

# **Process Visualization of a Manufacturing Plant Based On Lean Concept**

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## **Abstract**

Lean manufacturing is one of the popular concepts among the manufacturers nowadays in Sri Lanka. One of the main objectives of Lean manufacturing is to reduce different forms of wastes available in manufacturing. Time waste is one of them. Even the organizations with lean background find it difficult to reduce time wastage, since it is difficult to identify. In order to identify time waste, every activity has to be observed sharply and it is turn out to be a costly and time consuming procedure. In this study, it is proposed to visualize the process in real-time with the assistance of virtual lookup. For the sake of practical convenience, real time process visualization of apparel manufacturing plant will be given the priority. This will assist to identify and troubleshoot particular work stations which waste time easily. The main advantage of this is its ability to make the best decision out of the accurate information available. In this application, each and every operation in a module of a garment factory will be tracked and acquire data to a central monitoring system. Then it will be visualized through an interface with the assistance of Yamazumi chart and Learning curve.

## **1. Introduction**

In a country like Sri Lanka with less technological exposure and lower labor cost, many manufacturing companies relaying manual operations. Working with humans is harder than automation because the routines of humans vary considerably within different time frames. Therefore, to increase the efficiency in the intended operations, works have to be standardized. Further, they have to be monitored and visualized along with real time study. Process visualization is a kind of virtual lookup of the overall process or the some specific area of the process in a manufacturing plant or service providing organization. Visualization means creating a clear image of a process to make decisions, or to get an idea about situation. It may be a drawing or a flow chart or a graph or some similar tool. Some process visualization tools are used some standard symbols in order to present in a standard way. But some of the tools may be very unique to the organization. But in both ways, it may very helpful to get a clear idea of the process that present by the tool. Process flow chart, Value stream map, Network diagram can be taken as some examples for the Process visualization. The main advantage of Process visualization is it shows everything clearly in order to make decisions. So it can be taken as a decision making tool. It is also very useful as a communication tool (Can use to share information between departments as well as inside the departments.) too.

When it comes to Lean Manufacturing sector Process visualization can be taken as a basic Lean Tool. It is more familiar with the lean environment. But the most of the case, even in lean sector this tool used only to present past data or to present long term data as process flow chart, value stream map, etc. When making decisions by using past data is not much accurate because as mentioned above, human labor is not precise and highly accurate. Because of talents and skills are developed with the time, new people come to work when some resigns, when taking leave replacements are done, changes in the product take place, unexpected things happen. So in manufacturing industry studying the real-time process and then taking the important decisions is a must. For that there should be real-time process visualization. Lean is basically about reducing wastages and it has categorized wastes in to seven factors. One of those factors is “waiting”. Waiting is always where the places without proper time management. Time waste or the waiting is one of the major problems that most of the industries face. Even the organizations with lean background find it difficult to reduce time wastage as they are unable to identify the waste correctly. So it is need to keep real time process visualization method in time management. It will be very helpful to realize the ongoing situation of the process. Also it may increase the sensitivity for variances, may avoid risks of higher lead time and helpful to identify sudden breakdowns. Totally it helps to make decisions where it is necessary.

As far as the apparel industry is concerned, most of the companies today, use a system based on the lean manufacturing concept. So in this work, for the sake of practical convenience, process visualization and tracking the operations real time in the apparel industry will be given the priority. Because in apparel industry there are

so many problems regarding time related process visualization. So they have to keep a non-value added, but look as necessary job role for this specific task. Well known Work-study job role comes under this. Some apparel industries have allocated one work-study officer per two or three modules. They have to study and monitor each and every operator properly and should keep details about the operators. Mainly those details are time related details. Those are very useful in line balancing, making new module arrangements, making worker skill matrix, studying module efficiency level, etc.

## 2. Methodology

The proposed methodology consists of several stages. In the initial stage, reliable and robust data acquisition system. Main objective of this system is to receive real time information, identification of signal, and transferring it to useful information. Second stage consists of online data analysis which includes the designing of data base as well. Online data analysis is done in the next stage and visualizes them real-time. In the stage, learning curve against the Yamasaki chart. This comparison is used to improve problem porn areas based on comparisons. The schematic representation of the method is shown in Figure1.

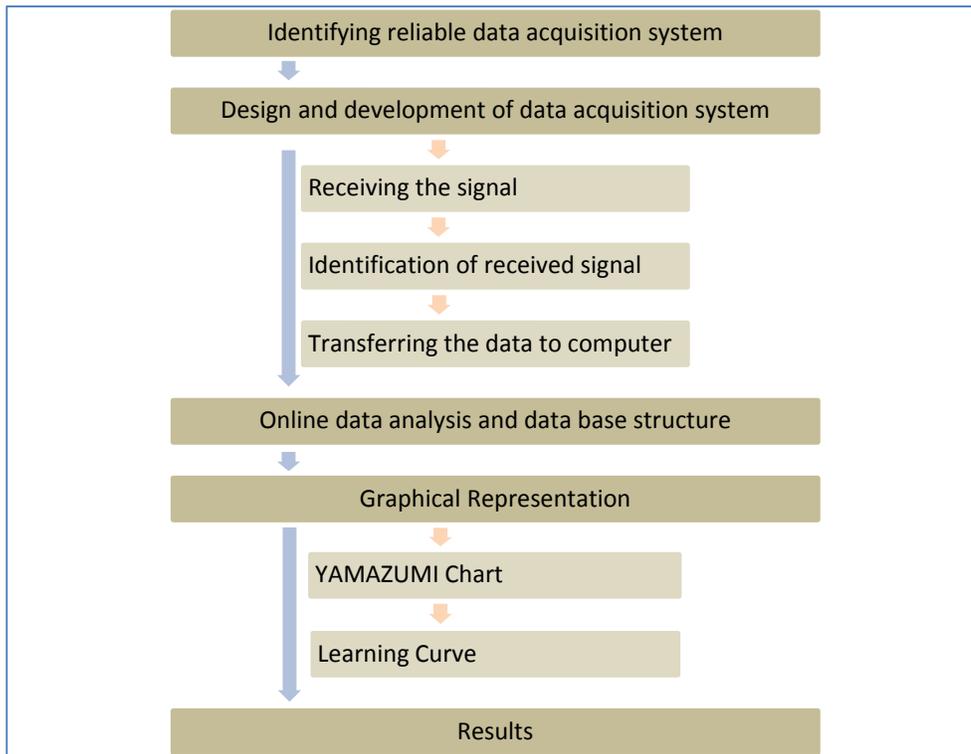


Figure 1 : Methodology

### 2.1 Identifying reliable data acquisition system

Here, the main problem is to collect real time data with an accurate manner with user friendly way. Collecting data separately at every workstation is also fairly difficult problem to handle. As a remedial strategy, a user-friendly touch button switches were used at each individual works stations, which is much similar to operating digital counters available with some apparel manufacturing plants. At the end of every cycle, operators were advised to mark when each cycle is completed.

### 2.2 Design and development of data acquisition system

The data acquisition system consists of receiving the signal, identification of received signal, transferring data to computer. Signals will be received via every machine operator. The prime requirement of this is to track the cycle time accurately. Accordingly, respective machine operator should provide a signal at the end of every cycle. For that, convenient switching method is to be used and will be positioned it at a place where it can be handled easily. Time difference between each signal from same workstation is taken as the cycle time.

Along with the identification, those signals are collected relatively to the module. Generally, module is comprised of about 10-25 operators (workstations). The signals received by them cannot be referred to the computer directly. That is because, signals must be pre-processed and developed to protocols so that the computer can identify. Pre-process is the identification of the signal separately. Since we need to find which machine generated the signal. Here, we used Pic CSC as the compiler for Microcontroller. Interrupt function of Pic 16f877A was used for identification of signals. When it is compiled the extension file was created as .hex file. After building the .hex file PIC kit 2 was used to save the file in to the Microcontroller along with RS 232 serial port for communication purposes.

### 2.3 Online data analysis and database structure

The data coming from the RS232 module is only a bunch of signals. So the computer had to do storing those signal data separately and calculate the cycle time. Cycle time was directly taken as the difference between two adjacent signals which come from the same workstation. Those cycle time values stored workstation wise in VB data grid view. When the data is storing it is automatically calculate the average values. As an advance op we were made some boundary conditions for the cycle time calculation. Here we made an option to enter upper and lower limits for the each workstation. The times between the limits only taken as cycle time and others are neglect from the calculation. The schematic diagram of the information flow is shown in Figure 2.

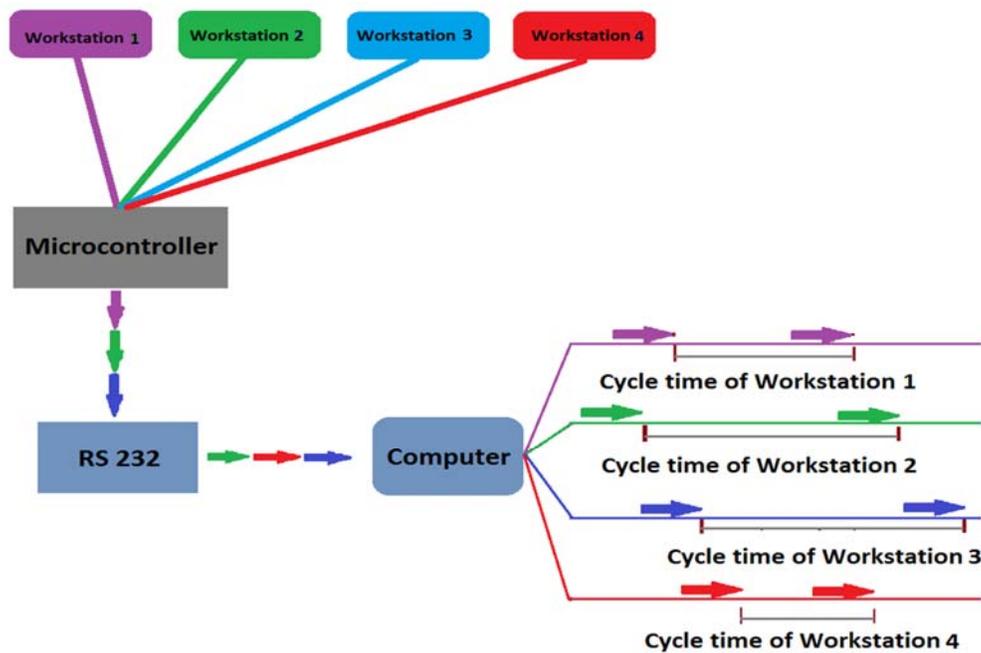


Figure 2: The schematic diagram of the information

### 2.4 Graphical Representation

Most significant section of the research is the way of process visualization. It has to be easy to understand and should be able to draw the attention of employees of the plant. In addition, this should not be a complex and it should visualize information in a manner that everyone can understand. Considering above factors we have developed our application which able to cover large area of process visualization. In this application we are used YAMAZUMI chart and Learning curve as presentation methods. YAMAZUMI is a graphical tool that present the average cycle time of every work station. It is a simple X-Y bar chart which presenting workstations in X axis and time in Y axis.

Here this chart is basically designed to present average cycle time of workstations which are in the same module. Because the data we used are from one module. We have provided space for 25 workstations. Average cycle time of every workstation can be seen in the same chart. The data for the chart is directly taken from the data grid view which is we are keep as data base. When we taking this average values for a long period there might be some issues. Because these operations are manually operate changing with product to product. So with the time efficiency of the operators will increase. So when we take cycle time with considering data from the start of the production it will not give the real time information. So we had to illuminate that error. So we are developed our application to consider the average cycle time from last hour signals. As an example, if we are

looking the chart at 10.30 am, it is present average values of cycle times between 9.30 am to 10.30 am. If we look at 10.45 am, it will present 9.45 am to 10.45 am values. Data base was developed to keep average cycle time value hour by hour. It has provided facility to change the time period that considering to calculating average cycle time. Also it can change to number of cycles. It means we can consider the last 15 cycle times or last 20 or last 22 or last 100 or any acceptable number.

Learning curve is also an advance visualization tool that can use for predictions and scheduling. But it is not well used in apparel industries. Learning curve is a graphical representation tool which presents the variation of efficiency rate with the time of a given activity. When we are modifying this option we have to calculate the efficiency of the each workstation. After the calculation, we had taken the smallest efficiency value as the module efficiency. And then we have developed a method to draw the efficiency curve. For the curve we are taking efficiency values by hour and hour. And also we have provided option to draw the predicted curve also in the same interface. By doing this we can compare the actual one with the predicted one. Here we have modified another option to compare the efficiency rate variation of each workstation with the efficiency of the module. Through this we can find the workstations that could improve.

### 3. Results and Discussion

As results we were able to develop software application which is included following features and interfaces. Application is mainly consist with a Main interface, Yamazumi interface, Learning curve interface and two settings interfaces. It can be used as any other software application and it is able to represent the captured data in a polite form. Most important factor is this application is always connected with the data acquisition hardware circuit and it is updating for each and every signal which use to calculate the cycle time. In main interface it has provided functions to open Yamazumi chart and the learning curve. This application included functions to change settings related to both charts and saving options for each work.

#### 3.1 Yamazumi window

Yamazumi window is mainly consisting with the Yamazumi chart. By using this chart we were able to present real time average cycle time values of each and every workstation with in a module. And this graph is always updated with the time. This interface has functions to open new settings window for the chart, to open saved settings of previous charts, to show the SMV (Standard Minute Value) graph with the cycle time, function to reset the graph. SMV is the standard time for the operations separately. There are defined standard steps along with the sewing operations. And all these steps have standard cycle times which are identified by studying number of sewing operations. So any sewing operation can be breakdown in to standard steps along with those standards. Then SMV for that operation can be found by adding standard cycle time value of all the steps. This SMV is used to measure the efficiency rate.

The main objective of this research was to design and development of a real time process visualization system to maintain an efficient sewing module. To show how this system is help to maintain an efficient sewing module, we have done few test runs by using few machines from a sewing module. The results obtain from those test runs describes how the system is help to achieve our target. Yamazumi chart is helps to maintain a balanced line in the process. This chart is very simple tool. Figure 3 and 4 shows two Yamazumi charts which we have captured during our test runs. And there is a table in this Yamazumi interface below the chart to show the average cycle times of each cycle in figures.



Figure 3: Yamazumi chart from test run 1

In the figure 3, columns which are in blue color shows the average of actual cycle time while yellows show the standard minute value (SMV) of each operation. The highest value is 11s and the lowest is 8.6s. Deference between those two (2.4) is not much larger value. And the average time of those seven workstations is 10.1s and it is shown by red color line. The highest and lowest values are not much away from the average line. Throughput rate of this module is depending on the highest value. This module produces a product per every 11 seconds. Total inefficient time of the module is 6.2s (from 77s) per cycle. As a percentage it is only 8% from the working time. If this module was ideally balanced one it will take 10.1s for each product. It is not much greater than the value in the above situation. So this module can be identified as a balanced line. The chart is shown that clearly. So we do not need to go through any calculations to identify that. Furthermore actual time taken in workstation A is less than the SMV value. So the efficiency of that worker is more than 100%. As a conclusion we can introduce that worker is much more suitable for a module which has higher efficiency more than this module.



Figure 4: YAMAZUMI chart from test run 2

In the figure 4, workstation D has the highest cycle time 12s and B has the lowest 7s. Difference between those two are very high when compare with the lowest one. We do not need any calculation for identifying these unbalanced features. Just looking this graph we can identify what are the workstations should improve. For the above case workstation C and D are much time taken. To make it balance we can share some operations of C and D with A and B. furthermore both C and D have huge difference with the SMV value. So there may be some problems with those workstations such as use of wrong techniques, ergonomic aspects.

### 3.2 Settings window

Settings window shows in figure 5. It is included facilities to enter the number of workstation in the module, enter the SMV value of each workstation, enter the upper and lower limits that data should include, and also the number of data set that use to calculate the average cycle time. We can save those settings by using save option as well as save settings option. Save option is to save the whole data of the document. Save settings option to save only the settings that we have entered.

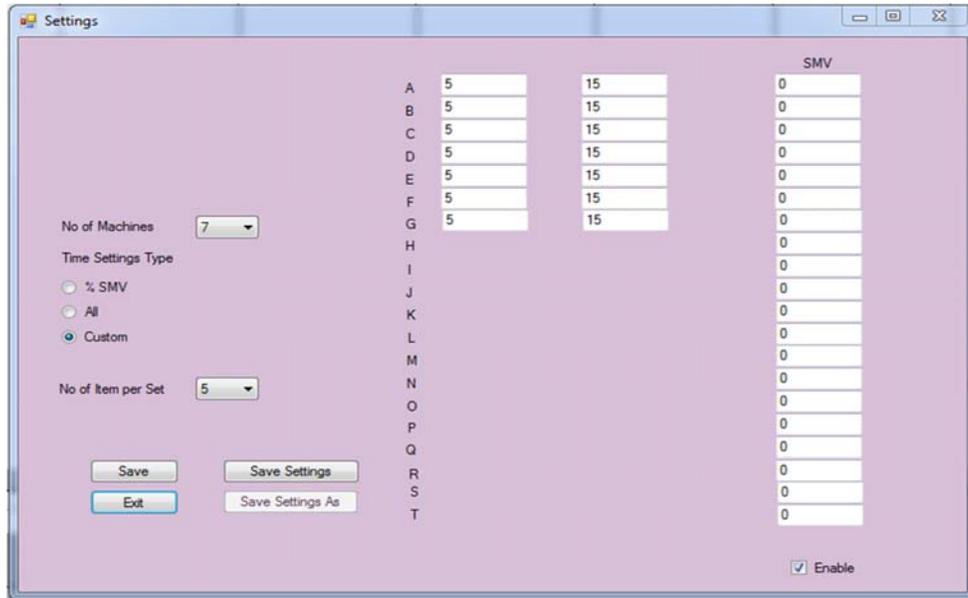


Figure 5: Settings Window

### 3.4 Learning Curve window

Learning curve window has three facilities. Major one is the curve of efficiency rate of the module. There is an option to enter the data for predicted learning curve. By pressing Predicted curve button we can go to the predicted curve settings window. It has provided facilities to enter some points of predicted efficiency rate. Furthermore we are providing an option to compare efficiency of workstation by each other. The three buttons available in the right top is used to select the workstation that is needed to be compared.

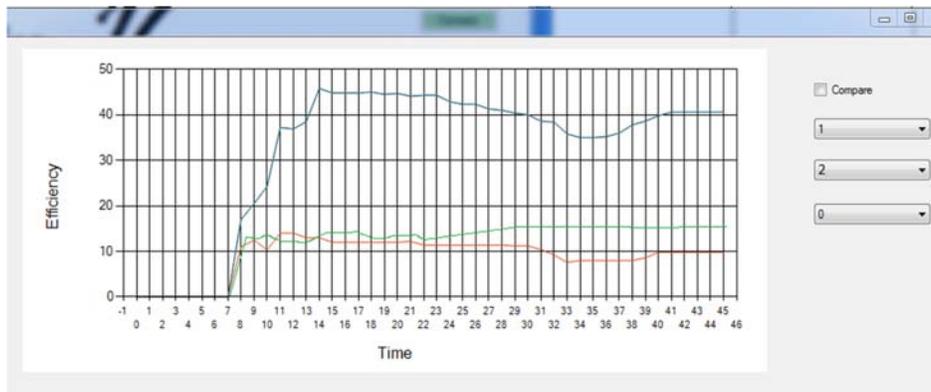


Figure 2: learning curves from test run 3

Figure 6 shows the Learning curve from our test run 3. The red line shows the overall learning curve of the module. Blue one shows the first workstation’s curve. Green one shows the second workstation. We can identify that the workstation 1 has higher efficiency rate with compare to the module. So this workstation is not suitable for this module. Its better we should change the worker to another module which has same type of learning curve.

Figure 7 and Figure 8 shows the behavior of the actual learning curve and the predicted learning curve. In figure 7, both curves have same pattern at the beginning. But at the end, actual curve is behaved in a constant line which is not achieving the predicted level. But in the figure 8, both curves behaved in the same manner. So this chart is help to identify any variations of the predicted and actual efficiency rates.

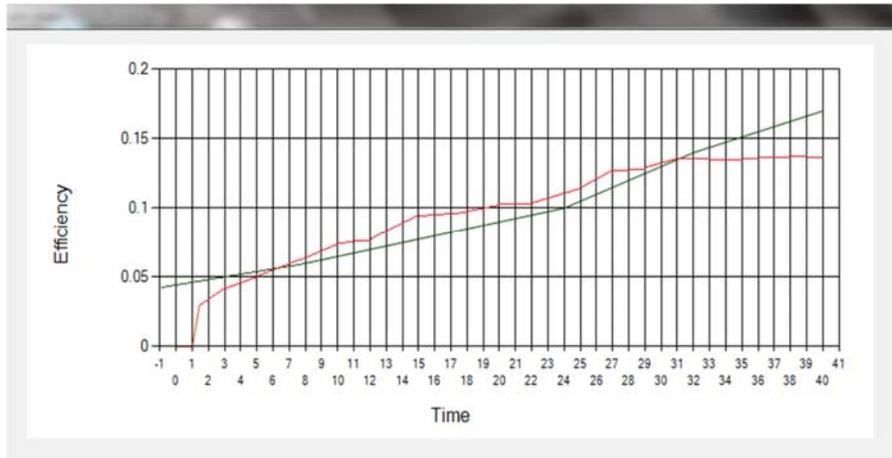


Figure 3: Actual learning Curve with the predicted curve. (1)

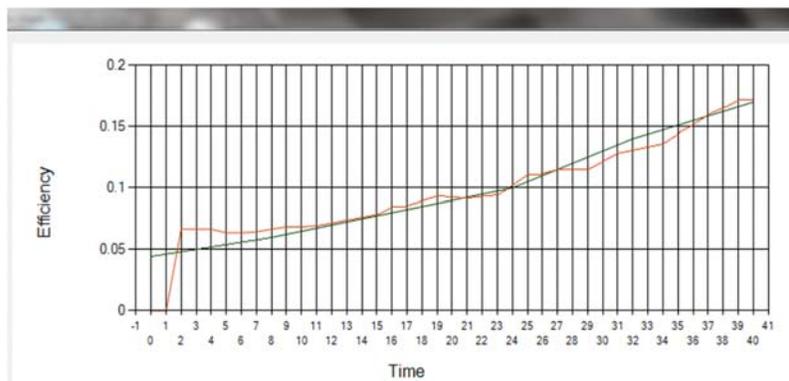


Figure 4: Actual learning Curve with the predicted curve. (2)

## 5. Conclusion

This paper presented a real time manufacturing process visualization method along with Lean Manufacturing concept related chart generation. It is very rare to find similar type of mechanisms currently used in the local manufacturing sector or even in the literature. But for the sake of decision making the presence of such system is very much useful and that will enhance the overall productivity of the process and in the plant. Some experimental study was carried out in a medium scale apparel manufacturing plant. We decided to develop a real time process visualization system mainly for the apparel industries that have moved more in to lean manufacturing and use more human resources. Sewing is one of the key operations in the apparel industry. In this sector, what they are focused on is reduce the time waste and increase the efficiency. Therefore measurements related to time are very important. Every selected machine operator's cycle time were tracked in order to get a fine outcome from this project. By that we were able to develop an application which could be used in line balancing.

Inside the application cycle time calculation, absence of calculations at the negligible data, calculation of average cycle times, presenting them in a proper order, facilitating to compare SMV against the average cycle time, updating of cycle time per each signal, data consumption at recent statics for average cycle time calculation are some of the features of this application. And also it consist with efficiency calculation for each workstation and for each module, graphical representation of the efficiency curve, facilities to compare the efficiency rate of work stations as well as with the predicted efficiency rate. All these functionalities are done through a Yamazumi Chart and Learning Curve. When making the tracking device, we did not have the luxury to use most appropriate accessories. But we figure out later that some of the functionalities we wanted could have been achieved with some other devices in the market. But there are expensive and our chances are limited under that.

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