	1251	1256	0
17 to 21	60	1089	1149	1161	1221	72
10 to 14	50	901	951	1116	1166	215
14 to 18	60	951	1011	1166	1226	215
18 to 22	25	1011	1036	1226	1251	215
22 to 28	5	1036	1256	1251	1256	0
28 to 29	645	1256	1901	1256	1901	0
29 to 30	135	1901	2036	1901	2036	0
30 to 31	25	2036	2061	2036	2061	0

Table -5 Optimum Scheduling Time Estimation

It is seen in above table the total float along the critical path is zero, the activity which are not comes in the critical path having total float.

4 RESULTS

Because crashing a non critical activity does not affect the overall project duration, only critical activities can be crashed are crashed are considered. The activities to be crashed are chosen in order of increasing expanses. Thus the activity with the smaller crash cost in table is chosen to be crashed first. Initial cycle time for 1 complete oven was 34.01hours after crashing the cycle time reduces up to 28.23hours The total time saved is 5.78hours (347minutes). The normal duration of the project is 34.01hours and the corresponding cost was 27470, the minimum duration of project is 28.23hours and its cost is 35139 The number of hours saved = 5.78 hours (17%) The common activity duration reduced by 189minutes (54.46%) The parallel activity duration reduced by 158minutes (45.53%) Further crashing will results in change in critical path so after that crashing is stopped.

6 CONCLUSION

The aim of this project was to reduce assembly time of industrial oven, by using various industrial engineering concepts. in the current method the assembly of the machine is done in 2040 min i.e. 34.01hours and 4.3 working days. Critical path method is the proposed method to carry out the assembly operations in parallel way so that the assembly of the complete oven can be completed in 1694mins i.e.28.23hours. by allocating extra resources to crashed activity Therefore saving 5.78hours i.e. (347minutes).

In order to validate the Critical path method results and it also showed the same result i.e. complete machine assembly can be done in 3.4 working days the minimum duration of project is 28.23hours and its cost is 35139 and the number of hours saved = 5.78 hours (17%).

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