International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 07 | July 2022 www.irjet.net p-ISSN: 2395-0072

TIME STUDY – A KEY TECHNIQUE FOR PRODUCTIVITY IMPROVEMENT

[1]Karthik J Iyer, [2]Jaydipkumar K Valaki, [3]Arpitkumar R Hathila, [4]Akil H Jariya

[1,2,3]Undergraduate Student, Production Engineering Department at Birla Vishvakarma Mahavidyalaya (BVM) Engineering College, Vallabh Vidyanagar, Anand Dist., Gujarat, India
[4]Assistant Professor, Department of Production Engineering, *Birla Vishvakarma Mahavidyalaya (BVM) Engineering College, Vallabh Vidyanagar, Anand Dist., Gujarat, India*

Abstract - *This study has been done for the productivity improvement of a motor manufacturing company. Data collection was done by which it was analysed that the reduction of time in certain operations can be done and performing certain set of operations simultaneously can over all reduce the cycle time of the assembly of the motors. Increase in production rate about 65 units/shift is observed.*

Key Words: Productivity Improvement, Production Rate, Cycle Time, Pareto Chart

1.INTRODUCTION

Time study is the baseline for any process. Without the time study, one can never know whether the process have possibility of any improvement in its performance or the process have improved compared to the previous. One of the important objectives of the time study is to analyse the activities for performing a job with the view to eliminate or to reduce unnecessary or repetitive operations. By which the human effort can be minimized. Time study also helps in evaluating the performance for the development of individual or group strategies for achieving the above average performance and the evaluation of workstation's productivity.

1.1 Data Collection

Data collection is one of the important parts of any study. Since data gives us the existing scenario of what exactly is happening or occurring. Data collection plays a vital role for any of the project. For any improvement to be done, one must collect the existing data so that after the improvement, the proposed data or the implemented data can be compared with the existing data.

1.2 Current time study of the assembly line

Current time study of the assembly line of the induction motor was recorded and the average of ten readings were taken.

Table -1: Existing Time Study

Sr. No.	Description	Avg. Time in sec.
1	Induction Heating of frame	130.0
2	Moving frame to fixture	7.7
3	Mounting of frame on stator winding	
4	Drilling of frame - stator assembly	3.5
5	Locking of stator winding with frame by dowell pin	5.3
6	Waiting for gasket mounting	10.0
7	Rubber gasket mounting with removal of wire from stator	52.7
8	Mounting of terminal block	6.8
9	Moves to next station	2.0
10	Cutting of wire ends	5.5
11	Ferrules for identification	18.4
12	Peeling of wire ends	8.3
13	Lug crimping	22.5
14	Subassembly moves to next station	2.0
15	Ensure and correct position of ferrules	25.0
16	Lugs fixed to terminal plate	119.8
17	Subassembly moves for T-box frame	2.0
18	Mounting of T-box frame	38.1
19	Subassembly moves for Rotor assembly fixing	2.0
20	Retreival of rotor assembly	3.0
21	Fixing of rotor assembly at driver's end flange	37.4
22	Mounting of cover at non drive end	49.0
23	Motor moves for testing	2.5
24	Routine Test	56.3
25		
26	Moves for further testing	1.0
27		
28	Routine Test	101.1
29		
30		
31	Star/Delta connections	24.2
32	O-ring on T-box cover and fitting of T-box cover	9.1
	Total =	**745.2**

2. METHODOLOGY

By the pareto analysis of the current assembly process we can know the most time-consuming step in the assembly and possibility of the improvement in any of the step is taken care. Then after, performing of certain assembly steps simultaneously in the assembly was suggested by which, reduction in cycle time was observed. So, by the implementation of new testing machine and if the suggested method for performing certain operations simultaneously was implemented then the overall cycle time is reduced and increase in the production rate will be observed.

2.1 Pareto Analysis

Principle [4] - The Pareto principle states that for many outcomes, roughly 80% of consequences come from 20% of causes.

The main motive of the pareto chart is to bring out the largest (important) one among the available data. Mostly this tool is used in the quality management for any of the industry to find out the most occurred defect among the occurrence of the defect. So, by the arrangement of the data in descending order as per the importance priority, one can identify the most targeted data (20% Causes) that can resolve the 80% consequences. We have the collected data (Table – 1) in which, by arranging the values of Average time in seconds column in descending order, we will get the most time-consuming operations from that. So, working on those operations will reduce the time consumption in the assembly process. Description number 24, 25, 26, 27, 28, 29 and 30 are the combined operation which is the routine testing operation. And practically the improvement of description number 1 (Induction Heating) was not possible as the time taken for the induction heating of the frame was constant.

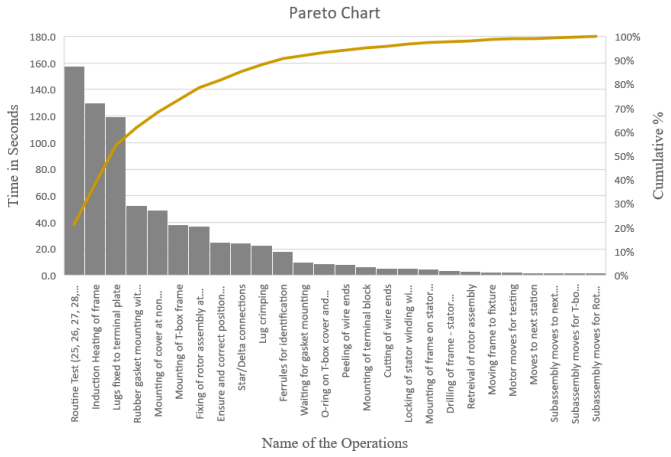

Chart -1: Pareto based on Time Study

As per the principle of the pareto analysis, we proceeded for the improvement of assembly line. Firstly, we focused on the routine testing machine as it was the most time-consuming operation among all the operations. Then after we focused on other operations and we found out that certain operations can be simultaneously performed by proper arrangement of the workers. By applying the pareto principle for our case, we proceeded for the improvement of the assembly line of the motors which positively increase the productivity of the assembly line.

Table -2: Comparison of Existing Time Study with Pareto Table (Descending Ordered)

Sr. No.	Description	Avg. Time in sec.
1	Induction Heating of frame	130.0
2	Moving frame to fixture	7.7
3	Mounting of frame on stator winding	3.5
4	Drilling of frame - stator assembly	5.3
5	Locking of stator winding with frame by dowell pin	10.0
6	Waiting for gasket mounting	52.7
7	Rubber gasket mounting with removal of wire from stator	6.8
8	Mounting of terminal block	2.0
9	Moves to next station	5.5
10	Cutting of wire ends	18.4
11	Ferrules for identification	8.3
12	Peeling of wire ends	22.5
13	Lug crimping	2.0
14	Subassembly moves to next station	25.0
15	Ensure and correct position of ferrules	119.8
16	Lugs fixed to terminal plate	2.0
17	Subassembly moves for T-box frame	38.1
18	Mounting of T-box frame	2.0
19	Subassembly moves for Rotor assembly fixing	3.0
20	Retrieval of rotor assembly	37.4
21	Fixing of rotor assembly at driver's end flange	49.0
22	Mounting of cover at non drive end	2.5
23	Motor moves for testing	56.3
24	Routine Test	1.0
25		
26	Moves for further testing	
27		
28	Routine Test	101.1
29		
30		
31	Star/Delta connections	24.2
32	O-ring on T-box cover and fitting of T-box cover	9.1
	Total =	745.2

Existing Time Study

Sr. No.	Description	Avg. Time in sec.
24	Routine Test (25, 26, 27, 28, 29, 30)	157.4
1	Induction Heating of frame	130.0
16	Lugs fixed to terminal plate	119.8
7	Rubber gasket mounting with removal of wire from stator	52.7
22	Mounting of cover at non drive end	49.0
18	Mounting of T-box frame	38.1
21	Fixing of rotor assembly at driver's end flange	37.4
15	Ensure and correct position of ferrules	25.0
31	Star/Delta connections	24.2
13	Lug crimping	22.5
11	Ferrules for identification	18.4
6	Waiting for gasket mounting	10.0
32	O-ring on T-box cover and fitting of T-box cover	9.1
12	Peeling of wire ends	8.3
8	Mounting of terminal block	6.8
10	Cutting of wire ends	5.5
5	Locking of stator winding with frame by dowell pin	5.3
3	Mounting of frame on stator winding	5.0
4	Drilling of frame - stator assembly	3.5
20	Retrieval of rotor assembly	3.0
2	Moving frame to fixture	2.7
23	Motor moves for testing	2.5
9	Moves to next station	2.0
14	Subassembly moves to next station	2.0
17	Subassembly moves for T-box frame	2.0
19	Subassembly moves for Rotor assembly fixing	2.0
25		
26		
27		
28		
29		
30		
	Total =	745.2

Pareto Table

From the time study table, we observed that the bottleneck operation was in the last few steps (i.e., Time taken for testing operation). Description number 24, 25, 27, 28, 29 and 30 consists of testing operations. 24 - IR Test (Insulation Test) ,25 - HV Test (High Voltage) ,27 - Resistance test ,28 - Reduced Voltage test, 29 - No load test, 30 - Locked Rotor test. And all these tests are done in testing machine which is denoted as 'Routine Test'. From the time study table, Number (24, 25) = 56.3 sec. and Number (27, 28, 29, 30) = 101.1 seconds. Therefore, the total time taken for the above mentioned will be: Number (24, 25, 27, 28, 29, 30) = (56.3+101.1) =157.4 sec. Now, 157.4 sec. is the greatest among all the timings in the table. Hence, the bottle-neck of the assembly is identified.

After the identification of the bottle-neck in the assembly line, it was found that the availability of the improved technology is feasible and company took further actions for the same and implemented the new machine which thereby takes about 90 sec. for testing a single motor.

3. Assembly Time Reduction

By analysis, we came to know that there are certain operations which can be performed parallelly (simultaneously) by which there will be reduction in the cycle time of the assembly line. But before proceeding we will first understand the operations in detail which can be done parallelly.

Table -3: Operations

Operation Number	Functioning
15	Ensure and correct position of ferrules. The ferrules are positioned to the end of the wire, near crimped lug (Top side) and now all these lugs inserted on the bolt.
16	Lugs are screwed to the terminal plate. The crimped lugs are fitted by nut, washer and bolt by the help of pneumatic gun
18	Mounting of T - box frame. The frame of terminal box is fixed on the top side of the motor with the help of bolt, nut and washer.
21	Fixing of rotor assembly at driver's end flange. Retrieval of rotor assembly is carried out then it is fixed to the drive side of the motor.
22	Mounting of cover at non drive end Fixing of end cover of the motor at motor's non-drive end.

Above mentioned operation numbers and its functioning is now understood. Now, for the mentioned operations, the time taken for performing the same are as follows:

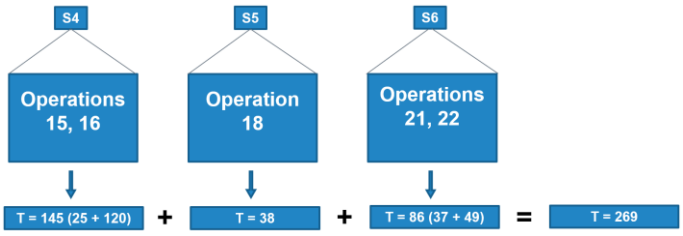

Fig -1: Block Diagram (Existing Method)

S (4,5,6) = Stations and T = Time taken for the respective station in seconds. For the imagination purpose, we have shown by the block diagram (Fig – 1) including the operation number and the respective time taken for performing that operation. We can see that the total time taken for performing the mentioned operations is 269 seconds. And these operations are performed in series in the existing layout. Regarding the layout and the position of the workers, we will be discussing further with the appropriate drawing. For understanding the proposed methodology of performing the set of operations parallelly and simultaneously we will first understand the existing layout and line up of the workers. All the mentioned operations are done in single line (i.e., One after one operation is carried out in sequence in single line as shown in the below figure)

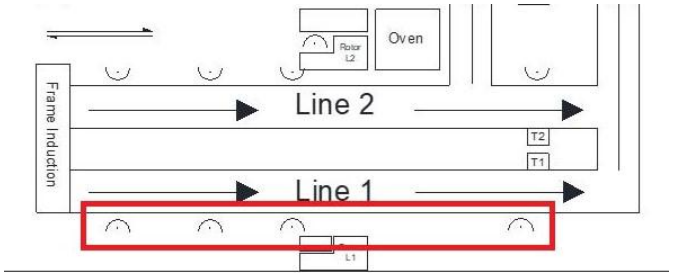

Fig -2: Current Position (Line up) of Workers

The above discussed operations (i.e., operation number 15, 16, 18, 21 and 22) are here carried out in sequence. After analyzing the sequence of operations, we came to know that the above discussed operations can be carried out parallelly in systematic way. The below figure conveys that the operations can be performed parallelly by scheduling them in systematic manner. As it is observed that the difference between the above and below figure is that, one of the members of line - 1 will be arranged on the opposite side of the line - 1 (As shown in below figure)

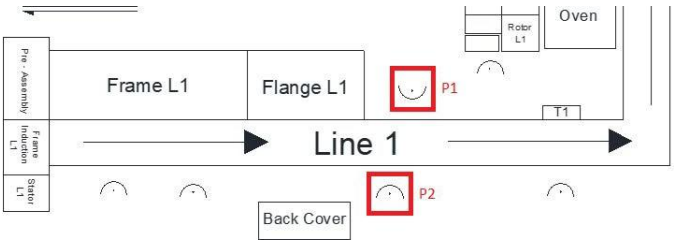

Fig -3: Proposed Position (Line up) of Workers

The following operations will be carried out as scheduled below to individual person [i.e., For Person 1 (P1) and Person 2 (P2) as indicated by red coloured box]. For person, the following operations will be carried out. P1 - Operation (15, 18, 21), P2 - Operation (16, 22). For the understanding purpose, we assume that the operation number 15 (i.e., Ensure and correct position of ferrules) is already finished for one motor. Now, this motor will proceed to the person (P1 and P2) in the induction assembly line.

The following operations will be carried out in the listed manner:

P2 will start operation number 16 (i.e., Lugs screwed to the terminal plate) simultaneously P1 will start operation number 21 (Fixing of rotor assembly at driver's end flange). Operation number 16 will consume 120 sec. and operation 21 will consume 37 sec. Therefore, P1 will be free for about = (120-37) =83 seconds. In this time, P1 will perform operation number 15 for the next motor which will consume about 25 sec. Therefore, the time remaining for P1 will be = (83-25) =58 seconds. Now, for the remaining time, person P1 can perform auxiliary tasks like, installing necessary stickers,

Helping the other by tightening the nut with the help of pneumatic gun. After 120 sec., P1 and P2 will complete their operations and will be proceeding with next operation discussed below, P1 will perform operation number 18 (Mounting of T-box frame) simultaneously P2 will perform operation number 22 (Mounting of cover at non drive end).

The block diagram for the proposed methodology is as follows:

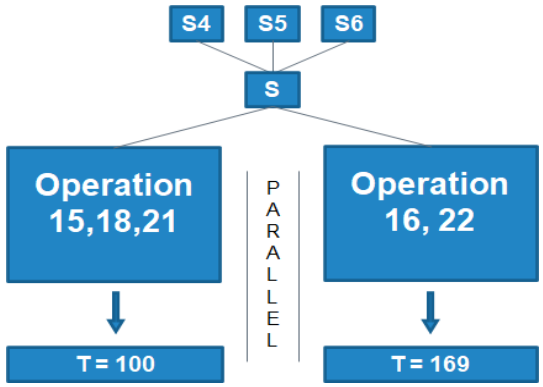

Fig -4: Block Diagram (Proposed Method)

From the block diagram we can see that the maximum time will be the station time (i.e., 169 sec.). T = Time taken for the respective station in seconds. By implementing the proposed method, the time saved will be,

Fig -5: Time Saved

Hence, the total time saved per motor will be 100 seconds. The existing time taken is 745.2 seconds as seen in below table

Table - 3: Comparison of current and proposed solution

Sr. No.	Description	Avg. Time in sec.
1	Induction Heating of frame	130.0
2	Moving frame to fixture	7.7
3	Mounting of frame on stator winding	
4	Drilling of frame - stator assembly	3.5
5	Locking of stator winding with frame by dowell pin	5.3
6	Waiting for gasket mounting	10.0
7	Rubber gasket mounting with removal of wire from stator	52.7
8	Mounting of terminal block	6.8
9	Moves to next station	2.0
10	Cutting of wire ends	5.5
11	Ferrules for identification	18.4
12	Peeling of wire ends	8.3
13	Lug crimping	22.5
14	Subassembly moves to next station	2.0
15	Ensure and correct position of ferrules	25.0
16	Lugs fixed to terminal plate	119.8
17	Subassembly moves for T-box frame	2.0
18	Mounting of T-box frame	38.1
19	Subassembly moves for Rotor assembly fixing	2.0
20	Retreival of rotor assembly	3.0
21	Fixing of rotor assembly at driver's end flange	37.4
22	Mounting of cover at non drive end	49.0
23	Motor moves for testing	2.5
24	Routine Test	56.3
25		
26	Moves for further testing	1.0
27		
28	Routine Test	101.1
29		
30		
31	Star/Delta connections	24.2
32	O-ring on T-box cover and fitting of T-box cover	9.1
	Total =	745.2

Existing Cycle Time

Sr. No.	Description	Avg. Time in sec.
1	Induction Heating of frame	130.0
2	Moving frame to fixture	7.7
3	Mounting of frame on stator winding	
4	Drilling of frame - stator assembly	3.5
5	Locking of stator winding with frame by dowell pin	5.3
6	Waiting for gasket mounting	10.0
7	Rubber gasket mounting with removal of wire from stator	52.7
8	Mounting of terminal block	6.8
9	Moves to next station	2.0
10	Cutting of wire ends	5.5
11	Ferrules for identification	18.4
12	Peeling of wire ends	8.3
13	Lug crimping	22.5
14	Subassembly moves to next station	2.0
15	P1 (Fixing of rotor assembly at driver's end flange, Ensure and correct position of ferrules, Mounting of T-box fram) (Parallel) P2(Lugs fixed to terminal plate, Mounting of cover at non drive end)	169.0
16	Motor moves for testing	2.5
17	Routine Test	56.3
18		
19	Moves for further testing	1.0
20		
21	Routine Test	101.1
22		
23		
24	Star/Delta connections	24.2
25	O-ring on T-box cover and fitting of T-box cover	9.1
	Total =	687.9

After implementing the proposed arrangement

Existing cycle time is 745.2 seconds and if the proposed arrangement is applied then the new cycle time will be 637.9 seconds. The % Reduction in cycle time will be = [((745.2-637.9))/745.2] ×100 = 14.4 %

3. CONCLUSIONS

The testing machine is implemented and if the proposed arrangement of performing certain set of operations parallelly (simultaneously) is also implemented then the result will be:

Table - 4: Existing Cycle Time

Sr. No.	Description	Avg. Time in sec.
1	Induction Heating of frame	130.0
2	Moving frame to fixture	7.7
3	Mounting of frame on stator winding	
4	Drilling of frame - stator assembly	3.5
5	Locking of stator winding with frame by dowell pin	5.3
6	Waiting for gasket mounting	10.0
7	Rubber gasket mounting with removal of wire from stator	52.7
8	Mounting of terminal block	6.8
9	Moves to next station	2.0
10	Cutting of wire ends	5.5
11	Ferrules for identification	18.4
12	Peeling of wire ends	8.3
13	Lug crimping	22.5
14	Subassembly moves to next station	2.0
15	Ensure and correct position of ferrules	25.0
16	Lugs fixed to terminal plate	119.8
17	Subassembly moves for T-box frame	2.0
18	Mounting of T-box frame	38.1
19	Subassembly moves for Rotor assembly fixing	2.0
20	Retreival of rotor assembly	3.0
21	Fixing of rotor assembly at driver's end flange	37.4
22	Mounting of cover at non drive end	49.0
23	Motor moves for testing	2.5
24	Routine Test	56.3
25		
26	Moves for further testing	1.0
27		
28	Routine Test	101.1
29		
30		
31	Star/Delta connections	24.2
32	O-ring on T-box cover and fitting of T-box cover	9.1
	Total =	745.2

In the existing method the cycle time is 745.2 seconds. So, after the implementation of both the discussed the new cycle time will be 569.5 (Table – 5)

Therefore, the % reduction in the cycle time will be = [((745.2-569.5))/745.2] ×100=23.57 %

Currently approximately 200 units are made per shift (25200 seconds) by 6 persons.

Therefore, for the new cycle time of 569.5 seconds the units made will be = (25200/569.5) = 44.24 (units)/person

Since, Assembly Line is carried out by 6 persons, the units made will be = (44.24×6) = 265 units/shift

Hence, by implementing both the discussed, the total number of extra units made will be = (265-200) = 65 units/shift

Therefore, the productivity improvement will be = (65/200) ×100=32.5 %

Table - 5: Cycle Time after implementation

Sr. No.	Description	Avg. Time in sec.
1	Induction Heating of frame	130.0
2	Moving frame to fixture	7.7
3	Mounting of frame on stator winding	
4	Drilling of frame - stator assembly	3.5
5	Locking of stator winding with frame by dowell pin	5.3
6	Waiting for gasket mounting	10.0
7	Rubber gasket mounting with removal of wire from stator	52.7
8	Mounting of terminal block	6.8
9	Moves to next station	2.0
10	Cutting of wire ends	5.5
11	Ferrules for identification	18.4
12	Peeling of wire ends	8.3
13	Lug crimping	22.5
14	Subassembly moves to next station	2.0
15	P1 (Fixing of rotor assembly at driver's end flange, Ensure and correct position of ferrules, Mounting of T-box fram) (Parallel) P2(Lugs fixed to terminal plate, Mounting of cover at non drive end)	169.0
16	Moves for testing	2.5
17	Routine Test	90.0
18	Star/Delta connections	24.2
19	O-ring on T-box cover and fitting of T-box cover	9.1
	Total =	**569.5**

REFERENCES

[1] Nikhil Verma, Pulkit Trivedi, Vivek Agnihotri, Productivity Improvement in Assembly Line of an Automobile, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 12, Issue 4 Ver. III (Jul. - Aug. 2015), PP 01-06M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] Abdul Talib Bon, Siti Nor Aini, Samsudin, Productivity Improvement in Assembly Line by Reduction Cycle Time using Time Study at Automotive Manufacturer, Proceedings of the International Conference on Industrial Engineering and Operations Management Bandung, Indonesia, March 6-8, 2018K.

[3] Productivity Improvement in Machining Industry by using Time Study and Method Study Techniques, International Research Journal of Engineering and Technology (IRJET), Volume: 07 Issue: 07, JULY 2020

[4] Productivity improvement by work and time study technique for earth energy-glass manufacturing company, 4th World Conference on Business, Economics and Management, WCBEM

[5] https://en.wikipedia.org/wiki/Pareto_principle

[6] https://www.dissertationhelp.co.in/our-process/importance-of-data-collection/