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Research Paper

Development and Implementation of Productivity Evaluation System: Design Standard Time Ratio

Engineering

KEYWORDS : Design Standard Time Ratio, Design Standard time, Multiple Activity Chart

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ABSTRACT

Automobile industries involve numerous repetitive activities. To improve their produc-tivity and efficiency different tools of Indus-trial Engineering are applied.However,there has not been a way to compare the efficiency of various methods or facilities on the same scale yet. This paper describes the develop-ment and application of a new productivity evaluation system – DSTR (Design Standard Time Ratio) which has universal application.

DSTR is an indication of the productivi-ty of the work station or production unit or plant under study. Lower the value, better the efficiency and utilization of the manpower at that station or production plant. DSTR was applied at different stations in Body Shop in an automobile company and on that basis necessary improvement such as line balancing for effective manpower management, eliminating non-value adding activities, layout/process change for effective floor space utilization etc. were suggested and after verifying decisions were made for applying them at the stations.

INTRODUCTION

Automobile manufacturing facilities involve numerous repetitive activities. This creates the need for applying Industrial Engineering tools and techniques for improving the efficiency and productivity of manufacturing systems. However, because of application of such different techniques for different facilities there has not been a way to compare the efficiency of various methods or facilities on the same scale, yet. This led to the development and application of a new productivity evaluation system – DSTR (Design Standard Time Ratio).

The DSTR is typically an indication of the productivity of the work station or production unit or plant under study. It is nothing but the ratio of the working time of the total workforce deployed to the Design Standard time. The Design Standard Time is the most ideal time required for an operator to complete its job. The Design Standard Time can be derived based on various parameters like the number of parts handled, the layout and the process used. This derived value is independent of the product of the facility under study. Lower the DSTR value, better the efficiency and utilization of the manpower at that station or production plant.

Before calculating DSTR, it is necessary to perform observations of each station, and note the important parameters. Observations are taken into a standard format. It consists of a 'Layout Sheet' which is a modified version of flow diagram of the station, and an 'Activity Sheet' which is similar to a flow process chart. Real time data is collected by direct observation at the station(s) under study. When the layout and activity sheets are ready, a compilation of the parameters for calculating DSTR is done and the value of DSTR for the respective stations or production unit is calculated.

Based on DSTR value and the observation sheets, improvements such as line balancing for effective manpower management, elimination of non-value adding activities, layout/process change for effective floor space utilization etc. are suggested. After verifying and evaluating the suggested improvements, decisions are made for applying them at the station(s) or the production unit.

DATA COLLECTION

For maintaining uniformity in observations of all stations, a standard format has been developed. This format consists of 2 sheets-

1)Layout and Parts Information Sheet:
Layout and Parts Information Sheet is one of the important aspects of DSTR observation procedure. In fact, it is a modified version of a flow diagram. It is divided in 2 main parts: Layout and Parts Details. Approximately the upper 75% portion is dedicated to the space meant for drawing layout. It optionally has dotted gridlines or assembly line markups built in the format if needed.The parts section has columns like serial, part number, part description, quantity per operator, dimensions, weight, category, photo file name etc. as and when required in the study. Part serial numbers are English language alphabets (A, B, etc.).

2) Main Activity Sheet:
Main activity sheet has basic information section at the top, which includes name of the observer, location, operation, equipment, special tools, conditions, quality requirements, operator name and number, fixture details, etc. Second section has table meant for noting the activities done by the operator at the station under study. The columns in this table are serial number, activity, VA/NVA/RNVA, distance, steps taken by operator, etc.

3)PROCEDURET
here are three main phases of the observation procedure – Real-time observation of stations, Preparation of rough layout and activity sheets and Final entry of data in standard formats. These phases have to be repeated for each station and operator, and every time observations are taken.

1) Phase I–Real-time observation of stations:
In first phase, observer has toobserve basic details about the station, such as the overall operation, number of operators, parts fitted, dimensions of the station etc. After noting the details, layout preparation can be started.

2) Phase II – Preparation of rough layout and activity sheets:
This includes preparation of a base layout denoting the positions of fixtures, storage racks, tools, worker'smovements etc. Information about the parts is noted and every part is assigned an alphabet (A, B, C etc.). Then, part details like part number, description, etc are noted. The same alphabets are shown on the layout in the respective positions of storage of parts at that particular station. If at any station, the number of parts exceeds 26, the next parts are assigned double alphabets (such as AA, AB etc.) and so on.

Finally, information about the tools used by the operator is noted, and assigned a unique identifier as suggested in the con-

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ventions chart. E.g.Spot welding guns are given Gc and Gx codes and so on.

3) Phase III – Final entry of data in standard formats:
Completion of phase III enables not only the observer, but also anyone else studying or analyzing the activity at the station, to identify the operation easily and precisely.

Finally, the standard format output of the observation procedure gives nothing but different values to be put in calculation formula, which will generate the value of DSTR. This value, along with the detailed final copy then is useful for suggesting improvements in the current situation.

CONVENTIONS
For easy interpretation of any diagram or chart, there should be some well-defined conventions. While drawing a layout of the standard format, it is not possible to accommodate all textual information in it. Some of these conventions and symbols along with their implications which are used in the DSTR study are listed in the table below-

Table-1
Conventions

Sr. no	Convention	Type	Title	Comment
1.	GC1, GC2	Tool	Gun-spot welding	C type gun
2.	GX1, GX2	Tool	Gun spot welding	X type gun
3.	N1, N2	Tool	Gun nut-runners	Nut runner
4.	C1,C2	Tool	Gun CO2 welding	For CO2 welding
5.	A,B,C,D, etc	Part	Parts-all types	Alphabetical representation of parts
6.	L0,L1,L2, etc	location	Location/ fitment spot	Location of fitment or spot on vehicle
7.	RED	Path	Tool motion	Motion for getting & parking tools*
8.	ORANGE	Path	Part motion	Motion for getting & placing part*
9.	GREEN	Path	Intermediate motion	Motion from one location to another location*
10.	PINK	Path	Motion for control panel	Motion for clamping& unclamping*
11.		Arrow	Direction of paths	Different operators

(*motion of operator)

5. ANALYSIS
Sample layout of FD70 & FD80 LH(front door sub assembly) in BIW shop (body shop)shows 1 person working on each station i.e. fixtures FD 70 (LH & RH), FD 80 (LH & RH).Therefore, there are 4 persons in all working on these four stations FD70 &FD 80 LH and RH. Locations of parts, spots on fixture and parking positions of CO2 gun and nut runner are shown. The paths shown are those taken by the operator while working. For easier interpretation, please refer conventions. L3, L4, L7 and L6 denote the location of the trolleys from. N1 and N2 denote position of nut runner. A and B indicate the position of the bins containing hinge and M8 bolt respectively. The following observations were made-

- Cycle time of FD 70 LH and RH= 4.2 min.
- Cycle time of FD 80 LH and RH = 1.3 min.
- Thus, total cycle time = 5.5 min.
- Thus idle time of 1 operator on FD 80 LH was 4.2min (initially) & 4.2-1.3 = 2.9 min (in each cycle)
- Same was the idle time of 1 operator on FD 80 RH station.
- Thus total idle time of both the operators = 2.9x2 = 5.8min (in each cycle)

Multiple Activity chart () of Original situation for 3 cycles is shown below-

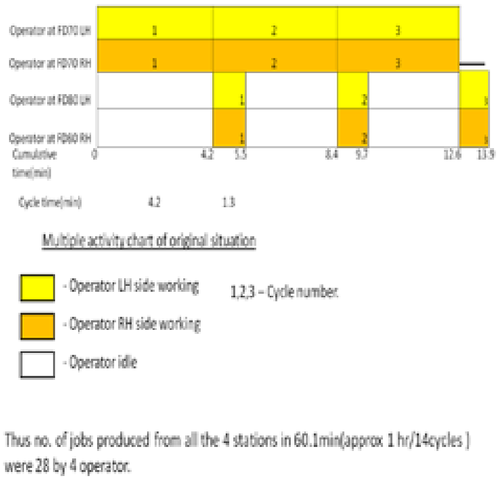

Fig .1 Multiple Activity chart of original situation

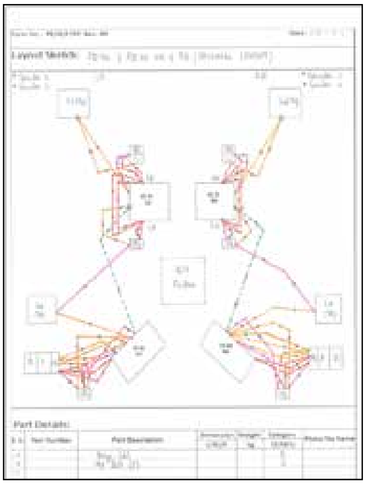

Fig. 2 FD 70 & FD 80 LH & RH (Original layout)

SOLUTION
In huge industries, it is required to evaluate every production unit in each facility on a universal scale for effective management and expansion decisions. Design Standard Time Ratio (DSTR) serves as a solution to this.

DSTR is an indication of the productivity of the work station or production unit or plant under study. It is the ratio of the Design Standard Time to the working time of the total workforce deployed. One major difference that separates DSTR from any other evaluation methods is that DSTR is independent of the product of the facility under study. It is however dependent on the layout and process at the work station which can be altered to achieve the desired DSTR.

Total workforce includes direct as well as indirect manpower. This means, not only the operator(s), but also the supporting manpower is considered. Design Standard Time (DST) is the ideal target time for an operator to complete the operation at a particular station. Calculation of DSTR should be as simple as possible, since we need to repeat the whole procedure at each work station under study. Also, use of DSTR for comparison must be as motivating as possible, so that it becomes an industry standard in the coming future.

In the method adopted to calculate DST, "the No. of parts fitted, the No. of tool uses and repositions, the No. of push button clamps etc." parameters must be multiplied by specific multiplying factors. These Multiplying Factors are derived by studying all similar manufacturing units. Similar activities are grouped together along with their MOST times, and the weighted mean averages of these times are taken as the multiplying factors for determining the Design Standard Time.

They are not the outcome of the same unit or any simulated study. These values come from data which is gathered in real-time at the other manufacturing units. This makes DST, and in turn, DSTR a truly universal comparison scale.

The formula for calculating DSTR is-

$$DSTR = \frac{\text{Working time} \times \text{deployed manpower}}{\text{Design standard time}}$$

Where,Design Standard Time can be derived based on various parameters like the number of parts handled, the layout and the process used. This derived value is independent of the product of the facility under study. It is based on the following factors –

1. Small parts handled
2. Medium parts handled
3. Large parts handled
4. Threaded parts hand-fitted
5. Non-threaded fasteners hand-fitted
6. Threaded parts fastened using tools
7. Welding spots
8. Push button clamps
9. Manual clamps
10. Welding gun repositions
11. Spot welding gun getting and parking

Working time – Time for which each of the deployed manpower works. Total available working time for the operator excluding breaks is considered as the working time. This time is 470 minutes per shift per operator.

Deployed Manpower –Total number of direct manpower, indirect manpower and other services is considered as the total deployed manpower. Direct manpower includes all the operators working at the respective station / production unit. Indirect manpower is the people responsible for material handling and logistics.

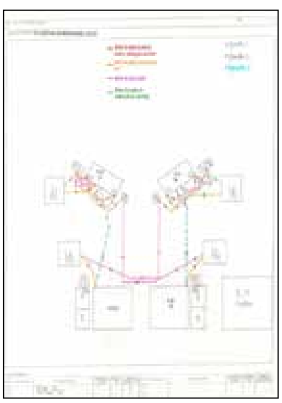

Fig. 3 FD70 & FD80 LH & RH (Improved layout)

Calculations-

1) Calculation of Design Standard Time -

Table-2
Data obtained from observation sheets

Sr.no	1.	2.	3
Activity	Get/Place large arts	Threaded arts using tool	Get/place small parts
Frequency/Job	4	8	4
Multiplication Factor*	5	20	2.5
Time(sec)	20	160	10

*(for representation purpose only)

1) TOTAL (Design Standard Time in seconds) =20+160+10=190
DST (in minutes per job)= 190/60=3.17
Total jobs produced per day@12jph(jobs per hour) = (12*470)/60 = 94 jobs
Therefore, DST for 94 jobs=94*3.17=297.98min

2) Calculation of Total Working Time -
Direct manpower deployed=4
Indirect manpower deployed=1
Total deployed manpower=4+1=5
Working time per person per day=470min

3) Calculation of DSTR-

$$= \frac{\text{Working time} \times \text{deployed manpower}}{\text{Design Standard Time}}$$

DSTR = 7.89
The DSTR values for stations FD 70 and FD 80 LH and RH in BIW is 7.89. The ideal DSTR value is 1. From the value derived it seemed clear that there was huge scope for improvement at these stations so that the efficiency and productivity of these stations can be increased to get a better economical output. The improvements were in the form of layout change, manpower reduction, less material flow, etc. which are shown below.

7. IMPROVEMENTS (DSTR IMPLEMENTATION)
To reduce the huge amount of idle time and to increase utilization and productivity it was necessary to develop a new method.The location of fixtures FD 70 LH & RH and FD 80 LH & RH along with the position of trolleys(i.e. L3, L4, L6, L7), control panels(i.e. CP1, CP2, CP3, CP4, CP5, CP6), bins containing hinge and bolts(i.e. A & B) and position of nut runners(i.e. N1 & N2) were changed in such a way that all the activities can be carried out by 3 operators instead of 4, output remaining same.Fixtures FD 80 LH & RH were brought closer to each other such that the work at these stations can be done by 1 operator instead of 2 operators.Bins A & B, nut runners (N1,N2), control panel(CP2 & CP6) were also brought closer to the fixtures FD 80 (LH & RH respectively) so that the excessive movement between bins and fixtures is reduced. This helps in fatigue reduction of the operator thus improving his efficiency as well. The improved layout is shown below with 3 operators working on 4 stations-

Calculations-
Calculation of Design Standard Time of improved situation-

Table – 3
Data obtained from observation sheets

Sr.no	1.	2.	3
Activity	Get/Place large parts	Threaded parts using tool	place small parts
Frequency/Job	4	8	4
Multiplication Factor*	5	20	2.5
Time(sec)	20	160	10

*(for representation purpose only)

TOTAL (Design Standard Time in seconds) =20+160+10=190
DST (in minutes per job) = 190/60=3.17
Total jobs produced per day@12jph (jobs per hour) = (12*470)/60 = 94 jobs
Therefore, DST for 94 jobs=94*3.17=297.98min

2) Calculation of Total Working Time -
Direct manpower deployed = 3
Indirect manpower deployed = 1
Total deployed manpower = 3+1 = 4
Working time per person per day = 470min

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3) Calculation of DSTR-

$$DSTR = \frac{\text{Working time} \times \text{deployed manpower}}{\text{Design Standard Time}}$$

= (470*4)/297.98

DSTR = 6.1

The DSTR value of original situation was is 7.89 and that of improved situation is 6.1. The decrease in the DSTR value indicates the improvement at the stations which is in the form manpower balancing. As already mentioned, the ideal DSTR value should be 1. This indicates that there is still huge scope for improvement.

Following observations were made of the improved situation-

- Cycle time of FD 70 LH and RH = 4.2 min.
- Cycle time of FD 80 LH and RH = 1.3 min. (cycle time will remain same as no process is changed)
- Thus idle time of 1 operator on FD 80 LH & RH
  = 4.2 min (initially) &
  4.2- 2.6 = 1.6 min (in each cycle)

Idle time for operator on FD 70 RH
=1.3min (after 1st cycle)

Multiple activity chart of improved situation for 3 complete cycles is shown below-

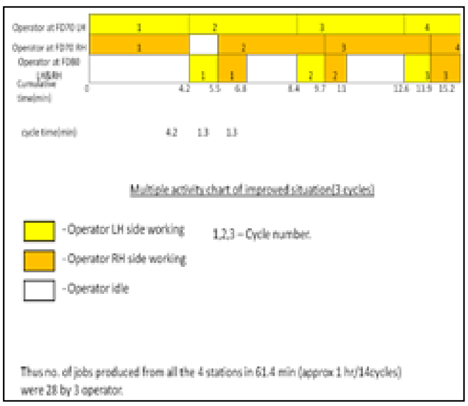

Fig.4 Multiple Activity chart of improved situation

8. RESULTS

The implementation of DSTR on station FD70& FD 80 included changing location of fixtures, racks, control panel, tools. This change resulted in reduction of man power. As already mentioned earlier there was 1 operator assigned on each station, thus in all 4 operators were working on these 4 stations. The fixtures of station FD 70& FD80 were reallocated and fixed in a manner which can let a single person to work on both stations. Hence, reduction of manpower is observed. It has affected parameters such as labor utilization percentage, productivity of labor and cost of labor which are analyzed below (Telsang, Martand [2006]).

1) Labor utilization percentage (for 14 cycles/approx 1 hour):

Labor utilization percentage =
Total operator man minutes/hour –Idle time/hour
Total operator man minutes/hour

a) For original situation=65.08%
b) For improved situation=85.38%
c) Percent increase in labor utilization = 23.78%

2) Cost of labor per product/hour:

Cost of labor/product =
No. of operators * cost of labor/hour
Number of products produced

Let us assume cost of labor/hour=Rs.250
a) For original situation=35.71Rs
b) For improved situation=26.79Rs
c) Percent decrease in cost of labor per product=24.97%

Though it is true that reallocating the fixtures is a lengthy and somehow cost carrying process, the benefits for the stations and for the production shop overallis long term.

3) Overall productivity of labor in terms of unit's produced/hour/employee (for 14 cycles/approx 1 hour):

Overall Productivity of labor =

Total production/hr

Total no. of operators
a) For original situation = 7units/op/hr
b) For improved situation = 9units/op/hr
c) **Percentage increase in overall productivity of labor = 28.57%**

CONCLUSIONS

DSTR is typically an indication of the productivity of the work station or production unit or plant under study

Using DSTR value, the efficiency and utilization of the manpower at that station or production plant can be calculated. And lower the value more is the efficiency and utilization.

Based on DSTR value and the observation sheets, improvements such as line balancing for effective manpower management, elimination of non-value adding activities, layout/process change for effective floor space utilization etc. are suggested. After verifying and evaluating the suggested improvements, decisions are made for applying them at the station(s) or the production unit.

It can be applied on universal scale. Its application does not depend on the product of the facility under study.

The cost of reallocation of fixtures with no overhead, suspended tools, or welding guns, as is the case considered here, is very less and the cost is one time investment.Also, the work of fixture reallocation can be completed in few hours.Thus, the above improvement by fixture reallocation and the resulting manpower reduction can prove beneficial in improving the productivity.

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