Identification and Characterization of Improvement Opportunities in Industrial Processes

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Abstract. Flexibility in responding to demand has become a major challenge for industries today. To achieve customer expectations, organizations must be flexible enough to offer a wide range of products and services that are available at any time and with the quality expected by customers. Digitization and Industry 4.0 have a strong impact on today's production environment. Established lean production methods are part of this flexibilization process and can be improved through new technologies. Any digitization must deal with waste and reduce it more effectively than a classic lean approach could. When compared to conventional automation, lean automation spaces are smaller, system prices are cheaper, inventory and energy use are lower. The system designer and operator, however, must have higher skills and knowledge. The integration of innovative automation technology along with lean production is an up-to-date and promising topic as industry 4.0 will not solve the problems of poorly organized and managed manufacturing systems. Furthermore, its tools must be applied to lean activities that are already successful even before automation.

Keywords: Industry 4.0. · Lean Manufacturing · Continuous Improvement · Industrial Processes.

1 Introduction and framework of the theme

The world social and economic situation is in constant change, creating in companies the need to adapt to remain competitive in the field in which they operate. In addition, the world is increasingly competitive, looking for good practices, efficiency and solutions that optimize production and distribution, so it is important to unite the practical universe with the academic world to enable the discovery of new paths for new solutions, solutions that are leaner in the area of waste, but highly effective.

Therefore, this initial research project aims to show how the combination of the application of Lean Manufacturing tools with Industry 4.0 is possible and facilitating inside organizations, with an emphasis on Kanban Pull System and visual management.

Lean Manufacturing is a tool used to carry out the dynamic process and seeks the new solutions mentioned above through continuous improvement, so that it works, it depends on the understanding and involvement of all the company's employees. It gives manufacturers a competitive advantage, reducing costs and improving productivity and quality. It improves production, processing, cycle, and setup time, as well as decreasing inventory, defects, and waste [2].

2 Principles of Lean Manufacturing (LM)

There is a sequence of five concepts that companies can adhere to improve their processes, with the objective of producing high quality products, reducing production costs and satisfying the needs of their customers. The five concepts are:

- Specify Value: the product's value must always be defined by the end customer, the company must meet these requirements only with tasks that add value to the final product, without waste.
- Identify the Value Stream: identify all operations that add value, from planning to marketing a particular product.
- Flow: Flow optimization is the fluid processing of a service/product, it only has activities that add value and minimize waste.
- Pull: a product must only be produced after a customer order. With this request, the production requirement for a given product is generated, in a given quantity and on a given delivery date.
- Perfection: eliminating waste and creating value must be continually pursued. This principle comes from the Kaizen philosophy that seeks perfection through continuous improvement [14].

3 Kanban Pull System and Visual Management

The pull production system is driven by the customer, that is, by the output of the production process and is integrated into the Toyota Production System philosophy. Its operation consists of a flow of information parallel to the flow of materials, but in the opposite direction, in the form of some kind of visual symbol, called Kanban [5].

The main objectives are: to minimize the inventory and fluctuation of work-in-process, in order to simplify its control; reduce production lead time; raise the level of factory control through decentralization: give area operators and supervisors a role of production and inventory control; react more quickly to changing demand and reduce defects [9]. Employees do not need to analyze whether or not there is a material shortage, with Kanban identification cards, stock levels are visible, as well as manufacturing orders to be processed.

The cards can be physical or virtual, usually in green, yellow and red, indicating if it is not necessary to produce, if the production is flowing well, or if it is necessary to produce more to meet the next process, respectively. As a rule, production must necessarily be started for cards that reach the yellow band. [3].

Information boards containing standard work methods, objectives, performance indicators, along with communication boards, are tools that facilitate working on the shop floor and increase employee satisfaction [13]. Physical Kanban cards are widely used in industries, however, the idea is to automate the system so that better results are achieved, visual management is very important in this scenario, as it facilitates the visualization and understanding of the system for employees.

In the kanban board, analogous to the card system, magnets and plastic chips are used as a sign. Contains all production processes, and as soon as the product is moved,

the flag is moved on the frame according to that move. When this product is consumed, the signal representing the product is moved to the Kanban board production queue [8].

With the light indication, the operator activates a light command at his workstation every time he consumes a product. This signal is transmitted to the production cell of that item, where a light will be turned on for each unit to be produced. The worker at the supplying station triggers a command for each unit he produces, which causes the lights to go out [10].

4 Industry 4.0 (I4.0)

The industrial sector has always been extremely important for the economic development of each country and the partnerships between them. Since the end of the 17th century, the industry has undergone transformations that revolutionized the way in which products are manufactured and brought several benefits, mainly the increase in productivity [11].

A study released by the Technische Universität Dortmund [6] states that there are some important components for the formation of Industry 4.0, they are:

- Cyber-Physical Systems (CPS): intelligent machines, products and devices are used that exchange information autonomously, working in collaboration with the physical world around them [4]. This information allows workstations to identify which manufacturing steps must be performed for each product and which ones adapt to perform a specific task [7].
- Internet of Things (IoT): is the network of physical objects, systems, platforms and applications with embedded technology to communicate and/or interact with internal and external environments [12]. RFID can be used as an example in the use of IoT, improving the production flow.
- Internet of Services (IoS): Similar to IoT, it uses services rather than physical entities. "Through IoS, internal and Inter-organizational services are offered over the internet and can be used by all participants in the value chain" [1].
- Smart Factories (SF): new industrial structures, with intelligent devices, connected to a network, where products and production systems have communication capability [11]. In smart factories, physical prototypes will become less important, simulations will promote real-time data to replicate the physical world in a virtual model [1].
- Vertical integration (VI) network of intelligent production systems: uses CPS to react quickly to changes in the level of demand, inventory and possible failure. All processing steps, including discrepancies, are automatically recorded.
- Horizontal integration (HI) of the value chain in a network: these are real-time optimized networks that allow for integrated transparency, offer a high level of flexibility to respond more quickly to non-compliances and allow for better global optimization.

5 Lean Automation and Applications

Lean Manufacturing and Industry 4.0 are concepts with different origins and moments of appearance, but they seek the same goals: reduce waste and improve companies'

production. However, they are executed in different ways, LM through waste reduction and I4.0 through exploring new technologies powered by the IoT.

At Table1 is shown which I4.0 tools can be inserted into the LM tools resulting in Lean Automation.

Table 1: Lean Automation.

	RFID	CPS	IoT	Cloud	Big Data	Augmented Reality	SF	H&V I
Continuous Flow	X	X	X	X	X		X	X
Just in Time	X		X	X	X			
Kanban	X			X	X			
Pull Systems	X			X	X			
Total Preventive Maintenance and Predictive Maintenance			X	X	X	X		
Work in Process			X	X	X	X		

All of the lean production techniques presented here are aided by cloud and big data tools to further improve results. This shows the utility and flexibility of Lean and Industry 4.0 integration. RFID, an improved version of the bar code, is also of great help, it can assist in logistics systems, such as the kanban pull system mentioned earlier, as it facilitates the identification and storage of merchandise information.

A lean production system must be designed to flow. Automation should be selected after deciding how best to improve the flow and adapt to it. It should also be noted that, after implementing lean improvements, selective automation has the potential to add value and further reduce human variability.

6 Conclusions

With the information presented on Lean Manufacturing and Industry 4.0, it is possible to observe the possibilities of improvements that the proper combination of the two tools can bring to manufacturing processes. Industry 4.0 is already a reality in industries, as well as the search for continuous improvement. Therefore, it is expected that within companies there are people interested and willing to apply Lean Automation.

For future work, this initial research project suggests the practical application of the Kanban Pull System and visual management, consequently data could be collected and there will actually be a study of how the application of lean automation improves companies' manufacturing and also the daily lives of employee.

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