Lean deployment in SMEs, performance improvement and success factors: a case study

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Abstract

SMEs play a critical role in the economic and industrial growth of countries. These companies need to improve continuously to survive. Therefore, effective lean implementation within Small and Medium-sized Enterprises is significant. However, it is found in the literature, that very few SMEs have given importance to the lean implementation. These companies are still suspicious of the Lean applicability and its benefits despite the various studies conducted in this area.
Through a case study of the Lean principles deployment in a small company manufacturing aluminum products, this paper aims to capitalize on the conducted approach, the results of performance improvement and success factors to carry out lean effectively in SMEs.

Keywords
Lean production, Small to medium-sized enterprises, Performance improvement, Success factors

1. Introduction

With the current economic climate, companies are forced to engage in improvement approaches to enhance their performance in order to keep their competitiveness in a context of globalization and great competition. Therefore, many practitioners have worked on continuous improvement initiatives covering all corporate objectives (reactivity, quality, cost ...). Of these, the most recent approach is that of Just in Time and Lean production (Womack, et al., 1992).
Nevertheless, these approaches have been developed by large companies and consider, in most cases, their specificities (White, et al., 1999; Shah & Ward, 2003). However, large companies are not the only actor in the economic context. Indeed, SMEs (Small to Medium-sized Enterprises) play also a significant role in the industrial sector worldwide in term of production volume and employment generation (Bhamu & Sangwan, 2014). Despite this, SMEs are still unable to benefit from competitive advantages gained by lean production, since most of them were not being given the opportunity to apply Lean as it is dictated by Womack, Jones, Liker, Åhlstrom, and other Lean leaders (Elbert, 2012).

Thus, SMEs are reluctant about the opportunity of lean deployment and not confident about its outcome and benefits, especially by putting before them the required investments and rushing the economic results (Achanga, et al., 2006). The objective of this paper is to present a case study of effective Lean principles deployment into a SME in order to improve its economic and industrial performance and thus allow it to expand its market and increase its revenue. Three aims are stated for this case study:

- To demonstrate, based on a proposed lean principles deployment approach, the applicability of lean in SMEs,
- To highlight the outcomes and benefits of the approach in term of improving industrial performance,
- To point out the success factors taking into account the specificities related to this type of companies.

The rest of the paper is arranged as follows: the second section introduces the concept of lean production and its principles. The third section elucidates the steps involved in lean principles deployment as the proposed approach. The fourth section attempts to summarize the success factors of lean deployment. The paper is concluded in the fifth section.

2. Theoretical background

2.1 Lean Production

Following the seminal work "The Machine that changed the world" (Womack, et al., 1991), the concept of lean production has become spread worldwide and has been applied in many fields beyond the automotive industry where it has originally appeared (Parker, 2003). This concept includes a variety of practices to achieve simultaneously several objectives of increasing capacity (Dennis, 2007), improving quality (Liker & Yu, 2000) and reducing lead time (Liker, 1996). These objectives are achieved by eliminating waste in the system (Lewis, 2000). The notion of waste is, therefore, fundamental to define the Lean. Womack and Jones (2003, p. 23) defined by a waste: « any human activity which absorbs resources but create no value ». These non-value added activities have been categorized according to Ohno (1988) in seven different types: (1) overproduction, (2) waiting, (3) unnecessary transport and handling, (4) unnecessary over-processing, (5) inventories, (6) unnecessary motion and (7) defects. The Lean philosophy aims, therefore, to eradicate this types of wastes anywhere within the organization, to optimize the use of resources and build a continuous corporate culture that leads to customer satisfaction (Karim & Arif-Uz-Zaman, 2013). Lean philosophy is based on the five principles defined by Womack and Jones (2003):

- Specify Value as perceived by the Customer,
- Identify the Value Stream,
- Make the Value Flow through the Value Stream,
- Pull the Value from the Value Stream,
- Strive for Perfection.

These principles are widely accepted in industry and have achieved an outstanding success for many companies in several areas. However, there is no consensus on the deployment methodology of these principles within companies. It is the responsibility of the company management to know these principles, develop a positive change culture to lean transformation, define Lean Production guidelines and support its progress (Emiliani, 2008).

2.1 Levers and constraints of Lean Production implementation within SMEs

According to Womack et al. (1991, p. 7),

> *…the principles of lean production can be applied equally in every industry across the globe and that the conversion to lean production will have a profound effect on human society…*

It means that Lean principles deployment is possible in all types of organizations including SMEs.

However, according to several authors and experiences, the deployment of Lean principles within SMEs takes a number of features related to the specificities of this type of company. As affirmed by Shah and Ward (2003) contextual factors including the company's size affect Lean deployment. In fact, application of some Lean practices, such as multifunctional teams or total productive maintenance, in SMEs is easier than in large companies (Åhlström, 1998; White, et al., 1999), while other practices, such as Just-In-Time, are more complicated in SMEs. Moreover, SMEs have several levers, because of their specificities, that promote the deployment of Lean principles compared to large companies. For example, SMEs have demonstrated more flexibility in term of management structure. Indeed, if the managers are engaged, they can achieve more easily the desired change in SMEs because of lower bureaucracy level and shorter communication lines (Haksever, 1996).

Notwithstanding, the number of SMEs, which are being given the opportunity to enjoy the benefits of Lean is very limited (Achanga, et al., 2006; Elbert, 2012). This leads to ask a multitude of questions about the barriers and obstacles faced by these companies. According to various schools of thought, the obstacles for SMEs are numerous. First, being small, which has been viewed as both an advantage and a disadvantage, gives rise to financing constraints and lack of

resources and management when seeking the Lean change (Achanga, et al., 2006; Chong, 2007). This lack of funding and resources affect the quality of employees training and hence, their motivation which can negatively influence both their competence level and their involvement in the deployment approach. Therefore, the actual contribution of the human factor is very restricted. On the other hand, if the company has in addition an unstable production program (Golhar & Stamm, 1991) and wide products variety (Cusumano, 1994), these are additional sources of disturbance to the proper deployment of Lean principles. Also, insufficient cooperation with suppliers is a major obstacle facing the Lean deployment within SMEs (Finch & Cox, 1986).
However, these obstacles can be mitigated by a set of success factors. One of the main factors for successful Lean implementation in any type of organizations is management involvement and support (Liker, 2004; Achanga, et al., 2006). Various other factors can also support Lean implementation such as all employees' involvement and proper demarche of lean principles implementation (Liker, 2004; Achanga, et al., 2006; McLachlin, 1997).

3. Case study

3.1 Company background

The case study presented in this paper is performed within a small company specializing in design, development and production of aluminum windows for Railway, Bus and Nautical sector. Table 1 presents the company's main characteristics.

Table 1. Main characteristics of the company

Activity	**Capital**	**Workforce**	**Management**
Aluminum carpentry	247.640 £	18	3

This is a small company with a small number of employees (18 individuals with 3 managers) and a low capital not exceeding 250.000 £. The company received two tenders from two giants on the automotive market. This was a great opportunity for the company to expand its market. However, the company has suffered from a state of disorganization leading in many problems with its usual customers. Therefore, the company was not sure of its ability to meet the new more profitable but very demanding market in term of industrial performance criteria: quality cost and delay. By the obligation, the company decided to adopt a new management approach and to engage in a lean transformation to meet effectively these new challenges in quality, costs and delivery, starting with the production process. The company has a simple and flexible production process that produces three types of products:

- Double windows for buses,
- Single and double windows for railways,
- Windows as needed for nautical sector.

3.2. Approach of Lean principles deployment

In the literature, there are several proposed approaches and frameworks to implement Lean principles. These approaches are based in most cases on the manufacturer's common sense (Karim & Arif-Uz-Zaman, 2013) and vary according to the context of Lean principles deployment. Based on Lean principles identified by Womack and Jones (2003) and several studies which treated the issue of Lean implementation (Karim & Arif-Uz-Zaman, 2013; Dennis, 2007; McLean, 2015; Bhamu & Sangwan, 2014), an approach is proposed to implement Lean in the organization and is delineated in figure 1.
This approach was chosen for various reasons:

- The approach follows directly from Lean principles,
- The approach has been tested for a process similar to ours and gave good results,
- The approach includes a measurement system that will be detailed later.

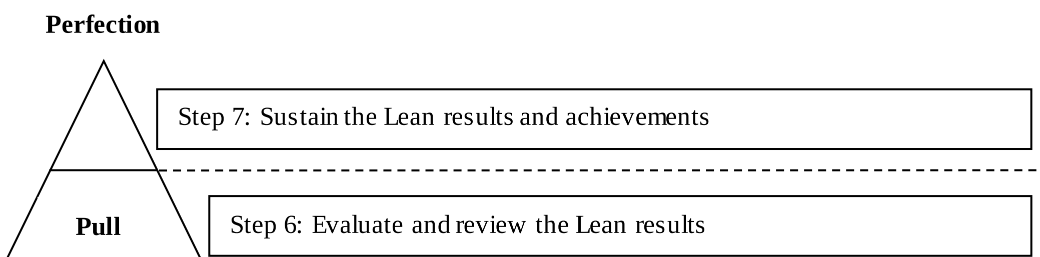

Figure 1. Proposed approach for Lean principles deployment in the organization.

3.3. Deployment of Lean principles within the company

3.3.1. Step 1: Define the system

The first meeting was held with the Director General and the Chief Operating Officer who showed their firm commitment to the process and explained their expectations for both cultural change and performance improvement.

However, improvement opportunities are virtually unlimited and must be handled by very limited resources (given company's size and nature). Therefore, the delimitation of the spheres of action is crucial. It should choose the top priority value stream, focus resources and maximize gains (McLean, 2015).

Based on the distribution of annual volume and revenue of the company during the previous year (Table 2), it is certain that we are targeting the most important product (product A3, family "Bus") representing 30% of the annual volume and 33% of the company's annual revenue.

Table 2. Distribution of the annual production volume and income during the previous year

Product family	**Product**	**Annual volume**		**Unit price (£)**	**Annual revenue**	
		Unit	**%**		**£**	**%**
Bus	A1	1 113	7,24%	120	133 560	7,76%
	A2	3 842	24,98%	80	307 360	17,85%
	A3	4 576	29,76%	125	572 000	33,22%
	A4	3 015	19,61%	120	361 800	21,01%
	A5	2 392	15,55%	90	215 280	12,50%
Railway	R1	142	0,92%	315	44 730	2,60%
	R2	97	0,63%	220	21 340	1,24%
	R3	110	0,72%	315	34 650	2,01%
Nautical	N1	42	0,27%	350	14 700	0,85%
	N2	16	0,10%	300	4 800	0,28%
	N3	33	0,21%	350	11 550	0,67%

The production process of the A3 product is shown schematically in Figure 2. It includes the following: The storekeeper prepares the necessary profiles in quantities and measures for the machining station which handles cutting, milling and bending. This is followed by a mechanical treatment comprising a chamfering of profiles edges to facilitate welding, followed by a degreasing with alcohol of dirt and soiling affecting the profiles during mechanical treatment. The profiles, that are already machined, chamfered and cleaned, are assembled in the welding station. The assembled frames are transported to the polishing station for the mechanical finishing of peeled surfaces and eventual cleaning. Finally, they are packaged and delivered to the clients.

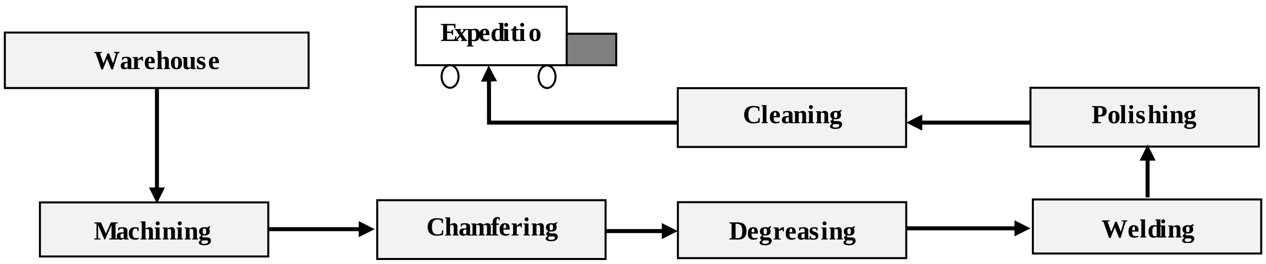

Figure 2. The production process of product “A3” of the family “Bus”

Key points from Step 1

1. Commitment and participation of management,
2. Selection of the product stream with Top-priority.

3.3.2. Step 2: Form the Lean team and the "Lean Leader"

The management commitment is anchored, even more in this step, by identifying Lean Leader who will form the Lean team whose structure is shown in Figure 3.

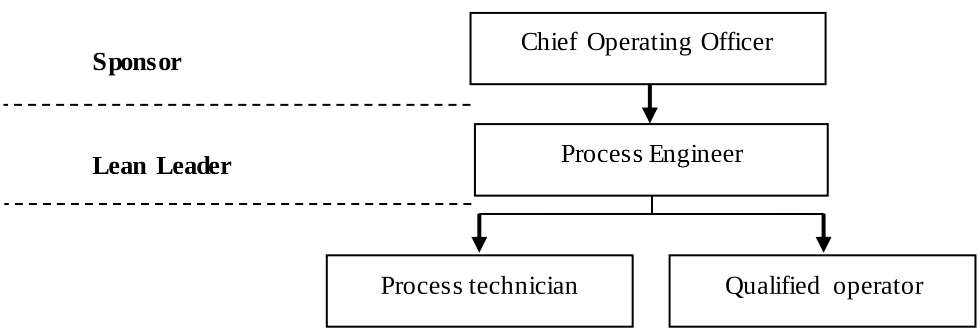

Figure 3. Hierarchical structure of the Lean team

The Chief Operating Officer is the project sponsor. He will support the project and make available the necessary technical, human and financial resources. The process engineer is the “Lean Leader”, his mission is to oversee the creation of stream mappings, ensure his training and his team’s concerning Lean concept, philosophy and tools, and coach the establishment of Kaizen projects. The other members are the process technician and qualified operator.
After its establishment, the Lean team must undergo training to raise their level of competence and acquire an early Lean culture. Generally, for larger companies, training is conducted by professional trainers or Lean consultants. However, in our case and taking into account the limited resources of the company, training will be driven by the Lean Leader. The quality of the Lean training may not be as perfect as that led by a professional trainer, but this will be overcome by the authenticity that comes from the personal experience of the Lean leader, in particular within the organization (Mann, 2010). To be effective, the Lean Leader has used the Competencies Matrix to monitor his team skills. The initial matrix is presented in Table 3.
For each member, the Lean Leader has identified the required level for each competency. The expert level is relative to the trainer that is the "Lean Leader" for certain skills or the technician Process who will undertake to transfer the

Knowledge to all operators in the sustainability phase. Then the Lean Leader has planned the training of team members according to the required level. Once reached the required skills levels, the team can begin the next steps.

Table 3. Initial Competencies Matrix of the Lean team

4	Expert Level (trainer)
3	Executant level (driver)
2	Participant Level (member)
1	Basic Level

	WHAT SKILLS DO WE NEED?						
WHAT PERSON DO WE NEED?	Lean Philosophy	Lean principles	Process of deployment	The seven wastes	Value Stream Mapping	Lean tool box	How to sustain Lean
Process Engineer (Lean Leader)	**4**	**4**	**4**	**4**	**4**	**4**	**4**
Process Technician	**3**	**3**	**3**	**4**	**4**	**3**	**4**
Qualified Operator	**2**	**2**	**2**	**2**	**2**	**2**	**2**

Key points from step 2

1. Management commitment,
2. Early Deployment of the Lean culture through training.

3.3.3. Step 3: Define the performance indicators

In the literature, there are several approaches designed to measure the "leanness level" of companies' value stream. The "leanness level", defined as the ability to achieve the company's objectives using less resources (Bayou & Korvin, 2008), depends on the priority dimensions that the company wants to track. Therefore, the Lean Team met with "Lean sponsor" in order to define three dimensions that result from the strategic objectives of the company: (1) quality, (2) cost, (3) time efficiency. For each dimension, the "Lean Team" has identified the indicators to be monitored (see Table 4).

Table 4. Lean performance indicators

	Indicator	**Objective**
Quality	% defect	Improve the quality at first time
Cost	% Up Time	Promote le JIT
Time efficiency	Takt Time/ Cycle Time	Pull flows
	Added value time / Cycle Time	Reduce wastes

According to Table 4, the first priority of the company is the "Quality" monitored by the indicator of defect rate. Then comes the "Cost" that is monitored by Up Time rate to control costs due to downtime and promote JIT. Finally, the "Time efficiency" is monitored by the ratio between Takt time and cycle time to synchronize output to the pace of customer demand. Furthermore, the indicator of value added rate aims to measure the degree of waste elimination in the value stream.

The second meeting was held in the presence of the sponsor, between the Lean Team and all operators. At this meeting, the Lean Team has communicated about the goals of the project, the monitoring indicators and the expected results.

Key points from step 3

1. Alignment of the Lean objectives to those of the company to maintain management commitment,
2. Awareness and involvement of all employees.

3.3.4. Step 4: Map and analyze the process current situation

The starting point is to follow and map the value stream. This step allows, beyond describing the starting point and serving as a reference, to put the whole "Lean Team" at the same level of information on flows (Chassende, et al., 2010). As proposed by Locher (2008), this step is carried out in 3 days:

- **Day 1:** Current situation,
- **Day 2:** Future situation,
- **Day 3:** Action Plan.

Day 1: Current situation

The first meeting was conducted in the workshop between the Lean Team with the simplest means possible (A3 paper, pencil, eraser) to sketch the current situation mapping. The process technician and qualified operator began by observing operators attitudes. They ensured that all operations are accomplished in compliance with usual work instructions. Then, the team followed the physical flow and took the necessary durations for each operation. The involvement of operators is essential to the success of this work. Therefore, the Team Leader explained to each operator what the team is doing in order to have his support. Table 5 summarizes the results of this work.

Table 5. Results of taking operations durations

Step	Cycle Time (C/T)	Changeover Time (C/O)	Up Time (U/T)	No. of operators	Defect (%)
Machining	1hr 59mn 59s	24mn 54s	68,42%	1	1,28%
Chamfering	32mn 01s	03mn 12s	99,56%	1	7,81%
Degreasing	08mn 24s	-	-	1	1,42%
Welding	46mn 37s	10mn 03s	91,14%	1	11,93%
Polishing	29mn 12s	02mn 57s	99,62%	1	3,69%
Cleaning	06mn 10s	-	-	1	3,41%

On the current situation mapping (Figure 4), the team mentioned all the data collected on Table 5 for each workstation, i.e. Cycle Time (C / T), Changeover Time (C / O), Up Time (U / T), operators' number and Quality Defects rate. After developing the map of the current state, the Team Leader gathered his team for a detailed analysis session. The first observation is that the production process operates with push flow (see Figure 4). The Lead time is 7.94 days which only 04h02min23s constitutes the cycle time. On the other hand, and with an annual demand of 4576 windows and an overall working time of 2288 hours per year, the Takt time is 30min. As shown in Figure 5, the production line is not synchronized to Takt Time. Some workstations (especially machining and welding stations) have cycle times more than Takt Time.

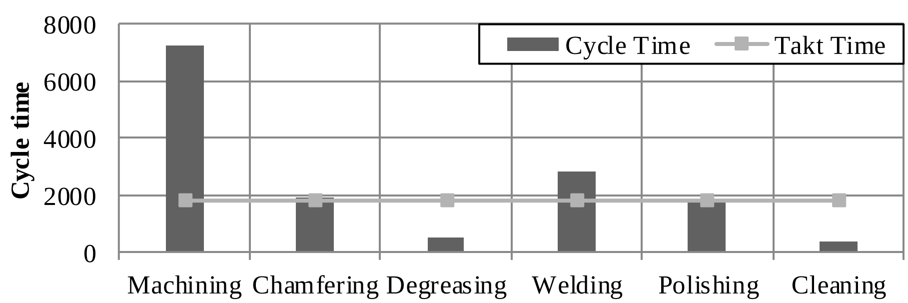

Figure 5. Current state of manufacturing for comparison between Takt time and Cycle time

In addition, each station cycle time includes a proportion of non-value added time (moving, changeover...), which is calculated, among on all the indicators based on time analysis, in Table 6.

Table 6. Calculation of the current state indicators based on time analysis

Step	Machining	Chamfering	Degreasing	Welding	Polishing	Cleaning	Total
Takt Time	30 min	30 min	30 min	30 min	30 min	30 min	3hr
Cycle time	1hr59mn59s	32mn01s	08mn24s	46mn37s	29mn12s	06mn10s	4hr02mn23s
Added-value Time	1hr02mn27s	30mn06s	07mn28s	41mn08s	27mn30s	06mn00s	2hr54mn39s
No added-value Time	57mn32s	01mn55s	56s	5mn29s	1mn42s	10s	1h07mn44s
Added-value Time / Cycle time	52,05%	94,01%	88,89%	88,24%	94,18%	97,30%	**72,06%**
Takt Time / Cycle Time	0,25	0,93	3,57	0,64	1,03	4,86	**0,74**

Table 6 shows that machining station has a large changeover time (24min54s). This station has, also, the lowest value added rate compared to its cycle time (52.05%). Moreover, machining and welding stations have cycle times that exceed Takt Time and contribute significantly to the imbalance of the production line. Reducing cycle times should be given priority on these two workstations. In addition, total defect rate is 4.07%, and overall workshop up time is 89.69%. Table 7 shows a summary of the initial situation indicators.

Table 7. Lean indicators of the initial situation

Indicator	Initial value	Target
% Defects	4,07%	2%
% Up time	89,69%	95%
Takt Time / Cycle Time	0,74	1,00
Added-value Time / Cycle time	72,06 %	90%

Table 7 shows the unfavorable state of the initial situation indicators. The "Lean Team" has felt the underperformance of the workshop and validated with the sponsor the opportunities offered to the project. Then, the team has set quantitative targets for the improvement of Lean indicators.

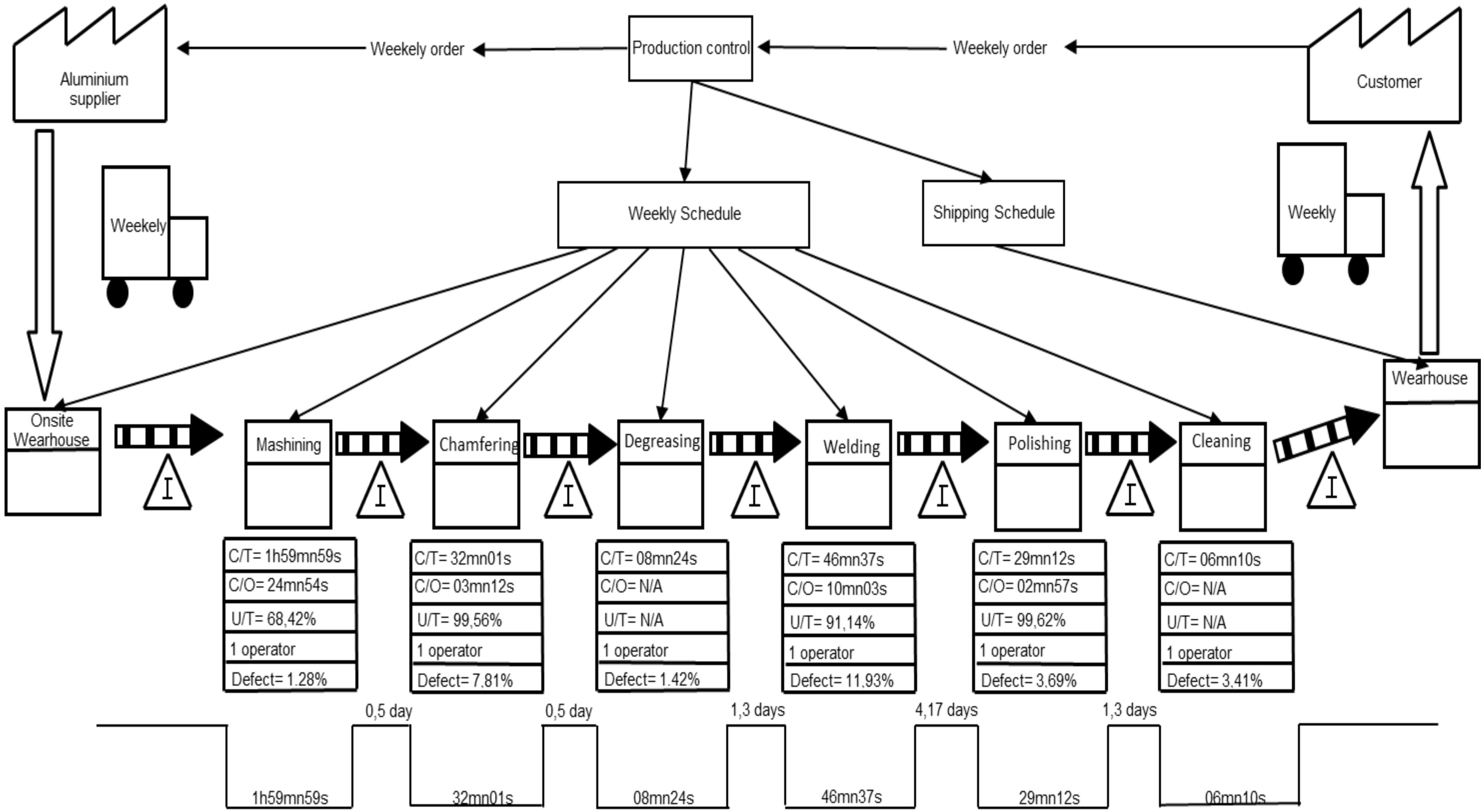

Figure 4. Current state map. Lead time = 7,94 days, Cycle Time = 04h02min23s.

Day 2: Future situation

The second day is devoted to developing the future situation mapping in order to redesign the value stream. For starting, the Lean Leader raised some improvement guidelines based on the analysis of the current state mapping:

1. Establishment of continuous flow,
2. Synchronization of manufacturing flow at Takt Time,
3. Establishment of pull flow in places where the continuous flow is interrupted.

Based on these guidelines, the Process technician and the qualified operator developed the value stream mapping of the future situation. As shown in Figure 6, the flow is pulled with Kanban deposits between workstations that are organized in cell. The only place where the flow is still pushed is the final storage that depends on shipping orders. Centralized production schedules were also replaced by autonomous planning based on customer-supplier relationship between the workstations. A study time based on simulation has allowed to estimate the total Lead Time that is around 1day and 5hours including 2h30min of cycle time.

To achieve these promising results, the team has identified improvement projects throughout the value chain. These projects include the reduction of downtime and changeover time in the machining station and the reduction of quality defects in the welding and chamfering stations.

Day 3: Action plan

The third day is dedicated to the elaboration of the action plan. A 12 months schedule is developed with regularly monitoring points. The schedule has been developed with all workers and validated with the sponsor. Table 8 shows the initial schedule of the improvement projects which contains provisional durations. This schedule was been subject to regular reviews and adjustments.

Table 8. Schedule of the improvement projects

		Month											
Action	**Objective**	1	2	3	4	5	6	7	8	9	10	11	12
Shop floor layouts redesign	Pull the flow	—	—										
Kanban project			—	—									
SMED project	Reduce changeover time of machining station				—	—	—						
Autonomous Maintenance	Reduce downtime of machining station					—	—	—	—	—	—		
Quality improvement project	Reduce quality defects							—	—	—	—	—	—

Then the Lean Leader carried out a wide communication on this schedule by involving all workers in the company. In addition, the sponsor was the responsible to make available the necessary resources to the completion of the projects.

Key points from step 4

1. Commitment and support of management,
2. Visualization of flows,
3. Involvement of operators and utilization of collective intelligence.

Figure 6. Future state map. Lead time = 1,21 days, Takt Time = 30 min, Cycle Time = 04h02min23s.

3.3.5. Step 5: Implement Lean program

Achieving the proposed future situation requires commitment at all levels to implement a set of improvement projects on the value stream.

- **Project 1. Pull the flow:** The exercise began with tracing, on an A3 sheet, the diagram of the workstations current location. Relying on the collective creativity of all operators, the Lean team made several iterations to achieve optimal location of workstations (minimal moving, workstations interconnections...etc.). The next step was the design and implementation of Kanban cards between workstations along with the standardization that is essential to sustain the project achievements.
- **Project 2. Reduce changeover time:** The machining station has a cycle time more than Takt Time. This is due primarily to the important changeover time of this station (24mn 54s). Therefore, the second project initiated by the Lean team was the changeover time reduction through the SMED methodology. A significant reduction was achieved in changeover time of the machining station from 25mn to 10mn. This was accomplished without any expense or major technical amendment, only with correct preparation of tools and optimal scheduling of tasks. Then final instructions were conceived by the "Lean Team" in the presence of machining operators and disseminated to sustain results and highlight the optimal changeover mode.
- **Project 3. Reduce downtime:** To reduce downtime, it makes sense to transfer the primary Maintenance tasks (cleaning, inspection and lubrication) to the production operators in the context of the autonomous maintenance. This mode is ideal for the organization given the lack of independent resources for maintenance. In fact, the Lean Leader has devoted special attention to two key points. On the one hand, the increase of the operator skills and the elaboration of standards as a condition to improve the equipment effectiveness. On the other hand, the culture change that is manifested in the commitment to conduct in a structured way all autonomous maintenance tasks.
- **Project 4. Reduce quality defects:** Quality defects have negative effects on the workshop productivity level. They cause flow decelerations when detected internally (scrap, rectification ...), or they cause additional costs (discount, repair ...) generated by customer complaints when detected externally. To reduce the rate of defects in the production process, the team made simple improvements (Quick Kaizen, Poka Yoke and Visual Management) on each workstation. Then, the essential step of working standards was carried out to capitalize best practices and reduce sources of variability within the process.

Key points from step 5

1. Involvement of operators,
2. Improvement by pilot projects,
3. Promotion of simple improvements based on the collective intelligence rather than expensive technical amendment.
4. Visual management,
5. Elaboration of standards to sustain actions.

3.3.6. Step 6: Evaluate and review the Lean results

The Lean Team met with the sponsor to present the project results. The results are convincing on several levels.

- **Operator Balance Chart:** The production line operates with pull flow driven by Kanban system. Table 9 shows the results of the time study and calculation of the final situation indicators.
  As shown in Table 9, the proportion of added value in the workstations cycle time has increased significantly, mainly on the machining station with the SMED project carried out on this station. Also, actions of layouts redesign and autonomous maintenance have led to reduce significantly the work stations non-value added time and then to reach an efficiency of 93.89% with a marked decrease in cycle times of workstations.
  Figure 7 shows the cycle time and Takt Time of the workstations. It is clear that, now, each station has a cycle time less than Takt time and the whole process is now synchronized to Takt Time.

Table 9. Calculation of the final situation indicators

		Takt Time	Cycle Time	Added-value time	No added-value time	Added-value Time / Cycle time	Takt Time / Cycle Time
Machining	**Before**	30mn	1hr 59mn 59s	1hr 02mn 27s	57mn 32s	52,05%	0,25
	After		28mn 23s	27mn 12s	49s	95,83%	1,06
Chamfering	**Before**	30mn	32mn 01s	30mn 06s	01mn 55s	94,01%	0,94
	After		19mn 12s	17mn 25s	01mn 47s	90,71%	1,56
Degreasing	**Before**	30mn	08mn 24s	07mn 28s	56s	88,89%	3,57
	After		09mn 04s	07mn 52s	01mn 12s	86,76%	3,31
Welding	**Before**	30mn	46mn 37s	41mn 08s	5mn 29s	88,24%	0,64
	After		19mn 39s	19mn 26s	13s	98,90%	1,53
Polishing	**Before**	30mn	29mn 12s	27mn 30s	1mn 42s	94,18%	1,03
	After		23mn 08s	21mn 12s	01mn 56s	91,64%	1,30
Cleaning	**Before**	30mn	06mn 10s	06mn 00s	10s	97,30%	4,86
	After		07mn 30s	07mn 17s	13s	97,11%	4,00
				Total	**Before**	72,06%	74,26%
					After	93,89%	1,68

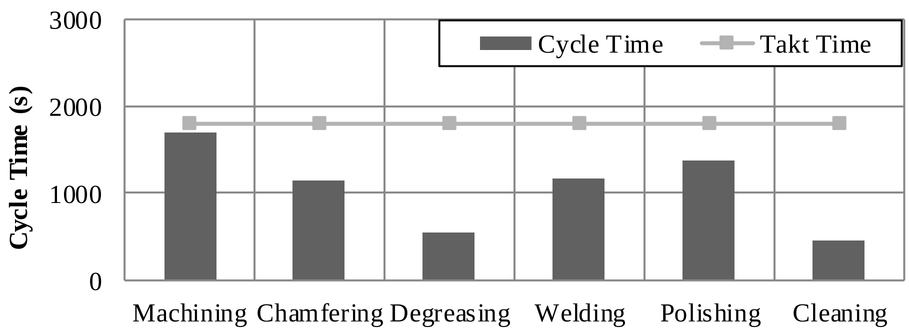

Figure 7. Final state of manufacturing for comparison between Takt time and Cycle time

- **Reduction of downtime:** The deployment of the culture of cleaning and inspection as well as the facilitation actions derived from autonomous maintenance have allowed to detect and resolve early all abnormalities. Consequently, the workstations downtime has shown a marked decrease and uptime has improved significantly.
  Figure 8 shows an example of the evolution of machining station downtime which was 13.9 hours in the first month. Now downtime is not exceeding the duration of the workshop planned shutdowns which is 2 hours per week (8 hours per month). Consequently, uptime rate of the machining station has improved to 81.8%. Overall, the workshop uptime rate has improved to 93.03%.

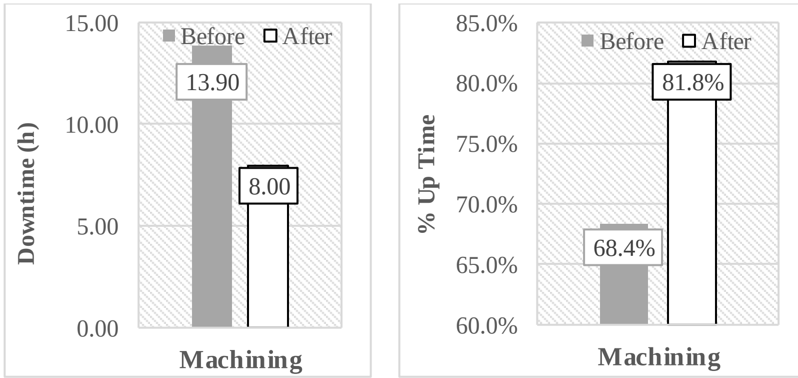

Figure 8. Evolution of downtime and uptime rate before and after improvement

- **Reduction in Quality defects:** Quality defects have also decreased. Table 10 shows the results achieved.

Table 10. Calculation of the Quality defects rate before and after the improvement

	Defects number		% Defects	
	Before	**After**	**Before**	**After**
Machining	18	8	1,28%	0,57%
Chamfering	110	27	7,81%	1,92%
Degreasing	20	18	1,42%	1,28%
Welding	42	12	11,93%	3,41%
Polishing	13	7	3,69%	1,99%
Cleaning	12	1	3,41%	0,28%
Total	**215**	**73**	**4,07%**	**1,38%**

The net reduction in term of quality defects rate, shown in Table 9, was carried out by acting on defects at high occurrence in the value chain. These defects were principally chamfering defects (110 defects) and welding defects (42 defects). This contributed to reduce the defect rate from 4.07% before improvement to 1.38% after improvement.

Review of the Lean indicators

In conclusion, the team presented a review of Lean indicators initially fixed. The results are shown in Table 11.

Table 11. Lean indicators of the final situation

Indicator	Initial value	Target	Final value	State
% defects	4,07%	2%	1,38%	Achieved
% Uptime	89,69%	95%	93,03	Not achieved
Takt Time/ Cycle Time	0,74	1,00	1,68	Achieved
Added-value Time / Cycle Time	72,06 %	90%	93,89%	Achieved

As shown in Table 11, only the target of the uptime rate is slightly not achieved. However, the deployment of Lean principles has had a positive impact on the company's economic performance by:

- Reducing and synchronizing to Takt Time all workstations cycle times,
- Reducing the proportion of non-added value in the overall cycle time,
- Increasing the uptime and the effectiveness of machines,
- Improving product quality and reducing quality defects rate.

Now the team has to move to a more advanced stage by more increasing indicators targets and even involving other indicators or areas to improve.

Key points from step 6

1. Management Review of Lean indicators,
2. Involvement of all workers in actual results,
3. Recognition of effort,
4. Long-term Vision.

3.3.7. Step 7: Sustain the Lean results and achievements

The main aim of the Lean is not only improving instantaneously the economic performance but also having the achievements and outcomes sustained in the long run. Therefore, the team has integrated the standardization during all project steps. Moreover, management decided to engage the following actions in order to sustain the outcomes of the approach:

- Systematic review of lean indicators,
- Regular visits to the workshop,
- Motivation and recognition of the employees to involve in the project and contribute in establishing best practices,
- Training employees regarding the lean concept and tools and how to sustain them.

This ended the implementation approach of the Lean principles. However, this is not the end of the whole process. The approach should be repeated continuously to sustain and increase the economic performance of the company. The company should also engage the similar approach for the others flow and products.

Key points from step 7

1. Management Review of Lean indicators,
2. Motivation and involvement of all operators,
3. Development the lean culture by training of all operators,
4. Standardization.

3.4. Summary of success factors of lean principles deployment into the company

At this point, we need to capitalize on the success factors that contribute to these positive results on the company's economic performance. These factors are prioritized according to the degree of their necessity and then occurrence throughout the steps of the Lean principles deployment approach (Table 12).

According to Table 12, management commitment and employees involvement are the most crucial factors that must be deployed practically during all the project steps. Moreover, visualization is an important factor which is manifested by the development of the process mapping during step 4 or the visual management during step 5. It is essential with standardization of work to support the sustainability of the project achievements. Other factors are also important in the context of SMEs, such as the alignment to the company’s objectives, improvement by pilot projects based on simple and non-expensive improvements to optimize the utilization of resources that are limited in the case of SMEs.

Table 12. The success factors of Lean principles deployment according to the approach steps

Success Factors	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Occurrence
Management commitment and participation	x	x		x		x	x	5 steps
Involvement of all employees			x	x	x	x	x	5 steps
Visualization				x	x			2 steps
Standardization of work					x		x	2 step
Deployment and improvement of Lean culture by training		x					x	2 step
Alignment to the company's objectives			x					1 step
Improvement with small pilot projects					x			1 step
Promotion of the simple and not expensive improvements					x			1 step
Selection of the product stream with Top-priority.	x							1 step
Recognition of efforts						x		1 step
Long-term vision						x		1 step

4. Conclusion

Through this case study, we have capitalized on the successful experience of a small-sized company in the deployment of Lean principles. The experience is successful given the impressive results achieved:

- A significant improvement was observed in the Lean performance indicators (defect rate, uptime rate, cycle time, etc.),
- Successful deployment of the Lean principles provided a framework to bring about change and help to build a Lean culture in the company,
- The pursued approach provided a structured system to the company. Consequently, the latter has reached a point where it was able to expand its market and initiate large-scale projects with large producers in the automotive-world.

These results are achieved through a set of success factors:

- Management commitment and employees involvement are the highest priority for all type of companies,
- Other factors are instead related to the specific features of SMEs such as the alignment to the company's objectives, and the improvement by small, simple and non-expensive projects,
- Visualization and standardization are key factors for the perpetuation of achievements and results.

Moreover, the proposed and pursued approach in this case study has shown its applicability for small organizations since it is not very resource consuming which is suitable to SMEs. However, the approach does not suggest a method of the assessment of the leanness level in the organization except the performance indicators monitored. This can be considered as one of the limitations of the approach that can constitute an area of future research. Further research may also consider the extension of the approach to the value chain entirely.

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Biography

Belhadi Amine is basically an Industrial Engineer. He works currently as production and process engineer in chemical sector. After graduated from The National School of Applied Sciences (Safi) in 2013, he became member in the Industrial Engineering Research Team at Higher School of Technology (Safi), Cadi Ayyad University subsidiary. His expertise area is the Industrial Engineering particularly Lean Manufacturing. He has participated in lean programs implementation in many companies.