Concepts and tools used to manage industrial manufacturing processes optimization

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Abstract. This work is the result of a study on the production process of a company that manufactures safety features for vehicles. Repeated problems encountered in the production process significantly affect the company's performance and reputation. The aim is to provide an overview of the problems of production, allowing identifying the causes of faults to remedy them. Once a fault has occurred and the product was delivered to the client it will be very difficult to recover both reputation and costs, and to replace the damaged stock. The paper contains arguments for the need to optimize the production processes as a whole, describing the concepts and tools used to analyse and solve a concrete case of improving the production system for a complex and sensitive product. The information obtained from the detailed analysis and improvements in the quality level, the decrease of the production costs and the keeping the delivery rate to the client are presented.

1. Arguments for process optimization approach

Due to a very high risk factor brought by an Airbag Curtain Lateral Project (ACL or P32S), it was decided to start an extensive workshop to improve the production process. A brief analysis reveals that an improvement area is a huge one because the production process was very difficult and brought the company's weakest results in 2014:

- Poor quality level - of the total of 20,000,000 airbags sold, ACL contributed only with 600,000 units, generating 19 of the total of 27 customer complaints (figure 1);

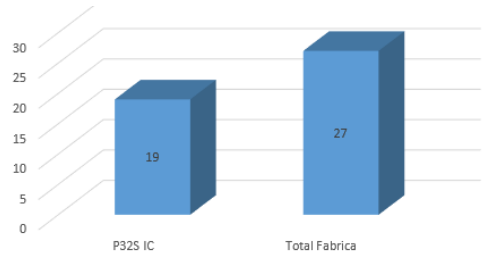


Figure 1. Number of customer complaints.

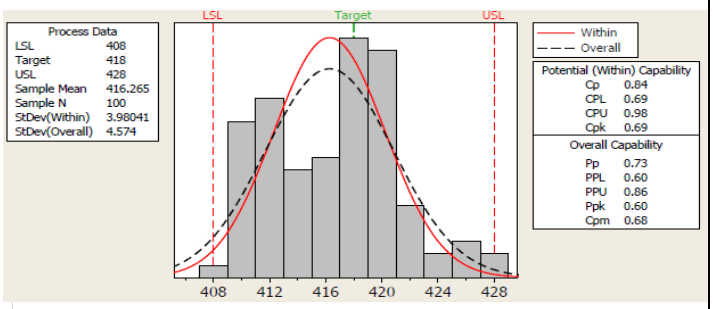


Figure 2. Gauss's curve on the Cp Process

- The ACL product defect rate was 3% and the factory target was 1.2%;
- The OEE for the ACL product was 65% and the factory target was 85%;
- The manufacturing process was far from 6sigma, PPK and CPK for most requirements was below the target of 1.33 / 1.67 of a production series, - (figure 2);

2. Tools used to analyze the production process

Lean Manufacturing Principles (5 in number) according to which all activities that do not add value to the client's eyes (but only generate costs) are identified as waste [1, 2, 3].

- One Piece Flow Concept (OPF) - which assures the customer what he wants, in the amount he / she wants, when he / she wishes. OPF is the production and movement of a single piece in a certain amount of time through a series of processes, as continuously as possible, in order to adjust itself to the best of tact time, at each stage achieving only what is necessary to proceed to the next operation. Implementation of the OPF requires: adequate number of operators with appropriate mentality, elimination of Muda, standardized work, production line balancing and in return a number of benefits in several areas: quality, inventory, productivity and safety [4];
- Value Stream Mapping (VSM) - both the Current State Map (graphical representation of the value flow in the existing situation) and the "Map of the Future State" (the improved value flow - by applying all Lean tools) are constructed by mapping the value flow based on process data (inventory, cycle time, change over time, up-time, default rate, etc.) [5, 6];
- "Zero defects" concept - quality defects have associated significant costs: materials, resources, time and reputation [7]. Debugging programs can be very expensive and can consume a lot of resources and time. Does the solution consist of eliminating defects without taking into account the necessary cost, or accepting a small percentage of defects? So far, Philip Crosby's solution has been superior, "everything has to be done first time and every time" [8].

3. Example of good practice in using concepts and tools to optimize the product manufacturing

The management study with optimization of ACL product manufacturing has been aimed at significantly reducing the presented difficulties and satisfying an increased demand from the customer.

3.1. Intensive Workshop Lean Manufacturing: „One Piece Flow"

First, they defined steps / stages that facilitate the implementation of OPF, planning necessary time for each step/stage, during 10 working days, as shown in Table1.

Table 1. Planning and scheduling of the intensive OPF workshop steps.

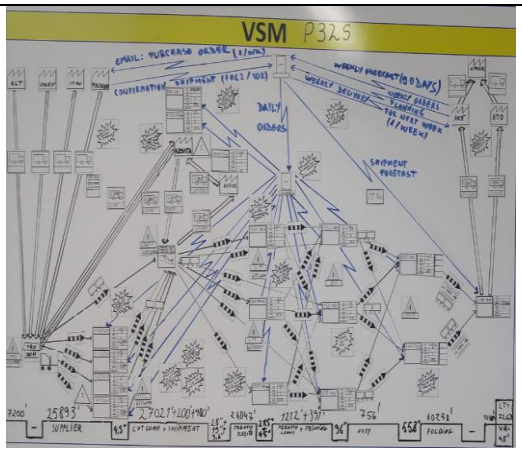
Step no.	Day	Step description	Time [min]
1	1st	Choosing the Team	10
2	1st	Choosing the Line (OPFWS Plan)	10
3	1st	Management challenge (Laminar flow, OPF	10
4	1st	Session Training (all team)	120
5	1st	GEMBA walk: data collection + Current Layout (all team)	210
6	1st	Scope /objective definition (all team)	60
7	2nd	Process Analyse and data collection form	480
8	3rd	Current layout drawing and attaching to magnet board	30
9	3rd	SWC coloured sheet for manual or automatized time	60
10	3rd	Compute CT/operator	120
11	3rd	Time introduction in SWCS form	120
12	3rd	Sequencing: update SWCS layout (Synchronicity)	120
13	4th	Takt time for 3 months	60
14	4th	Machine Improvements: updates SWCS layout	180
15	4th	Number of Operators = Manual time/TT*115% (the highest)	30

16	4th	Eliminating Muda	60
17	4th	Line balancing on board (it is used the smallest takt time)	150
18	5th	Redesign for line layout (reducing the space inside the line)	120
19	5th	Line adjusting/new layout	120
20	5th	SWI : SWS or STD work element	240
21	6th	Moving the line in choose configuration	300
22	6th	Re-measuring line CT	180
23	7th	Line documentation Update with SWS	240
24	7th	All the procedures from above will be repeated for all takt time configurations	240
25	8th	Operators Training	240
26	8th	New process release	30
27	9th	Line start	480
28	10th	Closing ceremony	30

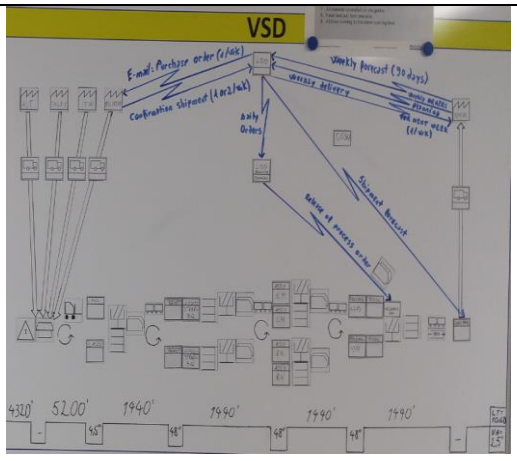
3.2. Mapping „Value Stream Design".

Due to a very high requirement from the customer and the very low logistics contract, there was a great risk of entering into a capacity shortage and no longer able to honour orders to the client. Only 3 production lines were available for the ACL and with the increase of the requirements, it was necessary to validate / qualify the product on a 4th production line also used for the same customer. Deliveries to customers were at a disappointing level, a 85% for the logistics contract reported under the logistics contract at a minimum of 95% and Lead time was very high, generating both large stocks and delivery delays. To solve these new problems, a Success Story has been used following a Best Practice.

The Improvement Workshop started with the formation of a team that, after attending a training session on flow, ergonomics and regular delivery themes, went to the macro-planning of activities to identify and analyze the causes and finalize the workshop agenda and the current Value Stream Mapping (see figure 3 - before).



(a)



(b)

Figure 3. Value Stream Design - (a)before (left) and (b) after workshop (right).

In order to implement the "Value papers" concept, it was necessary to set goals:

1. Production without variations: Time Takt, Logistic contract; Sharing and levelling customer orders.

2. Getting the shortest delivery time: Continuous flow, Laminar flow, One piece per stream, No isolated operators, No unnecessary objects at the work point, Separation of the operator from the work point and Creating standardized work instructions containing the work items ;

3. "Pull" flow (Kanban system);

4. Balancing production lines;

5. Standardized work.

Removing "non-value add" elements and optimizing the logistics operation process (line transfer, assembly line transformation, line transfer, merging operations, material changes, etc.) resulted in a Value Stream Design that reduced Lead time from 72.6 days to 10.6 days.

In addition to substantially reducing the lead time for the ACL product, following the use of this concept, three more important insights have been gained:

1. A new "Lessons Learned": Simplify processes by meeting the production plant's objectives regarding material flow and production organization.

2. Open new ways: a workshop on identifying components and material flow and then physically relocating equipment.

3. Clear and SMART objectives to be pursued in the future:

- Implementing the best actions on all production lines: "Yokoten Ergonomics and Performance" - to save about 50square meters, 3 operators and 11% Labor Minutes Per Unit;
- SMED (Single Minute Die Exchange [9]) on assembly lines - for shorter project change time from 43 to 10 min;
- SMED on Laser cutting lines - shortening project change time from 21 to 10 min;
- Continuous Improvement.

3.3. „Zero Defects" Workshop

It starts from the defect definition, on the production line is created the standard notice board as a visual management factor, and then the 8D - Problem Solving method is distributed successively in 5 steps:

1.*Prepare t*he objective of this preparatory work is to ensure that the workshop bases are set, that all documentation is ready and that the product specifications coincide with the reality of the prod. line;

2.Macro Workshop Planning - This step comprises the first two disciplines *(D1:* Forming a team for 8D Analysis [11] – it must be as a result of a thought process to get the best possible result under the given conditions. It has to go through all 8D analyse stages should be done following Category A complaints (highest severity), *D2:* Apply the Go & See method to find evidence);

3. *Troubleshoot current issues - t*he objectives of this stage are to eliminate all the problems one by one in turn and to ask for help from the management to solve the systematic problems or to support the engineering department to solve the technical problems. In this stage, the whole team is focused on problem solving *(D3:* Implementation of problem-limiting actions);

4. *Anticipating Potential Problems-t*he objectives are to identify potential problems using the experience gained in conducting a PFMEA Go & See [10], (D3: Implementation of problem-limiting actions as a first customer protection response, D4: Identify the main cause);

*5. Yokoten. - t*he objective of this step is to avoid recurrence of a problem in other areas as well *5. (D5.* Choosing and implementing corective actions. *D6. Evaluation of results, D7. Preventing the problem,* D8. Congratulations to the team).

4. Conclusions

In addition to the benefits already mentioned in sections 3.1 and 3.2, among the many improvements brought about by the application of the concepts and tools discussed, we only mention a few:

- Improving tool management in the production line, full check of inline tools and dedication of a special backup toolbox, implementing weekly verification and saving as an excel file in the database, implementation of stainless steel counter top to prevent friction and improve flow of tools, improvement of component detection system, Process Flow Modification and line layout integrating the One Piece Flow concept;
- A series of systems have been implemented which, if the deflector is positioned incorrectly sends an electric impulse and ignites a bulb, respectively, on a production line a Yokoten system and on the other two lines delivering directly to the customer instead of lighting a the bulb is set to stop the line.

As an overview of "how it was before" and "how is it after" the application of leadership concepts with optimization of the manufacturing processes of the ACL product in the considered company, we present two graphical suggestions regarding the evolution of the number of defects and their category (figure 4) and the number of customer complaints for this product (figure 5).

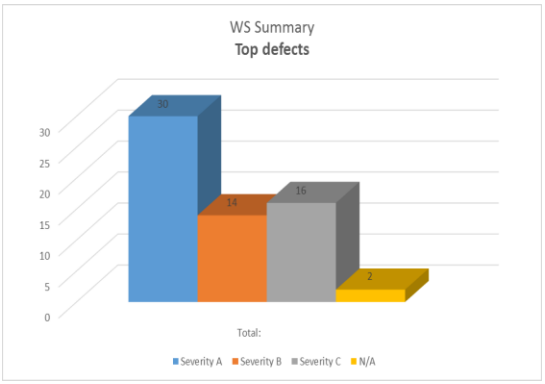


Figure 4. Defects classification.

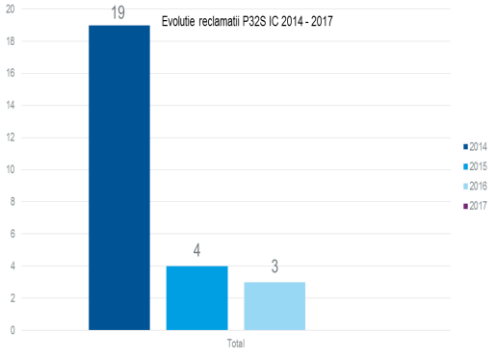


Figure 5. Evolution of customer complaints after improvements to the production line.

Finally, we note that the most important gain is that it was possible to prove that the "theory" of the concepts and tools of organizing and optimizing production is of great help in the case of rigorous application in practice and that already without them a firm no longer can survive nowadays.

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Acknowledgements: This work has been developed with the help of the Autoliv Company and the documentation provided by it. Data processing, implementation and technical advice to solve

production problems is the contribution of the authors.