

1 Optimization of Productivity by Work Force Management  
 2 through Ergonomics and Standardization of Process Activities  
 3 using M.O.S.T Analysis-A Case Study

4 Mr Vivek Agnihotri<sup>1</sup>

5 <sup>1</sup> SRMGPC, Lucknow

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8 **Abstract**

9 This paper highlights a methodology developed for standardization in the process activities by  
 10 using Maynard's Operation Sequence Technique and minimization of fatigue among the  
 11 workers in manufacturing line by using Ergonomics. Productivity is the primary goal which is  
 12 to be achieved for any profitable Manufacturing System. Optimization of productivity could  
 13 be achieved by integration of two techniques; which are M.O.S.T and Ergonomics. Thus, this  
 14 research will use Ergonomics as the work study and Maynard Operation Sequence Technique  
 15 (MOST) as the time study method. All this initiated by performing study on the manual  
 16 operators' activities. This case study was conducted at TATA MOTORS Lko Ltd and at a  
 17 small sized manufacturing enterprise VINAYAK Industries, Lucknow. From this study,  
 18 standard time and optimum utilization of man power could be achieved. The necessary  
 19 changes were suggested in the workplace and are successfully implemented. This methodology  
 20 can be used for standardization of time in any manufacturing organization.

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22 *Index terms*— ergonomics most, standard time, sheets, tmu

23 **1 INTRODUCTION**

24 The rate at which a company produces goods or services in relation to the amount of materials and number  
 25 of employees needed. This is usually expressed in ratios of inputs to outputs. That is (input) cost per  
 26 (output) good/service. For calculation purpose, expression of productivity is: Productivity = Output/ Input  
 27 ERGONOMICS (or human factors) is the scientific discipline concerned with the understanding of interactions  
 28 among humans and other elements of a system, and the profession that applies theory, principles, data and  
 29 methods to design in order to optimize human well-being and overall system performance. Ergonomics is  
 30 employed to fulfill the goals of health and productivity. Proper ergonomic design is necessary to prevent repetitive  
 31 strain injuries (RSI), which can develop over time and can lead to long-term disability MAYNARD OPERATION  
 32 SEQUENCE TECHNIQUE (M.O.S.T) is a predetermined motion time system that is used primarily in industrial  
 33 settings to set the standard time in which a worker should perform a task.

34 The main objective is to achieve OPTIMIZATION of the system with integration of M.O.S.T. and Ergonomics.

35 **2 II.**

36 **3 Literature Review**

37 **4 Foundation**

38 The foundations of the science of ergonomics appear to have been laid within the context of the culture of  
 39 Ancient Greece. A good deal of evidence indicates that Greek civilization in the 5th century BC used ergonomic

40 principles in the design of their tools, jobs, and workplaces. One outstanding example of this can be found in the  
41 description Hippocrates gave of how a surgeon's workplace should be designed and how the tools he uses should  
42 be arranged. The archaeological record also shows that the early Egyptian dynasties made tools and household  
43 equipment that illustrated ergonomic principles.

### 44 5<sup>th</sup> Century

45 In the 19th century, Frederick Winslow Taylor pioneered the "scientific management" method, which proposed a  
46 way to find the optimum method of carrying out a given task. Taylor found that he could, for example, triple the  
47 amount of coal that workers were shoveling by incrementally reducing the size and weight of coal shovels until the  
48 fastest shoveling rate was reached. Taylor examined, through time and motion studies, how people carried out  
49 their activities, what movement they made and how much time it took. Next he determined how all operations  
50 could be executed as effectively as possible to produce as much as possible in the minimum amount of time. That  
51 is what is called the 'Taylor system', resulting of course in rushed systems, assembly line production etc.

### 52 6 iii. Early 1900s

53 Frank and Lillian Gilbreth expanded Taylor's methods in the early 1900s to develop the "time and motion study".  
54 They aimed to improve efficiency by eliminating unnecessary steps and actions. By applying this approach, the  
55 Gilbreths reduced the number of motions in bricklaying from 18 to 4.5, allowing bricklayers to increase their  
56 productivity from 120 to 350 bricks per hour.

57 1935 -Essential progress, during the world war when many pilots were required and airplanes became  
58 increasingly complicated, it was discovered that the cockpits were not adequate i.e. logically organized, causing  
59 accidents to happen. This was an essential push in the progress of ergonomics. Edwin Link developed the  
60 first flight simulator. The trend continued and more sophisticated simulators and test equipment were developed.  
61 Another significant development was in the civilian sector, where the effects of illumination on worker productivity  
62 were examined.

63 This led to the identification of the Hawthorne Effect, which suggested that motivational factors could  
64 significantly influence human performance.

65 1949-Origin -The name ergonomics officially proposed at a 1949 meeting of the British Admiralty (July 12),  
66 by Prof. Hugh Murrell. The name 'Ergonomics' officially accepted in 1950. The name Ergonomics was derived  
67 from the Greek words: Ergon -work; Nomosnatural law. First use of the word actually can be traced to a series  
68 of four articles written by Prof. Wojciech Jastrzebowski in Poland in 1857.

69 1952-The Ergonomic Society was formed in 1952 with people from psychology, biology, physiology, and design  
70 in Britain.

71 1957-The Human Factors Society was formed in 1957. In the US "human factors engineering" was emphasized  
72 by the US military with concentration on human engineering and engineering psychology. US efforts also focused  
73 on the "role" of an individual within a complex system. Paul M. Fitts developed a model of human movement,  
74 Fitts's law, based on rapid, aimed movement, which went on to become one of the most highly successful and  
75 well studied mathematical models of human motion.

76 1960-First applied industrial ergonomics group was established by Harry along with Dr. Charles Miller in  
77 United States.

78 1965-The period saw a maturation of the discipline. The field has expanded with the development of the  
79 computer and computer applications.

80 1976-Christensen gave review of ergonomics, expresses the view that the fact that early man specially selected  
81 pebbles, made scoops from bone and fashioned tools and utensils in general, is an indication that those early  
82 hominids showed 'specific, intelligent reactions to the interactions between man and his environment', something  
83 that he considers is the very essence of ergonomics. 1980s-Decade of HCI and software ergonomics.

84 . 1983-Editorial in Ergonomics concerns the issue of attempts to define ergonomics "The strength of ergonomics  
85 is that it does not consider the findings from one discipline to be an irrelevance to the conclusions drawn from  
86 another; it is the interaction between the disciplines that makes ergonomics." Brazilian Ergonomics Society  
87 (ABERGO) founded on November 30.

88 1984-An informal group of the Irish Ergonomics Society was formed in October 1984 and in March 1985 was  
89 accepted as a Regional Group of the UK ii.

90 . [8] 1982-Office of the Society constituted. The Israel Ergonomics Society (IES) founded. 2002-  
91 Macro Ergonomics was defined by Hendricks and Kleiner .The Ergonomics Process model presented takes a "top  
92 down" approach to the design of work systems that carry through to the humanmachinesoftware interface within  
93 the organization. It also takes a "bottom up" approach by engaging employees in the process from the beginning.

### 94 7 Ergonomics Society

95 2004-Lean manufacturing principles were introduced by Liker which strive to eliminate waste, errors and  
96 unnecessary actions and include only those value-added components to enhance the process flow.

97 2007-The Ergonomics process model was implemented .

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98 JULY 2009-The Japan Ergonomics Society as a general corporate juridical body was founded. JUNE 2010-The  
99 1 st annual general meeting of members was held (during the 51 st conference of the JES at Hokkaido University).  
100 Till 2013-55 institutes are been established for research and study in various displines of ergonomics.

## 101 8 III.

### 102 9 Proposed Methodolgy a) The Concept of Ergonomics

103 Ergonomics is the study of designing equipment and devices that fit the human body, its movements and its  
104 cognitive abilities. Ergonomics is concerned with the 'fit' between the user, equipment and their environments.  
105 It takes account of the user's capabilities and limitations in seeking to ensure that tasks, functions, information  
106 and the environment suit each user.

### 107 10 b)

- 108 ? GEMBA Analysis Check Sheet
- 109 ? Posture Analysis Check Sheet
- 110 ? Scoring sheet on the basis of posture analysis check sheet
- 111 ? Summary sheet on the basis of scoring sheet.

112 Here the ergonomic study of any system is done with the help of 4 sheets which decides the fitness of any Unit  
113 on the basis of-1. Safety of the worker with respect to the working environment, machinery and equipments. The  
114 percentage achieved is checked on the basis of Y.G.R Analysis i.e. <40% GREEN, 41-50% YELLOW and >51%  
115 RED.

#### 116 c) The Concept of M.O.S.T.

117 It was considered that all manual operations were combinations of basic elements. So these were isolated  
118 and identified so that methods could be accurately explained and improved. It was reasoned that to reduce the  
119 motion of a task was to reduce the effort and time to perform the task. The result is higher production and  
120 increased service level.

121 M.O.S.T. is used primarily in industrial settings to set the standard time in which a worker should perform a  
122 task. To calculate this, a task is broken down into individual motion elements, and each is assigned a numerical  
123 time value in units known as time measurement units, or TMUs, where 100,000 TMUs is equivalent to 1 hour. All  
124 the motion element times are then added together and any allowances are added, and the result is the standard  
125 time. It is much easier to use form of the older and now less common Methods Time Measurement technique,  
126 better known as MTM.

127 Example-walk three steps and pick up a light package from the floor arise and place the package with some  
128 adjustments on a scale to be weighed.

### 129 11 ? The General Move Sequence Model

130 ? The is used for the spatial movement of an object freely through the air.

### 131 12 Controlled Move Sequence Model

132 ? The is used for the movement of an object when it remains in contact with a surface or is attached to another  
133 object during the movement (e.g., the movement of the object is controlled).

134 Tool Use Sequence Model is used for the use of common hand tools. All time values established using MOST  
135 reflect the effort of an average skilled, trained operator working at an average performance level or normal pace  
136 (3 Miles per Hour). This is often referred to as the 100% performance level that in MOST of skill and effort.  
137 Therefore when using MOST, it is not necessary to adjust times unless they must conform to particular high  
138 task plans used by some companies. This also means that a properly established time standard, using MOST,  
139 MTM or stopwatch study, will give nearly identical results in TMU.

140 IV. 1

## 141 13 EXPERIMENT AND RESULT

142 Total time required for complete manufacturing of 1 piece of shocker head is 7.17 mins According to our  
143 calculations ? Visibility problems of fitment especially in taking videos for the MOST. ? Safety risk involved on  
144 the line due to the use of heavy load machines. ? To cope up with the rate of production. ? Work on some  
145 stations was not according to the station description card of that station.

146 V.

## 147 14 Conclusion

148 The purpose of this RESEARCH was to give an idea of the basic functioning of a real industry. This ANALYSIS  
149 has not only given an exposure to the various techniques employed in production units but also has added a new  
150 dimension to vision of knowledge. It has given the basic idea of the working of an industry and the core of every

151 industry lie its fundamentals MAN MACHINE AND MATERIAL and how the cohesion between them is needed  
152 for the smooth running of any industrial organization.

153 The productivity of any system depends on the INPUT and OUTPUT associated with the work function.  
154 Hence for the overall OPTIMIZATION of any system requires- the fitness of the worker so that it may not lead  
155 to any temperamental or chronic hazard as well as VA/NVA of the product is calculated so that least value of  
156 NVA is invested per product.

## 15 Hence Ergonomics helps in complete WORK

157 FORCE MAANGEMENT of the system. So together the integration of M.O.S.T and ERGONOMICS leads to  
158 OPTIMIZATION of PRODUCTIVITY. <sup>1 2</sup>



Figure 1: 2 ©

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<sup>1</sup>© 2013 Global Journals Inc. (US)

<sup>2</sup>. Posture Analysis Check Sheet © 2013 Global Journals Inc. (US)

INITIAL EVALUATION SHEET				
GEMBA ANALYSIS SHEET				
Area:	Line:			
Operation:	Workforce type:			
GEMBA ANALYSIS	YES	NO	PPE	REMARKS
Fall by persons				
Falling parts				
Collision against fixed r moving obstacle				
Cuts, Wounds				
Crushing, Shearing				
Dragging by mechanical elements				
Projection of particles				
Use of chemical products				
Considerable presence of smoke, aerosols, dust				
Burns				
Contact with live elements				
<b>Incidents/unloading:</b>				
Parts & packaging by frk - lift truck				
<b>Operation carried out by the section</b>				
Changing of tools				
Maintenance				
Noise				
other				

Figure 2:

Observer's Assessment	Worker's Assessment
<p><b>Back</b></p> <p><b>A</b> When performing the task, is the back (select worse case situation)</p> <p>A1 <input type="checkbox"/> Almost neutral?            A2 <input type="checkbox"/> Moderately flexed or twisted or side bent?            A3 <input type="checkbox"/> Excessively flexed or twisted or side bent?</p> <p><b>B</b> Select <b>ONLY ONE</b> of the two following task options:</p> <p><b>EITHER</b></p> <p>For seated or standing stationary tasks. Does the back remain in a <u>static</u> position most of the time?</p> <p>B1 <input type="checkbox"/> No            B2 <input type="checkbox"/> Yes</p> <p><b>OR</b></p> <p>For lifting, pushing/pulling and carrying tasks (i.e. moving a load). Is the <u>movement</u> of the back</p> <p>B3 <input type="checkbox"/> Infrequent (around 3 times per minute or less)?            B4 <input type="checkbox"/> Frequent (around 8 times per minute)?            B5 <input type="checkbox"/> Very frequent (around 12 times per minute or more)?</p>	<p><b>Workers</b></p> <p><b>H</b> Is the maximum weight handled <b>MANUALLY BY YOU</b> in this task?</p> <p>H1 <input type="checkbox"/> Light (5 kg or less)            H2 <input type="checkbox"/> Moderate (6 to 10 kg)            H3 <input type="checkbox"/> Heavy (11 to 20kg)            H4 <input type="checkbox"/> Very heavy (more than 20 kg)</p> <p><b>J</b> On average, how much time do you spend per day on this task?</p> <p>J1 <input type="checkbox"/> Less than 2 hours            J2 <input type="checkbox"/> 2 to 4 hours            J3 <input type="checkbox"/> More than 4 hours</p> <p><b>K</b> When performing this task, is the maximum force level exerted by one hand?</p> <p>K1 <input type="checkbox"/> Low (e.g. less than 1 kg)            K2 <input type="checkbox"/> Medium (e.g. 1 to 4 kg)            K3 <input type="checkbox"/> High (e.g. more than 4 kg)</p> <p><b>L</b> Is the visual demand of this task</p> <p>L1 <input type="checkbox"/> Low (almost no need to view fine details)?            *L2 <input type="checkbox"/> High (need to view some fine details)?  <i>* If High, please give details in the box below</i></p> <p><b>M</b> At work do you drive a vehicle for</p> <p>M1 <input type="checkbox"/> Less than one hour per day or Never?            M2 <input type="checkbox"/> Between 1 and 4 hours per day?            M3 <input type="checkbox"/> More than 4 hours per day?</p> <p><b>N</b> At work do you use vibrating tools for</p> <p>N1 <input type="checkbox"/> Less than one hour per day or Never?            N2 <input type="checkbox"/> Between 1 and 4 hours per day?            N3 <input type="checkbox"/> More than 4 hours per day?</p> <p><b>P</b> Do you have difficulty keeping up with this work?</p> <p>P1 <input type="checkbox"/> Never            P2 <input type="checkbox"/> Sometimes            *P3 <input type="checkbox"/> Often  <i>* If Often, please give details in the box below</i></p> <p><b>Q</b> In general, how do you find this job</p> <p>Q1 <input type="checkbox"/> Not at all stressful?            Q2 <input type="checkbox"/> Mildly stressful?            *Q3 <input type="checkbox"/> Moderately stressful?            *Q4 <input type="checkbox"/> Very stressful?  <i>* If Moderately or Very, please give details in the box below</i></p>
<p><b>Shoulder/Arm</b></p> <p><b>C</b> When the task is performed, are the hands (select worse case situation)</p> <p>C1 <input type="checkbox"/> At or below waist height?            C2 <input type="checkbox"/> At about chest height?            C3 <input type="checkbox"/> At or above shoulder height?</p> <p><b>D</b> Is the shoulder/arm movement</p> <p>D1 <input type="checkbox"/> Infrequent (some intermittent movement)?            D2 <input type="checkbox"/> Frequent (regular movement with some pauses)?            D3 <input type="checkbox"/> Very frequent (almost continuous movement)?</p>	
<p><b>Wrist/Hand</b></p> <p><b>E</b> Is the task performed with (select worse case situation)</p> <p>E1 <input type="checkbox"/> An almost straight wrist?            E2 <input type="checkbox"/> A deviated or bent wrist?</p> <p><b>F</b> Are similar motion patterns repeated</p> <p>F1 <input type="checkbox"/> 10 times per minute or less?            F2 <input type="checkbox"/> 11 to 20 times per minute?            F3 <input type="checkbox"/> More than 20 times per minute?</p>	
<p><b>Neck</b></p> <p><b>G</b> When performing the task, is the head/neck bent or twisted?</p> <p>G1 <input type="checkbox"/> No            G2 <input type="checkbox"/> Yes, occasionally            G3 <input type="checkbox"/> Yes, continuously</p>	
* Additional details for L, P and Q if appropriate	
* L	
* P	
* Q	

Figure 3: Figure :

Exposure Scores Worker's name \_\_\_\_\_

Date \_\_\_\_\_

Back	Shoulder/Arm	Wrist/Hand	Neck																																																																				
<b>Back Posture (A) &amp; Weight (H)</b> <table border="1"> <thead> <tr><th>A1</th><th>A2</th><th>A3</th></tr></thead> <tbody> <tr><td>H1</td><td>2</td><td>4</td><td>6</td></tr> <tr><td>H2</td><td>4</td><td>6</td><td>8</td></tr> <tr><td>H3</td><td>6</td><td>8</td><td>10</td></tr> <tr><td>H4</td><td>8</td><td>10</td><td>12</td></tr> </tbody> </table> <input type="text"/> Score 1	A1	A2	A3	H1	2	4	6	H2	4	6	8	H3	6	8	10	H4	8	10	12	<b>Height (C) &amp; Weight (H)</b> <table border="1"> <thead> <tr><th>C1</th><th>C2</th><th>C3</th></tr></thead> <tbody> <tr><td>H1</td><td>2</td><td>4</td><td>6</td></tr> <tr><td>H2</td><td>4</td><td>6</td><td>8</td></tr> <tr><td>H3</td><td>6</td><td>8</td><td>10</td></tr> <tr><td>H4</td><td>8</td><td>10</td><td>12</td></tr> </tbody> </table> <input type="text"/> Score 1	C1	C2	C3	H1	2	4	6	H2	4	6	8	H3	6	8	10	H4	8	10	12	<b>Repeated Motion (F) &amp; Force (G)</b> <table border="1"> <thead> <tr><th>F1</th><th>F2</th><th>F3</th></tr></thead> <tbody> <tr><td>K1</td><td>2</td><td>4</td><td>6</td></tr> <tr><td>K2</td><td>4</td><td>6</td><td>8</td></tr> <tr><td>K3</td><td>6</td><td>8</td><td>10</td></tr> </tbody> </table> <input type="text"/> Score 1	F1	F2	F3	K1	2	4	6	K2	4	6	8	K3	6	8	10	<b>Neck Posture (G) &amp; D</b> <table border="1"> <thead> <tr><th>G1</th><th>G2</th><th>G3</th></tr></thead> <tbody> <tr><td>J1</td><td>2</td><td>4</td><td>6</td></tr> <tr><td>J2</td><td>4</td><td>6</td><td>8</td></tr> <tr><td>J3</td><td>6</td><td>8</td><td>10</td></tr> </tbody> </table> <input type="text"/>	G1	G2	G3	J1	2	4	6	J2	4	6	8	J3	6	8	10
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J1	J2	J3																																																																					
K1	2	4	6																																																																				
K2	4	6	8																																																																				
K3	6	8	10																																																																				
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<b>Total score for Back</b> Sum of scores 1 to 4 <b>OR</b> Scores 1 to 3 plus 5 and 6 <input type="text"/>	<b>Total score for Shoulder/Arm</b> Sum of Scores 1 to 5 <input type="text"/>	<b>Total score for Wrist/Hand</b> Sum of Scores 1 to 5 <input type="text"/>	<b>Stress</b> <table border="1"> <thead> <tr><th>O1</th><th>O2</th><th>O3</th><th>O4</th></tr></thead> <tbody> <tr><td>1</td><td>4</td><td>9</td><td>16</td></tr> </tbody> </table> <b>Total for Stress</b> <input type="text"/>	O1	O2	O3	O4	1	4	9	16																																																												
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Figure 4:

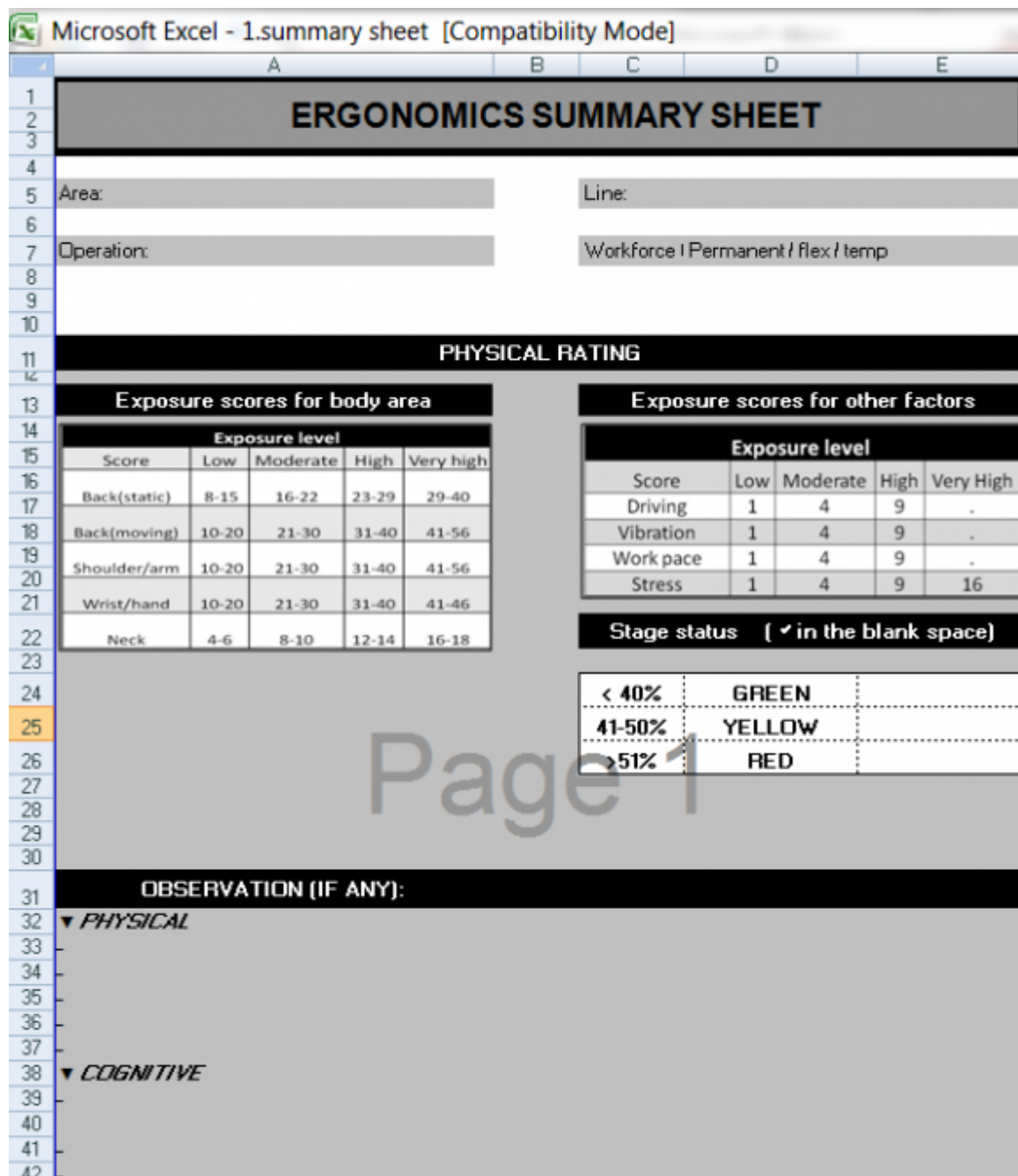
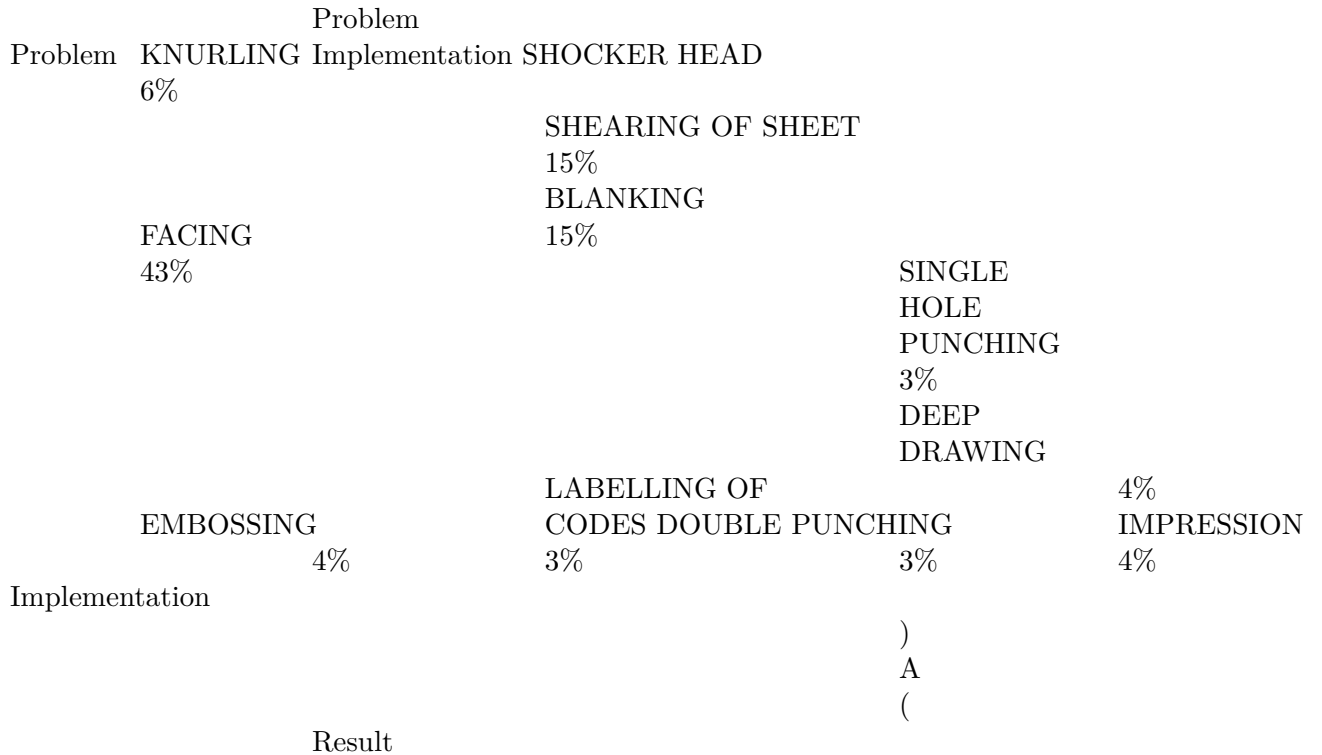


Figure 5:



[Note: Y.G.R ANALYSISRED-Shearing of Sheets (65.48%).Blanking (67%), Impression (50.76%),Labeling of Codes (53%), Facing (57.86%) and Knurling of Bolts (67%).]

Figure 6:

Figure 7:



160  
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Implementation :

Substation or platform of waist height of an average worker was constructed so that loading of crown wheel can be directly done at the platform (without bending) from the palette.

After loading at the platform punching of numbers must take place and then crown wheels must be forwarded towards the furnace .

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