THE RESOURCES OF SUPPLY CHAIN: EVALUATION OF THE AUTOMOTIVE SCENARIO POST COVID-19

Milton Carlos Soares[a], Thiago Barros Murari[a], Cristiano Vasconcellos Ferreira[b]

[a] PPG GETEC, Centro Universitário SENAI CIMATEC
[b] UFSC – Universidade Federal de Santa Catarina – Campus Joinville

Abstract:

The pandemic generated by COVID-19 affected the entire supply chain of the automotive sector. With concept of lean manufacturing, the suppliers of the automotive sector work to maintain inventories at minimum levels to avoid waste and downtime. With that, the sector stopped abruptly, and the entire chain was affected economically.

While the lack of proof of effective solution and the vaccine being still in process to be developed, vehicle manufacturers and auto suppliers are having to realign their business requirements and development of new products to meet market demand.

Thus, the intention of this paperwork is to evaluate the concepts of lean manufacturing and industry 4.0 and how these methodologies can support the restart of the automotive market.

Keywords: industry 4.0, lean manufacturing, waste.

OS RECURSOS DAS CADEIAS DE SUPRIMENTOS: AVALIAÇÃO DO CENÁRIO AUTOMOTIVO PÓS COVID-19

Resumo:

A pandemia gerada pelo COVID-19, afetou toda a cadeia de suprimentos do setor automotivo. Com o conceito de manufatura enxuta, os processos do setor automotivo trabalham com os estoques no limite mínimo para evitar desperdícios e capital parado, assim a parada do setor ocorreu abruptamente e toda a cadeia foi afetada economicamente.

Com a falta de comprovação de um remédio eficaz e com o desenvolvimento da vacina ainda em andamento, os fabricantes e auto- peças estão tendo que se readequar para voltar a atender a demanda do mercado e continuar o desenvolvimento de novos produtos.

Com isso, esse trabalho foi elaborado para avaliar os conceitos de manufatura enxuta e indústria 4.0 e como essas metodologias podem suportar a retomada do mercado automobilístico.

Palavras-chave: indústria 4.0, manufatura enxuta, desperdícios.

1. INTRODUCTION

The coronavirus outbreak has heavily impacted the manufacturing industry, Original Equipment Manufacturer (OEM) and parts suppliers have yet to return to full production capacity.

Without a cure for COVID-19, most of the Brazilian automakers cancelled their quarantine and returned to manufacture vehicles.

With the economy jeopardized by quarantine disruptions and the impact it has caused to public transportation, consumers who sit well with their financial situation prefer to buy their own vehicle. Therefore, in terms of the automotive industry, OEMs are running their operations and to continue working on the future programs. However, the OEMs and their supply chain are working in a contingency mode with less capacity to protect their employees against the pandemic.

Considering Covid-19 contingency mode that creates restrictions to the manufacturing floor, manufacturing processes, review meetings and visits to suppliers to keep the social distance in order to avoid contamination, this is changing the way that the OEM's deal with the suppliers.

However, the development of current and new suppliers is still necessary to continue the automaker's new programs development. Thus, it will be necessary to learn how to deal with this new paradox and how methodologies and new technologies like Industry 4.0 (I 4.0) and Lean Manufacturing (LM) may help maintain and sustain the development of the supply chain. With that, the purpose of this paper is to provide an evaluation of the concepts of I 4.0, LM and their interaction and how they can support the issues of waste caused by the COVID- 19.

1.1. Lean Manufacturing

The lean manufacturing methodology also known as TPS (Toyota Production System) has started being developed by Toyota after post war II, in order to understand this methodology a historical review about this automaker will be helpful.

In the beginning of the 1930-decade, Toyota Motor Corporation was responsible for the manufacturing of small trucks, but due to their limited capacity and technology, they were struggling to achieve an acceptive level of quality. In order to do a benchmark, Toyota has sent some leaders to visit Ford Motor Company however, due to the volumes difference from American and Japanese markets (9000 versus 900 vehicles per month) they learned they would have to adapt the mass production approach from Ford to the Japanese market [1].

After the World War II the situation got worse, Japan suffered several injuries in the country, lots of industries were destroyed, jeopardizing the supply chain and broken the economy. With that, Toyota worked to establish a process following the Ford Motor Company model, but they were limited by the lack of resources and little capital to invest.

Toyota decided to send their leaders again to Ford in order to learn how much Ford developed since their first visit. When the visit team came back to Japan, they reported that Ford was not developed so much in terms of technology since 1930, on the contrary, what they saw, Ford was working based in big lots, generating intervals between the step process with a large quantity of inventory, generating overproduction and different types of waste in the process [1].

Toyota and Japan products were seen as low cost and also low-quality manufacturers thus in order to support the improvement of their products, the Union of Japanese Scientists and Engineers (JUSE) brought two Americans (Joseph Duran and W.E Deming) engineers to teach them about SPC (Statistical Process Control) and Quality Management. A member of JUSE, Kauri Ishikawa was in charge to transform Deming's and Juran's work into Japanese, with that he was able to develop the Ishikawa diagram that is also known as Fishbone Diagram or Cause-and-Effect.

The Ishikawa diagram is utilized to develop potential causes to an effect or an issue through a brainstorming discussion. The brainstorming is developed by the team that interacts with the concerned item with the goal of raising the main causes of the issue based on the knowledge and experience of the team involved.

With the financial problems post war, Toyota was suffering to keep the operations running, they had to let 1600 people go, even the founder of Toyota Motor Company resigned as a way to show that he was also committed to the best for the company [2].

During the restructuring of Toyota, Taiichi Ohno was one the main managers that improved the productivity working to enable one operator to handle several machines, Shigeo Shingo was a consultant that worked with Ohno and together they developed several ways to avoid wastes and improve the process flow which was called the "Toyota Production System" [2].

Working together they developed the eight ways of MUDA, a Japanese word that means waste in English, in a process as mentioned below:

1. **Over-Production**: it is related to the utilization of the resources from the manufacturing to produce products that were not ordered by the customers. The best way to avoid this issue is to adopt the just-in-time (JIT) principle which means to produce according to the customer demand, controlling the work in process (WIP) and the finish goods (FG) consumption [1].

2. **Waiting**: the time that the operators, machines or any resource of the shop floor spends waiting for materials, information, orders, or anything else that impedes flow. Creating continuous flow, it will make the problems appear, so every time that the process is disrupted, it will be easier to identify the cause of the disruption [1].

3. **Unnecessary Processes**: anything that is made in the manufacturing that the customer is not willing to pay for. Heijunka is a Japanese word that means leveling out the workload considering the volumes and variety, applying this concept it will be possible to produce according to the customer demand eliminating overburden people and equipment [1].

4. **Defects**: Scrap, reprocessing, and poor-quality products means wasteful handling, time and effort. Jidoka is also a Japanese word and its meaning is basically never allowing a defect pass to the next station, another Japanese word, poka-yoke that means error proof has the intention of avoiding human errors in the process.

Principles like built in quality and First Time Through (FTT) are fundamental to guarantee the customer satisfaction [3].

5. **Unnecessary Transport**: carrying the products that are being produced (WIP), moving the components or the finish goods to a warehouse or between long distance in the process creates waste. Utilizing pull systems based on the customer demand, standardized process controls (SPC) and a continuous flow will keep the process ruining without the necessity of excess of transportation or movement [1].

6. **Inventory**: all the excess of Raw Material (RM), Work in Process (WIP) and Finished Goods (FG) waiting to be processed or sold are excess capital. The overload of the inventories can be avoided through the implementation of Kanban that is basically a concept utilized to optimize the inventory management that supports the manufacturing to produce only what is required by the customers. The concepts of Heijunka and JIT are the key elements to support the Kanban implementation [3].

7. **Unnecessary Movements**: Every walking or movements that employees do to reach or search for a material, tools etc. Lay outs should be always projected with short distances and barriers to allow the execution of the operations without excessive movements.

8. **Not Utilising Talent**: unused the full potential of the employees and the key people related to the process, not selecting the right people for the tasks is a waste that can jeopardize the rest of the other waste. In order to avoid this, a culture of selecting the right people for the right jobs, selecting by talents and setting the goals and managing by the accomplishments should be implemented [1].

Taiichi Ohno considered that the most critical waste was the overproduction since that it causes several of another wastes [3]. However, analyzing the scenario on the shop floor and gathering the physicals it is possible to analyze where the bottlenecks are and the main factors that are causing waste in the process.

The physicals can be considered any real data that is concerned to the manufacturing process, i.e.: cycle time, number of operators, number of machines, number of parts per cycle, planed and unplanned downtime, consumables, rework, retest, scrap and any other aspects that influences the production. Based on the gathered data, it is possible to calculate the takt time of the process that is the quantity of available time divided by the customer demand. With this number we can evaluate if the process is running balanced according to Heijunka principle avoiding wastes.

Through the takt time we can evaluate the performance of machines or equipment that are dedicated to a customer or shared with various customers, it is also possible to evaluate the balance of an operators work station, therefore, opportunities to reduce or even eliminate wastes can be raised in current and future programs.

1.2 Industry 4.0 parts

The term Industry 4.0 is related to the technology development and the digitalization process that brought significant productivity improvements, the first time it was declared was in Hannover Fair in 2011 by the German government as the beginning of the 4th industrial revolution.

To support the flexibility of demand and personalized products in small batches that has been increasing considerably in the latest times, a combination of several digital technologies like; Artificial Intelligence, Cloud Computing, Autonomous Robots, Augmented Reality, Additive Manufacturing and Internet of Things (IoT) had to be introduced to allow the connectivity between suppliers, OEMs and costumers.

All this leads to improvements of efficiency and productivity that are changing the main business processes and increasing the competitive power of the organizations [4].

A conceptual framework for I 4.0 is based on nine technologies that are transforming the industrial manufacturing: Simulation, Augmented Reality, Autonomous Robots, Industrial “Internet of Things”, the Cloud, Cybersecurity, Additive Manufacturing, Horizontal and Vertical System Integration and big data plus analytics. The Cyber Physical Systems (CPS) also have an important function in the I 4.0. They are responsible for the fusion between the physical and the virtual world.

Smart factories are the key feature for the I 4.0, listed below are the main sub-processes that support this [5]:

- M2M communication via Internet of Things (IoT)
- Consistent communication from the sensor to the cloud
- Integration of robotics and innovative drive technologies
- Radio frequency identification (RFID) as the basis for parts tracking and intelligent products

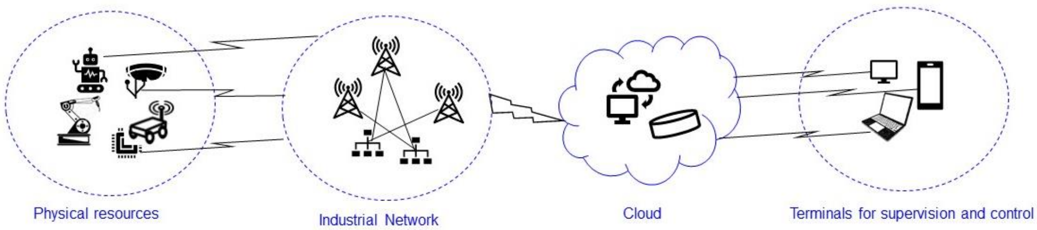
For the implementation of the I 4.0, it is necessary to combine three features: Horizontal Integration between the supply chain, manufacturing and customer; Vertical Integration between the manufacturing and the customers services and end to end connection of the overall value chain.

Material flow, stock management between the supplier and manufacturing, consists of Horizontal Integration that requires real data sharing, efficiency in resource allocation and accurate planning.

On the other hand, Vertical Integration enables the flexibility to produce small and customized products through the interaction of big data and smart objects with efficiency and profitability.

Regarding to the end to end, it is necessary to allocate supportive technologies considering customer requirements, product design, maintenance and recycling in order to assure the customized products with the high-quality levels to become competitive [6].

Figure 1. Framework of the smart factory of Industry 4.0.



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2. METHODOLOGY

This paper was developed based on the literature review of Lean Manufacturing and Industry 4.0 in articles, papers and books gathered from the Science Direct, Springer and IEEE portals, organized and synthetized through Mendeley and Excel software in order to eliminates duplicate information. The methodology was established through a flow chart in order to deploy the steps to achieve the specific goals of this work.

Regarding the impact of the COVID-19 to the automotive industry, in order to understand the issues and the waste that the disruption and the virus have caused, team made a visit to an Automotive OEM localized at Camaçari-BA and in some of its suppliers that are located inside the OEM Industrial Park.

After understanding about the issues that coronavirus outbreak may cause at the automotive manufacturing processes it was made a correlation between the wastes, impacts and the LM and I 4.0 tools that may mitigate them.

3. RESULTS AND DISCUSSION

It is already known that the principle of lean is to make more with less, avoiding waste, producing small batches according to the customer demands and chasing the continuous improvement to reach the best in quality product and the customization which is increasingly rising in the latest times.

The I 4.0 has the same objectives, with the highest technologies available. With that, the table was developed to show examples of how the COVID-19 pandemic may affect the automotive industry and how LM and I 4.0 can support to mitigate this waste.

Table 1. Evaluation of COVID-19 waste in an automotive OEM and methods to mitigate them

Waste	COVID-19 Impact	Lean Deployment Tools	Industry 4.0
Over-production	Necessary to build RM, WIP and FG inventories to avoid disruptions due to environment contamination.	Performance to Takt Analysis Shared Capacity Analysis Kanban	3D Printing IoT Data Analytics
Waiting	To prevent the work stations contamination, ergonomic job rotations are not allowed. With that, the lines are unbalanced, block and in starve conditions.	Work Operator Balance Analysis Motion Study Analysis Performance to Takt Analysis SMED Kanban	3D Printing Autonomous Robots Simulation / Virtualization IoT Data Analytics Cloud Computing
Unnecessary Processes	Multiple inspections and verifications to assure the quality of the parts between stations, re-stocking of the RM & WIP inventories.	In Station Process Control Standardized Processes Poke Yoke	3D Printing Autonomous Robots Simulation / Virtualization Cloud Computing
Defects	Deterioration and damages can occur with the raw material and components seated in between the processes and warehouses in the whole value chain.	In Station Process Control Standardized Process Poke Yoke FTT OEE	3D Printing Autonomous Robots Simulation / Virtualization IoT Data Analytics Augmented Reality

Table 1. Continuation

Waste	COVID-19 Impact	Lean Deployment Tools	Industry 4.0
Unnecessary Transport	Movement of the material may increase due to lack of line balancing and WIP sizes.	Line Lay Out Value Stream Analysis / BoP Spaghetti Diagram Dock to Dock Analysis	Autonomous Robots Simulation / Virtualization Data Analytics Augmented Reality
Inventory	The continuous flow will be disrupted due to lack of job rotation and line balance issues, causing FIFO issues too.	Performance to Takt Analysis Shared Capacity Analysis Work Operator Balance Analysis Kanban	3D Printing IoT Data Analytics
Unnecessary Movements	Employees are doing same job during the shift, IDL more affected by irregular deliveries.	Work Operator Balance Analysis Value Stream Map / BoP Motion Study Analysis	Autonomous Robots Simulation / Virtualization Data Analytics Augmented Reality
Not Utilizing Talent	Limited job rotation will affect employee's morale and this will decrease job opportunities. Constant worries regarding not to get infected and working remotelly difficulties.	Right people for the right jobs, Talents are recognized, Setting the goals and Drive for Results.	Simulation / Virtualization Work Skills Development

4. CONCLUSION

Difficulties and roadblocks that emerged due to actions implemented by the government against the COVID-19, have created consequent delays in delivery of new car model launches, shattered supply chains, and dampened vehicle sales in 2020.

The ways to reduce the impact of this pandemic, manufacturers have accommodated to new rules of guiding their business, such as:

- Restriction to operator rotations that was usually applied to avoid injuries due to ergonomics (repetitive job efforts) has been implemented to minimize continuous cleaning of the operation stations.
- The workload of some operations was increased to avoid movements and contacts with other operators. Work Operator Balance is necessary to improve this condition.
- The necessity for continuous environment such as cleaning, inspection, scrap of raw materials and components that were stored in the quarantine added a totally different meaning to lean continuous improvement.
- Cutting costs due to low demands, therefore, drop in sales.
- Psychological issues that affects the morale of the employees concerned with being infected and losing their jobs.

All the above-mentioned actions are jeopardizing the manufacturing environment and need to be taken into consideration when assessing suppliers within OEM value chain map.

The decrease in volumes (In Jun/20 it was registered a drop from 13.5% from Feb//20, the previous month that COVID-19 hit Brazil) [8] and losses generated by the COVID-19 pandemic brought restrictions to the investments, especially in countries of the emerging market like Brasil, since that it won't be possible to count on with the external sector once that the pandemic hit all the countries and the international market is stuck [8]. So, before migrating to the I 4.0 resources, it would be wise to understand the real necessity of the market and if some of those issues can be resolved through the use of Lean Manufacturing tools.

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