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Original Article

Validation of improvement in changeover of die bond process using basicmost technique

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Abstract

According to the lean manufacturing philosophy, productivity can be boosted via work and time measurement techniques by establishing suitable standard time and work methods. Standard is a level or grade that can be used as a measure for comparative evaluation as a benchmark. It is developed and documented for many evaluations. For the case study, a standard time was developed for the changeover process in die bond, which is a process in the semiconductor company. The standard time was developed for the new improved work elements of changeover process in the company. The work elements in the changeover process were first identified and established. Normal time, a value needed to calculate standard time was obtained by two work measurements namely stopwatch time study and BasicMOST. The non-value-added activities and their respective time in the changeover was identified via the synergy of data from both work measurements with the integration of both quantitative, comparison of normal time and qualitative analysis. In a flow process chart 7 out of 18 work elements were classified as transport activity, which was taken as non-value-added activity, and these took up 39 percent of the changeover time. A total of 7.56 seconds was then excluded from the standard time. The standard time was calculated to be 22.91 minutes using BasicMOST. Since there was only a minor difference in times, less than 27.84 seconds from BasicMOST, the standard time was based on BasicMOST, and the improved work procedures have been validated as effective.

Keywords: standard time, work Measurements, Maynard's operation sequence technique (MOST), BasicMOST, stopwatch time Study

1. Introduction

The current technological era has reigned for decades, and is still expanding rapidly in development and production. Due to this sustainable growth of technology for automation, the demand for semiconductors has been growing consistently. Today, there are many semiconductor-based industries that have become more competitive than ever before. As the competition becomes tighter, an incompetent or stagnant semiconductor company will not survive. In other words, semiconductor companies in this present time must be in continuous improvement for higher efficiency and effectiveness of their product quality and productivity. To increase productivity, namely the measure of output over input, there are two potential ways to do so. The first way is to invest in new machines or equipment that can produce output faster, but this in balance requires large initial investment costs. The second way is to make operating existing machines more efficient, such as in time spent for changeover, whereby a standard time is needed to be developed to measure and act as a guideline.

In general, the lean manufacturing philosophy stated that productivity can be boosted via work and time measurement techniques by establishing suitable standard time and work methods. Standard is a level or grade that can be used as a measure for comparative evaluation as a

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benchmark. It is developed and documented for many evaluations. In manufacturing, a standard time is important as it can be used for controlling costs, scheduling, salary, and budget calculations (Lusia, 2016). Work standardization has an important role in an organization for improved time use, capacity planning, and work methods (Matts, Sadesh, & Prabhukarthi, 2016). With the usage of standard time, a company can be more competitive in terms of productivity, costs, reliability, and safety. Additionally, standards or standard time create the fundamental foundation for development, as consistency of operation can be established through the improvement and corrections from standard time. Manufacturers and process planners can generate better output as it is made based on concrete data instead of wild estimates. With the competitive environment of business, an organization is required to reduce or remove non-added value time of operations and step up the current work techniques (Saravanan *et al*., 2014). Otherwise it will be a great challenge to stay on track with the competition.

Standard time is produced through the addition of allowance time in the normal time that is obtained from the work measurement used. Work measurement is one of two techniques under work study, which will be used to develop standard time in this case study. Work measurement is a work in order analytical tool to identify specific time needed to do important tasks in process, and is usually based on standard time of manual tasks (Harish, Shivappa, & Sangamesh, 2012). There are four ways to develop time standard, namely work sampling, standard data, time study, and work sampling predetermined motion study (Lusia, 2016). In addition to that, time study and motion study are associated with productivity. Stopwatch time study and Maynard Operation Sequence Technique will be put into focus as both will be used in synergy in development of standard time for the changeover operation in this case study, as well as to help determine any non-value added activities in the operation.

Palanisamy & Siddiqui (2013) claimed that reduced changeover time is needed across the industries. By having shorter changeover times and smaller lot size, a company can achieve client requirements of high delivery reliability and short delivery times. In order to maintain competitiveness in the industrial domain, non-value-added time must be removed, work methods should be improved, and time should be standardized (Waghambare, Londhe, Rakibe, Sneha & Sachin, 2016). Efficiency involving both man and machine is greatly influenced by the methodology used in the manufacturing system as non-value-added work will contribute fatigue to operators and ineffectiveness in machine utilization. In addition, the production line undergoes difficulty as operators do not have a standard time for their respective actions and lack methods (Matts, Sadesh, & Prabhukarthi, 2016). Workers will perform inconsistently and the quality of their work results suffers if time standard is absent (Abdul & Daiyanni 2010). To obtain better and true value of productivity, the effectiveness and efficiency are to be used as measurements (Roghanian, Rasli, & Gheysari, 2012). This indicates that feasibility of standard time implementation depends on the effectiveness and efficiency of the measurements used.

The demand for semiconductors and other electrical components is growing larger every day due to growth in industry and adoption of modern technologies. As the time passes, less raw materials are used in these type of products. Without a standard time, operations may suffer from a great variance in work performance, with inability to supervise productivity of operations properly. Workers will perform with inconsistently and the quality of their work results suffers if time standard is absent (Abdul & Daiyanni 2010). Note that a production line suffers when it lacks an established standard time for actions carried out by operators, and from inefficient methods (Matts, Sadesh, & Prabhukarthi, 2016). As time is wasted on non-value-added activities, productivity will drop; cost and price of product may rise and lead to losing to the competitors. According to Saravanan *et al*. (2014), there are two points of views as regards manpower. One of them is the incorrect manpower that is due to production quantity, while the other one is that resource utilization levels relying on the routine the work is performed, and tool is manipulated. In order to overcome manpower defects, measures must be taken to sustain competitiveness and productivity. The semi conductor company has gone through various continuous developments in their changeover operation procedures. Thus, the changeover operation procedure has changed and been revised to be better. The changeover time is the time span at which the machine is not producing output, and this is considered waste time with lack of production. This matter resulted query towards the current standard time data that is used to measure and improve productivity and manufacturing plans. Thus, with that matter in mind, the company found the need to produce a revision or remake of standard time for the changeover. This is so that the standard time used is parallel to the changeover process. In addition, the challenges in changeover time will be the consistency and effectiveness of actions as practiced by the operator. The outcome of the changeover process is linked to good productivity. The development of standard time can be done by using work measurements.

Work measurement is a divided branch of work study and it is used to evaluate effectiveness. Manufacturing unit by performing work study can utilize resources more effectively (Sujay, 2016). Work study is a very effective tool to increase productivity. By using the lean manufacturing philosophy, productivity can be improved by work and time measurement techniques by establishing suitable work methods and standard time. Besides that, time study aids the discovery of bringing positive changes, such as cost and time reduction in human involved processes (Abdul & Daiyanni 2010).

Lusia (2016) said that work measurement is good for an industry to boost up its productivity. Next, Yusoff, Jaffar, Abbas, & Saad (2012) mentioned that the versatility of the research tool called work measurement method can be put into use in measuring jobs or processes either from manufacturing or service industries. Work measurement is a form of knowledge, and with new knowledge we can bring improvements. Oke (2006) discovered that in order to produce a unit of product, the time is directly proportional to the number of stages and times spend in the production. Thus, the author suggested that one should take on more quantitative approaches, such as to determine standard time and work measurement.

There is a total of four types of work measurement methods that can be used to determine standard time of a process. These are work sampling, standard data, time study and work sampling predetermined motion study (Lusia, 2016). However, only two of these four techniques will be used and discussed here. The paper will only cover for stopwatch time study and predetermined motion time system study. The predetermined motion time system used was Maynard Operation Sequence Technique. Stopwatch time study is a work measurement technique for the taking down of times; working rates for a specified job performed in certain conditions and then analyze the data collected to produce a standard time to act as a benchmark of performance. The purpose of the time study is to remove nonvalue added work in the most effective manner. Maynard Operation Sequence Technique (MOST) is a work measurement technique developed to gather standard time of work elements to enhance work methods by maximizing utilization of resources. Work measurements used for the case study were stopwatch time study and BasicMOST. Both stopwatch time study and MOST require the identification of work elements of the specific process before the method can be used to develop a normal time or standard time. Time study approach is more towards manual data taken on the site while MOST is more towards analytical approach using parameters and index values. However, each method shares the same criteria as a quantitative approach.

2. Techniques and Methodology

2.1 Stopwatch time study

A single die bond machine and an operator were the subjects of this study, and the data collected are based on that machine. Before data collection, work elements were to be identified and established, and this was done in communication with the personnel in the semiconductor company. Each work element of the changeover process was identified and established. Data for stopwatch time study was taken manually using a snapback stopwatch. Upon finishing collection the observed times were converted to normal time. With a preliminary work that showed a mean of 1244.3 seconds, standard deviation of 18.8 seconds, confidence of 95 percent and 10 percent allowable error as percentage of average time, the sample size required was 0.09. Despite the small value, a total of 10 samples were taken for stopwatch time study for a continuous period span of 10 days. This was done to obtain a set of data that represents the actual dynamic, continuous, and fast-paced conditions of the process in the semiconductor company. The 10 days selected were at a time of high customer demand of products. Stopwatch time study was used to determine the current time spent in the changeover process, as well as to obtain the time that includes avoidable time.

2.2 BasicMOST

Breakdown activity for each identified work elements will be listed below. Data for BasicMOST were produced using the parameter and index tables in BasicMOST, and the data produced will be normal times in TMU before conversion to metric units. Three sequence models were used. There is namely general move activity, controlled move activity, and tool use. The data from BasicMOST will be used to establish the standard time, because MOST is a necessary technique to create ideal nonvalue added operation times (Puvanasvaran, Yoong, & Tay, 2017). Using MOST, non-value-added motions could be reduced (Puvanasvaran, Teruaki, Siang, & Sieng, 2016).

2.3 Analysis

The reason the data were collected from both work measurements was that data from stopwatch time study are used in synergy with the data from BasicMOST to identify focus and work elements that contain nonvalue added activity. From the activity, wasted time was identified and time that can be excluded in the standard time was determined as well in the documentation of data, and quantitative and qualitative analyses were done. Quantitative analysis, comparison of normal time using bar chart, and qualitative analysis, flow process chart, were used to identify any non-value-added activity and its time in the changeover process. The identification of non-value activity and its time will be achieved by integrating the data from quantitative analysis into qualitative analysis with addition of several conditions. The work element that had great difference of normal time between the two work measurements was put into focus. The focusing was applied only for those with normal time of stopwatch time study greater than BasicMOST. The flow process chart was used to classify each work element into their respective activities, as this allowed more focus of which work element in certain classification of activity is considered waste as according to the wastes of lean. The non-value-added work elements were identified through the flow process chart while the time that can be excluded was found via the integration of both analyses done.

Since BasicMOST is a work measurement that can establish normal time at higher accuracy, consistency and effectiveness compared to stopwatch time study (Tuan *et al*., 2014; Waghambare, Londhe, Rakibe, Sneha & Sachin, 2016), the total normal time of changeover process obtained from BasicMOST was selected and multiplied with an allowance factor that produced the standard time for the changeover. With this, time that was able to be excluded via findings was immediately eliminated as well. Further analysis was done afterwards to measure the increment of productivity and efficiency of production between use of BasicMOST as compared to stopwatch time study. The performance rating for an operator in stopwatch time study will be set to 100 percent while a 13 percent allowance factor will be used for calculation of standard time.

3. Results and Discussion

3.1 Work elements

There was a total of 18 work elements, divided into end a lot and get a new lot. End a lot consisted of 6 work elements. Table 1 shows the work elements in end a lot.

Table 1 shows that there are less procedures involved in ending a lot as compared to getting a new lot. Table 2 shows the other 12 work elements in the get a new lot.

Table 1. Work elements in ending a lot

No.	Work element	No.	Work element
1	Unload wafer to wafer cassette	4	End lot documentation
2	Remove empty wafer from wafer cassette and put to rack	5	Move empty wafer cassette to rack and return to station
3	Move completed lot magazine to rack	6	Move out (work stream)

Table 2. Work elements in getting a new lot

No.	Work Element	No.	Work Element
1	Walk to Work in progress cabinet 1 to get new lot	7	Put back lead frame recording book to cabinet
2	Walk to Work in progress cabinet 2 to get new lot	8	Take out lead frame from container to machine
3	Create lot traveler	9	Dispose container
4	Move in (work stream)	10	Insert lead frame to lead frame loader
5	Write on lead frame recording book	11	Machine setting to run machine
6	Get lead frame from mini store	12	Insert empty magazine to off loader

3.2 Discussion on sample size

Figure 1 shows the trend of changeover time taken over the span of 10 days.

From Figure 1 it can be seen that the changeover time for the first two days of the week was higher than in the rest of the week. This also shows the inconsistency criteria of a stopwatch time study.

3.3 Quantitative analysis

In the comparison of normal time between stopwatch time study and BasicMOST, it was found that BasicMOST had a shorter time by 27.84 seconds.

3.4 Qualitative analysis

In the flow process chart using data of stopwatch time study, it was found out that 7 out of 18 of the changeover processes were transport activities, which are non-value-added activities. Table 3 shows the summary of the flow process chart.

From Table 3, the transport activities took up 91.28 percent of overall distance travelled in changeover process. Moreover, the time spent in transport activities was measured as up to 39 percent. Figure 2 shows the percentage taken by transport activities in changeover process.

In Figure 2, it can be seen that the major activities were classified as operations in changeover process. This 39 percent of non-value-added activities was unavoidable for the measured changeover process. Among this 39 percent, it was found that a total of 7.56 seconds can be excluded in the standard time. The 7.56 seconds were found from the integration of both quantitative and qualitative analysis.

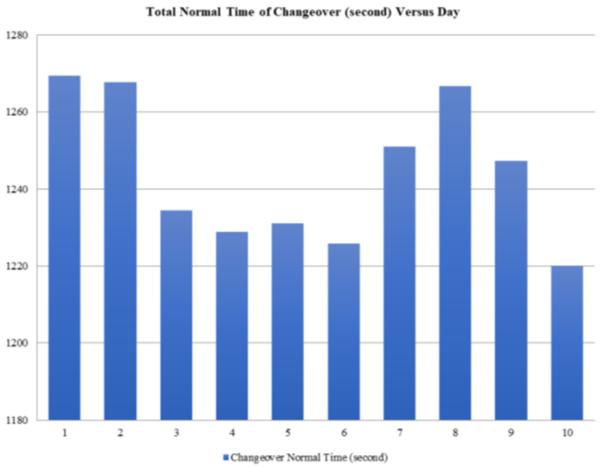

Figure 1. Changeover times observed over a span of 10 days.

Table 3. Summary of flow process chart

Activity	Proposed	Distance (meters)	Time (seconds)
Operation	11	9.9	758.11
Transport	7	103.6	486.17
Inspection	0	0.0	0.00
Delay	0	0.0	0.00
Storage	0	0.0	0.00

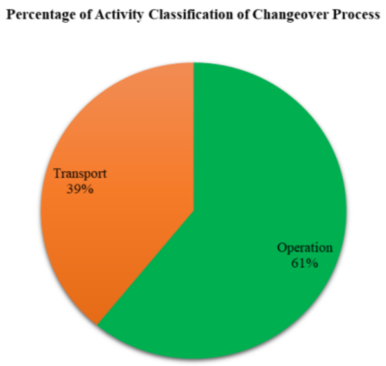

Figure 2. Activity type distribution during a changeover process

Figure 3 shows the excluded and included time for the standard time.

From Figure 3, a total of 7.56 seconds from transport activities were and 16.40 seconds from operation activities were possible to exclude from the establishment of standard time of changeover in the die bond process. Table 4 shows the calculation of standard time for the changeover process.

From Table 4, the standard time for the changeover in die bond process is 22.91 minutes.

3.5 Analysis of productivity and efficiency

Figure 4 shows the additional analysis of productivity and efficiency comparison between stopwatch time study and BasicMOST.

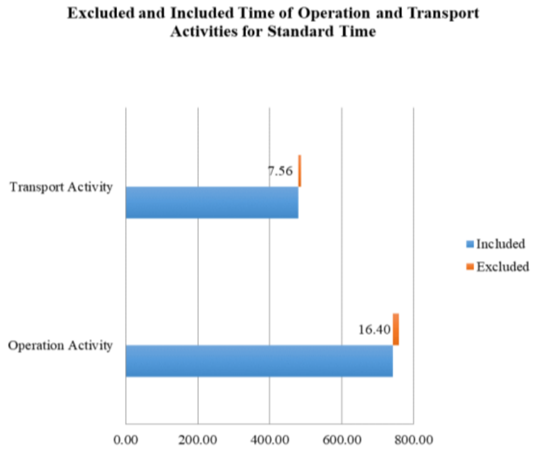

Figure 3. Excluded and included times in standard time

Table 4. Establishment of standard time

Total Normal Time (NT)		Allowance Factor (AF) (%)	Standard Time	
Minute	Second		Minute	Second
20.274	1216.44	13	22.91	1374.58
Standard Time = (NT) × (AF) = 22.91 minutes				

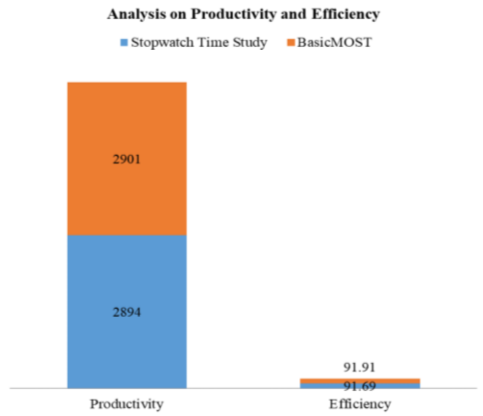

Figure 4. Analysis on productivity and efficiency in the work measurements

Making reference to Figure 4, by using BasicMOST to establish the standard time, productivity was raised by 7 units per hour and efficiency raised by 0.22 percent. This showed that BasicMOST is better than stopwatch time study, for establishing a standard time. The findings of the case study were alike the findings in past studies done using both stopwatch time study and MOST. An example of such similar findings is (Mishra *et al*., 2014).

4. Conclusions

The findings of changeover in die bond process showed that 7 out of 18 work elements were classified as transport activity, and this transport activity took up 486.17 seconds of the overall changeover time of 1244.28 seconds, in a stopwatch time study. The transport activities, which were taken as non-value-added activities, took up 39 percent of the changeover time. The non-value-added time was highly related to the distance travelled as 91.28 percent of distances were found in transport activity. Among the 486.17 seconds of non-value-added time, it was found that 7.56 seconds can be removed for the standard time. The standard time was calculated to be 22.91 minutes using an allowance factor of 13 percent. The standard time was established using the normal time obtained through BasicMOST as there was 27.84 seconds less when using BasicMOST. Productivity and efficiency when using BasicMOST were higher than when using stopwatch time study, as BasicMOST did not include any unnecessary transport activities while stopwatch time study included all activities regardless of whether they are value added or not. The minimal difference in time between both work measurements allows to infer that the improved work procedures of the company were indeed effective in removing non value added activities.

References

Abdul, T. B., & Daiyanni, D. (2010). Time motion study in determination of time standard in manpower process. *Proceedings of the 3rd Engineering Conference on Advancement in Mechanical and Manufacturing for Sustainable Environment, 1-6*. Retrieved from http://eprints.uthm.edu.my/id/eprint/3301

Mishra, A., Agnihotri, V., & Mahindru, D. V. (2014). Application of maynard operation sequence technique (M.O.S.T) at Tata Motors and Adithya Automotive Application Pvt Ltd. Lucknow for enhancement of productivity-A case study. *Global Journal of Researchers in Engineering*, *14*(2)

Harish, H., Shivappa, D.N., & Sangamesh, J. (2012). Establising time standards for assembly activity in chassis preparation area using MOST. *Proceedings of the National Conference on Trends and Advances in Mechanical Engineering, YMCA University of Science and Technology, 819-827*. Retrieved from https://www.yumpu.com/en/document/view/31963791/october-19-20-2012-ymca-university-of-science-technology.

Lusia, H. P. S. (2016). Work measurement approach to determine standard time in assembly line. *International Journal of Management and Applied Science*, *2*(10), 192–195. Retrieved from http://ijmas.iraj.in/paper_detail.php?paper_id=6148&name=Work_Measurement_Approach_to_Determine_Standard_Time_in_Assembly_Line

Matts Aby Jo, Sadesh, K., & Prabhukarthi, A. (2016). Establishment of time standards to improve productivity in the packing section of a pharmaceutical industry using method study. *Journal of Engineering, Scientific Research and Applications*, *2*(1), 136-144.

Oke, S. A. (2006). A case study application of time study model in an aluminium company. Pacific *Journal of Science and Technology*, *7*(2), 153-162. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiGucDNpcfrAhWAyzgGHYSZAGYQFjAAegQIAxAB&url=http%3A%2F%2Fakamaiuniversity.us%2FPJST7_2_153.pdf&usg=AOvVaw3K8u14FbW1Snvud9dkhAk7

Palanisamy, S., & Siddiqui, S. (2013). Changeover time reduction and productivity improvement by integrating conventional SMED method with implementation of mes for better production planning and control. *International Journal of Innovative Research in Science, Engineering and Technology, 2*(12), 7961–7974. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjm76LqpsfrAhUIyzgGHaNFCk0QFjAAegQIBBAB&url=http%3A%2F%2Fwww.ijirset.com%2Fupload%2F2013%2Fdecember%2F78_Changeover.pdf&usg=AOvVaw1tr_Tu_NJQ-i0HC6oaIGV3

Puvanasvaran, A. P., Teruaki, I., Siang, T. Y., & Sieng, Y. S. (2016). Examination of overall equipment effectiveness OEE in term of Maynard's operation sequence technique MOST. *American Journal of Applied Sciences, 13*(*11*), 1214-1220. doi:10.3844/ajassp.2016.1214.1220

Puvanasvaran, A. P., Yoong, S. S., & Tay, C. C. (2017). Effect of hidden wastes in overall equipment effectiveness calculation. *Asian Research Publishing Network*, *12*(*22*), 6443-6448. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjb05CRp8frAhU_yzgGHRV6BtIQFjAAegQIBBAB&url=http%3A%2F%2Fwww.arpnjournals.org%2Fjeas%2Fresearch_papers%2Frp_2017%2Fjeas_1117_6505.pdf&usg=AOvVaw1J0h0p3qUbSS3DnZkByPuh

Roghanian, P., Rasli, A., & Gheysari, H. (2012). Productivity through effectiveness and efficiency in the banking industry. *Procedia - Social and Behavioral Sciences*, *40*(*2012*), 550-556. doi:10.1016/j.sbspro.2012.03.229

Saravanan, T. T., Puchong, J., Alam, S., Karim, A. N. M., Kays, H. M. E., & Hasan, M. H. (2014). Improvement of workflow and productivity through application of Maynard Operation Sequence Technique MOST. *Proceeding of the 2014 International Conference on Industrial Engineering and Operations Management, Bali, Indonesia, 2162-2171*. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjopeKlqMfrAhUTfSsKHXEhDEcQFjAAegQIAxAB&url=http%3A%2F%2Fieomsociety.org%2Fieom2014%2Fpdfs%2F463.pdf&usg=AOvVaw2c4roVITfwa2m3cp90JNie

Sujay Biswas, A. C. (2016). Improving productivity using work study technique. *International Journal of Research in Engineering and Applied Sciences, 6*(*11*), 49-55. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwintefEqcfrAhWVfH0KHZIrCyUQFjAAegQIAxAB&url=https%3A%2F%2Feuroasiapub.org%2Fwp-content%2Fuploads%2F2016%2F12%2F5EASNov-4237-1.pdf&usg=AOvVaw1VhCvfYwbHMsYh-1PpTxZ0

Waghambare, S., Londhe, S., Rakibe, R., Sneha, N., & Sachin, B. (2016). Review on design and automation of axle assembly by using jig and fixture on conveyor process line. *International Conference on Emerging Trends in Engineering and Management Research, 5*(*2*), 95-104. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiMro3HqMfrAhWMc30KHej5C3UQFjAAegQIBhAB&url=http%3A%2F%2Fwww.ijarse.com%2Fimages%2Ffullpdf%2F1459175018_230N.pdf&usg=AOvVaw2urQlTG2ew091CmS3HbcjR

Yusoff, N., Jaffar, A., Abbas, N. M., & Saad, N. H. (2012). Work measurement for process improvement in the car seat polyurethane injection manufacturing line. *Procedia Engineering, 41*, 1800–1805. doi:10.1016/j.proeng.2012.07.386