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Productivity Enhancement by time Study Analysis of an Assembly Line in an Automotive Industry

Vijayalakshmi K[1*], Diwakar Reddy Vanimireddy[2], Venugopalnaidu Manubolu[3]
[*1,2]Department of Mechanical Engineering, SVU College of Engineering, Tirupati, India, 517502
[3]Asst. Professor, Department of Mechanical Engineering, R.G.M. College of Engineering and Technology, Tirupati, India, 518501
*Corresponding author email: vijayavasu19@gmail.com

Abstract

The rapid industrial progress necessitates that industries keep up and compete in order to stay in enterprise, particularly in the manufacturing process. Generally, industries need a shorter working period to reach production goals and boost profitability. In the manufacturing industry, one of the most important areas to examine for enhancing productivity is the assembly line. The goal of this paper is to research and recommend a new methodology to the relevant industry on order to boost its productivity. In many industries, the time study analysis approach is one of the productivity development strategies employed. Time study analysis is a scientific approach for determining the optimal way to carry out a monotonous activity and measuring the amount of time it takes an average worker to accomplish a specific task in a set workplace. By the usage of this Industrial Engineering tool, time study analysis technique, this paper tried to improve efficiency of an assembly line by identifying and eliminating the non-value adding activities and propose kaizen recommendations to avoid non-valve adding activities. Hence, each cycle time can be reduced, leading to lowering in total cycle time of assembly line consequently increasing its efficiency.

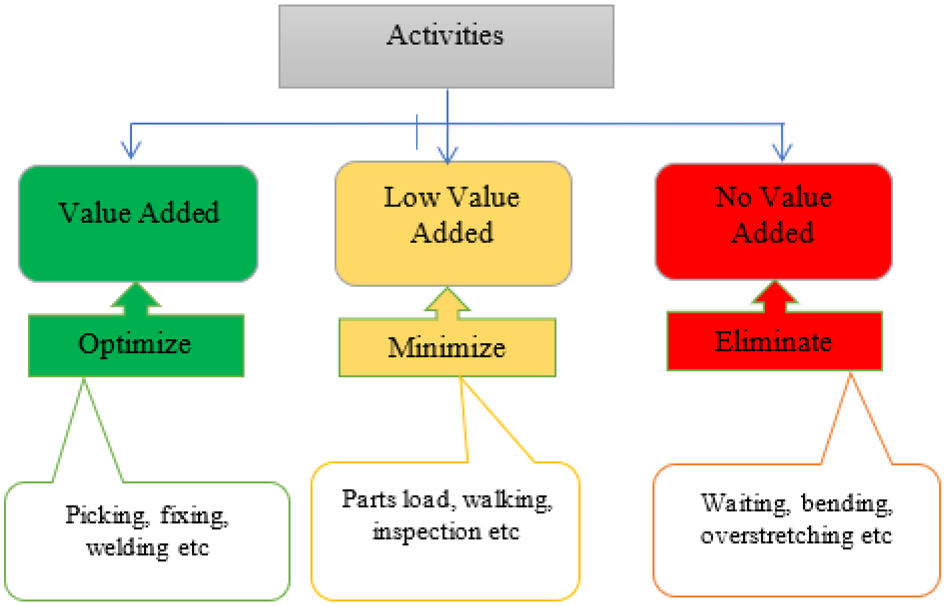
Key words: Industrial Engineering, productivity, time study analysis, value analysis, lean tools, Automotive Industry.

1. Introduction

Productivity is a metric that assesses the efficiency of the manufacturing process, which entails converting inputs such as raw materials, labour, and capital into completed items. It's usually represented as a ratio of the amount of output to the total amount of resources used to generate that product. Productivity usually deviates from production. Production is described as the methodical process of gradually changing one kind of material into another while ensuring the required quality and capacity to meet the demands of the consumer. It tends to mix both tangible which involves raw materials, labour, etc. and intangible inputs which involves to produce completed items or services. Production refers to an increase in output over a set period of time, whereas productivity refers to the ratio of output to input. To put it another way, increasing productivity has to do with people's ability to successfully integrate various resources in order to provide components and services that others desire. Improved output, greater values, and larger revenues may be achieved for every hour spent if the right decisions are made.This methodology includes value analysis, micromotion analysis and some of lean tools like Kaizen,5S.

Valve analysis: It is nothing but categorizing the activities in key operations and motions being performed by operator in order to synchronize costs [1] and identify wastes caused by using a check list. Basically, there are three types of activities are shown in Figure 1.

Figure 1: Activities categorization based on their purpose



Added value: Those activities which will increase the final worth of product or service from the customer's perspective, i.e., bare essentials of operations and motions that just get paid for customers' demands [2] such as Picking, setting parts, tightening and welding.

Low added value: the activities that will not add on any value to product but these activities are essential and necessary and customer is not willing to pay for these activities. Somehow, they can’t be avoided, i.e., operations and motions that are associated with bare essentials and preferred to be eliminated by improvements such as Passing, tentatively placing, re-picking parts, gun in and out etc.

No added value: The activities that will not add on any value to product and also these activities are not required, i.e., operations and motions that produce no added values and must be eliminated immediately such as waiting, squatting, bending and overstretching [3]. These no-added value activities are considered as completely wastage and the time being involved in low added activity and no value-added activity is considered as scope of improvement.

Micro-motion analysis: Micro-motion study is a collection of techniques for dividing manual activities into groups of movements or micro-motions or elements, and the study of such elements aids in determining the ideal pattern of movements for an operator to complete a task in less time and with less effort or fatigue [4]. The principles of motion economy have been shown to be quite effective in enhancing labour practises. They may be classified into three categories.

i) Utilization of human body, ii) Workplace layout, iii) Design of equipment and tools

Kaizen : The Japanese word "Kaizen" is nothing but continues improvement that focuses upon continues improvement of processes in manufacturing, engineering, business management or any industry. All employees from top management to assembly line operators are involved in this practice. The Japanese words: ‘zen’ gives meaning of ‘good’ and ‘kai’ gives meaning of ‘change’. This Japanese philosophy was initiated by Toyota in the 1980s and had been adopted by many organizations in the world. This lean tools promote culture of continuous improvement that improves quality, productivity, and returns over time.

An assembly line will have many workstations which are positioned along any transportation medium such as conveyor belt, to produce a finished item. The semi-finished or raw materials are transported from one station to another, with certain operations conducted at each station due to certain limits. Cycle time is one of most important constraint [5]. The cycle time is nothing but the amount of time interval will take for a semi-finished work part to travel between two successive work stations. This paper concentrates on this constraint i.e., total cycle time.

When the demand is more and products have several operations then the process of balancing the assembly line becomes more complicated. There will be two types of optimization methods to balance the line problem. first method is to fix the cycle time and strive to reduce number of workstations [6]. Second method is to strive for the reduction of cycle time for defined number of workstations. This paper will take second method. The overall objective of this paper is to enhance productivity through line balancing by decreasing the overall cycle time on the production line. The present work is studied at trim and chassis workshop in an automotive industry which manufactures the four-wheeler vehicles, in mass production way, located in South India. In the above, trim refers to interior components of vehicle and chassis refers to under floor and accessories in vehicle. With the all above mentioned statements in research developments, it’s concluded that the productivity of any firm can be improved with its cycle time reduction. In this report, a combined methodology of work study and lean tools is discussed.

- To study and identify, minimize and eliminate the non-value-added activities if any present in the system by applying time study and value analysis.
- To cut down the total cycle time of present system by proposing better ways.
- To increase the total availability time leading to increasing productivity of organization.

Requirements: Camera, Industrial Stop Watch, Data entry Application.

2. Methodology

A combined methodology is discussed which contains work measurement, work study technique, with kaizen, a lean tool. Work measurement involves synthetic analysis [7] of times to be taken for work elements. The steps to be followed are as shown below as Figure 2.

Fig. 2: Proposed combined methodology

Here, time study helps to breakdown the work into elements, value analysis is concerned with identifying the non-value adding activities and kaizen events to suggest the better ways considering micro-motion principles and ergonomics. All these combined together to increase line efficiency. Many organizations had tried one of these enhancing approaches, some had attempted both, but few of them had integrated the two approaches into a single approach for maintaining continual improvement [8].

Precautions to be taken during conducting the study is as follows

- Inform the Zone Supervisor, to take permission.
- Tell the operator what is going on and why.
- Tell the operator to work as normal.
- Do not obstruct the operator.
- Be aware of other influences – moving parts or machines.

- Do not slouch, lean, or sit down during the study.

Data collection: The following items should be investigated concerning the study.

- Workstation details.
- Name (description) of subject production line.
- Name and type of parts used.
- Operator, supervisor names and shift name etc.

Selecting the work stations to be studied. Generally, highest cycle timed stations are selected for bottleneck analysis or all the stations and noticing the objectives of the study and general information.

Data recording: it's also known as filming and it is to record the operations being performed in a particular station by respective worker with the help of Camera at normal speed.

Elemental split-up: smallest part of specified operation or micro-motions of operators which would have specified beginning and specified ending like picking the part or tool, walking, placing, fixing etc. This step is to distinguish the activities whether they are value adding or not.

DST setting: acronym of DST is Designed standard time. The time for which customer intends to pay for. Hence, each value-added element is assigned with respective standard time according to firm's DST manual and these values may vary from firm to firm including allowances.

OST setting: acronym of OST is Operational standard time and it's the time required to perform the standard operation. Here, low value added activates are also assigned with respective times according to firm's OST manual including the allowances.

OST time combines both values added and low value-added activities [9].

All the possible elements were generalized into 25 categories in entire line tabulated in the following Table 1.

The particulars in above table are shown as sample one. The codes seen in the table, GPC2, GPL2, HAM5, GPL4 and GPF2 are to represent the elemental type. These codes contain elemental category and level of handling with parts. Elemental category involves picking, locating, and fixing of spare parts and tools. Level of handling parts is based on weight of part i.e., small, medium, and large parts.

All the operations were recorded by a video camera while letting the operator performing given job normally. Then, the operations were observed keenly, based on which, elements were broken down and noticing the respective times to each element with help of stop watch. Similarly, elemental split-up and OST sheets were prepared for all stations in the assembly line so that all the activities are analysed.

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Table 1: OST setting sheet

S.No	Elemental study	category	Cumulative time (sec)	Individual time (sec)	time (min)	DST reference	DST (min)	units	final DST (min)	OST (min)
1	order sheet confirmation	checking	1	1	0.02	-	0.00		0	0.01
2	picking the part	picking	3	2	0.03	GPC2	0.05	1	0.05	0.05
3	walking to car body (3 steps)	walking	5	2	0.03	-	0.00		0	0.03
4	opening the door	door operation	6	1	0.02	-	0.00	1	0	0.01
5	placing part temporarily in the car	transient placement	7	1	0.02	-	0.00	1	0	0.01
6	waling to the tool kart(2 steps)	walking	9	2	0.03	-	0.00		0	0.02
7	picking the bolts	picking	11	2	0.03	-	0.00	2	0	0
8	picking the gun	picking	12	1	0.02	-	0.00	1	0	0
9	walking to car body (2 steps)	walking	14	2	0.03	-	0.00		0	0.02
10	picking part from temporary place	picking	15	1	0.02	-	0.00	1	0	0.01
11	cover removal	removing	16	1	0.02	-	0.00		0	0.02
12	walking to dust bin (1 step)	walking	17	1	0.02	-	0.00		0	0.01
13	placing covers in bin	peel off	18	1	0.02	-	0.00		0	0.02
14	walking to car body (1 step)	walking	19	1	0.02	-	0.00		0	0.01
15	positioning the part in the car	positioning	21	2	0.03	GPL2	0.04	1	0.04	0.04
16	adjusting it in car	adjust part	22	1	0.02	-	0.00		0	0.02
17	adjusting the harness	harness routing	24	2	0.03	HAM5	0.03	1	0.03	0.03
18	pre-tightening the bolt to gun with hand	pre-tighten	26	2	0.03	GPL4	0.02	2	0.04	0.04
19	fixing the bolt to car	fix	30	4	0.07	GPF2	0.03	2	0.06	0.06
20	applying torque wrench	torque apply	33	3	0.05	-	0.00	2	0	0.05
21	applying marks on bolt	marking	34	1	0.02	-	0.00	2	0	0.04
22	walking to table(3 steps)	walking	36	2	0.03	-	0.00		0	0.03
23	placing the gun on the table	place	37	1	0.02	-	0.00		0	0
24	walking to next vehicle	waiting	38	1	0.02	-	0.00		0	0

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Mathematically the times are given by
Actual time = OST+ Speed loss
OST = Value adding activity time (DST) + Low value adding activity times

2.1 Analysis

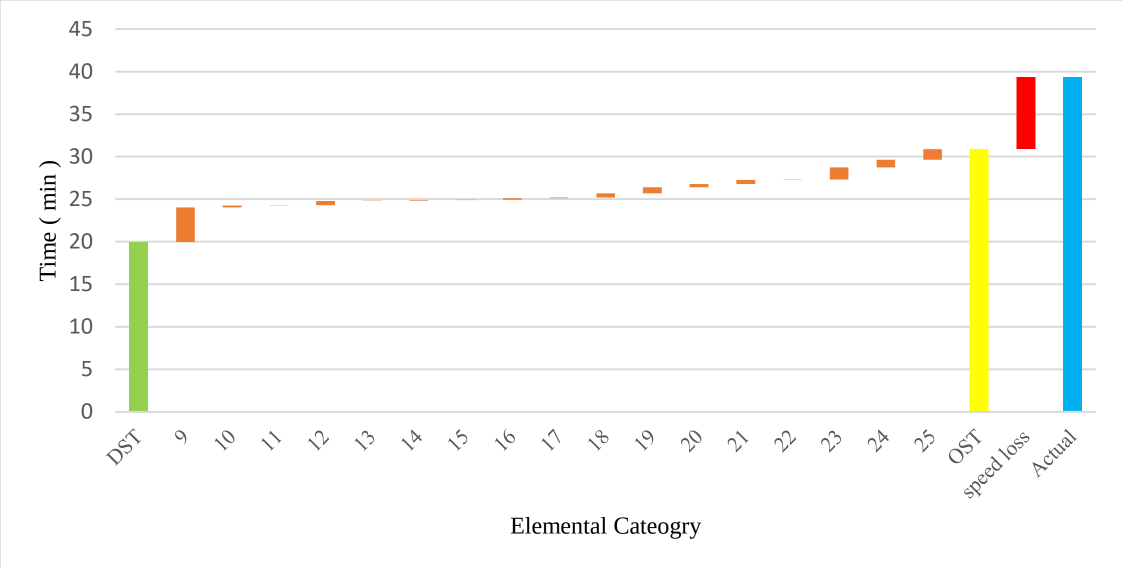
All the elemental times in entire line are summarized in the table and representing their contribution in total cycle time. The times being categorised as value added and non-value-added activities are undergone keen observation to search for any better way. There are total 30 work stations in this line and total cycle time summed up to 39.34 minutes. Due to company's privacy policy, some of exact details are not disclosed in this paper like each work station cycle time as shown in Table 2.

Table 2: Elemental category

S.No	Category	DST (min.)	OST (min.)	Actual (min.)
1	Fixing	9.85	9.85	14.85
2	picking	6.05	6.05	5.55
3	Positioning	2.10	2.10	2.90
4	Harness routing	1.01	1.01	2.11
5	Sticking	0.81	0.81	0.90
6	Feeding	0.04	0,04	0.08
7	Wax application	0.05	0.05	0.30
8	Peel off	0.05	0.05	0.02
9	Walking	0	4.09	5.29
10	Adjust the part	0	0.20	0.25
11	Button press	0	0.03	0.04
12	Checking	0	0.50	0.68
13	Door operation	0	0.06	0.10
14	Dust bin	0	0.06	0.07
15	Greasing	0	0.04	0.05
16	Pre-tightening with hand	0	0.20	0.29
17	Harness reposition	0	0.06	0.12
18	Jig handling	0	0.48	0.59
19	Unpacking	0	0.74	0.85
20	Marking	0	0.37	0.43
21	Removal	0	0.49	0.68
22	Tape taking off	0	0.04	0.04
23	Transient placement	0	1.43	1.48
24	Tool kart motion	0	0.90	0.11
25	Torque apply	0	1.25	1.83
		19.96	30.90	39.34

The pictorial representation of the above table is plotted below taking time along vertical axis and elemental category is taken along horizontal axis.

Figure 3: Elemental category chart



Above Figure 3 shows the individual contribution of each elemental category in total cycle time.

Figure 4: DST vs OST vs Actual

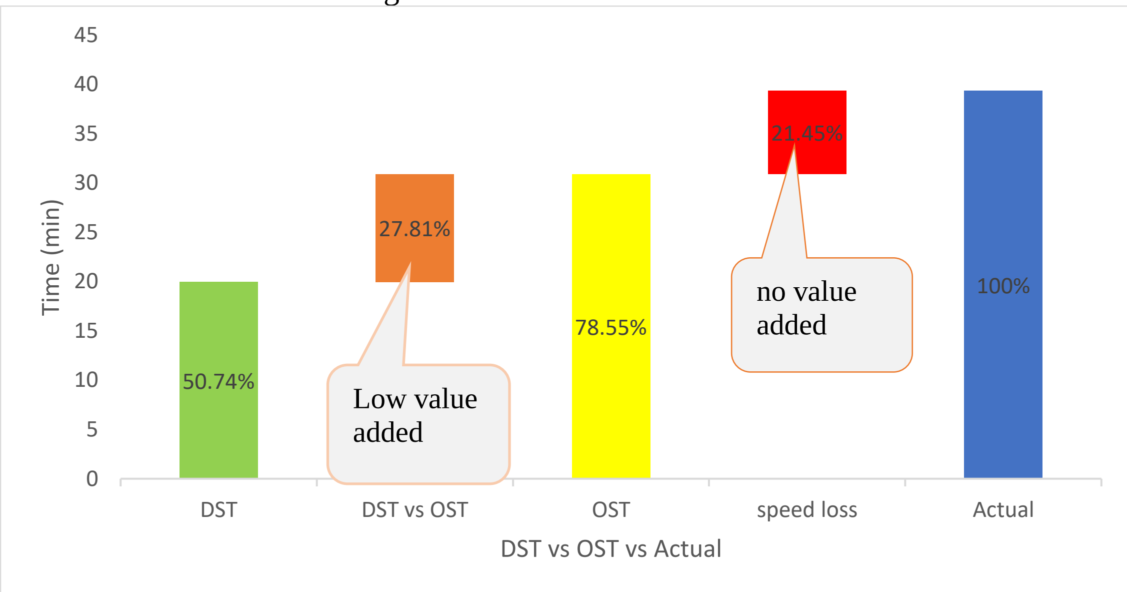


Figure 4 shows the summarized contribution in percentage of various activities in total cycle time. Here, Speed loss is due to both man and machine. Generally, speed loss is of two categories and, they are slow speed and micro stops. Slow speed is considered when machines or assembly lines run slower than the targeted run rate. Micro stops are happened when machine or production line stop briefly and frequently for a while.

By the above analytics, it was clearly seen that 49.26% of total cycle time including both low value-added activities and no added activities can be considered as scope for improvement.

2.2 Kaizen proposal

By observing these key concerns for variation between DST and OST, counter measures are proposed and intimated to respective departments through kaizen sheets. The following can be proposed.

- Layout modification:
  - Screw bin needs to be moved to nearer.

- Tool kart hard movement- smoother rails to be provided.
- Standard waste bin to be provided in kit kart itself.

- Provision of Apron, which has pockets to carry tools and small parts like screws, bolts etc., can reduce the repetitive walking to kit kart and tool kart.
- Packaging can be eliminated for specific parts which can have sufficient resistance to get scratched and can't be visible to customers so that the removal of those covers can be eliminated. And, unpacking can be done in kitting itself such that on-line time can be saved.
- Ergonomic design:
  - Hoist elevation can be altered according to operator's height.
  - Grip for tools should be maintained.
  - Eye catching format in order sheet for quick and easy confirmation
- Training for simultaneous part picking and rhythmic working gestures.
- Commonized parts for all models like clips, screws so that operator can pick screws without confirming the specification.
- Deployment of automation wherever feasible: deploying the DC nut runner can limit the operator to apply torque many times and get tired which can reduce operator fatigue.

2.3 Implementation and maintaining the new system:

After informing the proposed modifications to respective departments, activity schedule was prepared that would tell status of counter measures. The respective team will follow the 'plan, do, check and act' method with the help of kaizen sheet which will be showing the difference between before and after implementation and its contribution towards the cycle time reduction. The reduction of cycle time of each station leads to cut down the total production time for a given volume as shown in Table 3.

Table 3: Counter measures table

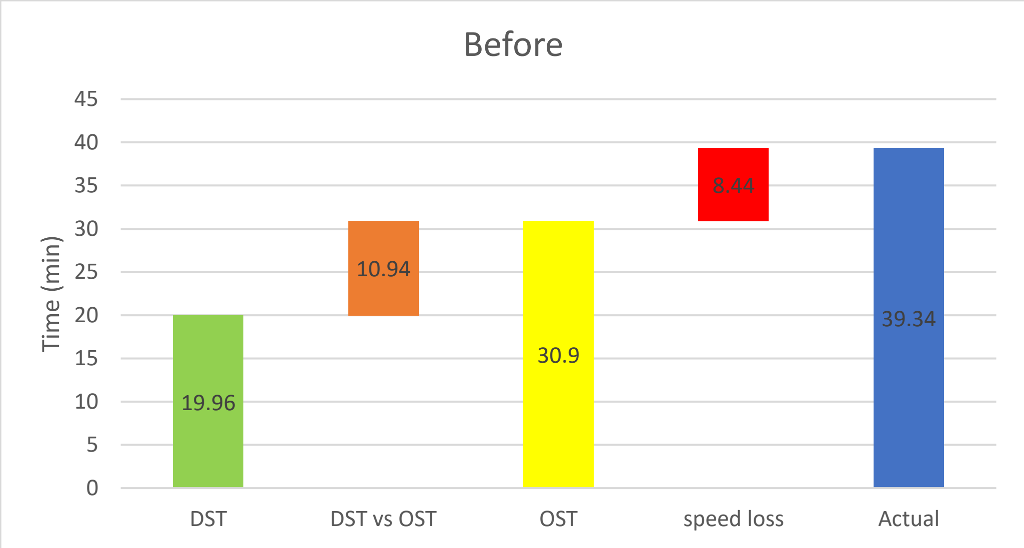
S.no	Concern	Counter measure	Responsible Department	Reduced time (min)
1	Walking	Layout modified	Kaizen	1.79
2	Frequently moving to kit cart	Apron with pockets provided	Store	1.04
3	Unpacking covers and throwing them in dust bin	Unpacking in kitting itself	Logistics	1.13
4	Diversity in parts	Communizing parts	Production engineering	1.01
5	Picking tools and parts successively	Simultaneous picking training	Logistics	0.93
6	Torque applying manually many times with bending leading to fatigue	Deployed DC nut runner	Production engineering	1.91
				7.81

The above table shows the key concern and their respective remedies to minimize the unnecessary activities. Hence, by deploying the counter measures, the time of 7.81 minutes had been reduced in total cycle time.

3. Results and discussions

By implementing the proposed system, it was noticed that the cycle time was minimised from 39.34 min to 31.53 min which is 19.85% reduction from current system.

Fig. 5: Cycle time before implementation of new method



Above Figure 5 shows the elemental category contribution by time in present system i.e. before implementation.

Figure 6: Cycle time after implementation of new method

This above Figure 6 shows the elemental category contribution by time in proposed system i.e., after implementing the recommended modifications by this study.

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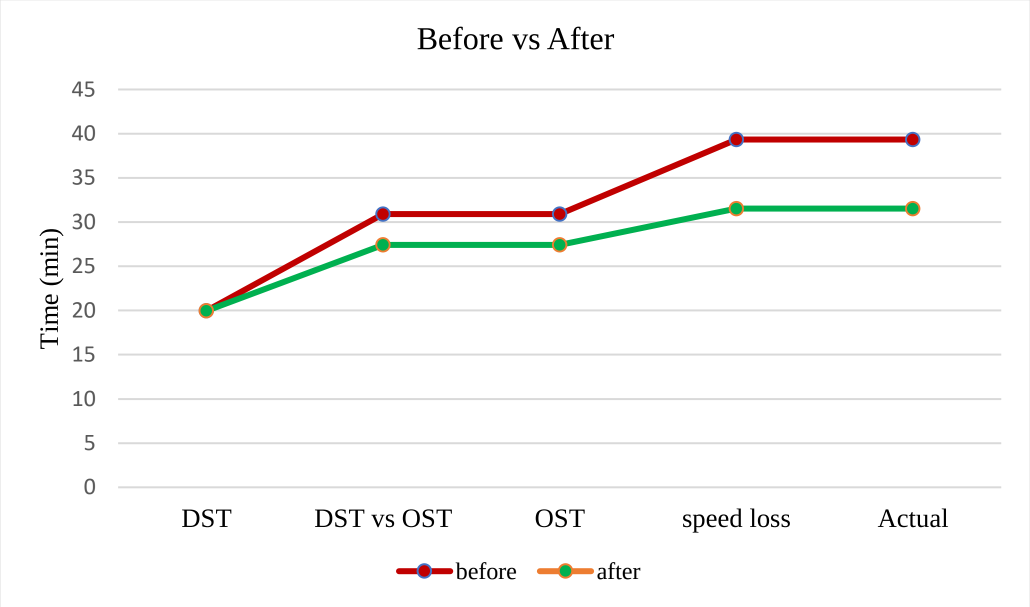
Figure 7: comparison between before and after implementation new method



The above Figure 7 shows the variation in total cycle time between present system and proposed system and it is clear that the proposed system is 7.81 min faster than the present system.

By implementing the proposed ways, it was noticed that the cycle time was reduced from 39.34 min to 31.53 min which is 19.85% reduction from old method. Hence, proposed method is 25% effective compared to existing system.

Mathematically it's represented as proposed system =1.25 existing system.

4. Conclusion

This paper has demonstrated how elemental time study analysis can be applied to an assembly line and it is concluded that the measurement of work can effectively enhance the efficiency of production processes, and the amount of industry's production targets. By implementing this combined mythology, production processes are faster by 7.81 min and hence providing the more availability time for production by approximately 20% when compared with previous system. Therefore, this methodology may be further researched and improved, and applied to other enterprises. But these research findings are from an automotive assembly line of mass production system, so the results may not be applicable to other types of industries. even this methodology has been applied to reduce the total cycle time, it can be noticed that there is still scope for improvement beyond this result. Non - value adding time must be minimized to zero but it's not easy as human actions are involved. Greater productivity can be achieved through fully automation.

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Conflicts of Interest:

There are no conflicts of interest in this work.

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