Digitalization of Lean Tools – Digital A3

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DOI: 10.29322/IJSRP.10.11.2020.p10790
http://dx.doi.org/10.29322/IJSRP.10.11.2020.p10790

Abstract- Digital transformation creates the balance of the world and positively affects the way of living, hobbies, health and even industries. In the manufacturing world, the Industrial revolution is based on the digital transformation of the process which brings the advantages and increases the capabilities of companies.
Manufacturing companies have used the lean tools and principles in order to reduce operational complexity and increase the production rate over decades. In fact, since the complexity of operations has increased from last few decades, difficulties raised for managing operations only with the traditional methods or lean tools. Due to emerging the Industry 4.0 revolution, new approaches offered to solve the complicated problems and improving productivity. For industries, it's important to decide how to involve or add Industry4.0 into their own working culture and manage their transformation process. The purpose of this paper is to study the requirement of digitalization of lean tools and its implementation for making the Plan-Do-Check-Act (PDCA) cycle through A3 reporting digital. This work emphasizes the ABC tools supported with VBA excel. It is decided to make the working prototype enabling A3 reporting by using lean concept and correlation of continuous improvement with the A3 thinking. Finally, the testing phase is on-going with few industries to understand feasibility and advantages of its usage.

Keywords: Lean Manufacturing, Continuous Improvement, Digital A3 report, Industry 4.0 revolution)

I. Introduction

Lean tools and lean management concept are used in the manufacturing and service companies for many years. Besides, digitalization is a new, rising trend in the world the main purpose of this work is to digitalize the principles of lean manufacturing and successfully implement. A combination of digitalization and lean management can be beneficial to the industry. Previously big analysis has made to understand what the missing points in the business life, how digital A3 can improve for the companies' usage and which problems should be focused to increase the biggest problematic areas. As a result, the prototype had been created of a new digital tool, which is called Polikaizen, for the companies that want to combine the advantages of technology and lean tools which works under the A3 thinking principles.
Lean concept provides numerous benefits to the companies. Companies which adopt a lean concept increase their productivity, product quality, and efficiency because of the fact that lean management eliminates the wastes, non-added value activities and costs. It allows companies to decrease the number of scraps, reworks and customer returns. Not only companies that adopt the lean idea, but also stakeholders which works with these companies increase themselves. Employees can find a chance to increase their own skills, so people development and knowledge sharing among the whole departments increase. Moreover, customer loyalty and satisfaction rise in light of the fact that companies provide better product and service with quick response time. Apart from the lean concept, digitalization has also great benefits for the companies adopting the technology. For example, digitalization leads companies to save time and money due to the fact that it reduces the time losses for data collection and improves communication between departments. Digitalization causes better decision making and resource utilization. Also, it increases the flexibility and competition level of the company.
In previous work which had done by lean excellence center of MIP, Polimi for the Tool name as Polikaizen from that focus was the digitalization and hence to understand the missing points and areas needed to be improved, the survey is performed by 71 lean experts. Experts analyze that digitalization of lean tools provides some benefits to the companies. Moreover, they have evaluated the efficiency of PDCA as well as A3 used in their companies. It is observed that the importance of digitalization of the A3 depends on the tools used for A3 reporting. Tools such as Pareto Chart, Fishbone Diagram, 5 whys, VSM etc. has been used while analyzing it. Additionally, experts think that most challenging topics to perform A3 in the company are involving the employees, the contribution of the top management, communication between departments, tracking of the steps and respecting of the deadlines.
After reviewing the above survey that a new digital tool should be created by respecting the experts' opinions. Digital tool, Digital A3 is created to perform PDCA which is easier for companies. It is designed to use for engineers and managers; hence managers can perform their management roles without losing internal roles or structure of the program while engineers are responsible to use all tools included in prototype. Polikaizen allows companies to personalize the program according to their company features. So, after completing basic settings, each company is able to use the program without any problem. All ideas of experts are taken into account during the creation of the prototype by respecting results of the survey.
For instance, templates for many of the tools we can get it easily online but to bring all these tools in one platform where A3 reporting will be done is very important. Which will reduce the time of the engineer and evaluate the all tools in terms of the amount of cost saving and time-saving and evaluate the

performance of all people in the projects. It improves the communication between departments since it pushes people from different departments to work together within deadlines. Also, A3 digital decreases time-consuming during data collection and analyses thanks to the digitalization of the processes. As a result, digital A3 is designed by considering the ideas of experts and the survey result to solve the problems that companies faced during the A3 reporting. To digitalized the process and to determine the aim of the topic, main thing it has to be done is to understand the lean thinking process and working process of A3 to make the system in continuous improvement. Conclusion will be evaluated by the detailed scenario obtained while understanding the thinking process and implementing it for the prototype.

II. PROBLEM STATEMENT AND LITERATURE SURVEY

In today's innovative and digital world everything has to be digitalized to reduce the work pressure and to make it easy and error free. This paper is based on the same scenario of digital world. This consists of the theory of lean concept, CI concept, A3 thinking framework and how all these are important and interrelated in this digitalized world. By considering all this concepts and as per the industrial requirement this paper is made and it consists of an innovative idea of Digital A3 by taking the help of digital PDCA prototype made by lean excellence center of polimi, Italy.

This chapter describes the theory about the lean management and its correlation with the A3 thinking report to understand the importance of digitalization in this era of industrialization by following theories.

Lean management

Lean Thinking is the practice of concentrating on the processes that create the values by reducing wastes from it. Toyota, a Japanese company proposed Lean concept first. This research had been done in the twentieth century. The founder of the system was Sakichi Toyoda, his sons Kiichiro Toyoda and Eiji Toyoda as well as Taiichi Ohno (1), a manufacturing engineer. Sakichi Toyoda then started working in the textile industry where he invented a motor driven loom with the specialized technique devised to stop in case of breaking off the thread (2). That mechanism then became foundation of Jidoka, one of the two main pillars on which Toyota production system is standing. Due to this lean management i.e. defect detection system, it was observed that defects occurring due to human errors were reduced and the production capacity was increased (3).

Lean system is also known as follows, each label highlighting a particular principle of Lean Thinking:

"**Just-in-time Production System**" - Just-In-time is developed by Taichi Ohno (4) and his colleagues at Toyota, which is one of the pillars of TPS (1). It means to supply to each process what is needed, when it required and how much quantity is required. Just-in-time allows to deliver the right amount of product at right time. It is the classic Pull system. When the production is initiated at the next or higher level then only the bottom line will produce the product i.e. Units are produced due to pull system from the higher level. The main purpose of Just-in-time manufacturing is to reduce lead time and stock holding time which can be achieved by reducing the work in process. Fig. No. 1 shows the Pillars of Lean and the Toyota Production System in which JIT pillar is one of the pillars.

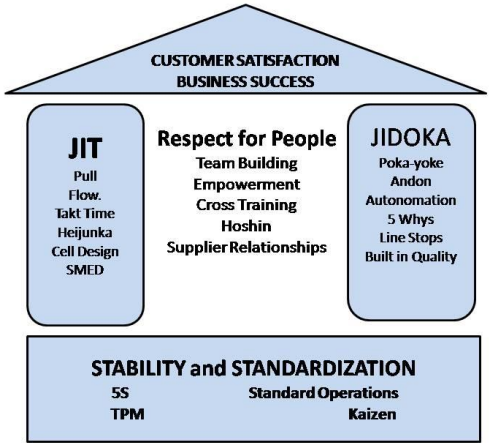

Fig. No. 1 (Pillars of Lean and the Toyota Production System)

"**Kanban System**" – Kanban System, a major tool of lean thinking which is one of the lean transformations from 1980s (5). In this concept, a downstream process uses the part from the upstream process. After use of every part, Kanban card is removed and sent back to the upstream process. When predetermined number of cards are collected at the upstream process, production refill the stock which is used by the downstream process. The basic principle behind the Kanban is to linking the supplier and the customers to the process which helps them to understand the behavior of each other through the formal request. It's a process of lean thinking which will helps to develop the process by reducing the waste. It is also the behavior to develop the customer and supplier relations. Fig No 2 shows the working procedure of the Kanban system in which it shows how the upstream process receives a Kanban card from the downstream process to reduce the inventory of the production.

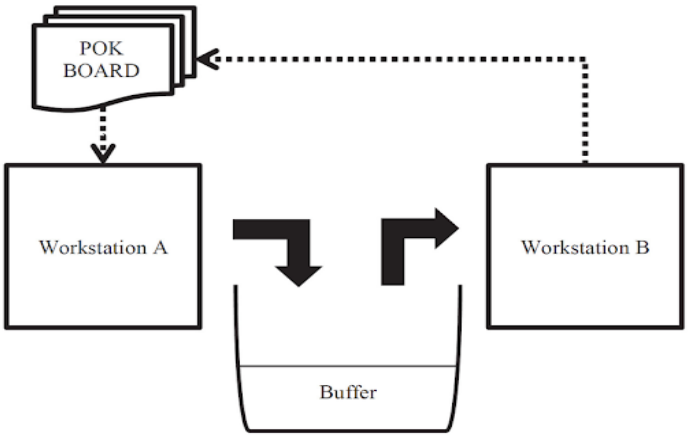

Fig. No 2 (Working of Kanban Process)

"One-piece Flow System"- Toyota Production System is also called as "One-piece-flow" production system. Lot and batch sizes has to reduced and make it one-piece production or small batch production. Standard manufacturing systems which has focus on the big lot production and continuous production to achieve the requirement in time and having long set-ups will generate over production and creates large inventories for the next station. Hence to make smaller batches, TPS focuses on set time reduction. So that A TPS line can operate as a mixed model line. It means, it can produce or assemble different models at the same time without changing setup time. Products from One-piece flow lines are good in quality and every station are highly productive to take care of every piece before delivering to the next station. Defects get reduced due to single piece production because of high concentration on one piece. Fig. No. 3 show how one-piece flow production systems works which help to reduce the over production

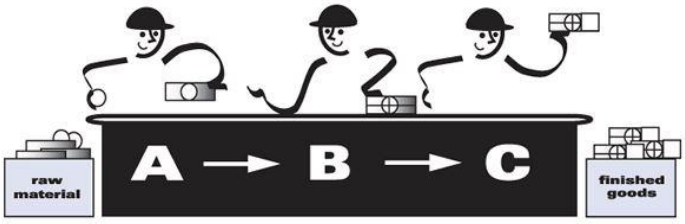

Fig. No.3 (Source: Lean Lexicon 5th Edition by Lean Enterprise Institute, Inc.)

"Pull Manufacturing System"- In a pull system, discharges are approved. That is, there is an endogenous sign dependent on framework status that decides if a discharge is permitted or not. Specifically, the framework status that triggers discharges depends on stock voids, which means that a pull system is controlled by downstream information and is inherently make-to-stock. In our nomenclature, closed lines are pull systems, because buffer spaces act as stock voids to trigger releases. (6).

Continuous improvement

The concept of CI was adopted by Deming in 1986 as his first quality principle by showing that constancy of purpose is achieved through Plan, Do, Check, Act (PDCA) which is also called as Deming Cycle. Moreover, As It's studied and argued by (7), CI is part of Japanese culture where it refers to kaizen - meaning improvement and underlined as a "company-wide process of focused and sustained incremental improvement". Kaizen is an approach of creating continuous improvement based on the possibility that little, progressing positive changes can procure real enhancements. Kaizen is core to lean manufacturing, or The Toyota Way. It was developed in the manufacturing sector to reduce the defects, eliminate waste, boost productivity, encourage worker purpose and accountability, and promote innovation. Kaizen is a compound of two Japanese words that together translate as "good change" or "improvement," but Kaizen has come to mean "continuous improvement" through its association with lean methodology. Kaizen required the typical mindset for improvement throughout the company. 10 principles which resemblance the way of mindset which can be referred a score to the philosophy (7).

1. Let go of assumptions
2. Be proactive about solving problems
3. Don't accept the status quo
4. Let go of perfectionism and take an attitude of iterative, adaptive change
5. Look for solutions as you find mistakes
6. Create an environment in which everyone feels empowered to contribute
7. Don't accept the obvious issue; instead, ask "why" five times to get to the root cause
8. Cull information and opinions from multiple people
9. Use creativity to find low-cost, small improvements
10. Never stop improving.

Kaizen works in seven steps in the cyclic way in which the problems are addressed inadequately. It involves identifying issues and opportunities, creating solution and rolling out them. These following seven steps create a cycle of continuous improvement and give proper way to implement them and execute them after success. (Fig. No. 4)

Fig. No. 4 (Kaizen cycle of Continuous Improvement)

(Source: https://searcherp.techtarget.com/definition/kaizen-or-continuous-improvement)

A3 framework

A3 problem solving is a structured problem solving and continuous Improvement approach which is first implemented by Toyota and specifically used for Lean manufacturing scenario. It provides a simple strict procedure that guides problem solving by workers. The approach specifically uses a single sheet ISO A3-size paper, by which the name has given as A3 framework. (8, 9) (10). A3 thinking consists of 8 parts which has to be plotted on the A3 paper. It follows the process from determining the problem to the solution and the follow up. A3 thinking is mostly develop with the help of PDCA cycle. From the previous work done about the PDCA cycle, 8 parts of the A3 thinking is segregated into the Plan-Do-Check-Act process. A3 thinking consists of following 8 parts which comes under PDCA: (11) (12).

Plan (1. Background of the Problem/Define the Problem, 2. Breakdown of the Problem, 3. Set the Target, 4. Analyze the Root Cause, 5. Develop the counter measure), Do (6. Implement Countermeasures), Check (7. Monitor Results and Validation Process), Act (8. Standardize the Improved process).

A3 can be applied for many varieties of applications. But it's a tool basically for the people with open-ended mind for problem solving. It is recommended to use A3 daily to solve small problems like "why did the machines fail?" by the operator. It can be used on strategic as well as corporate development problems like "why did market growth drop?" by the executives. These questions describe the thinking level of the managers more often just discussion and exchange of words. Does this thinking process improved you? Or does it help others? Instead of focusing on "Who" is responsible for the Problem, A3 thinking allows you to think about "Why" this problem occurred? Many organisations use A3 as an "A3 Counselling". It addresses the problem occurred due to manual error. Instead of blaming personally, they help each other to think about the problem or error occurred and helps to fix it. Hence A3 counselling goes from blame to improvement process and learning. Working with the team is more effective because while applying A3, organisational or personal issues become good starting point than the different problem-solving tools. Hence A3 can be used for daily issues by which organisational performance will improve. (13) (14)

A3 thinking is the collaborative way to improve the process and to reduce the problems and waste. Due to the huge size of A3 paper, teams have to focus on each A3 on a complicated or broadly compelling decision or a single size to mid-size problem. If A3 will be done correctly, then project updates can provide for senior oversite and can give faster input and feedback. A3 is the historical record of issues by which we can determine the process of improvement and take the corrective action if the same problem will occur in the future and how the respective team deal with it. This can be a useful document to refer for the juniors to understand the process and the methods used to solve the problem. A3 increase the confidence with senior leadership. Other advantages are:

- Root causes Identification
- Useful information to reference throughout the project can be put on the Dashboard for further studies.
- Team members can share knowledge for problem solving thinking.
- Reaching consensus among team members; and,
- Promoting deliberative, thoughtful decision making.

A3 process is good for learning and can be used as a learning tool. All the team members can sharpen their problem-solving skills. Making an A3 without knowledge will leads to creation of waste. Hence A3 is good and learning tool by which organisation can reduce the waste formation and encourage people to develop their problem-solving skills. (8, 9)

Digitalization of A3

Digital A3 will be a digital platform where you can perform all the analysis and process which now a days are doing manually. It will contain all the analysis tools by which it will be quite easy to solve the problems which can raise in regular life or in day to day life of the organization. Digital A3 will be an application made by using IoT concepts. Which will contain tools of lean management analysis like Pareto, Fishbone diagram, 5 whys etc. These tools will perform their functions by which Process can get connected with the top corporate management with the bottom management by which they can keep all the process working perfectly and they can also reduce the time of Performance.

Digital A3 will be so helpful for the organisation. It will serve the purpose of A3 thinking in shorter period of time and it will directly connect all the stages of manufacturing with each other. It also helps personally to everyone for understanding the other process by ease. It helps the supervisors to know exact problem and type of problem so they can take corrective actions as early as possible. (15)

Digital A3 will be a simple application-based tool to serve the purpose. It will one of the best inventions of industry 4.0. Digital A3 will be a best tool for the organisation to adapt and to learn.

III. Survey and Implementation

Survey Report

Our first step was to do the survey in which 71 participants participated. Survey had been done for knowing the requirement of digitalization of lean tool and they found the data from the survey by considering age, gender, education and work experience as a demographic data. The data from survey showed that, 83,3% participant in the survey were in 26-45 ages while 13,9% participants were above 45 age and 2,5% were in 18-25 ages. Secondly, 76,4% were male and 19,4% were female and remaining participants didn't tell their age. Many of the participants are master's degree pursued candidates while some of them were bachelors, doctorate and high school finished candidates. From these educated candidates most of the participants were having experience more than 5 years and some of them were between 1-2 years of experience.

After collecting the demographic data, I surveyed the list of lean tools which industries uses (Table 1) and which tool has to be digitalized (Table 2)

Table 1: List of lean tools used by industries

Tool Name	Number of Answers
5S	38
Value Stream Mapping	26
PDCA	20
Kanban	20
Visual management	16
A3	13
SMED	11
Ishikawa diagram	9
Kaizen	9
TPM	9
5WHY	7
DMAIC	5
One-piece flow	5

Table 2: Tools has to be digitalized identified from survey

Tool Name	Number of Answers
Kanban	9
A3	3
PDCA	3
KAIZEN	2
SOP	2
Fishbone-Diagram	2
VSM	2
FMEA	2
OEE	2
Value Stream Map	1

From the list obtained of tools has to be digitalised, our first step is to started designing of the prototype of digital tool of PDCA cycle. So, from the previous work done, I have decided to use the theory and study of previous work and implement that for making digital tools. Hence from table 2, we have decided to make the PDCA cycle digitalised by making Digital A3. For making it digital, what we have done is explained in the next part of implementation.

Implementation

Starting from the results of the survey, it's been known that making the PDCA digital is quite important and essential. PDCA is based on the A3 thinking report. Digitisation of A3 reports basic functions has four steps.

1. Make PDCA cycle digital. Making the A3 digital, initial step is to understand and to brainstorm the PDCA functions of A3. To get the detailed view of the important functions from it, company will take decision according to their necessities. As an outcome of rigorous brainstorming, list of the functions is made which has to be considered in the different parts of the A3 report and listed out by its importance.

2. Select the most essential Function to discuss for this report, ABC analysis technique had been applied, by which clear picture came that which functions are so much important and has to be digitalized first by including in A3 digital. ABC analysis is a method of analysis that divides the tools into three categories: A, B and C. Category A represents the most valuable tool that we have. Tools which contributes heavily for the analysis. This category will be the smallest category. Category B represents the middle of the road tools. Tools from this category has the potential to shift into A category which can be valuable for analysis and Category C contains unimportant tools which increased the effectiveness of the whole system by working together but individually it is not important that much (14). After making this analysis, Pareto, Fishbone diagram, 5 Whys analysis, Value chain mapping, Benefits matrix, Waste management etc. found as the most important tools which has been selected for making it digital by using VBA excel tool. After selecting the tools from the A3 thinking which has to be digitalised, our working prototype which contain the A3 page. After filling the personal information part, the next part is to go with the A3 reporting part in which first step is identify the background of the problems. For that we can use 3 types of tools or functions like Pareto analysis, Value stream mapping and waste management, which can identify the problem and shows the way to solve that. For solving the problems firstly, we have to breakdown the problems which can be done by value stream mapping etc.

3. Target has to be set so that the study will proceed around that target.

4. Analysis of the root cause has to determine by using 5 whys, pareto or Fishbone diagram method. In the fifth and sixth step, development of counter measure by using tools like waste management or Benefits aspects matrix and Implementation of counter measures to test the system against the problem. After implementation of counter measure monitoring stage and improvement stage has to carried out by using tools like waste management or Benefit aspects matrix or Future value stream mapping. Every process has to go with these stages which will generate the A3 report. This research will make this report digital. To make this digital and to work all the functions of the tools, VBA excel is used to process the functions. It contains code to do all the functions after clicking and putting data at the proper place. So, the code which is called macro. Macro enables us to operate the functions as per command and direction. Every tool which is discussed further works under VBA excel macro code.

IV. Testing

The next step of our aim is to test the prototype with the companies for its feasibility and effectiveness. Similarly, take the comments from the respective guys to make it perfect and user friendly. A pilot has been created to test the tool and take the feedback from the companies with the help of survey. We gave our prototype to 10 companies for testing its feasibility and effectiveness. We started receiving comments from them. This testing phase is still in the process.

Feedbacks which had it already from some of the industries are as follows. Similarly, it contains the improvement what have done as per their requirements.

a. A comprehensive sheet with all the analysis used (can be a picture of all the results of the analysis) is needed in the same excel file or in the new one.

- For this suggestion, used different tactic to get all the analysis in one folder. After finishing the use of A3 digital, it is mandatory to save it. When you will save your work then you will get each analysis ex. Fishbone, pareto etc in one folder which you can use or share for further studies. As per the suggestion, this part we have included in our future development which will be done as early as possible.
A new function on VBA has been created in order to allow the user to save all the sheets in PDF format and after saving all the data will get cleared automatically. To use this prototype again, user has to install or download this tool again which will resist the malfunctioning of the tool.

b. All the analysis may be done more than one time (with different data). It can be useful to make them replicable. At least one of each analysis for each box.
- This suggestion has been solved in the solution of first suggestion. Whenever the file be saved then all the data will get cleared and it can be used for how much times you want but as per the time bounding, we have set. Similarly, each box of A3 has minimum single of analysis except target and implementing counter measures.

c. It is not possible to write the target either the list of counter measure.
- This problem has been solved by providing space to list down the target and countermeasures.

For taking the feedback from the company, we have created the survey questionnaire from which received some feedbacks and some has to come. Survey contains 10 questions about the tool which we have created. Survey questions are as follows:

1. How would you rate the importance of the Digitalization of Lean management tools?
2. How would you rate the quality of our Digitalization of A3?
3. What is your first reaction to the product?
4. How innovative is our digital A3 thinking concept?
5. In our A3 thinking, which part you liked most?
6. When you think about our tool or concept, do you think of it as something you need or don't need?
7. How likely are you ready to replace your manual work with the digitalized product?
8. How likely you would recommend our digitalized A3 thinking to a friend or colleague?
9. Which another lean tool you want to add in this digital A3?
10. In your own words, what are the suggestions you want to give for this tool?

Above survey has created and received some Feedbacks which included in the future development plans and some feedbacks has to come.

V. Conclusion

In This paper, Analysis has made to understand what the missing points in the business life, how A3 can improve for the companies' usage and which problems should be focused to increase the biggest problematic areas. As a result, we have created a prototype of a digital tool according to the needs which is digitalised by using VBA excel. It contains lean tools i.e. Fishbone analysis, Pareto analysis, Value stream Mapping, 5 whys, waste management analysis and benefit Matrix, etc which has been digitalised to process it easily and to increase the efficiency of the process. After making the prototype the tool is testing with the companies and this phase is in process for collecting feedback.
Digital A3 allows company to do all the analysis by using tools like Fishbone diagram, Pareto analysis etc in one workspace by respective digital tools and allows company to increase process efficiency and reduce time and defects which can occur in manual working. This tool restricts the company's behaviour of lengthening the process of analysing and it allows them to have a look on each step of A3 in one platform. It also helps the management to understand the each and every process and employee's mindset to achieve the close deadlines, track their work, look overview of all A3 projects, evaluate all A3 projects in terms of efficiency with respect to time and cost. It improves the communication between the employees and pushes them to work together within the deadline. Also, Digital A3 gave the opportunity to understand the new things which can be put in original digital A3 which companies are facing in their regular work. It gave the opportunity to take the feedback from the companies in the testing face and managed to implement some of them due to ease of the tool and easy process of making changes. In the end, would like to give some suggestions for the future development of Digital A3. The prototype is designed with all details in the scope of this paper. Also, the business canvas model can be performed before selling the Digital A3 to the companies or consultancies. It can be useful to evaluate the general sales and marketing model for companies since business canvas provides cost and revenue streams, customer segments and channels, partners, resources and value proposition at the same analysis. Moreover, the last suggestion is to create premium and standard version of the Digital A3 to sell it to the different customer groups with different features.

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