Review of Lean Manufacturing with IR4.0 in Automotive Industry

To cite this article: Dara Affydah *et al* 2021 *J. Phys.: Conf. Ser.* **1874** 012050

Review of Lean Manufacturing with IR4.0 in Automotive Industry

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Abstract

This paper aims to study the possibility of integration between Lean Manufacturing (LM) and Industrial Revolutions 4.0 (IR4.0). LM is generally known and acknowledged as a feasible system in the industrial sector. However, a new paradigm of IR4.0 has influenced manufacturers to look further into how LM could be implemented and adopted. It drives the integration of an intelligent factory to control machines, humans, products, and cloud solutions along the value chain. Manufacturers, especially in the automotive industry such as Toyota Company, have been using lean concepts and methods for so many years to eliminate wastes, reduce operational costs, and improve production performance. By integrating LM with IR4.0, the manufacturers could enhance productivity and quality by using the implementation chain. Besides, it enables self-management operational processes that could ensure the customer's quality of production.

1. Introduction

Nowadays, manufacturers have to produce a product with high accuracy, efficiency at optimum cost. Due to the challenges of competitiveness, it adapts to the demand for consumer requirements [1]. Numerous systems have been introduced to the industries to eliminate waste and minimize cost, such as Lean Manufacturing (LM), agile manufacturing, six sigma, and recently Industrial Revolutions 4.0 (IR4.0). Lean Manufacturing is aiming to maximize operation to be more efficient by eliminating wastes. These wastes will be identified, recognized, and eliminated by using LM tools and techniques. LM was developed based on the Toyota Production System [2]. It is a continuous and persistent process through LM practices to wastes reduction and disposal [3]. LM is considered the most effective system in the 21st century [4, 5]. It is the most current manufacturing system principle, empowering manufacturing companies to increase production to reduced manufacturing cost and improved quality [6]. SME (small and medium enterprise) could also execute LM for performance [7]. LM emphasises on removing any waste by categorising redundant activities in the production process by optimising the system and structuring processes. It is advantageous to the manufacturer to see the process in a production line and work areas with low complexity to be simplified by implementing automation and digital technology [8]. Present developments in manufacturing systems and data exchange considered and known as Industry 4.0 [9]. It is also known as 4.0 or IR4.0. It focuses on cyber-physical (CPS) machine tool transition and development [10]. A phrase IR4.0 originally came from the German government's strategy to promote the development and technological convergence between industry and digitalization of innovation. IR4.0 key concept is to link computers, device systems, businesses and other things to be intelligent platforms through the production system [11]. All these aspects are controlled autonomously. IR4.0 or Smart Factory is a technology that can predict the possibility of failure and initiate recovery before failure occurs. In IR4.0, plenty of machinery generated by automation that uses artificial intelligence (AI) [12].

The challenges in implementing IR4.0 are lack of expertise among managers and staff, incapable to ensure the efficiency of manufacturing processes and lack of expertise to respond to workers' reduction [13]. Uncertain regulatory issues and data security, excessive loss of influence over creativity, requirements and credentials, artificial intelligence production facilities in IR4.0 [14]. New digital information technologies such as cyber-physical networks, big data analytics, and cloud computing can anticipate the mode of failure before performance loss. After detecting the failure mode, they can be interrupted and verified immediately. It helps to upgrade performance and quality [15]. The changes in implementation have required commitment from top management [16-19]. The behaviour of reluctant to change from workers on daily repetitive routine is also considered the barrier of adapting IR4.0 [18]. Manufacturers must integrate with organizational transformation and corporate change to adapt with IR4.0 [16, 18, 20-22]. Lack of understanding of the IR4.0 concept creates confusion in setting up the organizational strategy [22, 23]. Lack of awareness of the impact and need for IR4.0 technologies will cause many problems for a manufacturer to adopt with IR4.0 [24].

Table 1. Challenges and benefits of implementation Lean Manufacturing in the Automotive Industry.

Type	Details
Challenges	Employees resign too often Employees oppose transition Misunderstanding of the lean principles Customer unpredictable timetable Bad staff engagement Inadequate support Supplier's delivery shortages Lack of senior management engagement Low-quality supplied pieces Time-factor lowering efficiency The human aspect Inadequate IT systems Economies unbalanced Staff's pessimistic views
Benefits	Improved commodity consistency Increased performance and correct standards Easier to handle the workspace. Safer workplace condition Develop employee morality Troubleshooting Improved efficiency Improved quality Improved productivity Reduced inventory

Source; [25] *A survey on Lean Manufacturing implementation in Malaysian automotive industry.* International Journal of Innovation, Management and Technology, 2010.

Some researchers have shown that there are obstacles to the IR4.0 transition which are uncertain advantages and significant returns [26]. Mostly in the new century, several manufacturing companies are prepared to implement IR4.0 [27]. Furthermore, there is a general level of confusion among organizations about the execution of IR4.0, due to a lack of funding and plans [28]. It is clear that obviously, it is also possible to recognize IR4.0 as a set of innovations that can be implemented into industries. Growing social uncertainty began to demand revolutions in various aspects of existence. Continuing shifts in lifestyle, social demands, and the quest for innovation in the production process have resulted in differences in progress and expansion among world countries, with technology providing the basis for these differences. IR4.0, evolving through time from the first, second, third and recent fourth industrial revolutions [29].

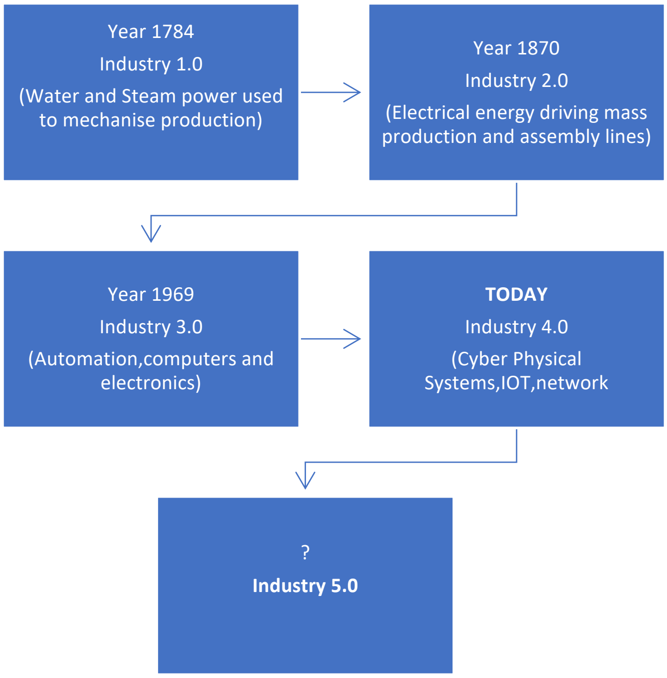

Figure 1. Industrial Revolutions

The industrial revolution began with water and steam (hydropower) mechanical processing machinery. The increasing usage of hydraulic power led to the development of combustion engines; the second industrial revolution came into being with the introduction of mass processing (mass production) utilising electrical energy; the third industrial revolution came into being at the end of the 20th century with the use of electronics and computing technology. The Fourth Industrial Revolution focuses on cyber-physical systems, which may occur more smart systems and less of a human being, yet the human being can function in an extraordinarily complex advanced technical landscape when doing the main interaction programming work [30]. This fourth industrial revolution is the time where the modern present first industrial revolution devices are related to the progressive present second industrial revolution devices and the ground breaking third revolution devices. Communications should be established through programming efficiently [31]. The fourth industrial revolution is regularly referred to as digitisation and automation of practice [32]. Thus, many called the most critical social and economic phenomena throughout the modern age: one that might fundamentally change the meaning of life, manufacturing and society in the generations ahead [33, 34].

2. Automotive Industry in the Industrial Revolution 4.0

2.1. *Internet of things (IoT)*
The study showed there are major benefits using radio frequency identification unit (RFID) technology in the automotive industry. RFID is used to distinguish artefacts via radio signals [35]. The use of RFID methods in automotive production especially in the production process is extensively explored in the previous IoT technology literature. The goal is to link the real and cyber world to implement a system from end to end. [36,37]. A research on RFID technology has been shown that can promote the management of the product lifecycle (PLM) sector. Another example of RFID deployment in the automotive industry can be seen at Volvo Truck's cab plant in Sweden. To increase the transparency of the whole process, they introduced an RFID scheme in their paint shop service. Effective to this excellent accomplishment, more RFID systems have been introduced in the trim store. The goal of this

implementation is to gain accuracy [38]. RFID technology plays an important part in IR4.0. It is seen as an enabler of innovation, as it increases the traceability of the operation and the production of products in the supply chain. It also allows the gathering of information about the application of items. It also assists manufacturing with the application of facts and awareness about the product lifecycle across the supply chain. It would also allow the producer to reduce the differences between commodity knowledge cycles [37].

3. Integration between Lean Manufacturing implementation and IR4.0

For a successful system adaptation to IR4.0, three features need to be considered. These features are horizontal integration through value chains, vertical integration, and networking of production or service systems from end-to-end engineering of the overall value chain [39]. Vertical integration required smart Cross-linking and digitalisation units within the organization at various hierarchical levels. Vertical integration, therefore, enables a highly flexible transformation into a smart factory. It provides acceptable levels of profitability for the manufacture of limited and customizable items. Smart machines, for example, create a self-automated ecosystem. It can be dynamically subordinated to various categories and enormous amounts of data. Data are stored to easily operate development processes. However, horizontal integration provides a total value between organisations. Enrich the product development cycle by leveraging knowledge structures, effective financial monitoring and product flow [40]. Horizontal and vertical convergence facilitates real-time data exchange, the productivity of resource distribution, unified corporate units, and detailed planning critical to integrating systems. Finally, end-to-end innovation enables product design by digitally incorporating consumer preferences. This can be done by supporting technologies, product design, maintenance, and recycling [39]. IR4.0 is driven from its core by permanent advances in all three fields within their respective disciplines as well as a major acquisition together. These three drivers can be summarised in Table 2.

Table 2. Technological drivers for the Fourth Industrial Revolution

Technology drivers	Fields
Digital	Digital platform Internet of Things (IoT) Big data and cloud computing Artificial intelligence and machine learning
Biological	Genetic Engineering Neurotechnology
Physical	3D printing Autonomous Cars

Source: LI et al. (2017)

Although the Third Industrial Revolution's major technical forces originated from the hardware industry, the Fourth Industrial Revolution's technological factors emerged primarily from the internet technology.

4. Fourth Industrial Revolution in the Lean Manufacturing

Any employee should aim for excellence when producing a product or services to the customer needs. Manufacturers could improve their performance once practicing IR4.0. IR4.0 builds on the digital revolution and integrates various technologies that could lead to the significant for improvement in environmental, business, community, and interpersonal paradigm improvements. For the digitalization of all networks, the system requires the combination of cyber physical systems, the internet of things, and the internet of systems which could make the company becomes smart factory. The process monitoring could be carried out through the development of smart phone. As a result, the company becomes smarter with the ability to access more data and be more productive. Implementation of the IR4.0 will inevitably impact the routine of workers, training, creative work arrangement methods and changes in interaction and communication in the human-machine environment structure, which might be defined as new digital modes in the framework of a smart factory [41].

Conclusion

In future, technical developments would often contribute to a future supply-side transformation, including long-term improvements in production and productivity. Costs of shipping and material processing will decline, networks of manufacturing and industrial output will become more competitive and rates of exchange will decline, setting new market opportunities and boosting economic and social development. Scholars also pointed out that the transition leads to greater inequality, particularly in transforming labor markets. Automation will replace jobs in the economy, a complete substitution of workers by robots which will exacerbate the gap between capital gains and labor gains. In the other hand, it is also possible that replacing workers with technology will inevitably contribute to the growth rate in stable, profitable employment. Being more efficient, IR4.0 crosses environmental, technological, and social needs of existing and future generations. As part of IR4.0 's latest growth, cybersecurity is monitored at the level of proven automation and automotive machinery expertise, as well as at the data development and process or interaction protection point. Development of IR4.0 will have a very interesting socio-technical impact as studying the results of full integration and a lot of study data would be interesting. And if there are already several current systems and reference models for IR 4.0 situations, challenges will still be treated as unanswered or at least not adequately managed. Thus, further analysis is required to combine existing approaches with additional core IR4.0 aspects.

Acknowledgement

This research is sponsored by the Ministry of Higher Education of Malaysia for FRGS/1/2018/TK03/UMP/03/3 (RDU190193) and is also supported by Universiti Malaysia Pahang (UMP).

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