

# Comparison of two methods of bolt and washer assembly

Ayush Anand<sup>1</sup>

<sup>1</sup>Student, Department of Production Engineering, BIT Mesra, Jharkhand, India

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**Abstract** - Ergonomics is defined as an appropriate design for people, the design of systems, processes, equipment and environments so that tasks and activities required of them are within their limitations but also make the best use of their capabilities (Salvendey, 2012). The function of specialists in ergonomics is to design or to improve the workplace, equipment, and procedures for workers to ensure the safe, healthy, and efficient achievement of personal and organizational goals. Poor work layout leads to fatigued, frustrated and hurting workers. In the present paper, two methods of bolt and washer assembly have been compared using some general ergonomic procedure, which was well verified using some software like Minitab, CATIA etc. According to the stats and results, the better method had been chosen among the two and was verified that the principle of motion economy is well applied in the final case.

**Key Words:** Bolts and washers; RULA analysis; Spaghetti diagram; Normal distribution plot; Two hand process

## 1. INTRODUCTION

The first step towards reducing ergonomic risks in a production system is to devise methods to understand and characterize the risk events (Montgomery et al. 2009). By making improvements to the work process, workers are provided with a job that is within their body's capabilities and limitations. Ergonomics can have a profound impact on any organizations like cost reduction, productivity and quality improvement and safety culture. This particular experiment is being done to find out the best work layout and working procedure for the assembly of bolt and washer among two proposed method, which had been proven theoretically and experimentally. A general and systematic procedure had been used which are following:

- Critical examination
- Two hand process chart
- Normal probability plot
- Standard worksheet chart ☐ RULA (Rapid upper limb assessment) analysis

These above tools would help us to optimize the procedure.

Hardware used:-

Decimal minute stopwatch, stock bins, bolts, steel washer, leather washers, rubber washers

Software used:-

MINITAB, CATIA

## 2. PROCEDURE

### 2.1 Critical examination

In method study, recording is always followed by a critical examination of that recorded date. The examination should be critical but impartial. So examination is just a technique to check the significance or bottlenecks of a process (Jayaram et al. 2006). But which activities to be examined first and now, are the points to be kept in mind while examination. A critical examination table, table 1 had been made to keep an eye on the methods used.

Primary questions		Secondary questions	
Established facts	Why	Alternatives	Proposal
<b>(What)</b> 1.Assembly of bolts and washers	Class lab work	Buy assembly products	No change
<b>(How)</b> 1.Assembly using both hands	Normal practice	Use fixture	Fixture
2.Assembled thing placed in a bin	To be used for future	Stored in gravity feed	Gravity feed
<b>(Where)</b> 1.On a table of height approx. 100 cm	Better for lumbar and thoracic	Using machine	No change
<b>(Who)</b> 1. Students	Custom and practice	Machines	No change

Table- 1: Critical examination table

### 2.2 Practical observations

A person was made to do assembly of washer and bolts in both methods, say method 1 and method 2.



**Fig- 1:** Method 1 setup

In the method 1, a person had to do assembly of one washer and one bolt at one time. The right hand would be used to bring a washer and left hand would be used to bring one bolt which would be assembled using both hands and then being put in an another bin. This would be repeated till all the assembly has been done. Now, the time had been recorded for every assembly as in table 2.

**Table- 2:** Method 1 time analysis

S. No	Assembly time for one bolt and washer(in sec)				Mean( sec)	Range(sec)
1	6.89	7.13	7.23	6.64	7	0.59
2	6.93	7.2	7.25	6.68	7.17	0.57
3	6.13	7.1	6.8	5.73	6.44	1.37
4	6.31	7.5	6.7	6.1	6.88	1.4
5	6.25	6.6	7.1	7.21	6.79	0.96
6	7.23	7.4	6.7	7.39	7.18	0.7
7	6.5	7	7.2	6.21	6.85	0.99
8	6	8.3	7.2	10.06	7.89	4.06
9	5.9	6.9	7.5	7.54	6.96	1.64
10	6.5	8	7.3	8.2	7.5	1.7

In the method 2, a person had to do assembly of two bolt and washer at a time by inserting the bolts into grooves.



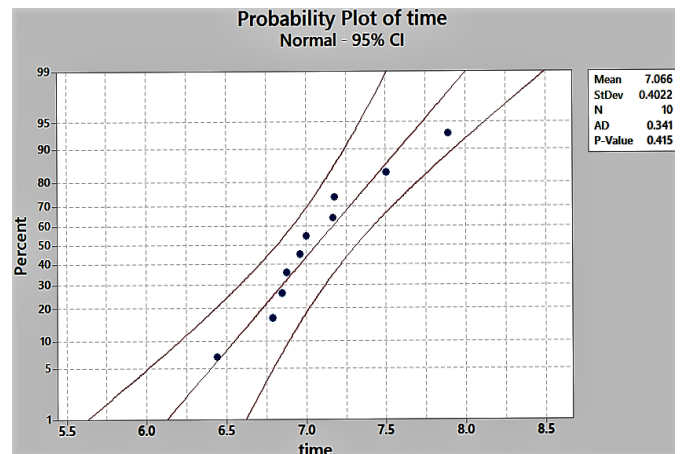
**Fig-2:** Method 2 setup

**Table 3:** Method 2 time analysis

S. No	Assembly time for one bolt and washer(in sec)				Mean( sec)	Range(sec)
1	11.53	13.01	10.59	12.91	12.01	2.42
2	11.4	12.1	10.9	11.0	11.36	1.2
3	9.9	11.6	10.3	8.	10.05	3.2
4	10.5	9.83	9.76	10.37	10.31	0.74
5	8.9	9.8	9.2	10.6	9.57	1.7
6	10.1	10.86	11.1	9.38	10.36	1.72
7	10.5	11.2	11.3	10	10.8	1.3
8	11.2	12.1	11.8	8.1	9.89	4
9	10.5	9.1	10.6	9.36	10.80	1.5
10	9.1	10.2	11.2	9	9.85	2.1

### 2.3 Normal probability plot

A normal probability plot had been plotted for the above observations. This plot helps in the evaluation of both old and new method. The plotting had been done in MINITAB with 95% confidence interval.



**Chart-1:** Normal distribution plot for method 1

The mean time for assembly of a bolt with the washers, as shown in fig.3 comes out to be 7.066 seconds. The black dots in the above figure are the observation values from table 1.

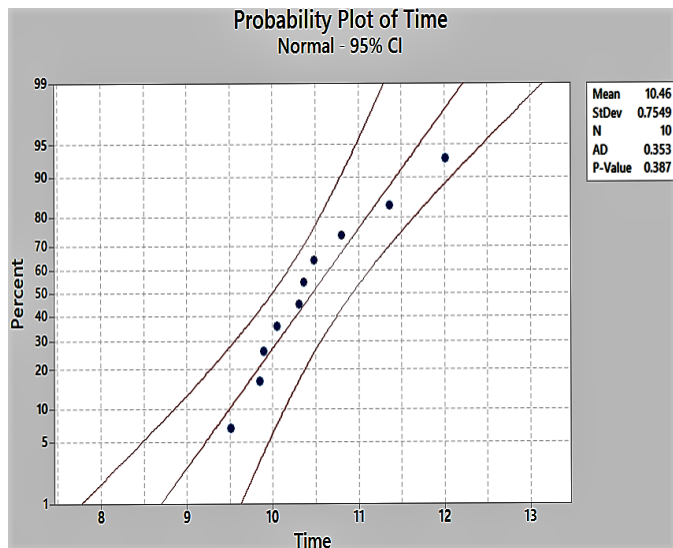


Chart -2: Normal distribution plot for method 2

### 2.4 Two hand process chart

A chart in which the activities of a workers hands (or limbs) are recorded in their relationship to one another. Generally used for repetitive operation, when one complete cycle of the operation is to be recorded.

It is being done for both the observations.

Table -4: Process chart for method 1








Left-hand activity	Symbol	Right-hand activity	Symbol
Moving hand to bolt	<-----	Moving hand to washer	----->
Picking bolt	0	Picking lock washer	0
Moving to assembly	----->	Moving to assembly	<-----
Assembly	0	Assembly	0
Holding bolt	D	Picking steel washer	0
Holding bolt	D	Moving steel washer	<-----
Assembly	0	Assembly	0
Holding bolt	D	Moving hand to pick nut	----->
Assembly	0	Assembly	0
Storage	Δ	Delay	D

Table -5: Process chart for method 2

Left-hand activity	Symbol	Right-hand activity	Symbol
Moving hand to washer	<-----	Moving hand to washer	----->
Picking lock washer	0	Picking lock washer	0
Moving to fixture	----->	Moving to fixture	<-----
Drop in fixture	0	Drop in fixture	0
Move to leather washer	0	Moving hand to leather washer	----->
Picking leather washer	0	Picking leather washer	0
Moving hand to fixture	----->	Moving hand to fixture	<-----
Assembly in fixture	0	Assembly in fixture	0
Moving hand to steel washer	<-----	Moving hand to steel washer	----->
Picking steel washer	0	Picking steel washer	0
Moving to assembly	----->	Moving to assembly	<-----
Assembly	0	Assembly	0
Moving hand to bolt	<-----	Moving hand to bolt	----->
Picking bolt	0	Picking bolt	0
Moving to assembly	----->	Moving to assembly	<-----
Storage	Δ	Storage	Δ

The symbols used have the following significance:-

Fig-3: Process chart symbols meaning

Sym	Name	Action	Examples
	Operation	Adds Value	Saw, Cut, Paint, Solder, Package
	Transport	Moves Some Distance	Convey, Fork Truck, OTR Truck
	Inspect	Check For Defects	Visual Inspect, Dimension Inspect
	Delay	Temporary Delay/Hold	WIP Hold, Queue
	Storage	Formal Warehousing	Warehouse or Tracked Storage Location
	Handle	Transfer Or Sort	Re-Package, Transfer To Conveyor
	Decide	Make A Decision	Approve/Deny Purchase

(<http://tohproblemkyahai.com/left-hand-right-hand-chart-two-handed-process-chart/>)

### 2.5 Standard worksheet chart (spaghetti diagram)

The path followed by a worker in doing assembly had also been analyzed on a standard worksheet chart for the both method.

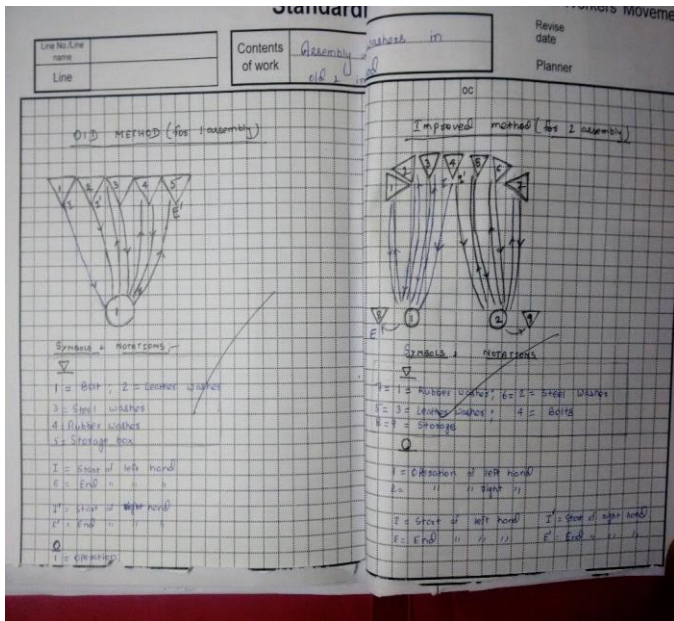


Fig -4: Standard worksheet chart

This helps in evaluating the movements of both left and right hand which is fertile and productive. Clearly, method 2 involves in fewer movements of limbs.

### 2.6 RULA analysis

Rapid Upper Limb Assessment (RULA) was developed to evaluate the exposure of individual workers to ergonomic risk factors associated with upper extremity MSD (McAtamney, Lynn, and Corlett 1993). The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities.

So, a RULA analysis has been carried out for both the posture and the RULA score helps in finalizing best posture for a particular method. This had been performed in CATIA.

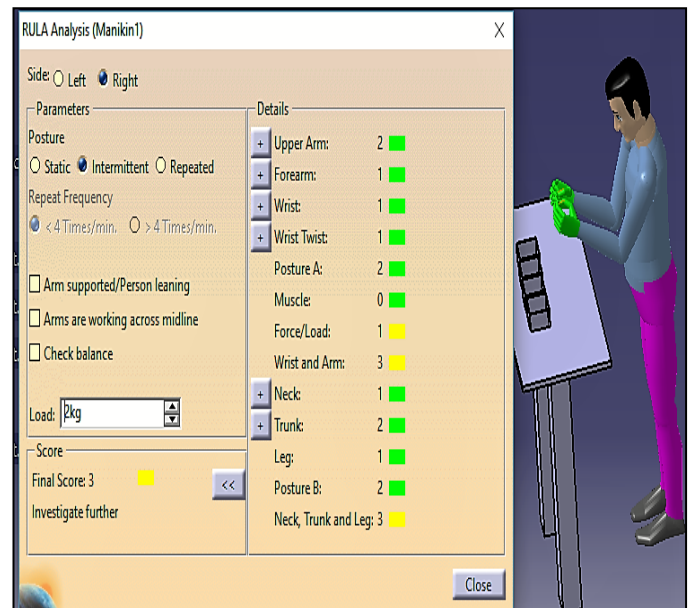


Fig -5: RULA analysis for method 1

For method 1, as shown in fig.7, arms were not leaned on any support and gravity load has been considered while arms were doing the assembly.

The final score for this observation was Rank 3.

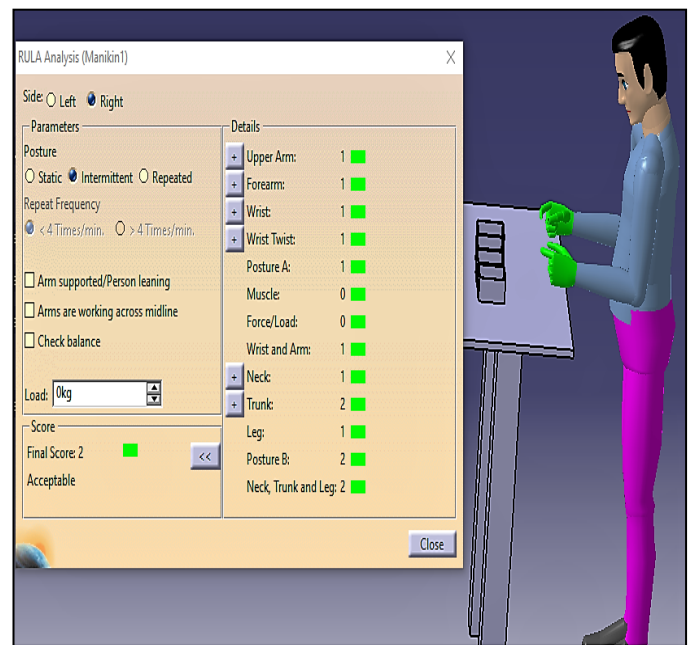


Fig -6: RULA analysis for method 2

All the input were same in both method except that in improved method, worker arms were leaning and have good support.

The final score for this observation was Rank 2.

### 3. RESULT AND DISCUSSION

As inferred from all the above procedures, method 2 is better in all the perspective from method 1 and this method should be processed while doing assembly of bolts and washers. Also, method 2 is being able to incorporate all the principles of motion economy.

### 4. ACKNOWLEDGEMENT

The present work is an effort to compare the bolt and washer assembly using different aids. The work would not have been possible to come to the present shape without the able guidance, supervision and help by Dr. Vijay Kumar Singh sir, and my HOD Dr. Vinay Sharma sir. With deep sense of gratitude, I acknowledge my department and my colleagues who helped me for completion of my project.

### 5. REFERENCES

- [1] Azzalini, Adelchi, and Alessandra Dalla Valle. "The multivariate skew-normal distribution." *Biometrika* 83, no. 4 (1996): 715-726.
- [2] Basu, Amit, and Robert W. Blanning. "A formal approach to workflow analysis." *Information Systems Research* 11, no. 1 (2000): 1736.
- [3] Burke, Michael J., Sue Ann Sarpy, Kristin Smith-Crowe, Suzanne Chan-Serafin, Rommel O. Salvador, and Gazi Islam. "Relative effectiveness of worker safety and health training methods." *American journal of public health* 96, no. 2 (2006): 315-324.
- [4] De Looze, M. P., J. W. Van Rhijn, J. Van Deursen, G. H. Tuinzaad, and C. N. Reijneveld. "A participatory and integrative approach to improve productivity and ergonomics in assembly." *Production Planning & Control* 14, no. 2 (2003): 174-181.
- [5] De Verdiere, Alain Colin. "Lagrangian eddy statistics from surface drifters in the eastern North Atlantic." *Journal of Marine Research* 41, no. 3 (1983): 375-398.
- [6] Haines, Helen, John R. Wilson, Peter Vink, and Ernst Koningsveld. "Validating a framework for participatory ergonomics (the PEF)." *Ergonomics* 45, no. 4 (2002): 309-327.
- [7] <http://tohproblemkyahai.com/left-hand-right-hand-chart-two-handed-process-chart/>.
- [8] Jayaram, Uma, Sankar Jayaram, Imtiyaz Shaikh, YoungJun Kim, and Craig Palmer. "Introducing quantitative analysis methods into virtual environments for real-time and continuous ergonomic evaluations." *Computers in industry* 57, no. 3 (2006): 283-296.

[9] McAtamney, Lynn, and E. Nigel Corlett. "RULA: a survey method for the investigation of work-related upper limb disorders." *Applied ergonomics* 24, no. 2 (1993): 91-99.

[10] Montgomery, Douglas C., George C. Runger, and Norma F. Hubele. *Engineering statistics*. John Wiley & Sons, 2009.

[11] Pheasant, Stephen, and Christine M. Haslegrave. *Bodyspace: Anthropometry, ergonomics and the design of work*. CRC Press, 2016.

[12] Salvendy, Gavriel. *Handbook of human factors and ergonomics*. John Wiley & Sons, 2012.

[13] Zhu, Yuejian. "Ensemble forecast: A new approach to uncertainty and predictability." *Advances in atmospheric sciences* 22, no. 6 (2005): 781-788.

### BIOGRAPHY



**Mr. Ayush Anand** is currently pursuing his BE (Third year) in production engineering from BIT Mesra, Ranchi.