

# Continuous Flow in Labour-Intensive Manufacturing Process

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**Abstract.** A continuous-flow manufacturing represents the peak of standard production, and usually it means high production in a strict line production. Furthermore, low-tech industry demands high labour-intensive, in this context the efficient of the line production is tied at the job shop organization. Labour-intensive manufacturing processes are a common characteristic for developing countries. This research aims to propose a methodology for production planning in order to fulfilment a variable monthly production quota. The main idea is to use a clock as orchestra director in order to synchronize the rate time (takt time) of customer demand with the manufacturing time. In this way, the study is able to propose a stark reduction of stock in process, over-processing, and unnecessary variability.

## 1. Introduction

An international curtain maker in Lima-Perú faces up the challenge to improve the delivery time to customer. As many business, the curtain market in Peru is very competitive, i.e. low prices, high quality, short delivery time. The philosophy and techniques of lean manufacturing is a need in this business environment, especially if companies care not only to keep their customer but also increase their sales opportunities.

The proposed methodology is applied in the assembly line of curtains. Nevertheless the potential application is for all related sectors with manual assembly, labour-intensive and not much machines. Usually, industry of textile, footwear, leather, etc. has these characteristic in developing countries. In this context, the production planning task is the most benefited, because it allows working with customers under the perspective of Just in Time concepts. No more unnecessary overtime, defective products, high inventory, etc.

The idea of this project started in Brazilian filial of the curtain maker. Here, we will present the result of adequate procedure and methods to the Peruvian reality. The result is a flexible methodology that is easy to apply to other environments.

## 2. Literature review

According to Womack [1], lean manufacturing is based in five principles: value, mapping, flow, pull, and perfection. That means, value to understand client perspective, mapping to identify what we really do, flow to create an ideal future state map, pull in order to match with the customer demand, and finally perfection to search the continuous improvement.

Lean operations show common characteristics, like elimination of waste, produce what and when is required, no mistakes, tighten links in the value chain, and robust processes [2]. Many of the lean



techniques are simple and common sense. Nevertheless, most of the companies that tries to implement lean techniques fail. A large survey conducted by Industry Week in 2007 found that only 2% of companies that have a lean program achieved their anticipated results [3]. In July, 2010 Robert Miller, Executive Director of the Shingo Prize was interviewed on radiolean.com, he affirmed that a very large percentage of companies, that had received the Shingo Prize, had not sustained their progress after winning the award [4]. How to face this reality?

According to Spear [5], we need to decoding the DNA of the Toyota production system. In short, managers do not tell employees how to do their work, rather they use a teaching and learning approach that allows their workers to discover the rules as a consequence of solving problems. For example while a persons is doing his job, ask a series of questions: how do you do this work?, How do you know your are doing this work correctly?, How do you know that the outcome is free or defects?, What do you do if you have a problem?. In summary, the workers must be total involved by the kaizen philosophy, continuously improvement.

Our study, was based on the kaizen philosophy, and it was a challenge due to the demand of high labor-intensive, in a developing country. The one-piece flow principle was wide applied in the next case study, in order to identifying and eliminating the seven type of waste: overproduction, transporting, motion, waiting, processing, inventory, and defects. The one-piece flow principleproposes that single parts are transferred between different operations instead a complete lots [6]. That means, products that move continuously through the processing steps with minimal waiting time in between, and the shortest distance traveled, will be produced with the highest efficiency [7].

### 3. Methodology

This researchuses an assembly curtain line as case study. The assembly line demands labor-intensive and some no-complex machines. Five steps are applied as methodology for synchronize the customer demand with the manufacturing time:

*First Step:* Estimation of the forecast demand. For our case study, we take the historical demand of the last 57 month for a product. The forecasting demand for the year 2017 is presented in the Tabla 1.

**Table 1.**Forecasting Demand.

Month, year	X(t)	Y(t)	Seasonality Rate	Forecast
Jan, 2017	60 month	3157 unit	0.96	3027 unit
Feb, 2017	61 month	3198 unit	0.84	2681 unit
Mar, 2017	62 month	3239 unit	1.10	3569 unit
Apr, 2017	63 month	3279 unit	1.02	3337 unit
May, 2017	64 month	3320 unit	0.97	3210 unit
Jun, 2017	65 month	3361 unit	0.98	3292 unit
Jul, 2017	66 month	3401 unit	0.98	3336 unit
Aug, 2017	67 month	3442 unit	1.03	3537 unit
Sep, 2017	68 month	3483 unit	1.12	3912 unit
Oct, 2017	69 month	3524 unit	0.97	3430 unit
Nov, 2017	70 month	3564 unit	0.84	2998 unit
Dec, 2017	71 month	3605 unit	1.19	4293 unit

*Second Step:* It is necessary to fix the number of working days per month, and estimate the real work time per day. We need to identify all kind of activities that are realized during the working day, and differentiate activities that add value to the product from others. The Table 2 takes, as example, the forecasting demand for January 2017 (3027 units). The table shows the kind of daily activities and used time. For the case, it is considered that January 2017 has 22 production days.

**Table 2.**Estimated Working Time per Day.

Activities	Time	Percentage
Work Time	7.87 hours	82.9%
Meetings	0.05 hours	0.5%
Clean	0.08 hours	0.9%
Breaks	0.50 hours	5.3%
Lunch	1.00 hours	10.5%
Total	9.50 hours	100.0%

*Third Step:* Calculation of the takt time for the selected month production. For our case, we have an estimated demand for January 2017 of 3027 units (see Figure 1), 22 work days in this month, and 7.87 hours/day as real work time (see Table 2).

$$\text{Takt Time} = \frac{\text{Work Time}}{\text{Demand}} = \frac{22 \text{ days} * 7.87 \frac{\text{hours}}{\text{days}} * 3600 \frac{\text{seconds}}{\text{hours}}}{3027 \text{ units}} = 206 \frac{\text{seconds}}{\text{unit}}$$

The calculated takt time indicates that line must produce a finished unit every 206s, in order to fulfilment the demand of January 2017.

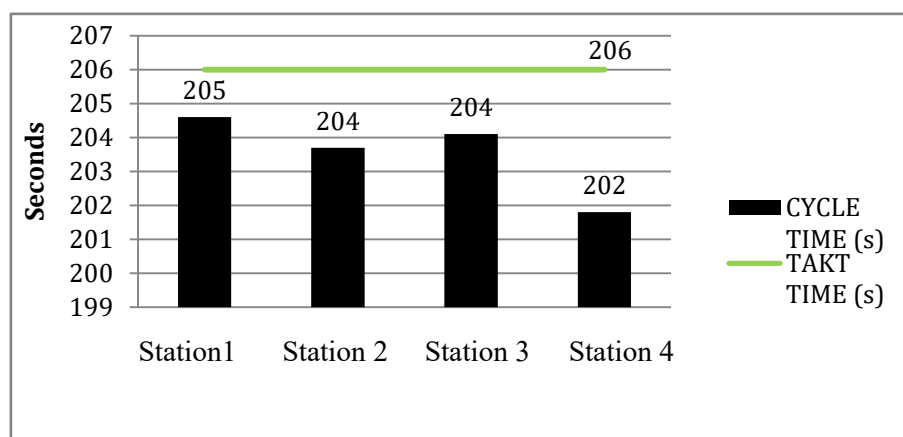
*Fourth Step:* Calculation of the cycle time. In this step, we identified all processes needed in order to finish the product. A time and motion study must be carried out in order to improve the efficient and better opportunities to control the processes variability. A resume of this step for the case study is presented in the Table 3. It is identified 39 processes and 820.2 seconds to finish one product.

**Table 3.**Resume of the Time and Motion Study – Cycle Time.

Process	P1	P2	P3	P4	P5	P6	...	P34	P35	P36	P37	P38	P39	Cycle Time
Time (s)	10.4	23.8	14.2	17.4	24.8	14.4	...	21.2	21.8	25.3	19.4	22.2	19.2	820.2

*Fifth Step:* Defining the number of workstations. We need to synchronize the cycle time (820 s) with the required manufacturing time. Thus, it is possible to fulfilment the monthly demand. For the case, it means that the line production must have a takt time of 206 seconds (step 3).

$$\text{Number of Stations Work required} = \frac{\text{Cycle Time}}{\text{Takt Time}} = 3.98 \cong 4 \text{ Work Stations}$$

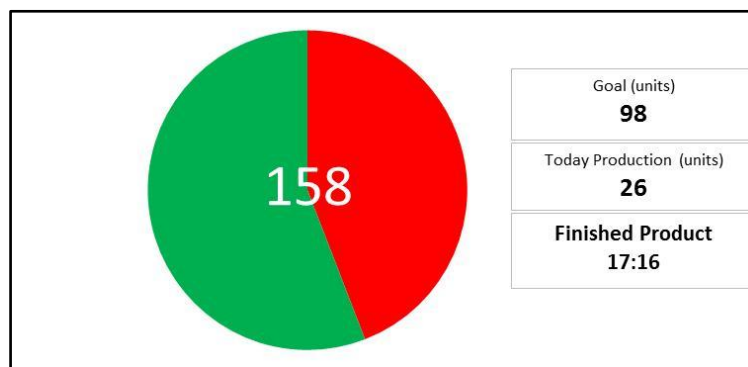
**Figure 1.** Synchronization Cycle Time with the Takt Time.

We need to group the processes (table 3) in workstations. Some processes could keep together due to production constraints. The Figure 1 presents the four stations required for the case study. The

workstation 1 includes from process 1 (P1) to process 11 (P11), the cycle time of this workstation is 205.6s. According to the figure, the standard deviation is 0.75s for the cycle time of each workstation.

After the five steps, we propose the use of a clock as orchestra director for the line production. The clock is an effective tool to keep the rate of the production, i.e. synchronizing the cycle time with the takttime.

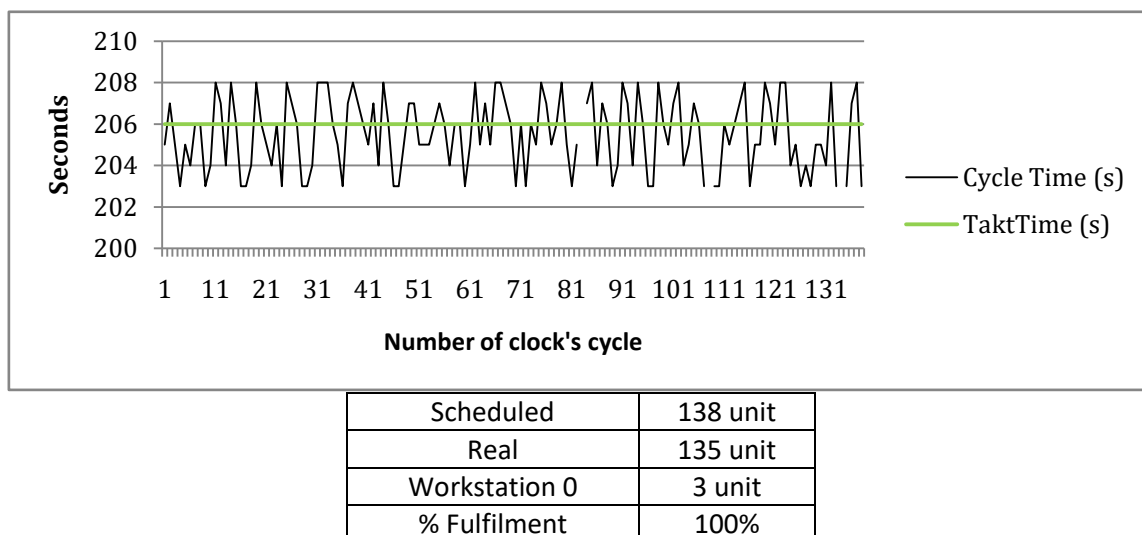
The figure 2 shows an example of the kind of clock required. Each time, that the clock completes its cycle, one finished product must be exit from the productionline. The cycle of the clock must be adjusted according the takt time (step 3). Each workstation must follow the rate of clock in order to fulfilment the production plan of the month. The figure 2 not only shows the cycle but also the quantity of products that must be produces in the day, and the remained estimated time needed to reach the goal production. This kind of information helps the workers to keep the rate production.



**Figure 2.** Clock as Orchestra Director.

#### 4. Results and discussion

The figure 3 shows results of the applied methodology during one day work in January 2017. The average takt time was 205.5 seconds with a standard deviation of 1.7 seconds.



**Figure 3.** Real Cycle Time vs Takt Time.

We can also notice that the goal production was achieved but it was necessary a “Workstation 0”. During the day production, three units faced some kind of problems and must been finished in a parallel workstation in order to not stop the line production. The takt time line, in figure 3, has three disruptions.

The Table 4 presents the summary results, and they are favourable spite of the forecast error (25 units). The demand was attended (3002 units), no client complains due to quality problems or incomplete orders. Before the firm applied this methodology, they could not attend the demand and needs to pay overtime.

**Table 4.**Summary Results (January 2017).

Forecast Demand	3027 unit
Real Demand	3002 unit
Real Production	3036 unit
Stock	34 unit

## 5. Conclusions

A high efficient synchronization between rate time of customer demand and the manufacturing time is possible, if we have a good forecast demand and a time and motion study. These studies allow estimating a good takt time and an appropriate number of workstations.

The proposed clock could be controlled in a web application, and it must be localized in order to facilitate the read along the production line. A called “Workstation 0” allows facing up eventual problems in the line production. Due to our case study is based on labour-intensive, manual assembly and not much machines, the proposed workstation is not expensive. At the beginning, the use of a “Workstation 0” is high, but as the workers come to be on better terms, the need of a “Workstation 0” decreases drastically.

## References

- [1] Womack, J., Jones, D., Lean Thinking: Banksh. Waste and Create a Wealth in your Corporation. New York: Simonand Schuster (1996)
- [2] Miller, J., Wroblewski, M., Villafuerte, J., Creating a Kaizen Culture - align the organization, achieve breakthrough resutls, and sustain the gains. McGraw-Hill (2013)
- [3] Industry Week, Everybody’s Jummping on the Lean Bandwagon, but Many are Being Taken for a Ride (2008)
- [4] Liker, H., Rother, M., Why Lean Programs Fail. Lean Enterprise Institute (2011)
- [5] Spear, S., Bowen, K., Decoding the DNA of the Toyota Production System. Harward Business Review, pp. 95-106 (1999)
- [6] Nyhuis, P., Vogel, M., Adaptation of logistic operating curves to one-piece flow processes. International Journal of PROductivity and Performance Management, 55(3/4), 298-299 (2006)
- [7] Liker, J., Meier, D., The Toyota Way Fieldbook: A practical guide for implementing Toyota’s 4Ps. Pp. 80-110. McGraw-Hill (2006)