Time and Motion Study in an Manufacturing Industry

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Abstract : This paper presents a study on utilization of time and motion study techniques applied to a production line of tractor loader backhoe in an manufacturing industry. The core objective of performing time study is to identify the non-value added activities and to determine manpower requirement and motion study techniques were utilize to identify posture difficulties and reduce the worker fatigue. Thus by performing time and motion study ,a better way of doing the work can be developed and standard motion and time are assigned which helps the organization to reduce waste and increase productivity.

IndexTerms **– Time study, Motion study, NVAA, SVAA, VAA, Muda, Muri, Kaizen.**

I. INTRODUCTION

As the market competitions is increasing day by day develops a continuous search for improvement and if the company does not aims at improving its products, process and services its market survival become very difficult . Thus to avoid such situations and with the goal of trying to eliminate the 7 wastes: overproduction, waiting, transportation, incorrect processing, inventory, motion and defects ,the techniques of time and motion study are being used.

There is a close link between time study and motion study, both are work measurement techniques which are used by industrial engineers to enhance the performance or the operational efficiency.Motion study concerned with the reduction of work content, wastes and posture difficulties that leads to worker fatigue and aims for establishing the best possible way of doing work whereas time study is concerned with investigating and reduction of any non-value added activities associated with the job and establishing standard time for an operation. Now companies started classifying operations as non value added activities(NVAA), Semi value added activities(SVAA) and value added activities(VAA) .Non-value added(NVAA)are the activities for which customer doesn't pay therefore these activities are financial burden to the company and does not increase the worth of what is delivered to the customer ,hence should be eliminated, Semi value added activity(SVAA) are the activities which are necessary and without these value added activities cannot be accomplished, but the customer does not pay directly for these,and value added activities (VAA) are those activities for which customer pays. These are the most necessary activities or the main activities constituting a process , hence their percentage should be higher to increase productivity. Thus by using time and motion study it is possible to reduce the waste and increase efficiency and productivity of an organization .

II. OBJECTIVES OF RESEARCH

The main objectives of performing time and motion study are:

- **In planning and controlling**:
  Time study data provide information and act as basis for production planning and scheduling activities.It helps to determine man-power requirement, future requirements of equipment & machines as well as number of machines a worker can conveniently handle that lead to proper balancing of the work distribution.
- **To identify the NVAA:**
  The techniques of time study is used in identification of non-value added activities(NVAA),which was consider waste, by doing so lines bottleneck can also be reduced that's leads to increase efficiency and production capacity of an organization.
- **To eliminate workers fatigue:**
  Motion study techniques are used to eliminate the posture difficulties faced by workers while doing work Which can lead to worker fatigue. It also helps in improving labour productivity and ensures safety of workers.
- **To Measuring employee performances:**
  Work measurement data is useful to check employee performance. It enables line management to find out if employee is making satisfactory progress and also helps in identification of substandard workers.The data also acts as basis for incentives to prepare for standards that needed to be achieved by worker.
- **To have more effective utilization of materials, machine and workers:**.
  Work measurement techniques is useful for the best utilization of resources available. Through complete utilization of man ,machine and material productivity can be increased

III. RESEARCH METHODOLOGY

3.1 Time study Procedure:

Time study approach helps in reducing or minimizing the time taken by 'non-value added activities' which is a type of waste(Muda). Muda means wastefulness, uselessness and futility. The study also helps in determining manpower requirement.The procedure for conducting the Time study by using chrono analysis technique are as follow:

(1) Select: Select the task or job that needs to be timed for study purpose. we have selected the engine station for performing time study. Our main aim is to identify and reduce non-value added activities and to determine manpower requirement.

(2)Define: Define the elements, break the job into elements convenient for timing. The job is divided into elements(main activities) and further into sub elements(sub activities) for convenience of observation

(3)Obtain & Record: Obtain and record the details regarding method, operators, job and working conditions likely to affect the time study work. To achieve performance standard accuracy it is necessary to record the correct method of working. Chrono-analysis was performed through the use of a recording camera.

(4)Measure: Measure the time duration for each and every activities. The time taken for each activity is measured. The time measured is known as observed time.

(5)Classification of activities into NVAA, SVAA and VAA: Classify the activities into non value added, semi value added or value added.

(6)Determine: Determine the NVAA which consumes maximum time with the help of pareto chart, so that we can take counter measure against that activity to reduce it.After that Yamazumi chart is drawn which visually shows the amount of work operators has to perform and through this we can determine the manpower required to perform the job.

3.2 Motion Study procedure:

Motion study aims at eliminating unnecessary operations and reducing posture difficulties(Muri) that leads to worker fatigue. Muri is a Japanese word meaning unreasonableness, beyond ones power. When operators or machines are utilized for more than 100% to finish their task, they are overburdened. Thus to avoid such situation motion study is performed. The procedure for conducting the Motion study by using chrono analysis technique are as follow:

(1)Select: Select the objective.Objective may be reduce the manufacturing cost,or to reduce bottlenecks or to reduce fatigue incurred by workers. Here , we have selected the station i.e engine station for performing motion study. Our main aim is to identify and reduce posture difficulties (muri) faced by the workers while performing activities.

(2)Define: Define the elements ,break the job into elements convenient for timing.The job is divided into elements(main activities) and further into sub elements(sub activities) for convenience of observation.

(3)Obtain & Record: Obtain and record the details regarding method, operators, job and working conditions likely to affect the study work**.** Chrono-analysis was performed through the use of a recording camera. As the camera provides a more accurate motion analysis, since it is possible to capture the operator's motion and by seeing and observing it we can determine whether operator is facing difficulty or not while performing the job.

(4)Classification of Muri: Muri are classified on the basis of type of posture difficulties faced by the workers such as flexion angle of waist ,rotation angle of the waist ,Height of working arm, Flexion angle of knee, Rotation angle of wrist, Picking up parts and material, etc. After identifying the type of muri they are classified into 3 categories (Red muri, Green muri and Yellow muri)and score is given to them on the scale of 1-3 on the basis of difficulties faced by workers to perform it . Red muri(Score 3) indicate high level of posture difficulties faced by workers which leads to fatigue ,Green muri(Score 1) indicate no posture difficulties and yellow muri(Score 2) is intermediate between the two. So the percentage of green muri should be high.

(5)Analysis of Data: After giving score to each and every activities now, the outcome is analyze .Through this the total no. of red , green and yellow muri for each posture difficulties faced by workers is obtained. For example muri of flexion angle of waist has 6 red muri,9 yellow muri and 85 green muri.

(6)Convert Red Muri into Green Muri: Next step is conversion of red muri into green this can be achieved with the help of improvement techniques (kaizens). Kaizen is a Japanese term meaning "change for the better" or "continuous improvement." Kaizen has been implemented with the help of improvement tool known as PDCA (plan-do-check-act).For example the worker is facing muri of flexion angle of waist while picking up tools or parts, now to eliminate this muri kaizen is made and tools or parts is now provided in trolley so now workers does not have bend its waist and thus the red muri of flexion angle of waist is converted into green muri.

(7)Maintaining: The new improvement practice must be maintained by monitoring the results and comparing them with original one. If the changes prove to be useful, the improvement techniques can be use continuously. Whereas, if they are thought undesirable, they can be eliminated through line management.

IV.DATA ANALYSIS AND CALCULATIONS

4.1: **Obtaining total percentage of NVA, SVA and VA activities:**

After classifying the activity, the NVA, SVA and VA activity of all the 6 operators are added to find total NVAA ,SVAA and VA.

Table 4.1: Observation table showing total NVAA.SVAA and VAA

NVAA	OP-1	OP-2	OP-3	OP-4	OP-5	OP-6	TOTAL
Unpacking / Opening	0	7	72	31	38	2	**150**
Remove excess material	85	55	43	4	27	77	**291**
Unfastening / Disassembling	0	0	0	0	0	21	**21**
Masking / Unmasking	0	4	0	0	0	5	**9**
Goes with/to reach parts & return	34	18	26	34	28	23	**163**
Goes with/to reach tool & return	0	17	0	0	10	47	**74**
Searching for parts	0	0	4	4	0	0	**8**
Searching for tools	0	0	0	5	0	0	**5**
Bend down / Rise up	0	0	0	0	0	0	**0**
Sit down / Stand up	0	11	0	0	0	4	**15**
Kneel down / Stand up	0	0	0	0	0	0	**0**
Waiting	32	0	0	0	4	0	**36**
Picking Up / Put Down Part	21	8	15	4	5	35	**88**
Holding Part	0	0	3	2	4	0	**9**
Rotating Part	0	6	6	51	42	20	**125**
Pickup/put down tools	83	145	114	58	141	174	**715**
Change Tool screw	0	0	10	0	6	12	**28**
Lock/Unlock the hoist to the piece	0	0	0	0	0	6	**6**
Move the piece with the hoist	0	0	0	0	0	8	**8**
Quality Inspections	0	0	0	11	0	0	**11**
Quality proofs	61	56	28	25	71	48	**289**
Paper fillings	0	0	0	246	0	0	**246**
Read / Look	0	0	0	0	0	14	**14**
Data Entry	0	0	0	0	0	0	**0**
Wiping / Cleaning	0	0	0	0	0	0	**0**
Adjusting	78	128	67	65	80	146	**564**
NVAA Total	**394**	**455**	**388**	**540.0**	**456.0**	**642**	**2875**
SVAA	**168.3**	**98.6**	**150**	**49.7**	**102.7**	**114**	**683**
VAA	**384**	**551**	**350**	**265.0**	**504.0**	**433**	**2487**

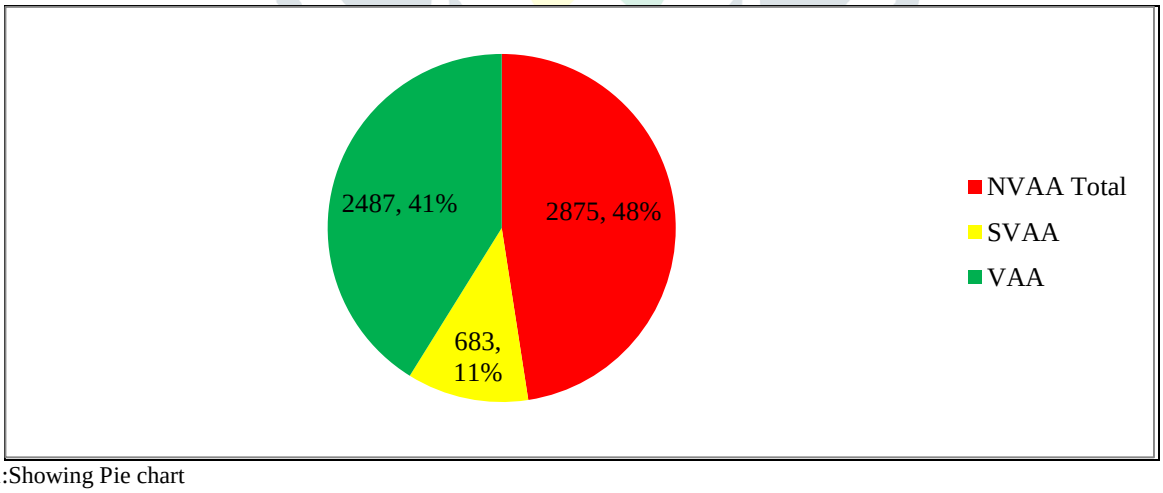

Figure 4.1:Showing Pie chart

4.2 Identifying Non-value added activity which consume maximum Time:

Now we have to identify non value added activities which consumes maximum time, and eliminate them from the production line, which results in reducing the line's bottleneck and increasing production capacity Pareto chart is also being used as cause analysis tool, To identify the root cause of problem .Now with the help of observation table we had plotted pareto chart. Through pareto chart we get the information about the activities which consumes the maximum. so that we can take our counter measures against that activity to reduce it.

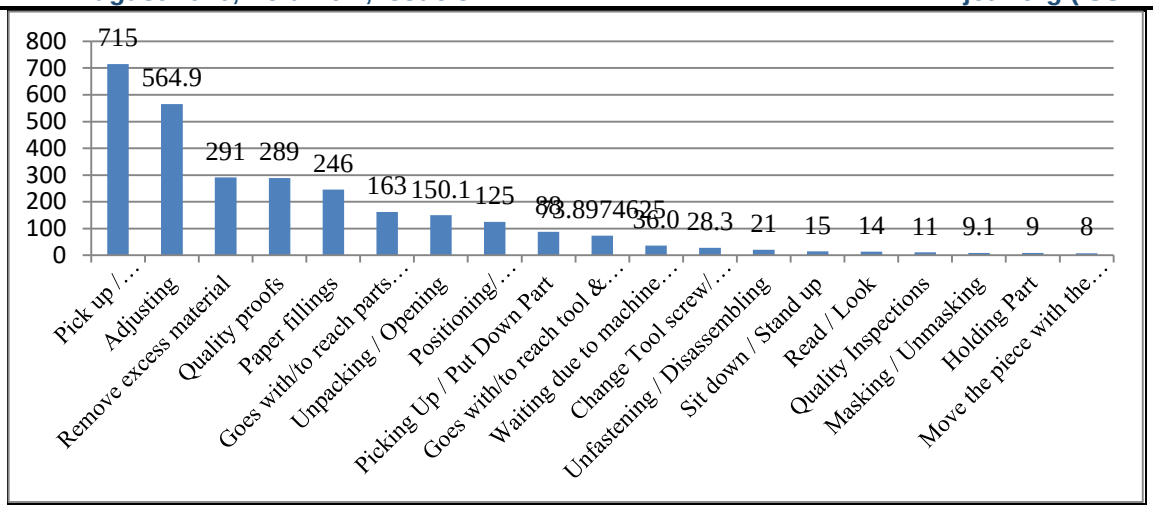

Figure 4.2: Showing Pareto chart

Through pareto chart we gets the information about activities which consumes maximum time.

1. Picking up /Put down material **-715ec**
2. Adjusting **-564 sec**
3. Remove excess materials- **291 sec**

These are the top 3 non value added activities which consumes maximum time.

4.3 Calculating Work content and Unbalancing:

Work content is the measured time content of an activity or task determined by using recognized work measurement techniques, at a defined performance level.Work content can be obtained by adding NVA,SVA and VA

WORK CONTENT=NVA+SVA+VA

Idle time or unbalancing is the time associated with employees waiting, or when a piece of machinery cannot be used.Unbalancing or Idle time can be obtained by subtracting work content from available time.

UNBALANCING = Available time - Work content

Table 4.2: Determining work content and unbalancing

NVAA		SVAA		VAA		W C	AVL. TIME	UNBALANCING
2875	718.8	683	170.75	2487	621.75			
719		175		625		1519	1800	281
716		172		621		1509	1800	291
718		165		620		1503	1800	297
720		171		621		1512	1800	288

4.4 Determining Man-power required:

Here, the work of six operator is divided efficiently between the four operators

Table 4.3: Determining operators needed to perform job

STATION	OPERATOR	NVAA	SVAA	VAA	UNBALANCING	TAKT TIME
ENGINE	OP 1	719	175	625	281	1800
ENGINE	OP 2	716	172	621	291	1800
ENGINE	OP 3	718	165	620	297	1800
ENGINE	OP 4	720	171	621	288	1800

A Yamazumi chart is a stacked bar chart that shows the balance of cycle time workloads between a number of operators typically in an assembly line.

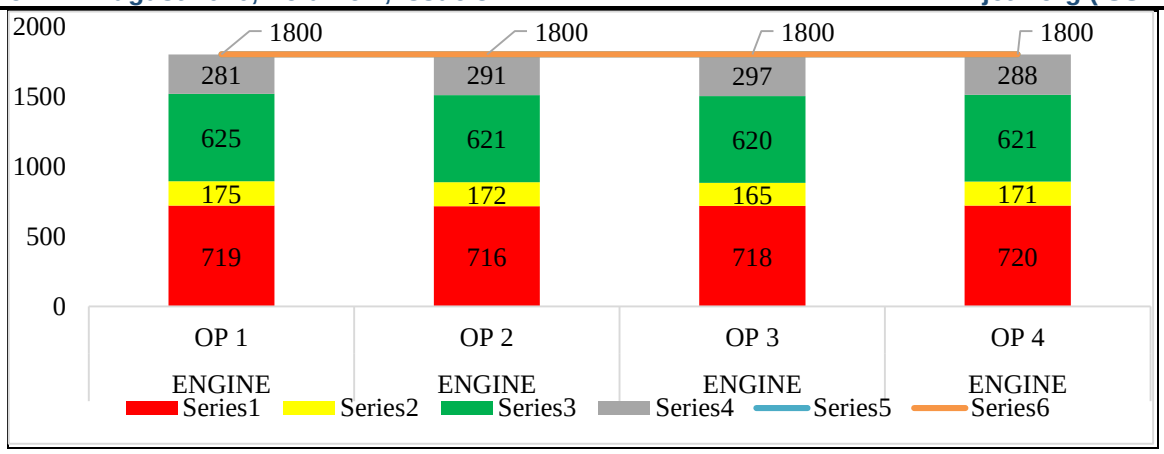

Figure 4.3: Showing yamazumi chart

A Yamazumi chart help in finding whether the processes or operators is overburdened or underutilized. Before 6 operators were doing this job .so through this chart we get the information that the operators is underutilized Thus with the help of yamazumi chart now the work is divided efficiently between 4 operators .It's also helpful when there is a need to rebalance the line or rearrange the process.

4.5 Muri improvement sheet:

After implementation of kaizens ,the posture difficulties(muri) has been reduced. Kaizen has been implemented with the help of improvement tool known as PDCA (plan-do-check-act, sometimes seen as plan-do-check-adjust) is a repetitive four-stage model for continuous improvement.

Table 4.4: Muri improvement sheet

N.	MURI TYPE	Problem Description	Improvement (kaizens)
1	flexion angle of waist	Muri during picking up gun	provide gun at front
2	flexion angle of waist	Muri during put down parts in trolley	provide material in dolly
3	flexion angle of waist	Muri during bend down to pick part	provide material in dolly
4	flexion angle of waist	Muri during pulling the transmission trolley	process improvement in transmission trolley
5	flexion angle of waist	Muri during positioning the transmission box	process improvement in transmission trolley during positining
6	flexion angle of waist	Muri during tightnining the bolt in transmission	provide stool bolt tightning in transmission
7	walking	Muri during picking up bolts	provoide bolt in dolly trolley
8	height of working arm	Muri during move to picking up hoist crane	provide transsmisson in engine trolley
9	walking	Muri during move to picking up gun	provide gun at front
10	neck flexion	Muri during picking up hoist crane	process change
11	working range	Move to engine to pick parts	provide parts in golden zone
12	working range	picking up gun	provide gun at front of operator
13	working range	Picking up parts	provide parts in golden zone
14	working range	Return back to for torquing	provide tools in golden zone
15	working range	move to another side to remove cap	provide parts in golden zone
16	working range	move to put down tool	provide tools in golden zone
17	working range	Putting down gun	provide gun at front of operator
18	walking	Move with switch coolant	provide parts in golden zone
19	working range	put down tool	Tool kept infront of operator
20	working range	move to left side of engine for pick bolt	provide parts in golden zone
21	working range	picking up bolt	provoide bolt in dolly trolley
22	working range	picking up bolts	provide parts in golden zone
23	working range	put down bolts	Parts provided in dolly trolley
24	working range	picking up washer	Parts provided in dolly trolley
25	working range	come back to engine	provide parts in golden zone
26	working range	move to picking up tool	provide tools in golden zone
27	working range	come back to picking up trolley of transmisssion box	provide parts in golden zone
28	working range	pulling the transmission trolley	provide parts in golden zone
29	working range	move with transmission trolley	provide parts in golden zone
30	working range	move to picking up starp cutter	Tool kept infront of operator

31	working range	Return back to transmission box	provide parts in golden zone
32	flexion angle of waist	move to put down crane switch	provide tools in golden zone

4.6 Comparison of muri map before and after:

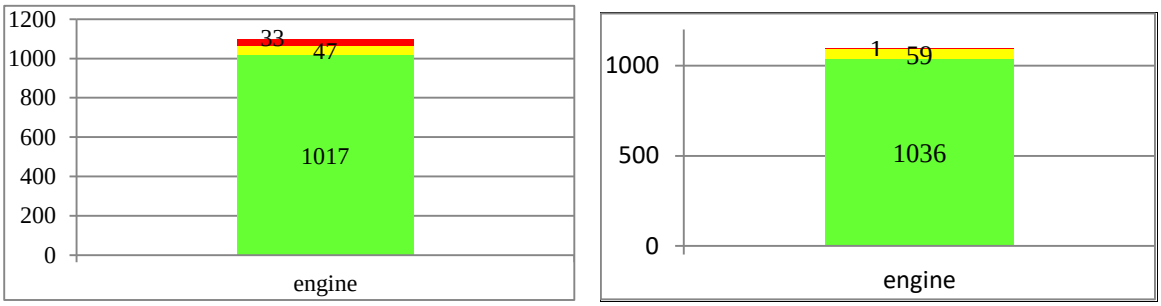

Figure 4.4: Showing Muri graph of before and after kaizens implementation

V. RESULT AND DISCUSSION

- Time required by NVAA ,SVAA and VAA is obtained .NVA activity which consumes maximum time is determined. So that counter action can be taken against that activity to reduce it, here activity of picking up/put down materials consumes maximum time.

NVAA	2875 SEC
SVAA	683 SEC
VAA	2487 SEC

- Manpower is reduced ,before 6 operator were required for engine mounting,now the job has been divided effectively between 4 operators. which reduces the overall cost and results in effective utilization of man, machine and materials.

- Red Muri reduction is 97%. The red muri are converted into green muri which helps in eliminating posture difficulties that leads to worker fatigue and also helps in reducing waste and improving the productivity.

MURI	BEFORE	AFTER
RED MURI	33	1
YELLOW MURI	47	59
GREEN MURI	1017	1036

- Improvement techniques (kaizen) has been made and implemented, which helps in reducing muri as well as improving safety of workers .

VI. CONCLUSION AND FUTURE WORK

6.1 CONCLUSION

This research uses chrono-analysis technique to perform Time and Motion study. From the time study results it was found that the actual productivity (VA activities) is 41% , NVAA is 48% and SVAA is 11%. The techniques of the time and motion study proved effective utilized of time and workers, it was also possible to identify activities considered as non-value-added and further can be eliminated from the production line, reducing the line's bottleneck and increasing production capacity . In addition, positive changes that occur can also be observed and concluded that the reduction time and man power helps in reducing overall cost of production. Furthermore, method study techniques helps in reducing posture difficulties faced by workers. Thus ensures safety of workers. Improvement techniques (kaizens) has also been implemented .Further these results can be considered to do continuous improvement programmes (CIP) to reduce the NVA activities of the assembly line.

6.2 Future Work

- We have done distinction between NVAA,SVAA and VAA and also identify NVAA which consumes maximum time. So now manufacturers can work to eliminate Non-Value Added activities so that waste can be minimized, while maximizing value added.

- Awareness is the first step to bring any change. During study it was found that majority of the workers are aware of stop watch time study method which is traditional work measurement technique. Hence training related to all other advanced work measurement technique should be given to workers so that they are much cautious and responsible towards their work measurement.
- Use of automated guided vehicles will results in further more reduction in motion and also time.

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