Productivity Improvement: A Work Study Analysis at the Audio Division of Hyundai Mobis India Ltd.

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Work study is the scientific research involving work techniques with the objective of identifying the best way of doing a work. This study performs a work study analysis at the audio division of Hyundai Mobis India Ltd. with the aim to offer suggestions to improve its operational and production efficiency. Primary data was collected from seven work stations of audio manufacturing process, through observation method (i.e., video-recording without the knowledge of the workers). The analysis reveals that the cycle time of all seven work stations is not equal, and the electronic equipments were often found hanging due to high temperature on production shop floor. The study identifies several reasons behind the increase in the cycle time, and accordingly offers suggestions to improve the production efficiency at the audio division.

Introduction

According to ILO, 'Work Study' is a generic term for those techniques, particularly method study and work measurement, that are used for the examination of human work in all its contexts, and which lead systematically to investigation of all the factors which affect the efficiency and economy of the situation being reviewed, in order to seek improvements.

Work study investigates the work done in an organization and aims at finding the best and the most efficient way of utilizing the available resources (man, material, money and machinery) to achieve the best possible quality work in minimum possible time. According to Delmar (1985), the three main goals in work study are: (1) To minimize inventory investment; (2) To maximize the efficiency of the production system; and (3) To improve customer service. To minimize the investment in inventories (idle resources that are waiting to be used), correct resources should be ordered as and when required by the product specification, taking into account tradeoffs between the order of quantity and total unit costs. This will result in reduction of holding costs and

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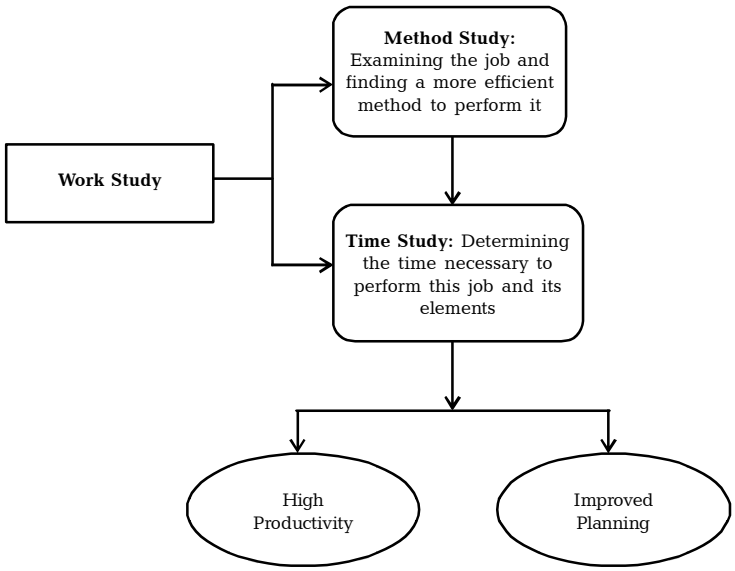
so the efficiency of the production system will improve, and hence, customer satisfaction will flourish because time and cost will be greatly reduced. The above should be carried out by the production planning department. Careful planning of the production system is required to improve efficiency.

Figure 1: Work Study Analysis



Work study is a management tool used to achieve higher productivity in any type of organization, whether it manufactures tangible products or offers intangible services to its customers. Work study helps to systematically analyze the present method of doing a job to develop a new and better method. It can also be used to measure the work content of a job and the time required to do the job for a qualified worker and hence establish a standard time (Figure 1). Presently, the audio division of Hyundai Mobis India Ltd. produces 60 audio units per hour which is far lesser than the capacity of the manufacturing line. Moreover, the productivity of experienced workers is different from that of less experienced workers. Hence, the present paper conducted work study analysis at the audio division of Hyundai Mobis India Ltd. to offer suggestions to improve the production and operational efficiency of the division by establishing the standard time and identifying the major causes that result in longer cycle time.

Literature Review

Sisay (2008) conducted productivity improvement through work study at Gullele Garment Factory in Ethiopia. Most of the enterprises in Far East countries highly utilize the scientific method of work study application. However, in government-owned domestic companies like Gullele Factory, there is a lack of awareness about different

methods, besides the poor working culture developed during the period of command economy. On the other hand, the new private companies are looking forward to following the best practices to improve productivity. The study showed that productivity improvement can be achieved by analyzing operation, motion study, time study, process organization (line balancing) and lay out in Ethiopian garment industry at large.

Wall (1986) performed work study analysis of common sheep handling operations. It was determined that common sheep handling rate is 300-400 sheep/man-hour. However, the observed rates ranged from 240 to 1,143 sheep/man-hour, with the high value achieved when drafting ewes from lambs because this operation did not require assessment of the sheep before the drafting. The study also revealed that the shepherds commonly spent 50-60% of their time treating (or handling) the sheep, while they spent 30-50% of their time unproductively, in moving sheep, and there is clearly a need for improved systems to minimize this unproductive time and thereby increase sheep handling rate.

Elnekave and Gilad (2005) used a digital video-based approach to enhance work measurement and analysis by facilitating the generation of rapid time standards. A genuine description of the work situation is imported into the analytical system via digital video input, thereby enabling a free-of-work site attendance study for evaluating time and work performance. The proposed method serves as a computerized tool for remote work measurement with the ability to derive rapid generation of time standards. The paper verifies the method's ability for rapid generation of time standards through five case studies. It compares the performance of work analysts for conducting a study using the proposed method and the traditional videotape analysis. About 40% of the time devoted to work measurement and analysis can be saved using this technique.

Data and Methodology

The study follows a descriptive research design. The target respondents are the employees at Audio Division of Hyundai Mobs India Ltd. The sample consists of seven work stations of Hyundai Mobis India Ltd. – Audio Division and the seven operators respectively.

Both primary data and secondary data were used for the study. Primary data was collected through observation method. Census sampling technique was used for observation method. Well-recorded video of the audio division work stations was used in collecting the primary data. All the seven work stations and the respective operators were observed and their activities were video recorded without the knowledge of the workers (refer Appendix). Three well-experienced and skilled operators were interviewed for measuring the standard time of the process and to gain an insight into the potential causes that affect the productivity. Secondary data was collected from a previously done company project by S K Lee (Senior General Manager of Hyundai Mobis India Ltd.) at Korea plant. Secondary data was used in different situations like for constructing a decision matrix of worst cause.

Results and Discussion

Temperature and Cycle Time

During the manufacturing process, the equipments were found hanging frequently and hence the cycle time was high. Hence, the data pertaining to different temperatures and cycle time were monitored and recorded. Table 1 presents the cycle time and the recorded temperature for 30 observations.

Table 1: Temperature and Cycle Time

S. No.	Cycle Time (s)	Temp (Degree)	S. No.	Cycle Time (s)	Temp (Degree)
1.	57.8	28.5	16.	62.3	35.2
2.	58	28.4	17.	62.5	35.3
3.	58.5	28.7	18.	63.2	35.4
4.	58.8	29	19.	63.4	35.5
5.	59.2	29.5	20.	62.1	34.5
6.	59.8	30	21.	61.8	34.4
7.	59.9	31	22.	61.2	34.8
8.	60	31.5	23.	60.2	34.5
9.	61.2	32	24.	59.9	34
10.	61.5	32.5	25.	59.5	30
11.	61.6	32.6	26.	58.5	29.5
12.	61.7	33.5	27.	57.9	28.5
13.	61.8	34	28.	57.8	28.2
14.	61.9	34.5	29.	56.9	28
15.	62	35	30.	56.4	28

Subsequently, the following hypotheses were tested:

H_{01}: *High temperature does not affect the cycle time.*

H_{11}: *High temperature affects the cycle time.*

The recorded data was analyzed using regression and ANOVA techniques and the results are presented in Table 2.

It is evident from Table 2 that the calculated *p*-value is less than 0.05. Hence, the null hypothesis is rejected. Thus, it can be concluded that high temperature affects the cycle time of a process.

Table 2: Test Results for Temperature and Cycle Time					
Regression Analysis					
The regression equation is: $C/T = 38.59 + 0.6776\ Temp$ $S = 0.772127$, $R^2 = 86.3\%$, R^2 (Adjusted) $= 85.9\%$					
ANOVA					
Source	***df***	**SS**	**MS**	***F*-Value**	***p*-Value**
Regression	1	109.285	109.285	183.31	0.000
Error	29	17.289	0.596		
Total	30	126.574			

Top Cover Assembly Stage Activities

The various top cover assembly stage activities were observed randomly for 10 different cycles. The corresponding cycle times recorded for the top cover assembly stage activities are presented in Table 3.

Table 3: Cycle Time for the Top Cover Assembly Stage Activities (s)

Number of Activities to Pickup Screw											
Set Pickup	**Putting Jig**	**Top Cover Pickup**	**Top Cover Assembly**	**Spec Label Pasting**	**Bar Code Pasting**	**Tightening 1 Screw**	**Tightening 2 Screws**	**Rotate the Set to Backside**	**Tightening 3 Screws**	**Tightening 4 Screws**	**Check Screws and Mark**
2.32	2.1	3.1	4.5	6.01	6.08	5.69	5.57	2.21	5.87	5.98	2.1
2.32	2.1	3.1	4.5	6.01	6.08	5.68	5.72	2.23	5.87	5.89	2.1
2.42	2.1	3.1	4.5	6.01	6.08	5.67	5.74	2.24	5.84	5.96	2.1
2.52	2.1	3.1	4.5	6.01	6.08	5.69	5.68	2.19	5.82	5.87	2.1
2.62	2.1	3.1	4.5	6.01	6.08	5.49	5.62	2.19	5.78	5.84	2.1
2.52	2.1	3.1	4.5	6.01	6.08	5.45	5.64	2.18	5.79	5.89	2.1
2.52	2.1	3.1	4.5	6.01	6.08	5.47	5.63	2.27	5.82	5.86	2.1
2.52	2.1	3.1	4.5	6.01	6.08	5.98	5.68	2.24	5.86	5.86	2.1
2.52	2.1	3.1	4.5	6.01	6.08	5.68	5.69	2.21	5.84	5.83	2.1
2.42	2.1	3.1	4.5	6.01	6.08	5.75	5.61	2.19	5.87	5.84	2.1

Subsequently, the following hypotheses were tested:

H_{02}: *More movement of the screwdriver in top cover assembly stage activities does not increase the cycle time.*

H_{12}: *More movement of the screwdriver in top cover assembly stage activities increases the cycle time*

The recorded data was analyzed using ANOVA technique and the results are presented in Table 4.

Table 4: ANOVA Results – Cycle Time and Top Cover Assembly Stage Activities

Source	*df*	SS	MS	*F*-Value	*p*-Value
Factor	11	334.9083	30.4462	8818.83	0.000
Error	108	0.3729	0.0035		
Total	119	335.2812			
S=0.05876, R^2=99.89%, R^2 (Adjusted)=99.88%					

It is evident from Table 4 that the calculated *p*-value is less than 0.05. Hence, the null hypothesis is rejected. Thus it can be understood that more movement of screwdriver in top cover assembly stage activities affects the cycle time of audio manufacturing process.

Assembly Work Station and Cycle Time

There are four assembly work stations at the audio division. It was observed that the cycle times of the assemblies are different, as shown in Table 5. Hence, an analysis was conducted to find out whether the assembly work stations influence the cycle time of the manufacturing process.

Table 5: Assembly Cycle Time

Assembly	Cycle Time (s)
ASSY-1	48.7
ASSY-2	46.5
ASSY-3	48
ASSY-4	53.8

Subsequently, the following hypotheses were tested:

H_{03}: *The assembly 4 work station does not affect the cycle time of audio manufacturing process.*

H_{13}: *The assembly 4 work station affects the cycle time of audio manufacturing process.*

It can be said that there are significant differences among stages. It is evident from Table 6 that the calculated *p*-value is << 0.05, hence null hypothesis is rejected. Thus, it can be concluded that ASSY-4 work station affects the cycle time of audio manufacturing process.

Table 6: ANOVA Results – Cycle Time and Assembly Workstation					
Source	***df***	**SS**	**MS**	***F*-Value**	***p*-Value**
Factor	3	301.30	100.43	87.76	0.000
Error	36	41.20	1.14		
Total	39	342.50			
S=1.070, R^2=87.97%, R^2 (Adjusted)=86.97%					

Bluetooth Manual Function Test and Cycle Time

The assembled audio sets are tested for functionality. Bluetooth function test was conducted manually in the audio sets. The impact of manual function test on cycle

Table 7: Cycle Time for Bluetooth Manual Function Test					
Number of Functions					
RF Power On	**BT, iPod Test**	**BT-Module On**	**BT-Add-Up**	**BT-Add-Den**	**BT-Add-Lower**
0.51	2.2	1.7	0.7	0.69	0.69
0.52	2.2	1.75	0.78	0.74	0.74
0.51	2.3	1.78	0.75	0.74	0.74
0.5	2.1	1.69	0.74	0.69	0.69
0.5	2.12	1.71	0.76	0.68	0.68
0.5	2.14	1.74	0.72	0.67	0.67
0.51	2.15	1.75	0.71	0.68	0.68
0.52	2.14	1.74	0.712	0.71	0.71
0.52	2	1.75	0.71	0.72	0.72
0.52	1.98	1.69	0.74	0.71	0.71
Number of Functions					
BT-Add-Upper	**P-Test Mode**	**Pair Level and s/n**	**P-Test Mode Out**	**BT-Model Off**	**RF Power Test**
0.69	0.69	1.89	1.2	1.57	0.71
0.74	0.74	1.75	1.2	1.58	0.71
0.74	0.74	1.78	1.3	1.57	0.72
0.69	0.69	1.89	1.4	1.54	0.72
0.68	0.68	1.78	1.5	1.58	0.71
0.67	0.67	1.76	1.1	1.56	0.69
0.68	0.68	1.78	1.2	1.57	0.68
0.71	0.71	1.75	1.3	1.62	0.67
0.72	0.72	1.74	1.4	1.62	0.67
0.71	0.71	1.72	1.5	1.58	0.69

time was analyzed. The cycle times of various activities in Bluetooth function test are presented in Table 7.

Subsequently, the following hypotheses were tested:

H_{04}: *Bluetooth manual On/Off function does not affect the cycle time of audio manufacturing process.*

H_{14}: *Bluetooth manual On/Off function affects the cycle time of audio manufacturing process.*

It is evident from Table 8 that the calculated *p*-value is << 0.05, hence the null hypothesis is rejected. Thus, it can be interpreted that manual Bluetooth functional test increases the cycle time of audio manufacturing process.

Table 8: ANOVA Results – Cycle Time and Bluetooth Manual Function Test

Source	*df*	SS	MS	*F*-Value	*p*-Value
Factor	11	34.79781	3.16344	1046.23	0.000
Error	108	0.32656	0.00302		
Total	119	35.12436			
S=0.05499, R^2=99.07%, R^2 (Adjusted)=98.98%					

Findings

1. It is observed that there are three audio function testing stages in the manufacturing process. They are: sub- main stage, Audio Radio Testing (ART) stage, and manual function checking stage. In the sub-main stage, the main chassis of audio is checked. The functions checked are: AM, FM, USB, iPOD, Aux, and Area. In the ART stage, fully assembled audio is checked at three different levels, i.e., AM testing, FM testing and CD testing. During the manual function checking stage, all the functions previously checked at sub-main and ART stages are checked manually. Thus, it is observed that the functions are repeatedly checked in all the stages and hence this strongly affects the cycle time.

2. Temperature at the shop floor is not maintained according to electronic material specifications and electronic testing equipment specifications. Temperature updating sheet is also unavailable. It is observed that many testing equipments hang due to high temperature. The production shop floor is not centrally air-conditioned. Data analysis evidently shows that during high temperature the function testing stage takes more time as the testing equipments are not responding properly.

3. It is further observed that in the assembly stages, distribution of work is not equal. The cycle time of the four assembly stages—ASSY-1, ASSY-2, ASSY-3

and ASSY-4—are 49 s, 47 s, 48 s and 54 s respectively. It is clear that the cycle time of assembly stages has to be minimized. The reasons for difference in cycle times are found in the recorded video. A perusal of the recorded video reveals that the number of screw fixings are more in assembly 4 than other assembly stages.

4. During the audio radio testing stage, it is observed that the Bluetooth On/Off manual function increases the cycle time.

5. During screw fixing stage, it is again observed that cycle time is high because of screw pickup delay. Delay in screw pickup is because the screw feeder is kept away from the screw fixing stages. Since movement of screw driver is more, it results in more cycle time.

Suggestions

Based on the findings, three suggestions are made for the management to improve the production efficiency at the audio division.

1. Electronic goods manufacturing company's shop floor should be air-conditioned (see Figure 2).

Figure 2: Shop Floor with Centralized Air-Conditioner

As is	To be
	
Audio manufacturing shop floor without air-conditioner	Audio manufacturing shop floor with air-conditioner

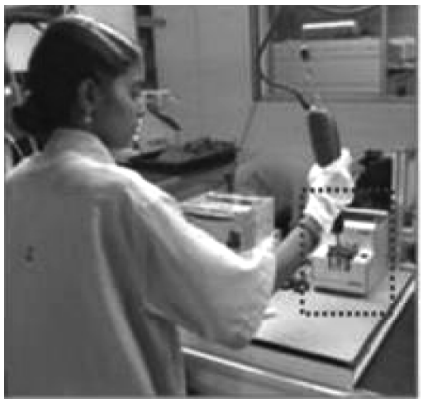
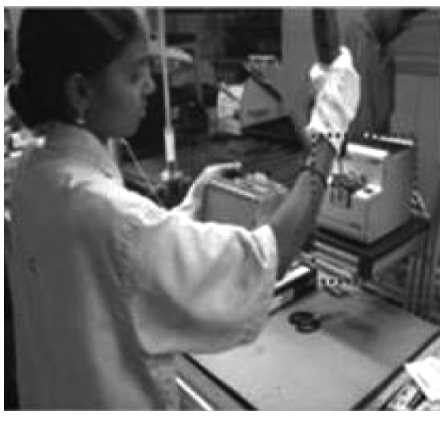
2. There should be sharing of job from higher cycle time assembly stage to lower cycle time stages (see Figure 3).

Figure 3: Job Sharing

As is	To be
	
Mount bracket upper and lower is fixed in the bracket fixing area (Without upper bracket)	In Assy-2 itself upper bracket is fixed because it reduces cycle time in Assy-4. (With upper bracket)

3. Screw driver movement can be reduced by locating feeder at the following location (see Figure 4).

Figure 4: Less Movement of Screw Feeder

As is	To be
	
Screw feeder movement is more	Screw feeder movement is less

Conclusion

This study performs a work study analysis at the audio division of Hyundai Mobis India Ltd. with the aim to offer suggestions to improve its operational and production efficiency. The following are found to increase the cycle time: (a) The functions are repeatedly checked in all the stages and hence it strongly affects the cycle time; (b) Data analysis of temperature reveals that during high temperature the function testing stage takes more time as the testing equipments do not respond properly; (c) The number of screw fixings are found to be more in assembly 4 than in other assembly stages; (d) During the audio radio testing stage it is found that the Bluetooth on/off manual function increases the cycle time; and (e) There is a delay in screw pickup because the screw feeder is kept away from the screw fixing stages. Existing audio production per hour is 60 audio units, and it is far lesser than the capacity which is 72 audio units per hour. By implementing the suggestions offered, the division can increase production by 12 audio units in one shift and 36 audio units (in three shifts) in a day. The manufacturing cost of one audio unit is ₹120. With an increase in the assembly of 500,000 audio units a year, the division can earn around ₹6 cr per year for the organization. ❖

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Appendix

Time Lapse Work Study – Video Recording

Sub-Main Stage

Front Panel Stage

Note: Time interval between the pictures is 4 s.

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