"A Computer based novel approach of ergonomic study and analysis of a workstation in a manual process"

Mr. Gurunath V. Shinde[1], Prof.V.S.Jadhav[2]

[1]*PG student, Department of Mechanical Engineering,*

Government College of Engineering, Karad, (Maharashtra-India), Pin-415124

[2]*Professor, Department of Mechanical Engineering,*

Government College of Engineering, Karad, (Maharashtra-India), Pin-415124

Abstract

Productivity of a manual workstation depends upon proper ergonomic design of workstation and human behaviour. Study of ergonomics helps to identify complex tasks which lead to less efficiency of worker. Various approaches have been developed including direct observations, questionnaires, interview, etc. for ergonomic evaluation of workstation. With increasing applications of computer, Computer based ergonomic study has been found to be more efficient and accurate. This paper discusses use of various computer tools for ergonomic study with applications of different IE tools. Complex issues have been identified and analyzed and finally suggestions are made for improvement.

Keywords: *Ergonomics, Productivity, IE tools, Computer etc.*

1. Introduction

Poor ergonomic of workstation and work method causes fatigue to workers which leads to less productivity of workstation. To analyze and improve ergonomic and work methods various scientific approaches are used for study. One of them is video recording and sampling of work, benefit of video recording includes no frequent data collection is needed, easy to analyze by computer tools and better accuracy. Different researchers have proposed methods of ergonomic study including direct observations, interviews, and use of archived data. Low cost and simple ergonomic method for ergonomic study have been used e.g. subjective assessment, direct observation , use of archived data and noise assessment. These findings are useful in solving Occupational Health and Safety problems in electronics industries [1].Ovako Work Assessment System (OWAS) method is used to assess area of discomfort repeated by operators by filling the survey questionnaire prior than analysis being done. WinOWAS software is used for modelling and analyzing working postures [2].Review has been done for various approaches whose aim is to achieve the ergonomically design of workstation for better productivity. Two approaches finally proposed as more efficient than the traditional [3]. New version of VIDAR software which runs on mobile and digital camera has been developed for ergonomic study. Further three different ways of using method are compared. Three different ways of usage are a person sees a film of himself, a person seen someone else in work and a group sees some one in work [4].Study has been done to analyze strategic change from old assembly work method to new assembly work method using multiple methods like recording and video analysis, questionnaire, interview and flow simulation [5]. Ergonomic study on manual component insertion in PCB assembly line has been done using method of questionnaire, direct interview and archived data [6]. Study of operator performance in repetitive assembly task has been done for comfort analysis [7].

2. Concept of ergonomics of workstation:

While working on machine or workstation one need to handle lots of tasks like material handling, tool handling, control system operating etc. For each of these tasks different members of human body are co-coordinating with different resources. State of working involves standard sequence of different motions of machine and human, if workers are not following specific sequence of motions it results into poor efficiency of worker and lead to less productivity of workstation. Ergonomic of workstation involves effect of workstation design and layout on worker's perception towards behaviour with machine, tool and resources like bins, control button etc. Ergonomic study is important to identify non-value added activities, frequent movements, complex tasks, fatigue causing factors etc.

This paper discusses a novel approach used for ergonomic study of workstation in welding shop facing

problem of low productivity. The ergonomic study of assembly process at workstation reveals bottlenecks in work method. Typical workstation involves four kinds of resources like man, machine, material, method (4m).These four factors are responsible for productivity of workstation.Fig.no.1.shows fishbone diagram that reveals how productivity depends on these factors,

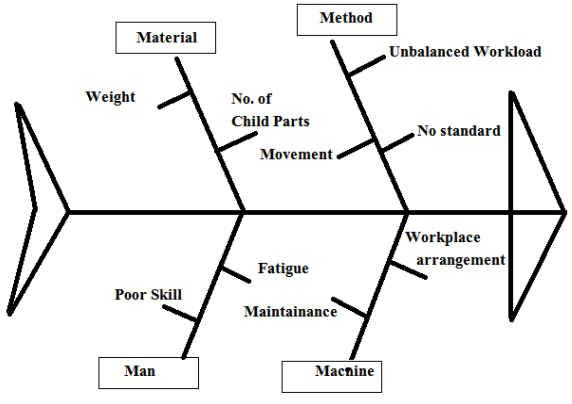


Fig.no.1.Fishbone diagram for productivity of station

As shown in the fishbone diagram productivity depends upon four factors as described below:

a) Material:

Task of material handlings and its technique effects the total cycle time of workstation. Also attributes like size, shape, weight etc. are also important factors regarding material which cause low or high productivity.

b) Method:

Every manufacturing process has its own standard sequence of motions. Proper motion sequence affects on worker's efficiency which leads to productivity of workstation. Poor method of work procedure also leads to unbalanced workload amongst different workstations.

c) Machine:

The workstation design and layout greatly effects workers efficiency. Proper ergonomically designed workstation causes less fatigue amongst the worker. Also every workstation has its own state of work i.e. busy, idle, breakdown, maintenance that also effects on productivity of workstation.

d) Man:

Efficiency of worker decides output of workstation. Efficiency of worker depends upon skill level of worker, his behaviour with machine, work design etc. poor skill and work design causes more fatigue to the workers and hence less productivity of workstation.

3. Motion Study:

For productivity improvement particularly in assembly process smooth operations is a need, and to achieve this objective there is need to go in details of body and hand movements so as to eliminate some unwanted movements and thus best possible and most economical pattern of movements can be developed to perform a work or activity [8]. Frank Gilbirth developed technique of making motion film of an operation which can be analyzed by breaking down it in small frames. Thus each frame represents single element of motion of an operation. Girlbirth defined these basic motion elements for human body movements; he named it as "therbligs". For each therblig, Gilbirth has defined a particular code representing element of an operation.

4. Basic procedure of motion study:

***Step 1:* Conduct time study on bottleneck workstation**

The preliminary time study of workstation is carried out by using electronic timer or stopwatch. The use of electronic digital timer is more suitable than stopwatch for accuracy and range.

***Step 2*: Set up high definition video recorder on workstation:**

After manual measurement of cycle time set-up for recording video of an operation is prepared. For recording of motion film high definition cam recorders are advised to use as near as possible to the target object provided that camera frame should cover total region of focus. Camera lens axis should be perpendicular to motions of worker and machine. Work environment should be provided with good lighting facility. It is advised to shoot target object at least 2-3 different angles so complex movements should be analyzed in good manner.

***Step 3*: Analyze the motion film using video editing tools:**

Recorded movie should be analyzed by projecting film on big screen to get clear vision of complex task. These tasks are marked by using video

editing tools like window live movie maker, the inbuilt software of windows operating system from Microsoft®.

***Step 4*: Prepare permanent record chart of results:**

Once motion films are analyzed, results are permenentatly recorded in SIMO chart, two hand process chart, why-why sheet etc.

***Step 5*: Suggest improvements for complex tasks:**

Analysis and recorded facts gives root cause for complex tasks, hence complex tasks can be simplified by suggesting alternative for doing the same task in most standard form.

5. Therbliigs analysis:

Therbligs are observed for each complex task which leads to discomfort related to different body members as shown by different colored portion in fig.2.

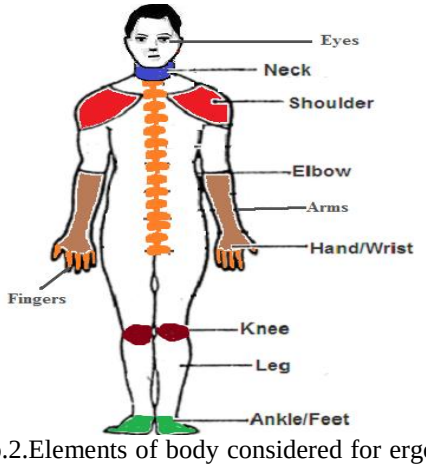


Fig.no.2.Elements of body considered for ergonomic study

Fig.3.shows that motion film of case study of assembly workstation. The left hand side shows running film at speed of 0.125X and the right side shows film breakdown in small elements for each body motion. These elements are nothing but frames which shows particular activity done by worker e.g. frame 1 shows loading of part 1 i.e. left end of frame is the start of picking part and right end is the end of frame means loading part to station. These activities belong to therbligs "grasp (G)" and "transport loaded (TL)".

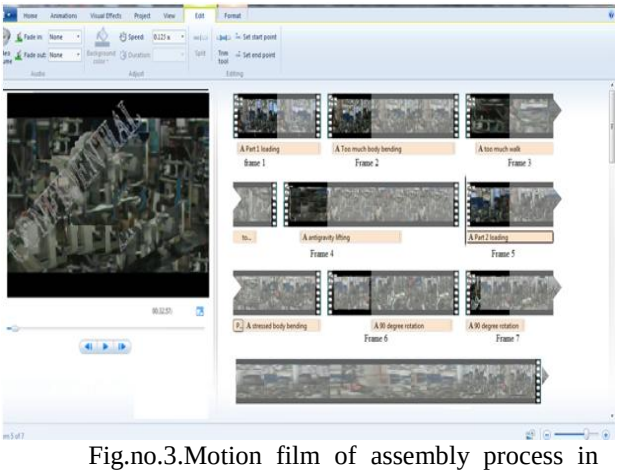
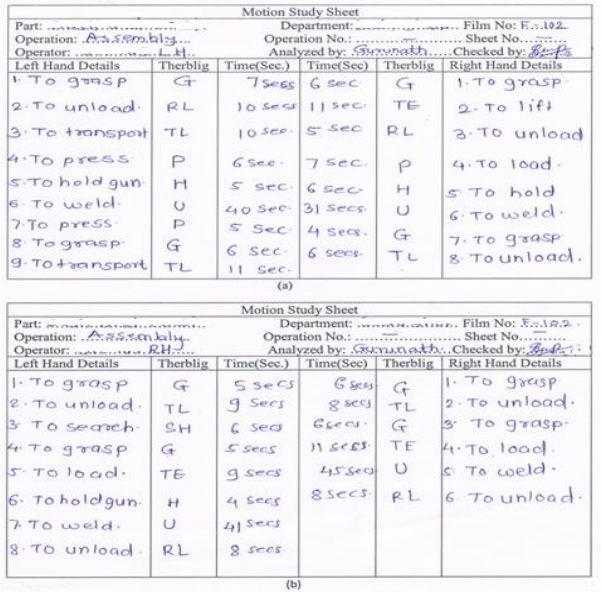


Fig.no.3.Motion film of assembly process in windows movie maker

6. Results:

6.1. SIMO chart:

Fig.no.4.shows SIMO chart prepared for both workers on left side and right side. SIMO Chart consists of details of left hand tasks and right hand tasks for each worker. For each tasks noted under column details has been coded with therblig as shown in column therblig next to each task. For each task, time has been recorded as shown.



Motion Study Sheet

Left Hand Details	Therblig	Time(Sec.)	Time(Sec)	Therblig	Right Hand Details
1. To grasp	G	7secs	6 sec	G	1. To grasp
2. To unload	RL	10 secs	11 sec	TE	2. To lift
3. To transport	TL	10 sec	5 sec	RL	3. To unload
4. To psess	P	6 sec	7 sec	P	4. To load
5. To hold gun	H	5 sec	6 sec	H	5. To hold
6. To weld	U	40 sec	31 secs	U	6. To weld
7. To press	P	5 sec	4 secs	G	7. To grasp
8. To grasp	G	6 sec	6 secs	TL	8. To unload
9. To transport	TL	11 sec			

(a)

Motion Study Sheet

Left Hand Details	Therblig	Time(Sec.)	Time(Sec)	Therblig	Right Hand Details
1. To grasp	G	5 secs	6 secs	G	1. To grasp
2. To unload	TL	9 secs	8 secs	TL	2. To unload
3. To search	SH	6 secs	6 secs	G	3. To grasp
4. To grasp	G	5 secs	11 secs	TE	4. To load
5. To load	TE	9 secs	45 sec	U	5. To weld
6. To holdgun	H	4 secs	8 secs	RL	6. To unload
7. To weld	U	41 secs			
8. To unload	RL	8 secs			

(b)

Fig.no.4 (a) and (b) SIMO chart for LH and RH worker

6.2. Why-Why Analysis:

Root cause of each complex task has been found out using why-why analysis. Root cause of problems is considered for five basic categories such as 3S (structures, systemize, sanities), AS (Automation system assistance), Design, E & T (education and training). Fig.5 shows the why-why analysis results. From root cause it is easier to suggest modification for simplifying work.

Physical Phenomenon : Complex Body Movements					
What is the final suggestion :Improve Workstation layout and modify tool, training					
	Why you have taken above action?	**Due to**			
Why 1	Why workers do complex movements?	Complex area working			
Why 2	Why complex areas?	Clamping and shape of parts			
Why 3	Why clamping and shape problems?	Tool not reaches to target area			
Why 4	Why tool not reaching?	Design of workstation and tool geometry			
Why 5					
Root cause is from following factors		**3S**	**AS**	**Design**	**E & T**
1	Poor Operation condition	√			
2	Lack of skill				√
3	Workplace layout			√	
4	Improper motion sequence				
5	Work content and design				

(a) Factor 1

Physical Phenomenon : Wrong gripping and grasping of objects					
What is the final suggestion : Training and use of jigs					
	Why you have taken above action?	**Due to**			
Why 1	Why workers wrongly grip and grasp?	Size, Shape & weight of objects			
Why 2	Why varying size, shape of parts?	Variety of small parts			
Why 3	Why there is different variety?	Assembly Operation			
Why 4					
Why 5					
Root cause is from following factors		**3S**	**AS**	**Design**	**E & T**
1	Poor Operation condition	√			
2	Lack of skill				√
3	Workplace layout		√		
4	Improper motion sequence				
5	Work content and design				

(a) Factor 2

Physical Phenomenon : Frequent movements around workstation					
What is the final suggestion :Training ,Improve Work Design					
	Why you have taken above action?	**Due to**			
Why 1	Why workers do frequent movements?	Arm of gun not reaching and loading			
Why 2	Why loading problems?	Assembly Operation			
Why 3	Why gun not reaching?	Shape of arms and size of part			
Why 4	Why Shape of arms and size of part?	Original Design			
Why 5					
Root cause is from following factors		**3S**	**AS**	**Design**	**E & T**
1	Poor Operation condition	√			
2	Lack of skill				√
3	Workplace layout			√	
4	Improper motion sequence				
5	Work content and design	√			

(c) Factor 3

Physical Phenomenon : Frequent Antigravity Actions					
What is the final suggestion :Improve Workstation Design and use mechanical Assistance					
	Why you have taken above action?	**Due to**			
Why 1	Why workers do antigravity actions?	Work content lifting process			
Why 2	Why Lifting Process?	More force required than normal			
Why 3	Why more force required?	Weight of objects is large			
Why 4	Why weight of objects is large?	Original Design			
Why 5					
Root cause is from following factors		**3S**	**AS**	**Design**	**E & T**
1	Poor Operation condition	√	√		
2	Lack of skill				
3	Workplace layout			√	
4	Improper motion sequence				
5	Work content and design				

(d) Factor 4

Physical Phenomenon : High Work Content					
What is the final suggestion : Balance workload and add manual or mechanical assistance					
	Why you have taken above action?	**Due to**			
Why 1	Why work designs have high work content?	No. of parts, No. of spots are large			
Why 2	Why large nos.?	Assembly Process and length of parts			
Why 3	Why assembly process have problem?	Involves more no of input parts			
Why 4	Why length of parts is large?	Original Design			
Why 5					
Root cause is from following factors		**3S**	**AS**	**Design**	**E & T**
1	Poor Operation condition		√		
2	Lack of skill				
3	Workplace layout				
4	Improper motion sequence				
5	Work content and design	√		√	

(e) Factor 5

Physical Phenomenon : Frequent Eye Movements					
What is the final suggestion : Improve Layout as per standard					
	Why you have taken above action?	**Due to**			
Why 1	Why Eye Directions are changing frequently?	Workplace Layout			
Why 2	Why Workplace Layout have problem?	Not as per standard (ILO)			
Why 3	Why not proper layout?	Original Layout			
Why 4					
Why 5					
Root cause is from following factors		**3S**	**AS**	**Design**	**E & T**
1	Poor Operation condition	√			
2	Lack of skill				√
3	Workplace layout			√	
4	Improper motion sequence	√			
5	Work content and design				

(f) Factor 6

Physical Phenomenon : Improper Workstation Layout					
What is the final suggestion : Improve layout and training					
	Why you have taken above action?	**Due to**			
Why 1	Why Workstation Layout is improper?	Workers dislocates storage bins			
Why 2	Why workers dislocate storage bins?	Less awareness about workplace layout			
Why 3	Why Less awareness?	Lack of training			
Why 4					
Why 5					
Root cause is from following factors		**3S**	**AS**	**Design**	**E & T**
1	Poor Operation condition				
2	Lack of skill				√
3	Workplace layout			√	
4	Improper motion sequence				
5	Work content and design				

(g) Factor 7

Physical Phenomenon : Noise ,Less illuminations , Smell					
What is the final suggestion : Use of advanced safety devices and training					
	Why you have taken above action?	**Due to**			
Why 1	Why Noise, Less illuminations, Smell have problems?	Less use of safety devices			
Why 2	Why workers not using safety devices?	Less awareness about safety			
Why 3	Why Less awareness?	Lack of training			
Why 4					
Why 5					
Root cause is from following factors		**3S**	**AS**	**Design**	**E & T**
1	Poor Operation condition	√			
2	Lack of skill				√
3	Workplace layout				
4	Improper motion sequence				
5	Work content and design				

(h) Factor 8

Fig.no.5. (a-h) WHY-WHY analysis of assembly process

7. Conclusions:

The novel approach of ergonomic study of a workstation helps in finding out bottlenecks related to less productivity of workers. This study of ergonomics includes application of various kinds of IE tools like fishbone diagram, time study, motion study, SIMO chart, WHY-WHY sheet etc. Since nowadays various computer tools are found to have very effective for various kinds of studies, here we have used of video editing software "Windows Movie Maker" for ergonomic analysis of workstation. Though there are various computer tools are available on internet for free and demo versions which in combinations are used for more effective analysis. This technique of ergonomic analysis is very useful to identify complex tasks and root cause of each complex task which is useful in simplifying it and hence to reduce stress on various workers movements.

Acknowledgement

Our study is greatly acknowledged for managers and workers of company for their kind help for getting any kind of accurate information. We are especially thankful to Principal Dr.prof.R.Y.Patil and Dr.Prof.C.Y.Seemikeri.

References:

[1] Bin W.S., Richardson S. (2010), "*An Ergonomics Study of a Semiconductors Factory in an IDC for Improvement in Occupational Health and Safety*". International Journal of Occupational Safety and Ergonomics (JOSE) , Vol. 16, No. 3, 345–356.

[2] Ismail A.R., Yeo M.L. (2009), *"Assessment of Postural Loading among the Assembly Operators: A Case Study at Malaysian Automotive Industry*". European Journal of Scientific Research. Vol.30 No.2, pp.224-235.

[3] Bossomaier T., Bruzzone A.(2010), "*Scientific approaches for the industrial workstations ergonomic design: a review*". Proceedings of 24th European Conference on modelling and Simulation.

[4] Forsman M., Paulette A.(2003), "*An easy-to-use participative video computer method for ergonomic evolution of complex work*". Proceedings of IEA 2003, Seoul, Korea, Vol.1, pp.592-595.

[5] Neumann W.P., Winkel J.(2006),"*Production System design elements influencing productivity and ergonomics*". International Journal of Operations and Production Management Vol.26.no.8.pp.904-923.

[6] Yeow P.H.P., Sen R.N., (2006), "*Productivity and quality improvements, revenue increment, and rejection cost reduction in the manual component insertion lines through the application of ergonomics*" International Journal of Industrial Ergonomics 36:367–377.

[7] Shikdar A., Al-Hadhrami M., (2007)."*Smart workstation design: an ergonomics and methods engineering approach*." International Journal of Industrial and Systems Engineering. 2(4), 363-374.

[8]Suresh Dalela and Saurabh,(1993). "*Text book of work study and ergonomics*".4th edition, Standard Publishers, Delhi.pp.145-146.

[1]Mr.Gurunath V Shinde is a scholar of M.E.Mechanical Enginineering at Govt.College of Engg.,Karad(MH-India)

[2]Prof. V. S. Jadhav,Mechanical Engineering Dept Govt. College of Engg, Karad(MH-India)