PRODUCTIVITY IMPROVEMENT OF A PRESTRESS CONCRETE POLE PLANT USING WORK STUDY TECHNIQUE

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ABSTRACT

The objective of this research is to improve productivity for small scale concrete pole manufacturing plant. This research focuses on the plant, which manufacture PSC poles and all type of prestress and precast products. This research used changes in work sequence of group work for better utilization of man power for improve productivity. Total study towards time study of group work in prestress concrete pole manufacturing and reduce total time required for manufacturing 30 prestress poles. This research uses time study tool for better implementation of existing work with new sequence. The improvement in productivity by means of reducing production time, number of pole manufactured increases and effective utilization of man power.

Keywords: Productivity, Time Study, Multiple Activity Chart, Flow Chart.

1. INTRODUCTION

1.1 Background of study

The Plant consist of total 11 number of workers. In manufacturing process work is implemented in three steps such as withdrawing precated poles from 15 pair of moulds, pretensioning to steel wire and concrete mix preparation and filling in to the moulds. Total 30 poles are manufactured per day. Total time required to manufacture 30 poles is 390.82 minutes. During manufacturing idle time of workers is more. Time is important in production industries because according to Fred (1992), [1] time is money and time tells us exactly how much money was used. Every industries focus on overall resources utilize during production.

1.2 Scope of Study

The scopes of this research are:

a. This study focus on small scale concrete pole manufacturing for power transmission lines.

b. The research is concentrates on time and the flow of work process in manufacturing of 30 concrete poles from withdrawing previous casted poles to concrete mix fill in to the moulds.

c. Systematic assignment of work to all workers during manufacturing process.

The data that need to be carried out in this study is flow process of the work, time required for specific process and raw materials required.

1.3 Productivity

According to Eatwell and Newman (1991) state that productivity is a ratio of some measure of output to some index of input use. It is nothing but arithmetic ratio between the amount produced and the amount of any resources used in the course of production.

Productivity = total output/total input which is identical to total results achieved/total resources consumed or effectiveness or efficiency. [1]

1.4 Work Study

Work study is a management service based on those techniques, particularly method study and work measurement, which are used in the examination of human work in all its contexts, and which affect the efficiency and economy of the situation being reviewed, in order to affect improvement.[5]

Work measurement techniques time study, predetermined motion standards (PTMS) and synthetics. Also method study techniques are process sequence charts such as outline process chart, multiple activity chart and two handed process chart. Also it includes charts using a time scale and diagrams indicating movements. [4]

1.5 Time Study

According to Meyers (2002), time standard can be defines as "The time required to produce a product at a work station with the following three conditions, 1. A qualified, well –trained operator, 2. Working at a normal space and 3.Doing a specific task." [10]

According to Barnes, (1980) time study techniques are Standard data, work sampling, predetermined time standard system (PTS), Stopwatch time study. [6], [2], [10]

1.6 Steps of Stopwatch Time Study

Steps that are required to perform time study is,

a. Check that prescribed method is being followed in doing the job.
b. Divide the job observable and distinct element.
c. Record the timing for each work element.
d. Rate of performance of operator in each element and repeat measurement through a statistically, determined number of cycles of the job.
e. Compute the normal time for a unit of out.[1]

II. LITERATURE REVIEW

According to Khalid S. Al-saleh research on "Productivity improvement of a motor vehicle inspection station using motion and time study techniques." The objective of this research is increase the productivity in the Motor Vehicle Periodic Inspection (MVPI) by reducing inspection time. According to him the research is to study about use bar code reader to read the chassis number instead of manual reading, improve and enhance the level of illumination in the computer screen, change the keyboard in inspection station, perform move around the vehicle element in other station, combine element, make two separate group of vehicle and add a second inspector in inspection station. All alternatives for existing system are evaluated with flow chart and time study. [2] According to Mayank Dev Singh, Shah Saurabh K, Patel Sachin, Patel Rahul B, and Pansuria Ankit P. research on "To improve productivity by using Work Study and design fixture in small scale industries."This research is based on fixture design due to which increase profit, reduce working time and increase the

production. They concluded that process can be improved based on the five parameters (work process, method study, time measurement, fixture design and cost analysis) it will improve the current work process. The modifications are made by eliminating the wasted time and reduction of the work contents. From the comparison between current and new work process, it indicates that the best alternative towards existing problem by new method. After implementing new method on this stay vane job production it will increase production as compare to company method. (In company method it would produce 19 stay vanes and after applying new method they can produce 21 stay vanes per month). This improvement was successfully implemented and it achieves the project goals and objectives, which improve processes, production layout and economy in human effort and the reduction of unnecessary fatigue. [1] "Overall productivity improvement in casting and fastening industry." this paper is based on plant layout improvement, concept of semi automatic moulding machine and make possible use of different due to which productivity can be improved. Here in casting industry use semi automatic moulding machine. Impact of this avoiding skill labour requirement, time reduction per mould making 5 to 6 minute expected, reduction in man power, avoiding marking and adjusting of cope and drag part. Also give suggestion of change plant layout due to which solve problem of Storage, Material Handling, and Material Movement. [3]

III. PROCESS DESCRIPTION

The study is made from total manufacturing of 30 poles to place it beside to the mould. The process of transfer pole from beside mould to the tank is excluded. Total sub work processes included in to main work process as per distribution of workers to different work processes.

3.1. Pre-work of withdrawing poles from moulds.

a. Hammering the mould. b. Withdraw mould holder. c. Hammer the end plate of mould and dissemble. d. Withdraw the bar & bar holder. e. Pre-stressed wire cutting by Arc Welding.

3.2. Withdraw 30 poles from mould.

3.3. Pre-work of pre-tensioning process.

a. Hammer the mould for cleaning purpose. b. Sweep the mould. c. End plate assembly of mould (Fasteners).

d. Dissemble Key in to the Holder + searching key. e. Oiling the mould. f. Ring preparation (total 150 rings).

g. Set Tension m/c manually beside mould. h. supply wire to mould. i. Placing rings in to the mould.

3.4. Actual pre-tensioning process.

3.5. Pre-work of concrete mix preparation.

a. Adjusting position of wire ring in to the mould & placing 2 lifting hook in to mould, b. Placing wire in to bundle. c. Fix bar and bar holder on the mould. d. Fix mould holder., e. Place 8 SWG G.I .earthing wire in to mould. f. Collecting borrower, vibrator & make power connection.

3.6. Material collection (cement bags).

a. Collecting 33 cement bags from storage and open it b. Water supply and the mixer power ON.

3.7. Preparation and filling concrete mix in to mould.

IV. DATA COLLECTION

4.1 Plant Layout

In plant layout consists of different elements as follows,

A-A, B-B, C-C, D-D – Pair of pole moulds.

E-E ,F-F– Manually operated rope hoist.

G-G – Electrically operated rope hoist.

H-H – Wire supply frame.

Also layout shows concrete mixer, water drum (W.D), aggregates, sand storage, wire bundle, store, Tension m/c (TMC), Tanks, Pole storage, etc. The plant layout of working site as shown in figure no.1.

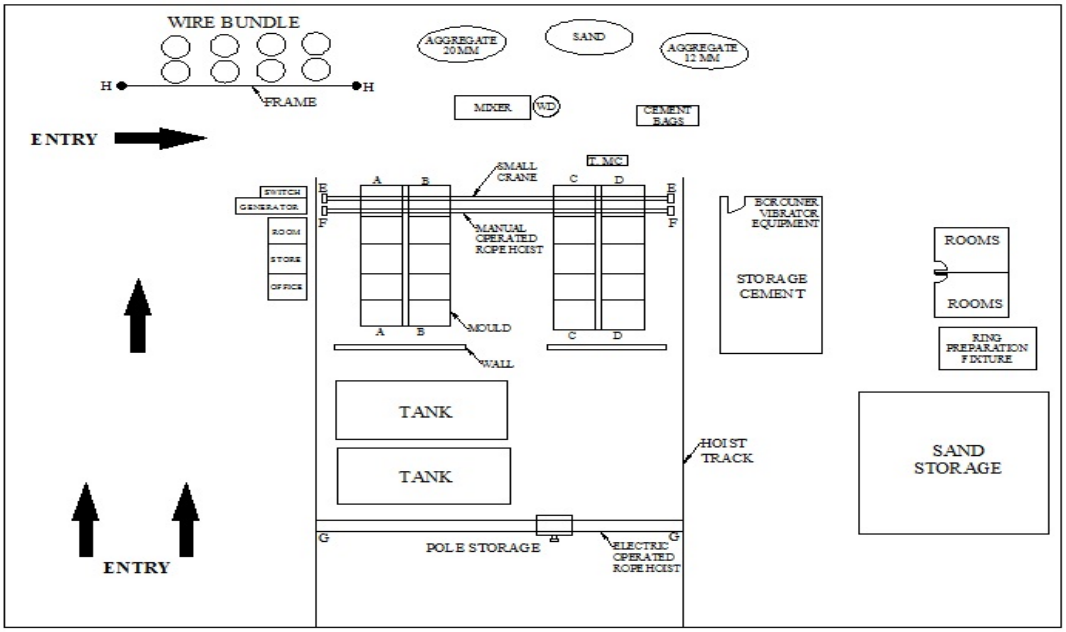

Fig.1: Plant Layout

4.2 Steps of Concrete Pole Manufacturing

Pre-stressed concrete pole manufacturing is categorized in to three steps, these are as follows

1. Withdraw 30 previous casted poles from mould.
2. Pre-tensioning to the steel wire in to the mould.
3. Prepare concrete mix and filling in to the mould.

The sequence of manufacturing process is as shown in table no.1. These work processes are performed by 11 workers. All working time in minutes.

Sr.No.	Work Name	Workers required	Time	Idle workers
1	Pre-work of withdrawing poles from moulds	8	30	3
2	Actual pole withdrawing	7	60.41	4
3	Pre-work of wire pre-tensioning	9	70	2
4	Pre-tensioning process	9	67	2
5	Pre-work of concrete mix preparation & filling	11	15	0
6	cement bags collection + supply water to mixer, mixer power ON	5	28.41	6
7	Preparation and filling concrete mix in to mould	11	120	0

Table No:1

Total Working Time is 390.82 minutes i.e. 6.513 Hrs. From table no.1 in 2 work element i.e. 5 and 7 total 11 workers are work at a time. In rest of the element some workers are idle.

V. PROBLEM STATEMENT AND OBJECTIVE

5.1 Problem Statement

At present situation in the prestress concrete pole manufacturing process, whole process is done manually. Total 11 workers are engaged in only 2 work process i.e. in 5 and 7. In remaining work processes minimum 2 workers are idle. There is no total utilization of manpower during manufacturing process. In element 2 total 4 workers are idle for the period of 60.41 minutes. There is a scope of identify the non-sequential work process from whole manufacturing process and assign these work to idle workers.

5.2 Objective

1. Identify non-sequential work processes which perform at any time during manufacturing.
2. Combine different work element.
3. Calculate rate of various quantity of workers in particular time period.
4. Reduce total working time of workers with systematic assignment of work.

VI. DATA ANALYSIS AND METHODOLOGY

6.1. Independent Work Processes

In pre-stressed concrete pole manufacturing some independent processes are present. These processes are,

1. Collecting borrower, vibrator & make power connection, etc. from storage.
2. Collecting 33 cement bags from storage and open it.
3. Ring preparation (total 150 rings).

So, total details of these processes are tabulated in Table no.3 as follows,

Sr. No	Independent Work	Time	Required worker
1	Collecting borrower , vibrator & make power connection from storage	9.16	3
2	Collecting 33 cement bags from storage and open it	28.41	4
3	Ring preparation (total 150 rings)	60	1
4	Water supply , power ON to the mixer	5	1

Table No: 2

6.2. Combine Pre-Work Process of Pole Withdrawing And Cement Collection Work Process

From table no.2 it is clearly shows that cement bags collection from storage is done in 28.41 minutes. By carefully observing the work element1 in table no.1, 3 workers are idle for 30 minutes. In existing work process 4 workers performed cement bags collection work as shown in table no.2. This bags collection work is carried out in 3 workers also by removing 1 storage worker out of 2 workers. The fig no.2 shows the flow process chart of 4 workers performing cement collection process from storage. The fig no.4 shows the material (cement bags) flow chart.

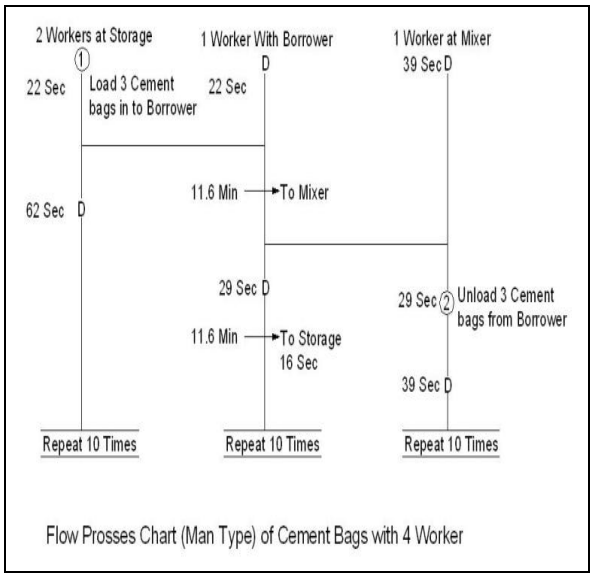

Fig no. 02.

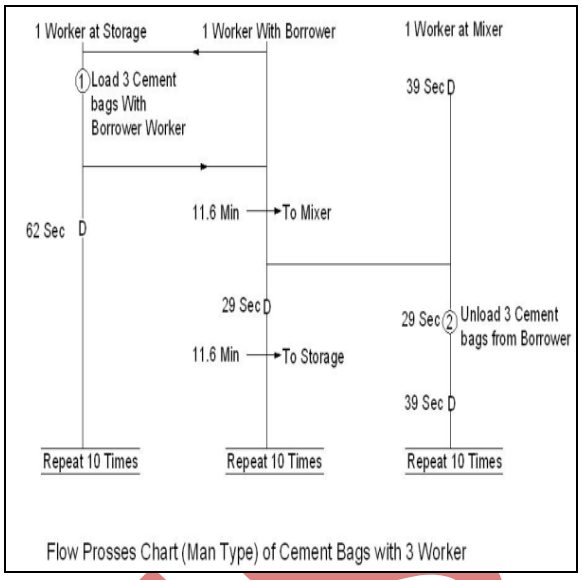

Fig no.03.

In cement bags collection process out of 4 workers 2 workers are at storage for loading 3 cement bags in to borrower, 1 worker is transfer cement bags to mixer and 1 worker set the cement bags in proper position. This work is performs with other way by reducing 1 worker from cement storage. A loading cement bags work is perform with 1 borrower worker.

Material Flow Chart for Cement bag

Description	Distance in Meter	Time in Second	Symbol
Stored in Storage			
Pick upto Borrower	0.3	22	
Transfer to Mixer	11.6	35	
Unload Beside Mixer	1	29	
Temporary Storage	-	-	
Transfer to Mixter Hopper	3.4	20	
Unload to Hooper	-	05	
Stay in Hopper	-	60	
Mixing in Mixer	-	160	

Total Time = 331 Second
= 5.51 Minute

Fig no.04.

The fig no.3 shows the flow process chart of 3 workers perform cement collection work process from storage. Duration of time will not change by suggested work process. The cement bags collection work is merging in to pre-work of pole withdrawing work process.

Fig no.5 shows multiple activity chart of pre-work of pole withdrawing work process for 30 minute time duration. This chart shows the all details i.e. time required completing each and every work processes, no. of workers required to work process and end time of each work process.

Pair of Mould	Pole Extraction Time in minutes
1	First 3.41 minute for set the rope hoist to proper position 3.41 + 11.19 = 14.6
2	
3	
4	14.6 + 11.19 = 25.8
5	
6	
7	25.8 + 11.19 = 37
8	
9	
10	37 + 11.19 = 48.2
11	
12	
13	48.2 + 11.19 = 59.41 & 1 minute for repositioning the hoist i.e. 59.41+1=60.41
14	
5	

Table No:3

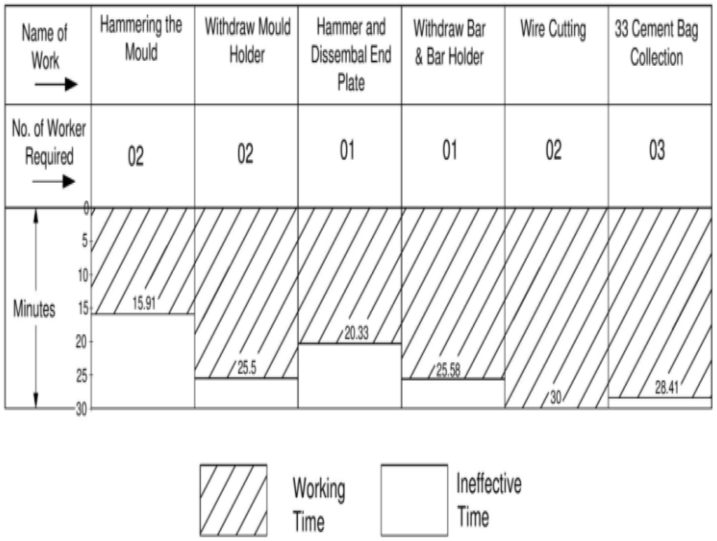

Fig No.05.

Multiple Activity Chart

6.3 Extend Pole Withdrawing Work Process and Combine Different Work Processes

Combine different work element as shown in process description with pole withdrawing work element. These processes are as follows,

a) Set tension m/c manually. b) Supply wire to bundle. c) Key withdrawing from key holder.

d) Oiling 7 pair of moulds out of 15 pairs. e) Ring preparation f) Mould end plate assembly

g) Hammering + Sweeping moulds.

6.3.1. Withdraw Poles + Set Tension Machine Manually + Supply Wire to Moulds

In existing work processes total time required to withdrawing 30 poles from 15 pair of moulds is 60.41 minute as shown in table no.1. This process is very useful to merge different work processes in to it. Total 4 workers are idle for 60.41 minute. We modified this pole withdrawing work process time up to 70.24 minutes by adding different work process sequentially to eliminate workers idle time. All work processes with poles withdrawing work process are tabulated in table no.04. Fig.no.6 shows the sequence of pair of moulds during pole withdrawing work process. After withdrawing poles from moulds by 7 workers then they perform tension m/c setting and wire supply to mould work process. Total time required to these 3 work is 70.24 minutes.

Sr. No	Name of Work	Required worker	Total time in minute	Idle Worker
1	Withdraw poles + Set tension machine manually + Supply wire to mould	7	70.24	NONE
2	Key withdrawing from key holder + Oiling 7 pair of moulds	1		
3	Ring preparation + Mould end plate assembly	2		
4	Hammering + Sweeping moulds	1		

Table No:04.

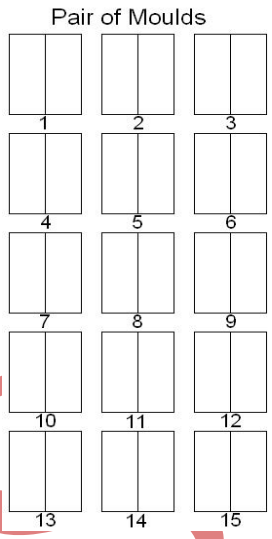

Fig no.06.

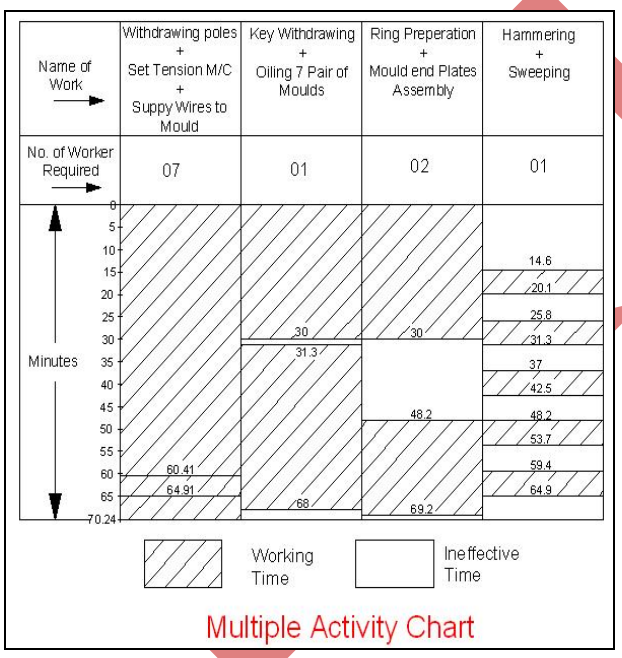

Fig no.07.

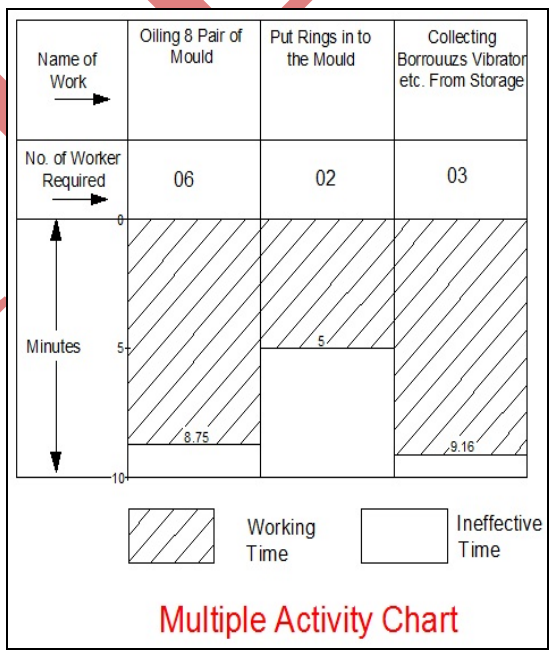

Fig no.08.

6.3.2. Key Withdrawing From Key Holder + Oiling 7 Pair of Moulds

After pre-stressed wires cut by arc welding, key holders are available to withdraw key from holder. This work is completed in 30 minute time duration. Only 1 worker is required to complete this work. Hence there is a scope of doing key withdrawing work simultaneously along with pole withdrawing process work. After 30 minutes this worker is applying oil to 7 pair of moulds. Here only 7 pair of moulds are consider because pole withdrawing process is extended up to 70.24 minutes in modified schedule of work. We calculate time of 1 worker to apply oil to 7 pair of moulds is as follows, 2 workers apply oil to 15 pair of moulds in 40 minutes. Out

of 40 minutes 1 minute for collecting oil & cotton cloths from store and 1 minute for cleaning hands after apply oil to moulds. So, total actual oiling work completed in 38 minutes.

∴ Total time required to 1 pair of moulds for 2 workers = 38/15 = 2.53 minutes

∴ Total time required to 1 pair of moulds for 1 worker = 2.53x2= 5.1 Minutes

∴ Time required to 1 worker for 7 pair of moulds = 5.1x7 = 35.7 minutes

One worker applies oil on 7 pairs of moulds. He starts from 31.3th minutes then 1 minute for taking oil and cotton cloths from store and 35.7 minutes for actual oiling process. The end time of 7 pairs of moulds can be calculated as, End time of oiling on 7 pairs of moulds = 31.3 + 1 + 35.7= 68 minutes

6.3.3. Ring Preparation + Mould End Plate Assembly.

Also ring preparation work along with additional fixture and a worker is completed in 30 minute. Because 1 worker prepared 150 rings in 60 minute. Then same work can be done by 2 workers in 30 minutes.

After 30 minute same 2 workers perform end plate assembly work of moulds. This work is started from 48.2th minute from starting pole withdrawing process work. This work is finished at 69.2th minute.

As per time study, time required to assemble 30 end plates of of moulds for 2 workers = 21 minutes.

∴ Time required to assemble 1 plate for 2 workers = 21/30= 0.7 minutes

∴ Time required to assemble 1 plate for 1 worker = 0.7 x 2= 1.4 minutes

∴ We can say, Time required to assemble 1 pair of plates for 2 workers = 1.4 minutes

If end plate assembly work is allot to 2 workers from the time of 48.2th minute (i.e. after poles withdraw from 12 pair moulds) then end plate assembly work end at 69.2th minutes. Pole withdrawing work, oiling mould work and mould end plate assembly work perform simultaneously from 48.2th minute.

6.3.4. Hammering + Sweeping Moulds

In this way total 10 workers are engaged for first 30 minute. One worker is not assigning the work up to now. After carefully study the hammering and sweeping the mould work processes time calculation, it is possible to allot hammering + sweeping work to remaining 1 worker.

6.3.5. Calculation of Time for Hammering + Sweeping Work for 1 Worker

a) Hammering Process time for 15 pair of Mould:

Total time required to hammer 15 pair of mould for 2 worker = 7.5 minute

∴ For 1 worker Total time required to hammer 15 pair of mould = 15 minute

∴ Time required to 1 pair of mould = 15/15 = 1 minute

∴ Time required to 3 pair of mould = (15/15)x3 = 3 minute

b) Sweeping Process time for 15 pair of Mould:

Total time required to sweep 15 pair of mould for 1 worker = 12.5 minutes

Time required to 3 pair of mould = (12.5/15)x3 = 2.5 minutes

Therefore Total time required to hammer + sweep 3 pair of mould = 3+2.5 = 5.5 minutes.

This time is beneficial to us for engaging 1 worker after extracting poles from 3 pair of moulds. When poles from 3 pair of moulds extracted then 1 worker hammering and sweeping work is performed for first 3 pair of mould. Here we consider 3 pair of moulds because if 3 pair of moulds are free after those workers are able to

perform hammering + sweeping work process otherwise not. The pole extraction time, hammering + sweeping time and idle time of 1 worker during this entire work is as shown in table no.5

Pair of Mould	Poles Extraction Time	Pair of Mould	Hammering + Sweeping Time	Idle Time
1	First 3.41 minute for set the rope hoist to proper position 3.41 + 11.19 = 14.6	0	Idle	14.6
2				
3				
4	14.6 + 11.19 = 25.8	1	14.6+5.5=20.1	25.8-20.1=5.7
5		2		
6		3		
7	25.8 + 11.19 = 37	4	25.8+5.5=31.3	37-31.3=5.7
8		5		
9		6		
10	37 + 11.19 = 48.2	7	37+5.5=42.5	48.2-42.5=5.7
11		8		
12		9		
13	48.2 + 11.19 = 59.41 & 1 minute for repositioning the hoist	10	48.2+5.5=53.7	59.4-53.7=5.7
14		11		
15		12		
7 workers are performing set tension m/c & wire supply work (up to 70.24 minutes).		13	59.4+5.5=64.9	5.34 (up to 70.24 minutes.)
		14		
		15		

Table No: 05 (All time in minutes)

For easy understanding table no.06 shows all end time of work processes during pole withdrawing or extraction work for 3 pair of moulds.

All time in minutes

Pair of Mould	Pole Extraction Time	Hammering + Sweeping Time	Time for Oiling 7 pairs of moulds	End plates assembly Time
1	14.6	20.1	47.6	52.4
2				
3				
4	25.8	31.3	62.9	56.6
5				
6				
7	37.0	42.5	68.0	60.8
8				
9				
10	48.2	53.7		65.0
11				
12				
13	60.41	64.9		69.2
14				
15				

Table No: 06. End Time of Work Processes during Pole Withdrawing Work

Also multiple activity chart for all work processes as shown in fig. no.07

After completing all work processes as shown in multiple activity chart in fig no.07 some work processes are yet to be completed. These work processes are as follows,

A) Work before pre-tensioning the steel wire.

1. Oiling 8 pairs of mould. 2. Placing rings in to the mould. 3. Collecting borrower, vibrator,etc. from storage.

B) Pre-tensioning.

C) Pre-work of concrete mix preparation and concrete mix fill in to the mould.

1. Adjusting position of wire rings in to the mould & placing 2 lifting hook in to the mould, 2. Placing wire in to the bundle. 3. Fix bar and bar holder on the mould. 4. Placing 8 SWG GI earthing wire in to moulds. 5. Water supply and mixer power ON.

D) Concrete mix preparation and concrete mix fill in to the mould.

6.4 Time Calculation for Pre-Work of Pre-Tensioning Work

6.4.1. Time for Oiling 8 Pair of Mould

In oiling work process, time required to 1 pair of mould for 2 workers = 2.53 minutes.

If quantity of workers increases up to 6 then time required to apply oil on 8 pairs of moulds is less. The time required to apply oil on 8 pairs of moulds is as follows,

Time required to 1 pair of mould for 2 workers = 2.53 Minutes.

∴ Time required to 2 pair of moulds for 4 workers = 2.53 minutes

∴ Time required to 3 pair of moulds for 6 workers = 2.53 minutes.

Then we calculate time required for 8 pair of moulds for 6 workers by cross multiplication as,

Let 8 pair of mould time for 6 worker is y,

∴ 3 Pair of mould = 2.53 Minute

8 Pair of mould y

$$y = \frac{8 \times 2.53}{3}$$

∴ y = 6.75 minutes

Actual time required to apply oil on 8 pair of moulds = 6.75 minutes.

But we have to add 1 minute for oil collection & 1 minute for cleaning hands after work.

∴ Total time required to apply oil on 8 pair of moulds = 6.75+1+1

= 8.75 minutes.

6.4.2 Time Required To Placing Rings In To The Mould

Time required to placing 150 rings in to the mouls for 1 worker = 10 minutes.

If 1 worker is add in to this process the time duration is decreases up to half time i.e.5 minutes.

∴ Time required to placing rings in to the mould = 5 minutes

6.4.3 Time Required For Collecting Working Equipments

Time required for Collecting borrower, vibrator, etc from storage = 9.16 minutes

Total pre-work of pre-tensioning shown in multiple activity chart fig.no.07

After 70.24 minutes following work processes are remains to complete.

1) Pre-tensioning of steel wire.

2) Pre-work of concrete mix preparation and filling in to the moulds.

3) Preparation of concrete mix and filling in to the moulds.

Above 3 work element will perform in same manner as existing work process performs. There is no any change in work element no. 4, 5 and 7 shown in table no.1. Only supply water and power ON work processes are perform at time of starting preparation and filling concrete mix in to the mould.

6.5 Total Working Time Calculation from Modified Schedule of Work Processes

The new schedule of work processes is simply rearrangement of work during manufacturing of concrete pole. Time required to withdraw poles from mould is 60.41 minutes. So, during this time some work is to be merged to reduce working time of manufacturing. Also systematic work sequence is followed. We try to eliminate ineffective time of workers due to which worker maximum idle time during entire working time is reduced and productivity is improved to some extent

Total working time of worker from reschedule work sequence is as follows,

Total working time = Pre-work of Of pole withdrawing work process + Pole withdrawing from mould + Pre-work of pre-tensioning + Pre-tensioning + Pre-work of concrete mix preparation + Preparation and filling concrete mix

= 30+70.24+9.16+67+15+120

= 311.4 Minutes = 311.4/60 Hrs = **5.19 Hrs**

Here we says that total time required to manufacture 30 concrete poles = 311.4 Minutes

Therefore time required to manufacture 1 pole = 311.4/30

= **10.38 minute**

Total time save = Existing Time - Reschedule Time

= 390.82 – 311.4 = 79.42 Minute = 1.323 Hr

In 1.323 Hr time duration we manufactured more number of poles.

Number of poles manufactured in 1.323 Hr = 1.323x60 / Time to manufactured 1 pole

= 79.38 / 10.38 = 7.64 Poles. (But poles are not manufactured infraction)

= 7 poles

VII. TOTAL PROFIT ANALYSIS

In data analysis new modified work process is prepared. With the help of modified work process total number of poles per day increases. Total profit is evaluated in table no.07on per year basis if plant running every day.

Sr. No	Details	Plant Work Structure	Modified Work Structure
1	No. of poles manufactured per day	30	37
2	No. of poles manufactured per month	30x30=900	30x37=1110
3	Total profit per month in Rs.	160x900=1,44,000	1110x160=1,77,600
4	Total profit per year in Rs.	12x1,44,000=17,28,000	12x1,77,600=21,31,200

TABLE NO: 07

Net profit per year in Rs: 21, 31,200 – 17, 28,000 = 4, 03,200

Here 160 is total profit on per pole in Rs.

VIII. CONCLUSION

The concrete pole manufacturing work process can be improved based on time study and work measurement. In manufacturing process new work method structure is developed which supports minimize worker idle time and maximize plant profit. From data analysis between existing work structure and modified work structure it indicates that the best alternative towards reducing worker idle time and also working time by new method. The proposed method helps to increase plant production in terms of number of poles as compare to existing method.

1. Manufacturing time of prestress concrete pole with the help work study reduced for 30 poles from 6.513 Hrs to 5.19 Hrs.

2. By analyzing existing working method , improving working schedule of concrete pole with time study techniques and per day production of poles increase from 30 to 37.

3. After calculating net profit for plant for producing concrete poles per year from table no.7 is Rs. 4,03,200.

This improvement will help the plant to achieve its goals and objectives with simple changes in production process without reducing labour and without addition of extra resources.

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