Available online at www.sciencedirect.com

ScienceDirect

IFAC-PapersOnLine 48-3 (2015) 1399–1404

A case study: SMED & JIT methodologies to develop continuous flow of stamped parts into AC disconnect assembly line in Schneider Electric Tlaxcala Plant.

Rodolfo Rodríguez-Méndez *, Diana Sánchez-Partida*,
José Luis Martínez-Flores*, Ezequiel Arvizu-Barrón **

*UPAEP University, 17 Sur 901, Barrio de Santiago, CP 72410 Puebla, Pue., México.
**Colegio de Postgraduados Campus Veracruz. Km 88.5 Carretera Federal Xalapa-Veracruz, C.P. 91700 Veracruz, Ver.
(Tel: (+52) 222 229 9400; e-mail: rodolfo.rodriguez@upaep.edu.mx, diana.sanchez@upaep.mx, joseluis.martinez01@upaep.mx).
(**Tel: (+52) 229 9207257 e-mail: arvizubarron@hotmail.com)

Abstract: The competitiveness in the globalized environment highlights the importance of becoming more efficient in the execution of the company's operative and administrative processes in order to improve the level of customer service, delivery times, quality of products or services, as well as to optimize resources. The great advantage of implementing integrated logistics activities as a strategy to achieve this is undeniable. This paper, therefore, presents the methodology and the benefits obtained, which, with properly forecasted demand, aggregate planning methodology and the synchronization of some lean manufacturing techniques using tools like JIT (Just In Time) and SMED (Single Minute Exchange of Die), make the enterprise more competitive in delivery lead time, improve customer service level and reduce inventory. This case study involved some functional areas like Demand Planning, Materials Planning, the Manufacturing and Production Departments and the Warehouse Area. The principal objective of this research is to create a continuous flow of the stamped parts, from the Stamped Area to the final Assembly Line; in order to avoid sending the materials to the warehouse as currently happens.

Keywords: JIT, SMED, Continuous flow, Forecast, Kanban, Aggregate Planning.

1. INTRODUCTION

Business decisions are often made with insufficient information and a greater or lesser degree of uncertainty, depending on the time and resources allocated to the search and analysis of information. Various techniques, philosophies and methodologies have been developed to address this in order to make decision-making more accurate (Kwak *et al.* 1977).

One of the most-utilized techniques for business decision-making is demand forecasting, which is based on corporate planning in the short, medium and long term, depending on the purposes behind using the strategy (Wallace, 2006).

In the finance, production, logistics, materials and purchasing areas, forecasts provide the foundation for the planning of budgets, and material and human resources, and therefore cost control in a given period of time, so it is important to use a method that provides the minimum forecasting error (Armstrong, 2001; Everett *et al.* 2001).

This method is called aggregate planning and is one of the most important responsibilities of the operations manager and key to efficient production. The results of the aggregate program lead to a more detailed master production program, which serves as the basis for disaggregation, task programming and MRP systems (Render, 2004; Mertins et al. 1999).

This case study was conducted in the Schneider Tlaxcala Plant (STP) and aims to synchronize demand planning, translating the requirements to the planning area of materials that are manufactured in-house and, at the same time, achieving continuous flow in the stamping operation to ultimately supply the sub-assemblies produced in-house to the final AC Disconnect assembly line, using the SMED/JIT system.

The rest of the paper consists of a description of the case study, proposed methodology, results obtained following implementation of the methodology, conclusion and future works.

2. PROBLEM DESCRIPTION

2.1 Current condition of the areas involved in the case study.

2.1.1 Demand Planning.

The Demand Planning office is responsible for issuing the six-monthly demand forecast to each of the support areas.

The sales forecast is calculated by the corporation and distributed to the rest of the North American plants. The forecast is basically calculated using the Simple Linear Regression Method. The received forecast is a weakness for the Demand Planning area of the Tlaxcala plant since they only receive it and have no further information to smooth the forecast, which, in addition, has a very high error rate. The remaining areas use this information to perform their own planning and adjust their resources according to the client's

Peer review under responsibility of International Federation of Automatic Control.
10.1016/j.ifacol.2015.06.282

requirements. Monthly revisions are also made to adjust any requirement not considered in the original forecast.

2.1.2 Materials Planning.

The Materials Planning process begins only with the forecast provided. This finished product forecast is delivered to the materials analysts and the volume of finished product is exploded into its different components through a materials structure called Bill of Materials (BOM). This explosion of components and raw materials will give the perspectives of when and how much material should be ordered from external suppliers and the in-house manufacturer to meet the demand of the end client.

Currently, requirements are requested based on the monthly demand forecast. An analysis of the history of projected demand against real sales obtained in the last 36 months reveals a variability rate in projected demand of more than 20% on 12 occasions, causing problems such as:

1. Shortage of raw material for the manufacture of sub-assemblies when demand increases.
2. Excess of raw material for the manufacture of sub-assemblies when demand is low.
3. Average service level was 93% in 10 out of 36 months when the goal is 98%.
4. Constant adjustments in the Kanban (KB) calculation for sub-assemblies manufactured in-house.
5. Lost Kanban cards due to constant adjustments in production levels, causing the Kanban to crash and cards are not reordered.
6. Excess inventory of stamped parts equivalent to 15,375 pieces (10 days' inventory).
7. Increase in the cost of inventory since the fluctuations result in a Safety Stock of up to 100% to ensure delivery to the client in response to its demand.

2.1.3 Manufacturing and Production Area.

The variations or peaks in demand forecast for production and manufacturing processes are also largely affected. These areas must react as quickly as possible to ensure the delivery of stamped sub-assemblies in due time and form to the finished product assembly line. Some of the problems caused by these fluctuations are described below:

1. Constant adjustments to increase or reduce the capacities of the work centers caused by constant fluctuation of the forecasts.
2. Adjustment of operative personnel to produce the required demand.
3. Large production runs made to take advantage of the tool assemblies adding the trigger option into the Kanban calculation.
4. 39 minutes wasted in adjustments for every tool change.
5. Ongoing training of hired personnel when monthly demand increases between 25% and 40% (data recorded from December 2013 to March 2014), equivalent to 6 people with a training cost of US $800.00.

2.1.4 Warehouse Area.

The main activity of this area is to temporarily store the stamped parts that comprise the finished product. Figure 1 shows the logistic movement of these components.

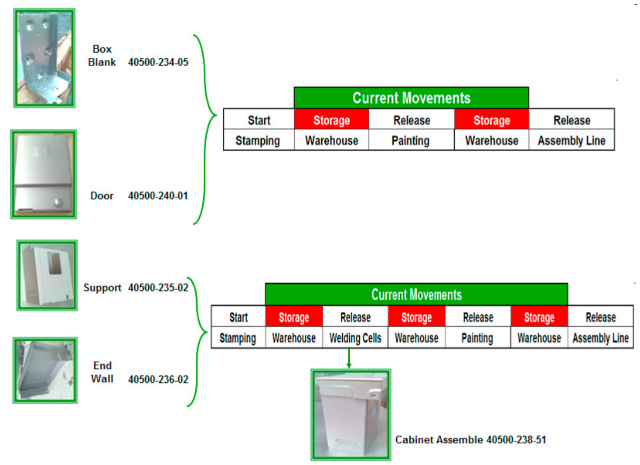


Fig. 1 Layout of the path of the stamped material.

It is easy to see that these products are stored three times before reaching their final destination, which is the finished product assembly line.

There are four different part numbers produced in-house that make up the finished product, speaking specifically of stamped parts. The back and door are only stamped and painted before being sent to the warehouse. The bracket and top are part of an enclosure; these are stamped, sent to manufacturing cells for welding together, and then painted and sent to the warehouse.

It should be mentioned that currently the lot sizes are disproportionate, some of 2000 pieces, 1000 pieces, 1344 pieces, etc. (when consumption is one to one and they should be calculated at the same size), with delivery times of up to three days, which implies having more material both in process and in store.

Other problems detected in the warehouse area during the analysis were the following:

1. Space problems in the warehouse.
2. More pallets being used due to the number of cards needed in the system.
3. Unnecessary ERP transactions.
4. Time wasted moving materials from each work center to the warehouse and vice versa.

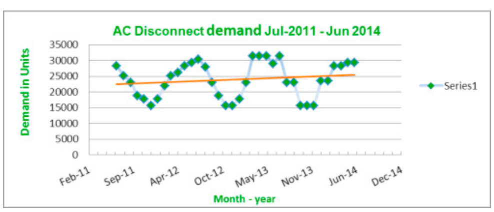
3. METHODOLOGY

The case study is described in three phases: In the first, the demand for the finished product is identified and a forecasting method suggested that reduces error as much as possible and obtains a smoothed demand. The second phase involves the development of aggregate planning for the final assembly line, selecting between chase demand and constant production the strategy that provides the greatest benefit and at the lowest operating cost. Finally, in the third phase, smoothed demand is used for the development of SMED/JIT methodology in the stamping line, which supplies sub-assemblies to the AC Disconnect finished product line, thereby generating a continuous flow of material without the need to send each one to the warehouse.

3.1 First phase.

As seen in the above analysis, the problem lies mainly in the sudden changes in production levels dictated by the Demand Planning department. This variation implies constant reconfiguration particularly for the materials planning and production areas.

For this reason, the first phase in this study was to identify the demand of the AC Disconnect production line. Graph 1 clearly shows that demand behavior generated in the last 36 months has a regular pattern with seasonality and a slight upward trend. Taking this into account, the most suitable methods to forecast the time series are the Simple Linear Regression Method or the Double Exponential Smoothing method, and also performing the error analysis (Ballou, 2004).



Graph 1. Identification of Demand.

We suggested to the Demand Planning department, prior authorization from the logistics management, that it use the double exponential smoothing method to perform the demand forecast for the AC Disconnect line only, on a trial basis.

This method allows compensations to be made for some trends or for a certain period by carefully calculating the variation coefficients. If desired, more weight can be given to recent months and the noise factor effects partly cushioned by giving less weight to older demand. The coordinator (who is the expert) must choose the values of the coefficients; the success or failure of the model will depend on that choice (Armstrong *et al.* 2001).

3.2 Second phase.

Smoothing the demand and reducing the variations directly impacts the availability and handling of resources in the operation. In this study, we developed an aggregate planning and tested it with constant production and chase demand strategies to reduce operating costs and increase profit.

3.3 Third phase.

In the internal Materials Planning and Warehouse areas, we suggest designing an in-house logistic flow of stamped materials from the stamping zone to the finished product assembly line, thus reducing the costs associated with the movement of materials and inventory; recalculating batch sizes of each of the stamped pieces ensuring that batch sizes are less than daily use, i.e. that each batch covers production hours; recalculating the process lead time according to the implementation of SMED; reconfiguring the system to eliminate the storage of stamped components in the warehouse (called Warehouse 4000), and for these to be processed at floor level (Warehouse 2000), having a direct impact on inventory reduction.

To do this, the Manufacturing and Production area must make all the necessary changes to the manufacturing dies of the components used in the AC Disconnect finished products, in order for assembly to be almost instantaneous. The development of a pit-stop team (a high performance team for rapid tool changes) will ensure coordinated assembly, reduced adjustment times and a production run with a very short delivery lead time.

4. RESULTS

The first results from the implementation of the methodology are the demand analysis and its forecast, which will be directly related to the flow of materials in the stamping line.

As part of the forecast evaluation we recommend performing additional analyses of forecast error which give the company more information; these extra analyses can be Median Absolute Deviation (MAD), Mean Absolute Percentage Error (MAPE), Mean Squared Error (MSE) and Mean Percentage Error (MPE), (Hanke *et al.* 2008).

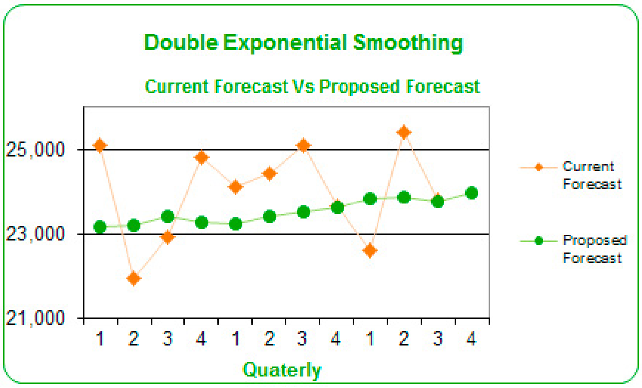
Table 1 shows a comparison of the forecast errors, both by the Simple Linear Regression method and the suggested Double Exponential Smoothing method, with data from July 2011 to June 2014. A difference in the MAPE can be observed of 17.7% between the two methods, representing a difference of 3737 pieces.

Table 1. Result scenarios of calculated forecasts.

Resulting error from the different methods

a) Simple Linear Regression		b) Double Exponential Smoothing	
N=	36	N=	12
MAD=	4673	MAD=	936
MSE=	5355	MSE=	1112
MAPE=	21.70%	MAPE=	4%
PME=	-5.81%	PME=	1.53%

Once a smoothed forecast has been obtained through the Double Exponential Smoothing method, also known as the Holt method, the forecast is introduced to the aggregate planning of the AC Disconnect line, evaluating strategies that can be used based on company needs. Graph 2 shows the smoothed demand.



Graph 2. Behavior of proposed forecast against current forecast.

The use of pure or mixed strategies normally works to perfection when demand planning has a certain degree of smoothing, with minimal error coefficients (Chase *et al.* 2001).

Mixed strategies are not applicable to the process under analysis here since the company manufactures safety products, rendering it impossible to give partial or total manufacturing to an outside supplier.

Some models, such as constant production or chase demand, can be used for aggregate planning with very good results (Chase *et al.* 2000; Heizer *et al.* 2004).

The company has worked with the chase demand strategy for years, and an evaluation has been made to identify whether changing to a constant production strategy can increase profit and reduce operating costs.

Pure strategies like constant production and chase demand were tested in the 6 month period from January to June 2014. These same strategies were then evaluated with the forecasts made for the January to June 2015 period.

According to the results obtained from the chase demand method, operating costs are 1.03 million dollars with an income of 1.87 million dollars, generating profit of 841,000 dollars. In contrast, if the constant production method had been used, the operating cost would have been 1.15 million dollars with a profit of 715,000 dollars, giving the conclusion that the operating cost is lower and profit is higher working with the chase demand strategy. Table 2 shows the comparison of the aggregate plans with different strategies.

Table 2. Comparison on plans with different strategies with data from real demand January – June 2014.

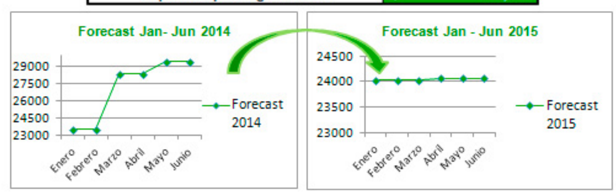
Chase strategy			
Real Demand - Jun 2014			
Operating Cost	$	1,032,908.80	Usd.
Incomes	$	1,874,301.12	Usd.
Profit	$	841,392.32	Usd.

Level strategy			
Real Demand - Jun 2014			
Operating Cost	$	1,149,050.07	Usd
Incomes	$	1,874,301.12	Usd
Profit	$	725,251.05	Usd

In the same way, from January to June 2015, the chase demand strategy works best for the company. Table 3 compares the results from 2014 against 2015 with the chase demand strategy, observing that by adjusting the forecast, the operating cost will be lower and there will be an increase in profit.

Table 3. Comparison of Profit and Operating Costs January-June 2014 vs January-June 2015 (expected) with the chase demand strategy.

CHASE STRATEGY		Profit (Dollars)
Profit 2014	$	841,392
Expected Profit 2015	$	967,695
CHASE STRATEGY		**Op. Costs (Dollars)**
Operating Costs 2014	$	1,032,909
Expected Operating Cost 2015	$	906,606



With these results it can be concluded that for the production period January to June 2015, there will be no significant changes in monthly production volumes, that is, the average monthly demand will be for 24,048 pieces according to the forecast obtained for 2015.

Furthermore, behind the finished product assembly process is the stamping process; this was in line with the forecast and the aggregate planning process.

As a consequence, batch sizes had to be readjusted given that it was necessary to establish the economic amount to manufacture daily of each sub-assembly and find the point of "economic" balance between a long run production and costs associated with the inventory.

The Economic Order Quantity (EOQ) model was used to calculate the economic batch of each component for daily manufacturing.

The ideal batch size was calculated at 514 pieces of each type of piece used for the assembly of the finished product. Following a sensitivity analysis, we decided to establish the batch size at 500 pieces of each sub-assembly. It should be pointed out that each stamped part is used one to one in the final assembly. This means that the manufacture of one finished product requires one back, one door, and the enclosure assembly described in Figure 1.

Based on the aggregate planning of this project and applying the chase demand strategy, the average monthly requirement will be 24,048 pieces for the final assembly line and, considering an average of 21 work days per month, the daily consumption of each manufactured component will be 1202 pieces. This means that 3 orders of each component must be manufactured every day, with 298 pieces remaining that will be used for safety stock purposes.

Based on the manufacturing and production analysis of the time records, tool changes and adjustments take an average 39 minutes for each tool assembly.

With the implementation of SMED methodology, the assembly time was cut from 39 minutes to just 9.59 minutes, reducing delivery times and eliminating excessive storage costs. SMED reduces the non-productive time by streamlining and standardizing tool change operations using simple techniques and easy applications (Carrizo *et al.* 2011).

To comply with the plan, the spare parts and tools had to be acquired to ensure a rapid, one-digit change time. The investment made to implement SMED was 7,500.00 dollars and the objective was finally met as planned.

One consequence of the smaller manufacturing batches and reduced set-up was the modification of the Kanban cards, which provide information about what will be produced, in what quantity, with what means and how the material will be transported. Kanban systems have been introduced in a large number of companies (Mukhopadhyay *et al.*2005; Wan *et al.* 2007).

To establish the right number of Kanban in the system of each catalogue, it was necessary to use the common Kanban calculation formula.

Table 4 shows the savings obtained in the inventory as a result of the new calculation of Kanban cards.

Table 4. Savings generated by new calculation of Kanban cards.

Before		
Inventory amount	$ 21,851.63	Dollars
Space Used in Warehouse	49	Locations
Lead Time	3	Days
Kanban Cards in System	49	Cards

After Implementations		
Inventory amount	$ 4,883.62	Dollars
Spaces in Warehouse	0	Locations
Lead Time Stamping parts	2	Days
Kanban Cards Reduction	24	Cards

Total Savings		
Inventory amount	$ 16,968.01	Dollars
% inventory reduction	77.65	%
Spaces in Warehouse	49	Locations
Lead Time Stamping parts	1	Day
Kanban Cards Reduction	25	Cards

All this work helped to eliminate inventory in warehouse 4000 of the sub-assemblies manufactured in-house that are used in the finished product line, and consequently reduce excessive movement of materials by streamlining processes and making them more flexible.

The redesign of continuous flow was based on the plant's current lay out, and the best way to deliver the painted material and return the empty carts for refilling. In Figure 2, the arrows with a continuous line from right to left show the flow of material from the painting area to the final assembly line; in contrast, the arrows with a broken line from left to right show the return of the empty carts to the painting area, eliminating the storage of materials in Warehouse 4000.

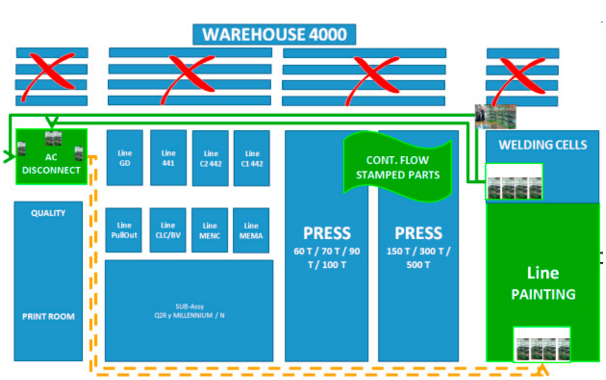


Fig. 2 Continuous flow of stamped parts for the AC Disconnect line.

Eliminating the movement of the stamped parts to Warehouse 4000 and then from the warehouse to each of the work centers, generated savings of 26,000 dollars in personnel and energy use for the vehicles used for those tasks.

5. CONCLUSIONS

The implementation of this project enhanced four of the company's key processes, involving the Demand Planning, Planning of In-house Stamped Materials, Manufacturing / Production and Warehouse areas, improving a series of logistics activities carried out by each of these departments and which are critical for ensuring that the finished product is delivered to the end customer in due time and form.

The Tlaxcala plant became the first Schneider plant to perform this practice, which is required by the Schneider Production System (SPS) internal audit system. Communication between the different departments increased thus obtaining efficiency in their day to day processes.

Since its implementation in October 2014, the demand peaks that were experienced year after year have been eliminated, with an increase of 98% or more in the level of service of the AC Disconnect line.

In addition, estimated savings of 126,302.27 dollars have been made in operating costs in the first half of 2015. The Warehouse 4000 storage configuration was eliminated from the SAP (Systems, Applications, Products in data Processing) system so that those components would be processed only in Warehouse 2000. The elimination of pieces in Warehouse 4000 freed 49 storage spaces, implying an inventory reduction of 77.6%, equivalent to 16,968.00 dollars per month. An additional saving of 7000.00 dollars over six months was obtained by eliminating the unnecessary movement of material.

Modifications to the dies were carried out reducing the assembly time from 39 minutes to only 9 minutes in the assembly of each piece used in the manufacture of the finished product, which equates to a 77% improvement in time saved for each tool. The creation of a pit-stop team was an important achievement since the Schneider Tlaxcala plant is the first to implement this practice.

Another successful result is the replication of this methodology in the other Schneider Electric North America units, and its adoption as good practice. It is intended to extend the implementation of this methodology to the remaining nine production lines, although this may imply the use of other tools because of the greater mix of stamped products.

ACKNOWLEDGEMENT

This research was developed in the Master's program for Supply Chain Logistics and Management assigned to the standard of excellence and supported with resources granted by the National Science and Technology Council (Consejo Nacional de Ciencia y Tecnología) – CONACyT. CV: 505175. Scholarship holder number: 287098