INDUSTRY 4.0 APPLICATIONS AND DIGITILIZATION OF LEAN PRODUCTION LINES

Hüseyin Şenkayas, Özden Gürsoy
Business Administration, Faculty of Economics and Administrative Sciences, Adnan Menderes University, Nazilli, Turkey
hsenkayas@adu.edu.tr
o.gursoy_85@hotmail.com

Abstract: *European economy faces two main problems in manufacturing sector: inefficient production with high costs and long time to supply new products to market. With these obstacles, economies cannot compete with other developing countries like China. In order to overcome these problems, leading firms works on new paradigms like lean production, digitilization and industry 4.0. Firms could simplify production lines by dealing with all the wastes, delays, faults etc. through the workplace. So they can shorten the production cycle times, data entry time, waiting semi-finished products, faults and scraps in the production lines. Industry 4.0 applications helps lean manufacturing lines to realize more efficient and quality production systems. Because, these applications will make the European economy grow increasing productivity and added value of the products. In today's industry digitization is vital for manufacturing processes. Especially in automotive supplier industry getting data from the machines and production lines by digital panels and monitors is vital for efficient production. Rim industry is one of the suppliers of automotive manufacturers. In order to provide quality and high performance products in time, rim producers try to apply lean manufacturing systems and industry 4.0 applications to their production lines. Jantsa is one of the biggest rim producer of Turkey with 200 different sizes and over 3,000 different designs and models. The factory is located on 95,000 square meters area with the production capacity of nearly1,900,000 wheels annually. They expert 75 % of these wheels to over 80 countries worldwide. The digitilization project realized in Jantsa aims to get information about the rim production lines and make necessary improvements in order to increase efficiency. The name of the project is Production Data Collection and Barcoded Product Tracking Automation. OEE (Overall Equipment Effectiveness) calculation method is used in order to digitalise production lines in lean systems for improving processes. According to test data we have three factors effecting OEE calculation: availability, performance and quality. When we make the calculation the test results of OEE is 93.1%. It is fairly high according to international production standards. The focus should be on increasing the performance of machines and equipment used in the operation.*

Keywords: *Lean production; Industry 4.0; OEE; performance; rim.*

JEL Classification: *L62; M11.*

1. Lean Production and Industry 4.0: Review

Firms could simplify production lines by dealing with all the wastes, delays, faults etc. through the workplace. So they can shorten the production cycle times, data entry time, waiting semi-finished products, faults and scraps in the production lines.

Industry 4.0 applications helps lean manufacturing lines to realize more efficient and quality production systems.
Lean production is an integrated socio-technical system and it aims to eliminate waste by reducing or minimizing supplier, customer, and internal variability (Shah ve Ward, 2007:791). Therefore, main task of lean production is to eliminate wasting in every part of the production from the first customer contact, through all supply networks, the production process itself to the dispatch of the finished product to the customer (Daneshjo, Pajerská, Klimek, Danishjoo, 2018:34). In order to simplify production lines we should deal with all the wastes, delays, faults etc. through the workplace.
For improvement in efficiency, speed of response and flexibility in production at many industrial enterprises, lean production techniques provide significant benefits by waste elimination. Lean management also allowed enterprises to put forward a various range of products, with minimum cost and high productivity, speed of delivery, minimum inventory levels and optimum quality (Arbos, 2002:169). The basic approach is a continuous improvement of production by an integration of the following principles: Kaizen, Just-in-Time (JIT), Jidoka, Heijunka, standardization, takt time, pull flow, man-machine separation, people and teamwork and Waste reduction. (Wagner, Herrman and Thiede, 2017: 127)
According to Mrugalska and Wyrwicka (2017:471), lean production is superior to the mass production practices with its good quality products aimed at customers' satisfaction. Every activity that does not add value to the product is accepted to be waste. Production systems can be flexible for complex products by lea production. It will be helpful to integrate IT (information technology) solutions with customers and suppliers by CPS (Cyber Physical Systems) and it is called "Industry 4.0".
New possibilities from information and communication technologies are matching with lean production environments. The other study shows that Industry 4.0 applications can stabilize and support lean principles. Furthermore approaches to integrate sustainability into Lean Production Systems are available and should be extended by an integration of Industry 4.0 technologies (Wagner, Herrman and Thiede, 2017: 130-131).
In order to strengthen the competitiveness in the field of digital technologies and to ensure that every European industry can fully benefit from digital innovations, European industry digitalization pretends to benefit from all the advantages of a digital single market (Luque, Peralta, Heras and Cordoba, 2017:1200).
Industry 4.0 became an important concept for researchers and companies at the same time. Germany is the country that put fort the idea of a digitilization of manufacturing that is called fourth industrial revolution which is supported by smart technologies (Paravizo, Chaim, Braatz, Muschard and Rozenfeld, 2018: 439). The term Industry 4.0 was coined to describe a system that evolved from a computer controlled automated facility into a system that gathers and analyses data from the floor to make intelligent decisions in an automated manner (Garza and Kurfess, 2018:1). 'Industry 4.0' was first coined at the Hannover Fair in 2011, and it has drawn great attention from academics, practitioners, governmental officials, and politicians all over the world (Sung, 2017:1).
Industry 4.0 is an emerging paradigm for the increasing digitisation and automation of the manufacturing environment. It is also important for the creation of a digital value chain to enable the communication between products and their environment and business partners (Scurati, Gattulo, Fiorento, Ferrise, Bordegoni and Uva,

2018:68). Information and communication technologies can be innovatively into the industry by Industry 4.0, so firms can encourage the intelligent networking of different products and processes through the value chain. Therefore, the organizational processes can be used more efficiently. (Barreto, Amaral and Pereira, 2017:1246).
The Industry 4.0 is used for three, mutually interconnected factors: 1) Digitization and integration of any simple technical–economical relation to complex technical–economical complex networks 2) Digitization of products and services offer 3) New market models (Zezulka, Marcon, Vesely and Sajdl, 2016:8).
The Industry 4.0 Working Group believes that action is needed in the following eight key areas (Kagermann, Wahlster and Helbig, 2013:6-7):

- Standardisation and reference structure
- Complex systems management
- A comprehensive broadband infrastructure
- Safety and security
- Work design and organisation
- Training and continuing professional development
- Regulatory framework
- Efficiency of resources

The literature review identified four key components of Industry 4.0: Cyber Physical Systems, Internet of Things, Internet of Services, and Smart Factory (Hermann, Pentek and Otto, 2015:8) Cyber-physical systems, refer to technical systems that are embedded into larger systems such as devices, buildings, infrastructures, and production facilities. (Xu, Liu and Zhang, 2018:382).
A Smart Factory is a manufacturing solution that provides such flexible and adaptive production processes that will solve problems arising on a production facility with dynamic and rapidly changing boundary conditions in a world of increasing complexity (Raswizon, Bilberg, Bogers and Madsen, 2014:1187).
Industry 4.0 has five main objectives: (Santos, Loures, Piechnicki and Canciglieri, 2017:1359)

1) The low, medium and high demand structure is important to apply to production needs by varying the product type,
2) Intelligent machines can track and self-recognize of parts and products,
3) Human Machine Interface (HMI) should be in better interaction,
4) Internet tools of Things (IoT) communication must be optimized by production based,
5) The business model that contributes to change is changed radically in the forms of interaction with the value chain.

Industry 4.0 combines embedded production system technologies with intelligent production processes, so it builds a new way for a new technological age that will fundamentally transform industry value chains, production value chains, and business models (Zhong, Xu, Klotz and Newman, 2017:616). Industry 4.0 tries to improve competitiveness by minimizing costs and increasing firm’s flexibility. It offers customized products for satisfying the customer markets. So, in order to stay competitive, firms should reach high productivity (Meissner, Ilsen and Aurich, 2017:165).

2. Methodology of the Research

The digitilization project is realized in a rim company in automotive supplier industry in Aydin province. The aim of the project is to get information about the rim production lines and make necessary improvements in order to increase efficiency. The name of the project is Production Data Collection and Barcoded Product Tracking Automation. OEE (Overall Equipment Effectiveness) calculation method is used in order to digitalise production lines in lean systems for improving processes. OEE is simply how we use time efficiently to produce quality products. It is a measurement technique that shows how an operator can benefit from a machine, counter or equipment. The following parameters shall be taken into account when calculating the OEE:

a) Equipment availability rate = (Planned production time – unplanned stops) / Planned production time
b) Performance rate = (standard cycle time x production rate) / (Planned production time – unplanned stops)
c) Quality rate = correct product rate / total production rate

OEE = Availability x Performance x Quality

Manufacturing execution and monitoring system (MAS) used in the firm is a computer aided system that gathers and integrates all the methods and equipments in the production online. In order to calculate OEE of the firm we need planned and unplanned stops of the machines, fault times, cycle time, best cycle time, machine performance, set up time, alteration and scrap rates and production rates. For real-time monitoring and productivity tracking, the data from the production site of the enterprise are collected. Firm aims more efficient production planning, less production cost, easy to use and flexible interface between machine, operator and ERP systems, identification of bottlenecks, monitoring productivity and OEE values instantly, and process improvement by managing processes in a simple, efficient and traceable structure.

3. Application of the Research

JANTSA is Turkey's one of the largest rim manufacturers. It was established in 1977 where it has produced its first three-piece dimensioned 5.50-16 SDC Commercial Vehicle Wheel. After a decade JANTSA offered a product range of 200 sizes with 3,000 different designs and models. The firm expanded its area of 95,000 square meters. Its production capacity is 1,900,000 wheels annually and it exports 75 % of it to 81 countries worldwide.

Before applying MAS in production system, firm is testing a pilot study in some levels of the production line. Data used in this research is test data before the pilot study and process improvement continues in a controlled manner. The aims of the project are tracking performance data of production lines by data collected in real time from the workplace, collecting information like production rate, period, machine stop times, scraps and failures, reporting at every level in order to make planning and take action, building infrastructure for efficiency improvement, cost reduction works, and creating Microsoft Dynamics NAV production records. Scope of the project is to

track production data and performances of 300 machines/lines. It also aims to build real-time OEE follow-up infrastructure and provide at least 10% improve in the total equipment efficiency.
Figure 1 shows the synoptic of production control of Colouring (Dying) section of the rim production line.

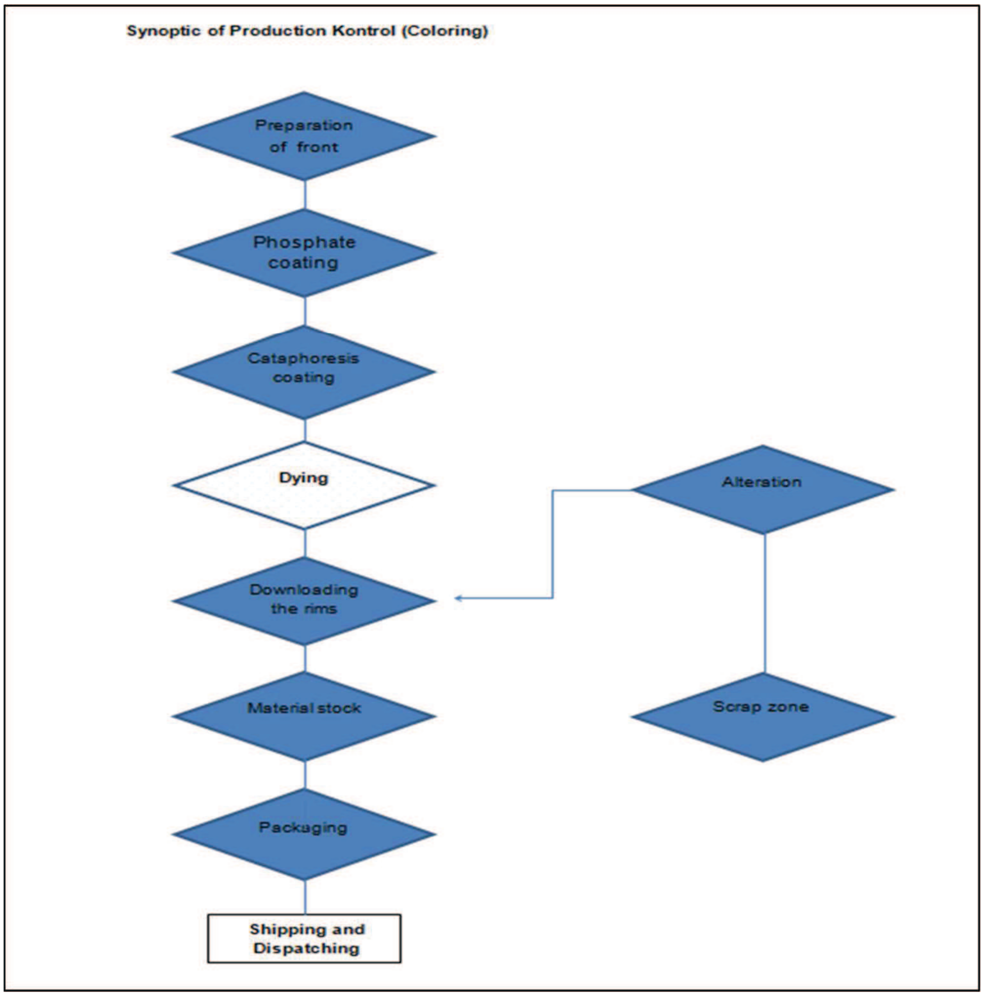

Figure 1: Synoptic of production control

According to test data we have three factors effecting OEE calculation: availability, performance and quality. Equipment availability rate is used to calculate the production time of the machine, that is the real used time of this machine during the day. For example, a machine is ready for 24 hours (1440 minutes) a day. However, as for the test data of dying stage it is really used only 16.896 hours for production. So available time for this machine is 70.4% (16.896/24). The lost 7.104 hours was spent for reasons like machine maintenance, eating break and machine malfunction or firm could decide not to run the machine during 7.104 hours. While calculating

availability we should consider meal breaks, planned maintenance, machine malfunction, cleaning, change over, machine stops, quality problems. This lags can be planned or planned, compulsory or preventable.
Performance or productivity is the rate between production amount of the machine during given time and maximum production amount. According to the test data machine is working with 132.2% (60/45.38) performance.
Quality is the rate between error free parts and faulty parts. As there is no faulty parts and scrap piece number is zero, quality rate is 100%.
If we put these calculations in the OEE formula;

$$OEE = 70.4\% \times 132,2\% \times 100\% = 93,06\% \approxeq 93,1\%$$

This 93.1% OEE rate is fairly high according to international production standards. For consistently getting the best results, the machines must produce quality products every minute within the given period. Figure 2 shows the OEE data of the production line in Jantsa.

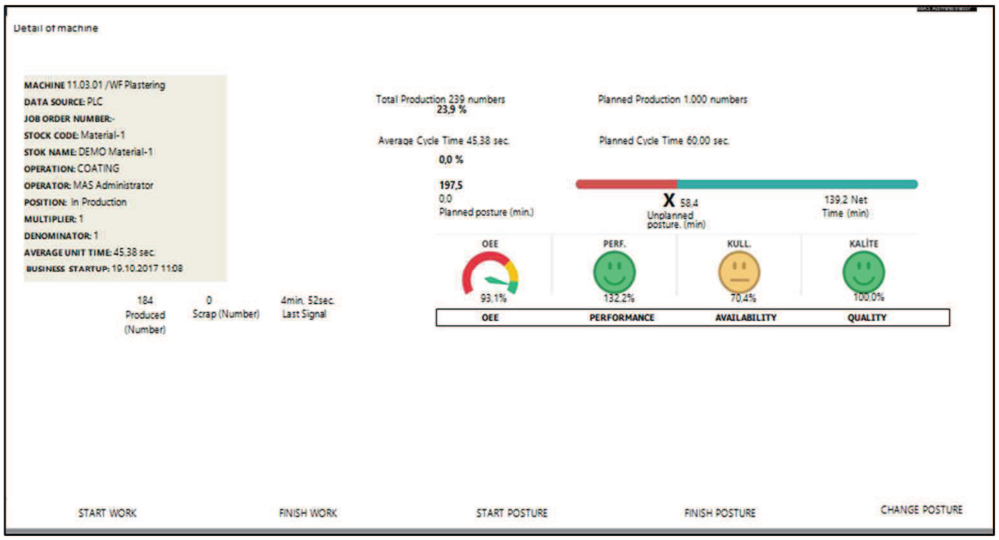

Figure 2: OEE calculations of MAS system in Jantsa

4. Conclusion

In order to compete with developing economies and digitized producers, firms apply lean production, digitalization and industry 4.0 systems in their production lines. One of the biggest rim firms in Turkey, Jantsa, also applies digital systems in its lean production lines in order to get data from the machines. Before applying MAS in production system, firm is testing a pilot study in some levels of the production line. According to OEE calculations of dying stage, firm increases its efficiency. 93.1% OEE rate is fairly high according to international production standards. For consistently getting the best results, the machines must produce quality products every minute within the given period. The focus should be on increasing the performance of machines and equipment used in the operation. This performance and efficiency increase will force manufacturing firms to apply lean production systems with industry 4.0 digitilization applications to their production lines. It is vital for academicians and firms to study and realize applications of new paradigms like lean systems and industry 4.0 much more intensively.

Acknowledgements

Hüseyin Şenkayas is an associate professor in the Business Administration Department of Adnan Menderes University where he teaches production management, managerial mathematics, ergonomics and supply chain management. He also teaches at graduate levels. His research interests focus on industry 4.0 applications, productivity, food supply chains and dangerous goods transportation.
Özden Gürsoy is a Ph.D. student in the Business Administration Department of Adnan Menderes University where she also studied MBA with a thesis about marketing. She worked in a bank and in a rim factory as a sales officer. Her current thesis is about industry 4.0 applications and digitilization of lean production systems.

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