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Research paper

Lean Manufacturing: from the Craft Production to the Global Emergence

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Abstract

Thanks to its promises of the industrial corporate performances improvement, Lean manufacturing is able to draw a lot of attention these last years. Since 1980, Lean manufacturing began to invade the world, thanks to the IMVP "International Motor Vehicle Program" led by MIT "Massachusetts Institute of Technology". From this time, the concept of Lean manufacturing is a subject of study so much for the researchers who try to understand and to encircle it, that for the practitioners who want to pull the maximum from it. It is in this context that our work aims at a proposal of the Lean manufacturing definition based on the different definitions given by different authors, an analyze of the exact origin of the Lean manufacturing via a literature review and defining the six big steps that Lean manufacturing knew since its establishment until now.

Keywords: *Lean manufacturing, Ohnism, timeline, Toyotism*.

1. Introduction

Thanks to its results to increase the company's profitability, the Lean manufacturing is the object of a business strategy guaranteeing the competitiveness and the environment preservation [1]. For that purpose, the field of the industrial counselling, of the service and the public administration show a big interest to the Lean manufacturing [2].

Lean manufacturing offers a set of tools and techniques as well as a systematic approach allowing to eliminate the waste and to increase the production flexibility [3]. It aims at the improvement of the corporate performances by eliminating all existing waste [4].

Since the 1970s, the researchers were committed to understand better and predict the results coming from the transformation in Lean manufacturing, while the practitioners continued the application of the concepts of Lean manufacturing to improve their manufacturing process [5].

Lean manufacturing have not yet a universal definition. Indeed, certain researchers define it according to its philosophy as Meier and Liker in their book "The Toyota Way Field Book", others define it as being a set of tools to be applied, as reference [4], the rest considers it as a system containing a set of concepts to apply [6]. Whatever is its definition, Lean manufacturing demonstrated that its application could give considerable profit to the corporate [7].

Most of the scientific researchers think that the origin of Lean manufacturing returns to Toyota and to Taiichi Ohno, while the application of Lean manufacturing appeared well before this period [8].

This article has for objective to extract a definition of Lean manufacturing based on the various definitions given by several authors using Pareto method. In addition, we analyze the existing in terms of the Lean manufacturing history and we define the big historic periods of the Lean manufacturing from the artisanal era to the global emergence.

2. Definition of the Lean Manufacturing

According to several authors, the lean manufactuing has no stable identity because it is every time associated with several concepts [2]. Even the vocabulary is not unified: we talk about Lean manufacturing, Lean production, Lean management, Toyotism, Ohnism or about Lean at all. This fact, puts us on a vocabulary variation with the difficulty to be organized [3].

Lean manufacturing results from the philosophy aiming at the realization of the improvements by following the most economic ways while focusing specially on the waste reduction (muda in Japanese) [9], [2]. The waste is anything other than a minimum of equipment, of material and of work time essential for the production [10].

No common definition of the Lean manufacturing is identified in the literature; however there is certain agreement on the operational concepts characterizing Lean manufacturing [11]. However, the definition of Lean manufacturing is more precise in the first Japanese books published regarding it [10].

Taiichi Ohno, the founder of the Lean manufacturing [13] defines Lean as being the total hunting of waste; it is based on two pillars: the just in time and the autonomation (jidoka in Japanese) [14].

Several other definitions are associated with Lean manufacturing. Indeed, some researchers give specific definitions to the process of production, while others use general definitions that can be used in a variety of industry [15].

Reference [16] defines Lean as being a set of practices aiming at waste and steps with no added-value reduction [16]. Reference [17] defines Lean according to 4Ps: philosophy, Process, Partner and Problems resolution [17].

Having a common definition of Lean manufacturing is a big challenge [11]. For that, we based ourselves on the various definitions given by several authors from 1988 till 2017.

2.1 Methodology

We extracted the different notions contained in the different definitions, and then we classified these notions according to the following three points:

- Point 01: What is the Lean manufacturing?
- Point 02: What is the purpose of Lean manufacturing?
- Point 03: What are the ways of Lean manufacturing allowing reaching its purpose?

After we calculate the frequency of appearance of each notion in each definition given by each author. Then we sum the frequencies for each notion. Then for each aforementioned point, we establish the Pareto diagram.
NB: for the definitions from 1988 to 2012 we based on [18]

3. Result

The tables below show the extraction of the different notions from the different authors' Lean manufacturing definition from 1988 to 2017:

Table 1: Extracted notions of what is Lean manufacturing

Author	Is													
	Philosophy	System	Practice	Culture	Strategy	Approach	Dynamic process of change	Way	Pradigm	optimal use of ressources	Program	Concept	Model	Standardization of all processes
[19]										X				
[20]							X							
[21]														
[22]										X				
[23]		X	X							X				
[24]	X													
[25]		X	X											
[26]										X				
[27]	X									X				
[28]	X													
[29]														
[30]								X						
[31]								X		X				
[32]				X										
[33]	X													
[34]	X													
[35]						X								
[36]	X													
[37]		X												
[38]														X
[39]									X					
[40]														
[41]			X											
[42]									X					
[43]														
[44]														
[45]	X													
[46]	X													
[47]									X		X			
[48]						X								
[49]													X	
[50]														
[51]												X		
[52]					X									
[53]	X													
Occurrence in the given Lean manufacturing definition	9	3	3	1	1	2	1	2	3	6	1	1	1	1

Table 2: Notions of the Lean manufacturing aims and means

Author	Aiming at						via						
	Cost and time cycle reduction	Quality product	Sustain humain needs	significant continuous improvement in performance	increasing efficiency	Satisfiying customer need/market demand	Tools	Methodes/techniques/ practices	Strategies	eliminating non-value adding activities/ waste	Principles	continous improvement	human involvement
[19]													
[20]											X	X	
[21]							X	X	X				
[22]													

[23]					X								
[24]													
[25]					X								
[26]												X	
[27]								X		X			
[28]										X			
[29]										X			
[30]						X							
[31]						X		X					
[32]							X						
[33]	X											X	
[34]	X	X											
[35]						X		X					
[36]	X									X			
[37]	X												
[38]									X	X		X	
[39]								X					
[40]										X			
[41]					X					X		X	
[42]										X		X	
[43]										X			
[44]										X			
[45]										X			
[46]													
[47]					X								
[48]	X	X						X		X			
[49]						X						X	X
[50]	X	X			X	X				X			
[51]			X										
[52]				X						X			
[53]						X				X			
Occurrence in the given Lean manufacturing definition	6	3	1	1	5	6	2	6	2	15	1	7	1

The data analysis via Pareto method gives the following diagrams.

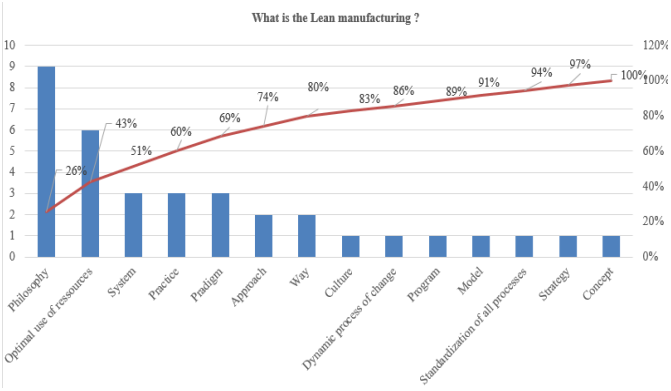

Fig. 1: Pareto of what is the Lean manufacturing

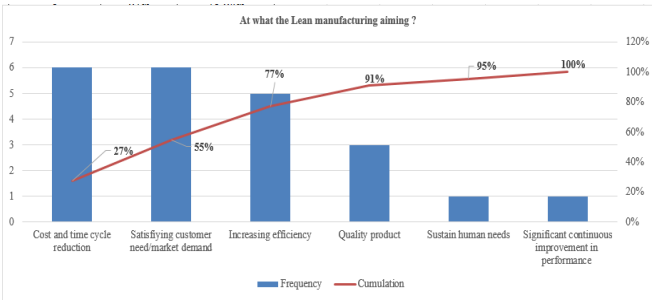

Fig. 2: Pareto of the Lean manufacturing aim

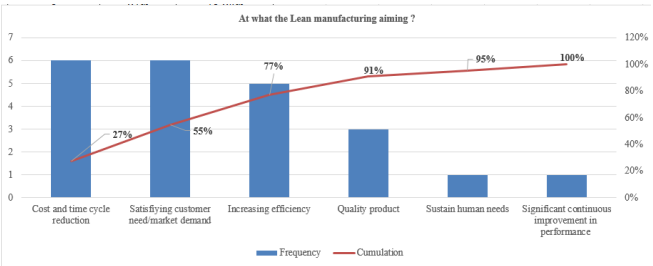

Fig. 3: Pareto of the Lean manufacturing means

According to Pareto diagrams, we conclude that the most common definition of the Lean manufacturing is that the Lean manufacturing is "a philosophy aiming at the cost and the time cycle reduction via eliminating non-value adding activities and waste"

4. Lean Manufacturing: from the Primitive State Until the Global Emergence

Most of the authors refer the origin of the Lean manufacturing to Toyota because they consider it the fruit of thirty years of Taiichi Ohno experience, an engineer at Toyota [54]. Several tools connected with Lean manufacturing were created in Toyota as the SMED (Single Minute Exchange of Die), while others were well known before, as the calculation of the "just time" essential for the realization of the various tasks and the elimination of the useless gestures; developed by Taylor [6]

Shah considers that the tools of Lean manufacturing are only those who were used by the Fordism with an improvement made by Taiichi Ohno [14]. Furthermore, the origin of the just-in-time comes from the American supermarket where the customer can obtain what he wants timely [7 and 17].

Sugimori and his colleagues published the first academic article on Lean manufacturing in 1977 [6]. While the starting point for the Lean manufacturing propagation in the world is the IMVP

program "International Motor Vehicle Program" leads by MIT "MASSACHUSETTS INSTITUTE OF TECHNOLOGY" in 1980s [55].
According to Shah, Lean manufacturing crossed five steps from 1927 to the 2007, these steps are [14]:

- Before 1927: the period of the Fordism
- Between 1945 and 1978: the phase of the progress in Japan.
- Between 1973 and 1988: the period during which Lean manufacturing arrived to North America.
- Between 1988 and 2000: the phase of the academic progress in terms of scientific researches on Lean manufacturing.
- Between 2000 and 2007: the period during which Lean manufacturing propagated well in the world as well as the progress of Toyota in the automotive sector.

Via a literature review of four decades, Stone define five phases of the Lean manufacturing propagation [5]:

- From 1979 till 1990, "Discovery phase"
- From 1991 till 1996, "Dissemination phase"
- From 1997 till 2000, "Implementation phase"
- From 2001 till 2005, "Enterprise phase"
- From 2006 till 2009, "Performance phase"

Vattier sends back the first use of Lean manufacturing, by Marcus Fabius Quintilianus (known by the name Quintilien), in 100 years before Christ in the form of "5 why" [8].
Vattier returned the first use of Lean manufacturing in 100 years before Christ [13]. Shah studied the evolution of the Lean manufacturing from the Fordism until 2007 [14]; whereas, for Stone the origin of the Lean manufacturing returns to Fordism and Deming contributed well in the elaboration of the Lean manufacturing [5].
Certainly, is not easy fill all the Lean manufacturing history, but there are key steps that we cannot ignore the Lean manufacturing history review. These key steps are in number of six:

4.1. Key Step 1: Lean Manufacturing in the Primitive State

For this period people apply the Lean manufacturing unconsciously in their everyday life (in their houses and in their daily works). At that time, the production was hand-crafted, based on well qualified and experimented labour [56]. The qualification of the staff is always asked by the Lean manufacturing [17].
The Japanese philosophy always aims at the perfection in any activity, it is the source of the Kaizen and the problem resolution concepts; the last two are among the bases of the Lean manufacturing [17 and 55].
In the Japanese culture, the problems resolution begins always with their understanding where it exists, it is the origin of genchi genbutsu, which means going by yourself to see what takes place on the field to understand the situation [57]. Furthermore, to solve a problem, the Lean manufacturing recommend to well understand it and prepare all the necessity for its resolution before beginning the action, this approach is also inspired by the Japanese culture [55]. "Hansei" is among the Lean manufacturing Problem resolution concepts, it results from the Japanese philosophy aiming at the identification of what is wrong and taking the steps to resolve the problem [17].
Another concept taken from the Japanese culture is the fact of having a ' sensei ', this Japanese term indicates a person who be there before me and who is a guarantor for the knowledge and for the know-how [57]; this principle exists also in the Moroccan handicraft sector, where the craftsmen always ask the master craftsman assistance to solve any problem [58].

4.2. Key Step 2: Lean Manufacturing in Production before Taylorism

In this period the world pass from the craft production to the industrial production. Belonging to the classic school of organizations, Adam Smith is the father of " the division of labour " because it is the source of productivity increasing and eliminating of the dead time [59] .the division of labour is among the basic items of the work standardization, because without labour dividing, the company will have no clear idea on all the tasks to be made to satisfy the customer need. Lean manufacturing is based on the standardization [6].

4.3. Key step 3: Lean Manufacturing and Taylorism

For this period Taylor elaborated a set of principles for the scientific management by using the principle of timing [6]
The aforementioned principle will be afterward a base for the application of Takt-time and for elimination of the dead time and useless gestures [59]. The latter two are among the seven muda announced by Tiichi Ohno [54]. Furthermore, Taylor is the first one who evoked the necessity of standardization by the meticulous definition of the tasks in order to realize the possible maximum of profits [61].
Taylor also introduced the principle "Staff challenge" because he defined the tasks and holded employees liable on the targets achievement [17]. He also worked on the organization of the production units [60], this we refer to 5S. In addition, The Taylorism and the Toyotism join for the establishment of work instructions [6]. Taylor, in its philosophy, relies on the scientism by being convinced that the science can solve any problem in the company [61], it is very well with the Toyota Lean manufacturing culture based on the fact that to propose or implement a solution to a problem, it is necessary to rely on scientific [17].

4.4. Key Step 4: Lean Manufacturing and Fordism

Ford was based on the Taylorism to establish the principles of Fordism [24]. Ford's biggest added value, in terms of Lean manufacturing, is the use of machines in factories as well as production lines [62]. These production lines will play an important role for the establishment of the jidoka (autonomation), one of the two pillars of Lean manufacturing [63]; and the standardization which will be, afterward, among the foundations of the continuous improvement [6]. Furthermore, Ford introduced the idea of the continuous flow into the assembly line of his factory [62].
In addition, Ford initiated the concept of pace [6] which will be afterward a base for the takt-time. The concept of the 'simplicity' is a common point between Fordism and Toyotism [17], [64].

4.5. Key step 5: Lean Manufacturing and Toyotism

The history of Toyota with the Lean manufacturing begins when it wanted to apply Fordism but it did not have the means to do it correctly; then it merely equip some workshops by the production lines [6]. Toyotism is only an extension of Fordism [17] with additions inspired by the other organizations; Taiichi Ohno was inspired by the American system of the supermarket to set up the just-in-time [17]. However, several practices were developed to Toyota; as the poka-yoke system (allowing to avoid the errors during the production) invented by Sakichi Toyoda [17], and the approach SMED (Single Times Exchange of Die) invented by Shingo [64], allowing to convert in an effective way one manufacturing processes from a product to another one.
Toyota played a large part in the development of the practices of Lean manufacturing in terms of development of the practices (already invented by the various theories of previous organizations) and of their 'organizations' and classifications according to a complete system allowing to guarantee an improvement of the corpo-

rate performances. Toyota did a sheer hard work to the extent that it was able to join the Japanese culture in the industrial practices creating an enabling environment to practice their culture while satisfying the demand of their customers.

4.6. Key step 6: Lean Manufacturing and the Global Emergence

In this stage, the Lean manufacturing becomes a global topic due to the birth and the change of several concepts and tools Lean out of Toyota. Indeed; previously, the andon be in the form of torch or of descriptive plate (patch) used by the operator in case of problem [65]. With the development of the technologies, the andon gets into several electronic devices containing audiovisual signaling [65]. For Toyota, the andon means that in case of problem the operator activates an alert so that the supervisor intervenes to solve the problem before the end of the cycle of production and if he does not make a success, the machine stops [62]. General Motors applied the andon system but with a modification consisting in not giving the possibility to the machine to stop automatically [17]. As already quoted, the SMED is a creation of Toyota [64], aiming at the change of production tools in less than 10 minutes 4. In our days, we begin to speak about the OTED (One-Touch Exchange of Dies), it is the continuation of the SMED [66] that aims at passing of less than 10 minutes unless 100 seconds in the change of production tools [65]. On the other hand, 5S was applied in Japanese companies before Toyota [56]. At the beginning, Toyota applied 3S then 4S and finally 5S [66]. Now we speak 6S, the 6th is the Health and Safety in the work [67]. In addition, the industrial world is working on the development of different information systems guaranteeing a total quality throughout the added value process [68].

5. Conclusion

Based on a multitude of definitions given by different authors we extract the most common definition of the Lean manufacturing which is " the Lean manufacturing is a philosophy aiming at the cost and the time cycle reduction via eliminating non-value adding activities and waste".

Most of the researchers send back the Lean manufacturing to Toyota or in the best of the case to Ford. While the application of some tools of Lean is known 100 years before Christ and its philosophy was inspired by the Japanese culture and the theories of previous organizations; as the continuous improvement which is known to the western world well before its application to Toyota. For all these reasons we proposed six big stages to define the origin of the Lean manufacturing:

- Lean manufacturing in the primitive state
- Lean manufacturing in production before Tay
- lorismLean manufacturing and Taylorism
- Lean manufacturing and Fordism
- Lean manufacturing and Toyotism
- Lean manufacturing and the global emergence

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