A Literature Review on Lean Manufacturing in the Industry 4.0. From Integrated Systems to IoT and Smart Factories

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Abstract. Since the Industry 4.0 nature is a world-scale phenomenon, lot of information are available today from several sources, presenting different point of view. From the scientific papers, the research is focused more on the theoretical steps for a future implementation and the benefits achievable, with important information on the development path followed by the Industry to reach the today situation. Other important resources are represented by the companies operating in the consultant and high-tech sectors, because the revolution is completely intertwined with the digital world and their reports can provide interesting information. At the end, the government reports of the most important manufacturing countries have been a good information source for the practical steps and the necessary requirements in order to create a favorable field for the implementation. Therefore, this chapter is intended to contribute over all these mentioned areas of knowledge, providing a brief state of the arts regarding the Industry 4.0, the role of IoT and Cloud computing in today's and future factories, as well as a view along all those enabling technologies that complement among each other in the diverse industrial scenarios.

Keywords: State-of-the-Art, Asset Management, Cloud & IoT, Lean Manufacturing, Industry 4.0, Maintenance, Uncertainty.

1 Introduction

In the manufacturing world the trend of shortening the productive cycle and increase the variety of products, trying to reduce the costs and decrease the wastes, is always more researched. Higher importance is therefore given to the ability in answering rapidly to change in customers' requests; for this reason, productive systems with higher flexibility and easiness of upgrade are gaining more and more importance in the market, avoiding a fast obsolescence, which is the investment's first enemy. An approach based on these paradigm is the Lean Manufacturing (LM), defined as the philosophy of always reducing wastes in every plant section and in every way, in order to decrease the productive times and costs (James P. Womack and Daniel T. Jones, "Lean Thinking"

1996”); this concept resumes the production technics developed by Toyota Production System in the middle of the 1990s thanks to Taiichi Ohno. This one is only one of the several LM definitions, that all share the followings aspects:

1) Strategy: it is necessary to implement LM as part of a business strategy and, subsequently, spread in the company with an adequate approach. This is an operation quite complex, also because it is linked to the concept of cultural change.

2) Removal of the wastes: with a continuous research, the productive operations can be performed in the most efficient way and at minor costs; the efficiency has to be translated in the ability to adapt the business to client’s needs. Wastes can be divided into 7 categories:

   - Inventory: excess of products or materials not used yet in the productive processes.
   - Waiting: time lost waiting the step-by-step process.
   - Motion: not necessary movement of production personnel.
   - Defects: wastes due to re-work of products, scarps and erroneous information.
   - Transportation: not necessary movement of products and materials.
   - Over-processing: work used to achieve a higher quality, not requested by the standards of the market.
   - Over-production: production of more products than what necessary, or production faster than what necessary.

3) Reduction of production times: it can be achieved with the elimination of all the activities without added value for the processes. Jointly with wastes’ elimination, more efficient operation should be performed, increasing the profit margin and the products quality.

A term strictly related to LM is common sense, intended as a series of activities performed in the proper way and applied in the right production environment. These activities are defined as the 5 S and are used frequently in the LM implementation. Some operations have a key-role for a successful implementation and for obtaining the defined results: must be taught to all the employees the basic principles of improvement and how to identify a starting point for wastes elimination.

A 5S system includes the following activities:

- Sort: tools’ sorting in relation to their utilities in the determined area and removal of useless tools.
- Set in order: stabilize organization of useful tools in order to guarantee an easy and efficient access.
- Shine: cleaning and maintenance of the optimal situation, in order to share the concept of a well-organized environment.

- Standardize: diffusion of the guidelines in order to comply with the previous activities.
- Sustain: educate workers, in order to make them follow the guidelines.

The LM can be considered as the starting point for all the companies that are trying to optimize their productive methods. This approach brings to the companies to create a simplified and very organized productive environment, that can be modified when needed by the company as reply to companies' or customers' needs. The gained flexibility moreover allows a fast change in productive processes, in order to exploit the personnel, the equipment, the space and time available.

2 The term Industry 4.0

The term "Industry 4.0", introduced for the first time by Siemens in the Hannover exhibition in 2011, refers to the fourth industrial revolution, and represent today a phenomenon, continuously evolving, described as the process that will bring the manufacturing industries into a completely automatized and interconnected reality. Industry 4.0 is considered the last evolution of the industry from its birth:

- In the middle of 1700, the steam engine allows to implement new systems able to improve and mechanize the productivity of the common processes. This is the first industrial revolution.
- From 1870, thanks to an always more diffused utilization of the electricity; the concept of mass production is born. At the same time, the utilization of the combustion engine starts.
- In the years around 1970 the digital era took place. The goal is to increase the automatization level, towards the exploitation of the Information Technology.
- The fourth and last industrial revolution is based on the technologies available today; it hasn't an official precise starting day, yet, because its development is still in progress.

The origins of this revolution must be searched in the today's scenario, characterized by a growing use of information technologies that can radically change the approach towards innovation, reducing the time necessary to reach quality and performance goals. On top of that, the market is influenced by a strong competition, significantly increased in all the sectors, creating the right circumstances for a drop of prices and augmentation of quality. Another interesting phenomena is related to the reduced lifecycle of the product, driven by the necessity to react quickly and respond rapidly to the market desires in order to keep the pace with competitors and avoid losses in market share. Obviously, the product design and manufacturing is changing along with it, giving importance not only to quality but also to flexibility, intended as ability to react, resilience and customization of product.

(Lee, Lapira, Yang, & Kao, 2013). (Koç, Lee, Ni, & Bandyopadhyay, 2016).

These new conditions obliged the main manufacturing countries to put in place an economy effort to support the national companies to develop renovation strategies. In particular Germany, in 2012, developed a governmental strategic initiative (Industrie 4.0) to establish the position of country as a leader in the market advanced manufacturing solutions provider; subsequently USA government presented a partnership, called Manufacturing USA, with the main ICT companies for improving research project in the Smart Manufacturing Area; the same happened in France, with the "Industrie du Futur", China with "Made in China 2025", Japan with "Industrial Value chain Initiative", England, India, and others. Recently (2016) also Italy has prepared a set of Government investment to improve research and development, start-up creation and university competences (Piano Nazionale Industria 4.0, 2016).

Today we are at the beginning of the fourth industrial revolution that aims to put in relation the world of automatized production with the connectivity: this is achieved through the utilization of Internet of Things (IoT), an environment where the machines are enabled to independently generate and transmit data to a server for operations such as back-up, reports, diagnostic, comparative analysis, role assignment, and so on. Another important step is done with the technologies for system integration and the creation of the Cyber Physical System (CPS), identified as an interconnection of physical machine and its digital counterpart, where the operational activities can be run in parallel or in different time scale, providing crucial information about the behavior and the context (US National Science Foundation, Cyber-Physical Systems); intelligent machines, logistic systems and production plants can be considered CPS. All these tools are can be used to develop the Industry 4.0 and integrate the automation with the connectivity in the manufacturing industry, in order to create a flexible and customized business.

3 From integrated system to IoT

The Information and Communication Technologies (ICT) have a main role in the implementation of these innovative solutions and technologies of the Industry 4.0: intelligent integrated systems and global networks are the engines for the technological progress and have a fundamental role in the equipment and products used in the everyday life, such as smartphone, ABS and ESP car systems, house's informatics systems and so on. The integrated systems are the central control unit for the management of the operation in the modern technological devices and, generally, are designed for a specific operation and aren't re-programmable for other scopes. These systems relate to the external world through a network and are able to co-operate and transmit information with other intelligent systems. The evolution of these technologies is still an interesting point in several areas, because further research can guarantee benefits at different level, like finance and informatics.

Furthermore, more advantages and evolution can be obtained from CPSs than traditional ICT. The ability to interact with the external world and enlarge the possibilities with calculations, connection and control has a crucial role in the development of future trends. CPSs are defined as Key Enabling Technology (KET), technologies whose adoption can boost innovation for a variety of industrial environments. Those technologies can be essential for a change towards environment sustainability as well as modernization of industrial processes, key element for reshoring of production that is vital for Europe industrial policy; they are characterized by high knowledge intensity and rapid innovation's cycle, with necessity of high investment to provide high qualifying employment (European Commission, Growth and Industry). The interaction between high performances integrated systems and dedicated interface that communicate through digital networks enables a high variety of new functionalities: an example is given by the smartphone that today is providing functionalities, applications and services exceeding the original purpose of the phone. Moreover, CPSs represent a step forward also in the business and marketing models, since are adding new elements and applications to the Value Chain: these reasons are behind the progressive transformation of the industrial sectors and the increasing importance gained by security, efficiency and convenience for humans. Can be clearly understood how CPSs represent the evolution step following the integrated system, because reach that function through the cooperation of internet and online services: one of the main goals is therefore the development of always more advanced, secure and autonomous system, with higher reliability, through the integration of scientific, engineering, and computational activities in order to develop a new science over CPSs and provide support to technology and knowledge.

CPSs are creating the basis for the development of IoT, which is, itself, in direct relationship with data and services, in order to realize the industry 4.0 project. The expression Internet of Things describes the technological development path that from the internet network empower every object of an own digital identity. This concept is revised in industrial meaning and generates the Industrial Internet of Things (IoT) and the Smart Machines, i.e. machines with intelligence ability that uses M-2-M technology: so that the fourth industrial revolution will change the way of working in the plants. In order to equip a machine of "intelligence", in the meaning of an ability to give information at a higher level than standard communications (status identification), it is necessary to provide the machine with new elements for the communication and interaction: measurements sensors, dedicated control system for performance optimization, storage ability for data about working performances. These elements entail the diffusion of the IoT environment that can be controlled and monitored by experts from a centralized position (Internet of People): all these factors result in economic benefits for the company, through the optimization of the production, and for the client; this phenomenon is described as Internet of Services.

Even if some technologies and application mentioned before have been developed recently, the idea of interconnection and dialogue between the different parts of a plant is an argument already known in the past decades: with less advanced technologies, the objective was to obtain a simplified dialogue, i.e. an information transmission to central points from measuring sensors, with reduced abilities of interface and connection with external world. Nevertheless, the original idea has been realized and extended thanks to some factors:

- Contamination and transversality of innovation and attitudes: referred to the ICT, for the implementation in the industry, and t the industry for the adaption at the improvements provided by ICT, in an always higher convergence between the two sectors.
- Interconnection: its development and diffusion is related to the decrease of technologies' cost and increase in computational ability of the platform.
- Change in company attitudes: it starts with a preparation and approach change in the company, linked with the new business opportunities related to the social media in order to define production and diffusion strategy for a product.
- The interconnection and the adequate complexity level provide advantages:
- Improvement of the plant management through the increase of productive efficiency, reduction of energetic costs, better organized maintenance, new services creation, real time interaction with information about production towards augmented reality devices.
- Improvement of product quality and customization: customer request and change are flexibly handled, using also the Big Data analysis.
- Distribution of intelligent products with information about their production, use and disposal.

It will be possible to embrace new business opportunities, thanks to the big amount of data available from products and transmitted through industrial internet, from which derives a higher productivity, reduction of costs and wastes, general improvement of quality and fundamental concept that are at the basis of the Lean Manufacturing, the starting point of this revolution (Deloitte, 2015)(Scheer, 2013)(Bagheri, Yang, Kao, & Lee, 2015).

4 Smart factory: Future of automated production

IoT is therefore the result of a progressive evolution of systems that starts from integrated systems and ends up with the internet connection and CPSs creation. Consequently, IoT and the previous steps, lead to the creation of Smart Factory (SF), one of the main objectives of Industry 4.0. In fact, Smart Machines constantly share information about stock, problems, failures to production line, orders' modifications: the union of these machines' necessary needs coordination, in order to improve efficiency and optimize time, product quality, consumption, and development. For these reasons, Smart Networks are developed, i.e. intelligent networks made up of several machines, cooperating with products and users along all the chain value; this is the basis of the

SF. Products, resources and processes are managed by CPSs, which provide significant advantages to the live quality analysis and reduction in time, costs, resources compared with the standard productive system: the SF is more intelligent, flexible, dynamic.

The Smart Factory is built for a customer service-oriented business: in order to reach these goals, it pushes on levels at high automation and independence, guaranteed by the interconnections of CPSs and the automated supervision of processes. This is a revolution in terms of innovation and money/time savings, and, at the same time, it results in creation of new market opportunities. It is necessary to keep and analyse data from Smart Machines and to manage in a correct and automated way the interconnected Smart Factory; in fact, every machine produce a high volume of data, which represent a further tool able to improve the productive system. (Radziwon, Bilberg, Bogers, & Madsen, 2014); (Sales Webinar Atos, 2014); (Zuehlke, 2010).

5 Industry 4.0 characteristics

From the government plan of the different countries, mentioned before, and especially from report of research international group, the picture of Industry 4.0 is colorful and different points of view and strategies are depicted in order to handle in the proper way the industrial revolution; but all of them have some common points, that are here presented as the principal characteristics of the Industry 4.0, related with the quantity of work necessary for an improvement of the traditional production.

Vertical network of the intelligent productive system: CPSs are exploited in order to react rapidly to customer request change, stock level, production defects, and general problem. Smart Factories are managed autonomously and generate a production adequate to the customer requests: this is possible only with a high integration and connection between all the smart tools. CPSs permit the autonomous organization of the production management and allow the maintenance management of different tools: resources and products are connected to the network system and can be identified in real time, while all the production phases show the undertaken operation, recording eventual problems or variations to the optimal situation. In this way, possible change to the work order, to the quality, or machinery problems are dealt rapidly. It is useful as well the evaluation of production plant manager, which are responsible for the efficient use of CPSs.

Horizontal integration through new value chain network: they are like production system network and are connected in rea time along all the chain value, providing transparency and flexibility. The production, therefore, can be adapted to the customers' needs, changing the development, planning, composition, distribution of products; factors such as quality, times, prices can be managed dynamically in real time for all the chain phases, creating new business and cooperation models between clients and smart factories.

Engineering coordination throughout the value chain: every new product needs customized manufacturing system for an integrated and coordinated production where the data and information are available at every phase of the product's lifecycle.

Exponential technologies impact are bringing adequate flexibility to any solution, together with money savings in industrial processes. Starting from high automation solutions, e.g. the artificial intelligence (AI) and advanced robotic, able to take decision autonomously and increase exponentially the tools autonomy, intelligence and flexibility. AIs improve products and resources transfers in the production process, increase reliability analyzing data directly from machines, and enhance a better cooperation man-machine. Additive manufacturing is an example of exponential technology because it ensures new functional solutions, more complex and without cost upraise. Between the exponential technologies available today must be mentioned the Augmented and Virtual Reality as well, with simulation ability, and Cloud, with all the related situation, such as Cloud Computing and cyber-security. (Dujin, Geissler, & Horstkötter, 2014; McKinsey&Company, 2015; Rüßmann et al., 2015). Differences between today's factory and an Industry 4.0 factory can be summarized in table 1.

6 Enabling technologies of Industry 4.0

The Industry 4.0 KETs are a list of innovative technologies that covers different aspects of industry disciplines but are all characterized by an enormous potential of innovate and change radically the methodologies used today to design, manufacture and manage a product. The scope of Industry 4.0 is to create an intelligent factory based on the interconnection between the physical manufacturing assets and a digital system; this interconnection is indicated as CPS. The adoption of digital enablers can revolutionize the way the orders are sent to machines, can increase the number, type and frequency of data stored, can increase storage capacity and accessibility to information pick-up. Obviously, the availability of data, intended as rapid access, when needed, of a various information related to machine performance, can transform the manufacturing processes increasing the convenience and the accuracy. On top of that, the data driven approach applied also to market and customer analysis can lead to a strict link between production chain and customer / market needs. This topic is mainly related to Industry 4.0 intelligent factory and its management; on the other side also the manufacturing technologies can benefit from the KETs, in particular, considering the adoption of Additive Layer Manufacturing (also known as 3D printing) or the HMI revolution with digital tools and equipment, such as Augmented Reality. As a general statement, the industry need to develop a new and innovative approach towards technologies, models methods and demands.

6.1 Big Data and Analytics

As presented in the previous paragraph, the introduction of Industry 4.0 KETs, CPSs in particular, can generate a new capability of creating and storing data, coming from every connected equipment of the production plant. Those data, due to their size, are known as Big Data, and due to their complexity and variety, needs specific algorithm and rules to be analyzed in order to provide value adding and usable information. Those information, extrapolated from Big Data, are crucial to empower the decision-making process, giving insight to actual status of the processes.

Big data can be used in 3 different ways: first of all, can influence the company path thanks to the analysis of customer dynamic data. Secondly, can be used to monitor and predict the performance of the product, refine the after-sale response and product improvement capability. The third aspect is related to industrial big data and possibility to collect data related to machines and plants performances, quality issues, energy absorption, anomalies, and similar, providing the right tools for manufacturing processes optimization, reduction of costs, planning of maintenance activities. The last one, industrial big data, has an impact also in the optimization of the supply chain; particularly significant to optimize storage and distribution activities, saving costs.

Factories that adopt KETs and use Big Data are often called intelligent factories, because the big data management can contribute significantly to the awareness of the company about their current status and their weakness points; and this point is crucial for the survival of the industry inside this competitive and fast paced market.

6.2 Industrial Cloud and Cloud Computing

Starting from the fact that our age is defined as the "information age", the fuel of this age is clearly the data. Every day, a huge amount of data is generated everywhere from all sort of devices and users.

As presented before, Big Data and its Analytics are a key element for future success of industry, but those technologies need an investment in terms of storage and computing capacity. For this reason, we have to consider also the Cloud Computing: the possibility to operate simultaneously different steps of the same calculus on different computer, interconnected to the same web. This distributed architecture is essential because one computer only can't manage all the data, and the investment for large number of computers can't be competitive versus the flexibility of Cloud Computing. All those aspects carry new challenges for the next future: security and integrity of the data must be guaranteed even if the data is geographically dispersed.

Cloud computing is service-oriented and is characterized by versatility, scalability and virtualization. Those characteristics will be essential in the acceleration of hardware's and software's upgrade, and in the introduction of the technology inside the industrial chain. The versatility of Cloud Computing will enhance the possibility to differentiate appropriately and accurately the computing capacity in accordance with the requirements in order to handle the different problems in the best way. At the same time, enlarging the data pool generated by industrial equipment, more and more time will be necessary to analyze the data and retrieve the key information, forcing the use of Cloud Computing for a faster and cheaper solution.

6.3 Internet of Things (IoT)

The interconnection between the physical and digital world, empowered by Big Data analytics and Cloud Computing, is the key point of Industry 4.0.

This interconnection is achievable with a wide adoption of sensors and network technology, in order to create what is known as Internet of Things (IoT). The devices that we use every day contains embedded sensors and software used to collect and analyze data; and these technologies have raised enormously in the last decades. In the same way, those smart sensors and chips will be used in the manufacturing plants to track and compute information related to production processes. Differently than traditional embedded systems, IoT works on multiple levels, because not only is able to receive and transmit real time data, but also is able to provide an aggregated result derived from processing and analysis. This type of information, are vital for the industrial infrastructure and are necessary to link all the steps of the production chain, in a scenario of auto-control of the system, that put in action defined countermeasures when specific target value of process parameters are hit. This concept of industry is revolutionary and can provide significant economic benefits to companies.

6.4 Augmented Reality

Augmented reality (AR) is defined as the enrichment of real world with information generated by computers and integrated in the same environment. The most common AR applications integrate the user’s view with specific information retrieved by the computer and related to his surroundings. In this way it is possible to improve the efficiency of the user activities, providing him with specific information related to the task that is performing, avoiding loss of time and reducing the probability of errors.

AR systems are available since 2000’s, but were characterized by several limits that reduced their application into industrial environment. Today, thanks to the technological advances and miniaturization of devices, AR is a usable and ergonomic tool ready to be used. With the spread and availability of information typical of Industry 4.0 smart factories environment, the use of AR of productivity applications can represent an additional step towards effectiveness and efficiency, resulting determinant for industrial development.

6.5 Simulation

The Industry 4.0 meaning of "Simulation" is not related to the process of simulating products characteristics, loads situation or fluid-dynamic aspects, but is related to the simulation of industry behavior and plant operations management. This simulation will transport the real time data of the industry into a virtual environment, which obviously includes equipment, production lines, operators, but enriched with the collected data and elaborated information. This allows the company management and manufacturing managers to test and optimize the overall functioning of the next product line, prior its real starting and avoiding potential issues in the setup of machines or in start-up phase. This is a powerful tool that can represent a revolution for the design and implementation of production plants and logistic centers, where investment and cost can be enormous and a proper cost/benefit analysis must be conducted.

In the virtual environment various operations can be simulated: resource allocation, production rates, equipment selection, system delays, buffer size, and so on.

It is extremely advantageous to test extensively the industrial environment, without consequences in case of failures, before implementation in the real world. With simulations, the management can obtain confidence in the different scenario and under various operative conditions, gaining experience for the time of deploy. In this way, the risks are reduced to the minimum and the investments are placed only when the right confidence is reached, empowering once more the decision making process. On top of that, there is also the benefit coming from the reduced time and cost in the real deployment phase, achievable because of the experience gained through the simulation.

Obviously, the results and benefits of the simulation are strictly inversely related to the grade of uncertainty of the data in input: good, reliable and complete data are propaedeutic to achieve positive results. In this Industry 4.0 scenario, once more, the availability of data in huge quantity and variety, and the availability of tools to analyze and process them, is a key pillar also for simulation.

6.6 Autonomous Robot

Inside the modern manufacturing industry presented above, an important role can be played by autonomous robot, because in an Industry 4.0 factory all the ingredients are available for a complete autonomy of specific work operations, and, on top of that, there is also the capability to track and evaluate remotely their performances. Since 2004, the number and type of robots developed by the companies is doubled, in order to cover all the aspects of an industrial manufacturing process. Today, a wide use of intelligent and collaborative autonomous robots in several manufacturing steps, can represent an improvement of safety, flexibility, versatility, without diminishing the importance of human work. In this way, the integration between human and machine operations can open up new applications in industries, reducing all the risky situations where human operators are implied. Autonomous robots can be used on a variety of tasks, not only strictly related to manufacturing processes, but also logistic and office management; it is possible to control their operations remotely, with the use of mobile devices, linked to webcam or just enabled to receive data about robots' activities, with the option of give instructions and orders to fix potential problems and avoid productions stops, guaranteeing the 24 hours/day production.

6.7 Horizontal & Vertical Integration

Horizontal integration occurs when the technologies here presented are used to exchange relevant information related to a production process and its management. An example of this integration is the use of augmented reality devices for maintenance operations.

Vertical integration is intended at the various level of hierarchy in an industry. The interaction between these levels is complex and involve different IT systems, and this is where CPS can result significant in the integration of all the value chain of the product, starting from the design and development of the goods, passing from its manufacturing process, and ending to the customer management. All this steps, joint and correlated by the data connection, are the base of the product life cycle management.

6.8 Additive Manufacturing

A key manufacturing characteristics of Industry 4.0 is the ability to make the products faster, with less steps and resources and without fixed constraints. Those goals are easily achievable with the adoption of Additive Layer Manufacturing (ALM) technologies. With this term is indicated a vast type of technologies able to process metals, polymers, ceramic and composites, with a common characteristic: the component is realized layer by layer. The first 3D printer was invented in the early '80s, and today on Amazon there are several home 3D printers for few hundred dollars.

Obviously, considering the technology at an industrial level, the investment is completely different, but the benefits that ALM can guarantee are disruptive: faster time to market thanks to a reduced time between prototyping phase and production; free form and complex geometries impossible to realize with traditional manufacturing technologies; flexibility of change and improvement available because there are no fixed tools or equipment for the production apart the 3D printer itself.

Technology first and easiest use is the rapid prototyping: application involving mainly polymers, where the goal is to manufacture a component that is similar in shape to the final one, but is missing its properties. The fourth revolution has the challenge to enlarge the use of ALM at an industrially structured level, with the production of fully functional components, designed for the technology, and able to bring flexibility inside the value chain.

6.9 Cybersecurity

The importance of Data has been already presented in different paragraph, and in parallel with the practical usefulness of data for Industry improvement, it must be considered also the strategic importance of data related to key process parameters, customer's information, intellectual properties and so on. On one hand the iper-connectivity can increase significantly the efficiency and effectiveness of industries, but on the other side it is putting at risk the security of the data itself. Since we are at the beginning of this revolution, the expectation of results can overcome the caution, relying too much on old connectivity protocols not designed for this extended connectivity. For this reason, another challenge of this revolution is to prepare and give companies the right tools to manage the interconnectivity putting at first place the security of the data, online as well offline.

7 Conclusions

The goal of this chapter has been to gather the state of the art related to lean manufacturing in industrial application of new technologies as Cloud computing and IoT-based tools. As it has been commented, the new support technologies for productive processes, as the connectivity and the utilization of new data, are going to have a key role in the development phase. These elements bring to the Big Data, the Internet of Things, to the connection between machines, to Cloud Computing; all processes that allow to centralize and store data, that, subsequently, are analyzed and interpreted, in order to obtain valuable results.

Another result depicted in this chapter has been the consideration of Artificial Intelligence. In this regard, between the process used to convert the data into information, there are the Data Mining, as the computational process of discovering patterns in large data sets involving methods of statistics and database systems, and the Machine Learning, the machines' improvement obtained through algorithms able to learn the necessary modifications to implement from the data analyzed. High importance is given also to Human-Machine Interface and the related change to the way of interact with the manufacturing products, due to new technologies and competences, such as Augmented and Virtual Reality, that apply what is computed and analyzed from the digital world to the real one; Additive Manufacturing is another important point in the industrial revolution because can be exploited for cost reduction, waste's minimization and performances' optimization.

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