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PARTICULARITIES OF IMPLEMENTING INDUSTRY 4.0 CONCEPT IN THE AUTOMOTIVE INDUSTRY

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Abstract: *The paper presents the new stage to be carried out by the current industry, in which technology has an important role and all the advantages brought by it, the optimization of the production processes and the real-time surveillance through the Internet connection. The principles and stages of implementation of the new concept Industry 4.0 (smartfactory) are presented, which incorporate intelligent machines, development applications and production facilities, capable of ensuring the exchange of information between them, autonomously and to control the final product, maintenance. predictive independently. This new stage of the industry represents the "fascination" of the moment, because it is predicted before being implemented, ensuring an increase in the efficiency in the industry and the development of new business models. Industry 4.0 involves the development of independent business activities, managing, supplying, manufacturing autonomously, creating a virtual copy, identical to the reality, managed by Cyber-Physical Systems (CPS), human personnel intervening only in critical situations, putting themselves emphasis on continuous increase of efficiency and productivity, permanent integration of information technology and technological communication.*

Key words**:** *Industry4.0, CPS, SmartFactory, artificial intelligence, digitization*.

1. INTRODUCTION

The beginnings of industrialization were marked by the mechanical use of production systems at the end of the eighteenth century, when mechanical work equipment emerged; one can mention loom that has made it easier to achieve a product segment. The next stage of industrialization began in the twentieth century through the division of labor and the production of consumer goods using electric power. The third industrial revolution, in the early 1970s, laid the foundation for electronics and information technology to implement automation in production processes; this stage is not yet completed, competition in the industrial engineering sector precedes, through dynamics and complexity, the next stage of "advanced production".

After the first stages of industrialization (steam engine, conveyor belt, manufacturing lines, personal computers), a new stage appears, known as Industry 4.0, referring to intelligent factories, switching to digitization − Artificial Intelligence.

Industry 4.0 is the most up-to-date subject in all advanced industries, an advanced technology strategy, as it refers to intelligent automated systems capable of collaborating with each other whatever the manufacturer or technology used to achieve them [2]. This new industrial revolution has become a "fascination" of the moment because it is predicted a priori, not ex-post, as most other technologies, offering multiple opportunities for companies to "model" their own future by increasing the efficiency of industries and developing new models Business.

The future belongs to industries that will use gobal networks that incorporate Cyber Physical Systems, including intelligent machines, storage and este eche systems capable of providing information exchange between them in an autonomous and achieve quality control of finished product, predictive maintenance independently [3].

The new concept combines production methods with state-of-the-art information and communication technology, the products can be manufactured on the basis of individual customer needs, allowing the production of unique items at high quality and at a price equal to that of serial products. Intelligent systems, connected to manufacturing flows, serve as a technical basis for this, defining the whole life cycle: product - conception − development − production − use and maintenance − recycling.

Even though the Industry 4.0 concept is ever-present in everything that technology and technology currently represent, it is quite limited as a term in research centers and universities; this new concept targets 6 principles of design and implementation: modularity; virtualization; interoperitivity; orientation of activities; decentralization; ability to respond in real time.

The trend of implementing autonomous systems and new technologies is an introduction to a world in which omnipresent calculation becomes a reality. There will be cars that will adapt to human needs, not vice versa; there will be learning technologies in the workplace of the employees: they will no longer connect manually to the

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installations they serve today but will exploit them through the new intelligent manufacturing systems in the same way they use the social networks of today - Remote communication through virtual interfaces with secure network control, with fast telepresence maintenance.

Even if Industry 4.0 becomes a major priority, companies face difficulties when they try to develop ideas for improvement and integration into the new industrial revolution, because it is difficult to show the way, the identification and implementation of scenarios. The strategy of the new industrial revolution is to incorporate intelligent machines and installations into the Cyber-Physical System (CPS), making it a permanent connection, capable of exchanging information, controlling and making decisions, in other words, the autonomous industry. Intelligent products will be uniquely identified to easily locate and troubleshoot any abnormalities, all in real time allowing vertical connection with business processes within a factory and horizontally with dispersed value networks.

Production digitization includes hardware and software used in up-to-date manufacturing processes with new, sometimes self-managed, remote management facilities that enable enterprises to integrate perfectly between all the steps needed to complete the product (product design, production planning, quality, delivery logistics and support for the sold products warranty), effectively realizing a combination of several fields – engineering, human resources, manufacturing, logistics, marketing. Integration and consolidation of IT into production is imperative for the transition to Industry 4.0.

CPS allows for dynamic configuration of production process characteristics such as quality, time, risk, robustness, price and environment.

2. INDUSTRY DEPLOYMENT PRINCIPLES 4.0

In order to help companies, of the identify the pilot activities for the implementation of smart technologies, activities with the possibility of ensuring the equipment and the autonomous installations, the following basic principles were established [5]:

Interoperability − people are connected via IoT and IoS, these becoming standards of communication in CPS; all systems within a plant being able to communicate with each other (tprocessing center; tassembly center; distribution area), showing how flexible the production can be [7].

Virtualization - that is, CPS can monitor physical processes; virtual models translate into real patterns, making a copy of reality, managing ongoing activities; any identified failure is reported to a human "supervisor" who can handle any abnormality [1].

Decentralization − The demand for individual products involves additional actions, rather difficult to control by centralized systems. The individual production activities are inscribed on RFID tags, the cars following the steps in order; in case of failure, the tasks are transferred to a superior [4] level for analysis and alerting, ensuring the quality and traceability of each product.

Real-time analysis capability − data needs to be collected and analyzed permanently, and detection of an abnormality transfers the activities to another analysis and processing center.

Service Orientation − the activities of a CPS and employees serving the system can also be used by other participants; these systems can provide services both internally and externally [7].

Modularity − the ability of systems to adapt to changing requirements by replacing or expanding individual modules [5]. Modular systems can be easily adjusted or modified depending on product characteristics and market fluctuations.

3. STAGES OF INDUSTRY 4.0 DEPLOYMENT

Adapting an entire production cycle to a new and innovative concept, in order to increase competitiveness by transforming an existing factory, must go through several stages that guarantee an improvement of existing processes in compliance with the stages established in the project [6]:

- Network architecture standardization - to introduce new companies into a global network that meets the same standards and facilitate their implementation;
- Managing complex production systems - planning and realizing management models and tools (broad, reliable, comprehensive and high-bandwidth network infrastructure);
- Information security and security − mandatory conditions in the intelligent industry (it is imperative that production and manufacturing facilities do not pose any danger to people and the environment, the transfer of intelligence between intelligent systems is secure and guaranteed for proper functioning); • Organization and design of work - all activities will be transformed/ improved, the role of the employee becoming management and control;
- Training and professional development − the work process is improving, hence the need to improve skilled skills through digital learning projects and networks of good practices, in order to be able to contribute to the new type of industrial activity;
- Regulatory framework − compliance with existing legislative requirements will be adapted to take account of new innovations, including data protection and manipulation, contract liability and trade restrictions;
- Resource efficiency − resources need to be streamlined; smart businesses have to apply innovative technologies and solutions to increase their competitiveness while protecting the environment.

Aspects that characterize Industry 4.0's vision

- A new approach to the socio-technical interaction between all those involved in the manufacturing process and the resources needed in production, all being developed within the fabrication networks - machines, machine tools, robots, transfer and transport systems, storage areas etc., who will become autonomous, capable of controlling activities, configuring themselves according to unforeseen situations, interpreting the data transmitted by tracking systems and making the best decisions (self-organized adaptive logistics, customer-integrated engineering, business models, everything to be a dynamic and profitable business for everyone involved);

- Work organization and design models will complement standard training and ongoing professional development (CPD) activities to meet the demands of implementing new technologies, decentralizing leadership and manufacturing processes management;
- Promotion of decentralized activities, made outside factories, in virtual spaces for design and assistance activities, in locations different from the factory, for activities involving actual work;
- Promoting freedom of decision in human activities, through awareness of importance in the innovation process, ensuring independence and applying actions that support successful transition.

4. CHARACTERISTIC ASPECTS OF IMPLEMENTATING INDUSTRY 4.0 IN THE AUTOMOTIVE INDUSTRY

It has emerged as a necessity for the efficiency of production processes, mainly in the automotive industry and its suppliers, which is quite developed in our country, by the novelties in the field of industrial engineering and the "mouth of air" brought by the companies with roots in Germany, the most advanced country in the field of intelligent factories, through suppliers such as IFM [8] (with IO Link in sensor, actuator and command system), Bosch[9] (with IoT Gateway − a physical device or software that serves as a cloud connection point users, smart sensors and devices), AtlasCopco [10] in Sweden with Smart Connected Assembly (industrial tools and assembly systems, pneumatic and electrical). and vendors dedicated to the IT industry, through processing power, storage capacity and the multitude of developed applications, supporting the transition to the new industrial revolution.

Among existing industries in Romania that have started the transition to Industry 4.0 we can notice Dacia car plant.

To cope with the hard competition in the field of motor vehicle manufacturing, the producer had to implement the new technologies in all activities carried out, in order to increase the productivity and to make competitive products at low prices.

The transition to Industry 4.0 is mainly to digitize the installations and equipment so that there is a permanent communication between them, through the Internet or internal networks, based on new technologies (IoT, IoS CPS, etc.) [3]. The digitization umbrella includes not only the production equipment and facilities, but also supply and transfer flows, activities that require real-time coordination of all participants (the suppliers know and respect the manufacturing program of the enterprises).

Following the concepts of the new industrial revolution, the vehicle produced in the following years must be adapted to the market, in other words it must be customizable, environmentally friendly, connected and autonomous. For all these commitments, the production process must support the digital transformation process.

As a result, the project teams implemented the following steps (Fig. 1).

- Digitizing operators who check product quality (use of tablets in the product validation process);
- Responsible for connected activity − digitization, for reducing activities without added value. The 100% WiFi coverage allows the analysis of workstations, in digital format, as well as the interrogation / signaling functioning anomalies;
- Kaizen 4.0 − permanent implementation of the latest technologies (hard and soft implementation allowing the evolution of the new industrialization process);

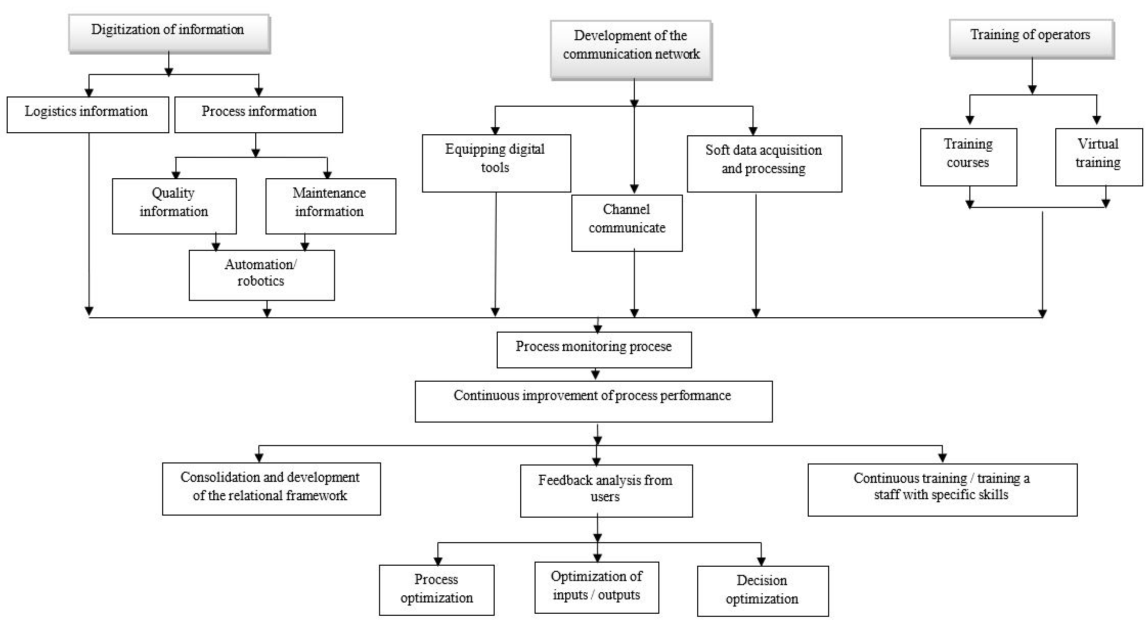


Fig. 1. The stages of the digitization of industrial processes.

- Virtual training / augmented reality − training required to increase competences is held with the help of information technologies. Digital tools implemented in the workplace (through tablets, digital screens, etc.) offer real-time access to production and quality data.
- Dynamic work management, through automation and mobility;
- Computerization of the packaging of spare parts, for a correct availability and optimization of the packaging capacity;
- Connected packaging - 100% integration of RFID tags for packages; automatic optimization of the inputs / outputs;
- Traceability of parts and processes; the online management of the suppliers and the defects produced, the reduction of the lots of parts taking into account the commercial forecasts;
- On-line management of supply and transfer circuits (over 250 AGVs that transfer parts/ components, capable of transmitting the location and signaling any defects);
- Car geolocation (manufacturing line; expedition park, etc.). After leaving the manufacturing line, the vehicles are stored in a dedicated space; geolocation reduces the time of storage/ shipment to customers, thus making significant savings);
- Computerization maintenance/ predictive maintenance - management of information on defects, to reduce the time of equipment / installations.
- Conditioned maintenance - defect detection, repair of machines, robots, machining centers;
- Computerization of human resources processes for employees;
- 3D printing for the equipment used in the manufacturing process.

After a period from implementing the project, the performance of the system has been optimized according to the logic scheme of Fig. 2.

For the development and consolidation of the Digital Model, regular meetings will be organized with the specialists of the company and the partners in the profile clusters and the clusters in related fields.

4.1. Digitization of workstations

From the beginning of the workstation digitization project, several manufacturing indicators were pursued that were supposed to indicate the efficiency of this project (the number of defects entered in the pilot workshop and the number of defects resulting from this workshop / manufactured product unit).

In order for a workshop to be efficient, the number of defects coming out of the section must be as small as possible and the number of retouched defects, among those entering the workshop, must be as large as possible.

These indicators were also monitored at the factory level, in order to observe the impact of a pilot workshop in the global indicators.

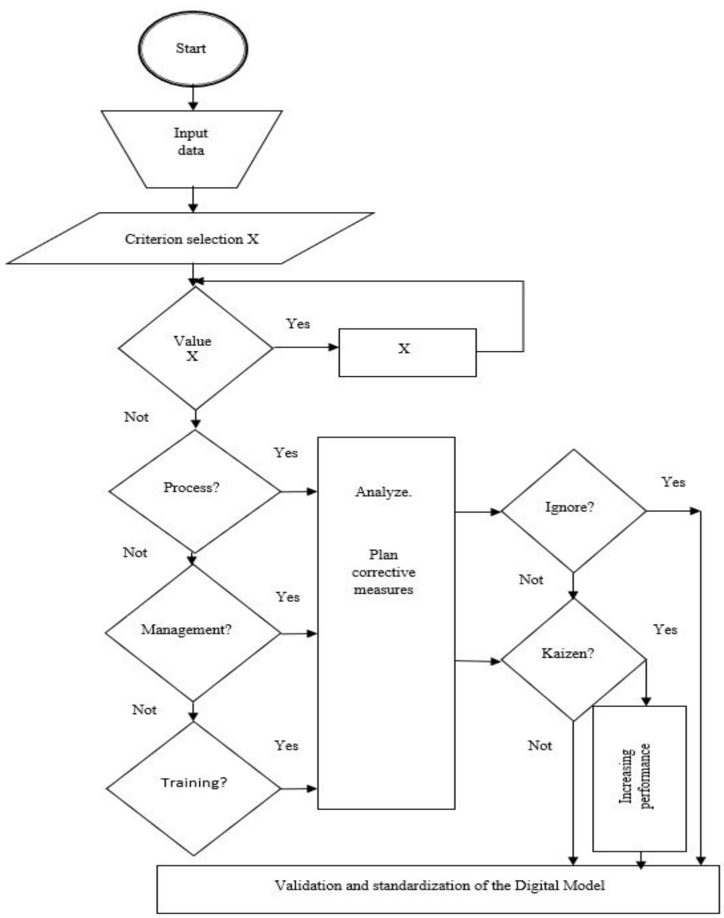


Fig. 2. Optimization of the digital model.

The project of digitization of the workstations (implementation of some tablets in each workstation) with the information regarding the achieved product, so that they are correct, at the right time and place, when they are necessary without loss of time and anomalies of the installations and equipment, the entire logistics circuit.

We can list the strengths of workplace digitization:

- presentation of the operations with defects appeared during the manufacturing / assembly process;
- which operation was omitted;
- which stage is not done in the established order;
- what gesture made by the operator degrades the resulting product.

The implemented system is built based on a web platform compatible with smartphones and tablets offering customization features for each workstation, indicating exactly from the type of vehicle, to each component that is mounted in the respective station, indicating even its mounting order.

With the help of the application one can analyze the defects produced, the assembly stage that was skipped; if the mounting order is the one according to the specification established by the engineering department; what gesture of the operator is not done well; how much time was lost on the sequence of the operation that penalized.

Among the strengths of digitalization of workstations, one can list:

- a better reaction of the operators that fix the assembly errors (skipped / forgotten work steps; different parts compared to the specification);
- quick identification of the missing pieces from the collection dedicated to a certain workstation;
- damage to the vehicle, in the working area;
- unplanned events that occur during work (drops in tension; tool failure; physiological needs of operators; lack of parts, etc.);
- information about the diversity of the made product / preview;
- a better management of the activity by the first line manager.

In Fig. 3,*a* one can observe the favorable evolution of the indicators followed, at the level of pilot workshop (25 workstations), from the start of the project until now.

In Fig. 3,*b* can be seen how the number of defects coming out of the workshop is decreasing and the number of defects, that enter the pilot workshop and are eliminated, decreases. Digitization influenced the indicators presented due to the fact that the defects appeared during the manufacturing stage (from the pilot workshop) could be signaled quickly; Before digitization, the defects were recorded in the tracking sheet and until the vehicle reached the station where it was checked, there was no time to fix the problem. The defects were registered in the computer system and the vehicles were retouched at the end.

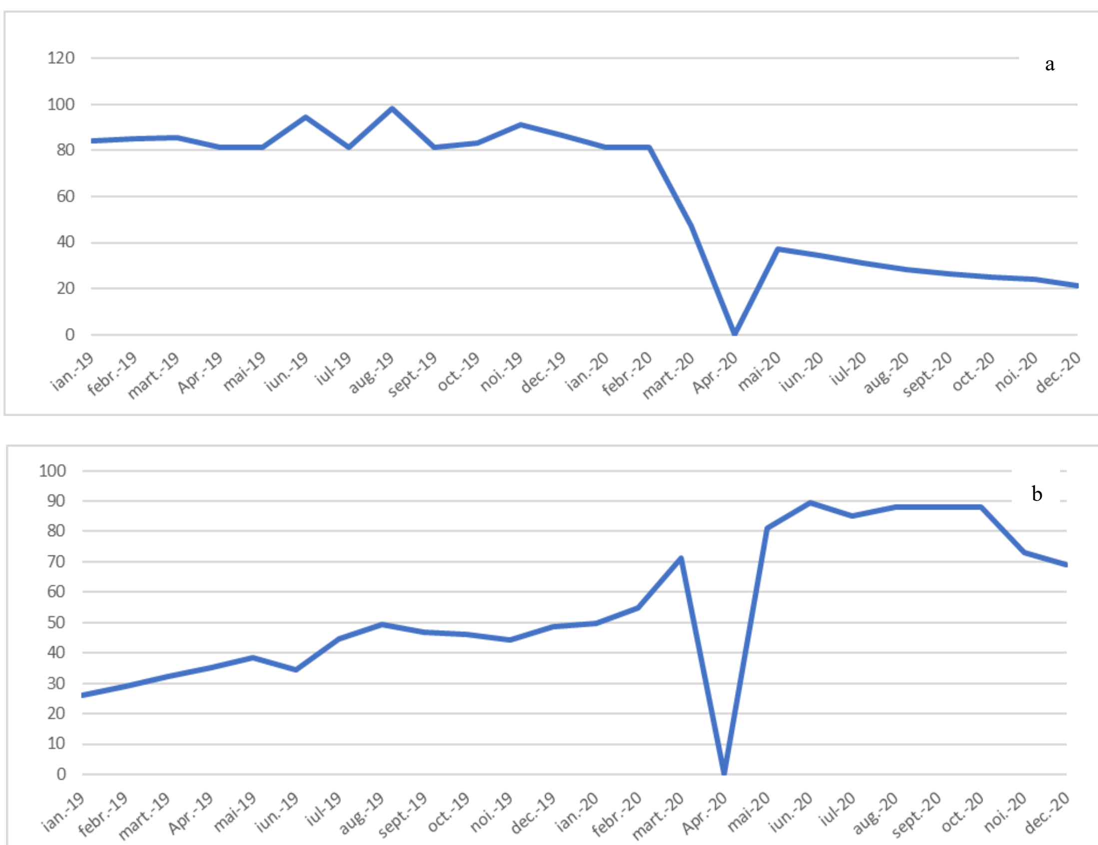
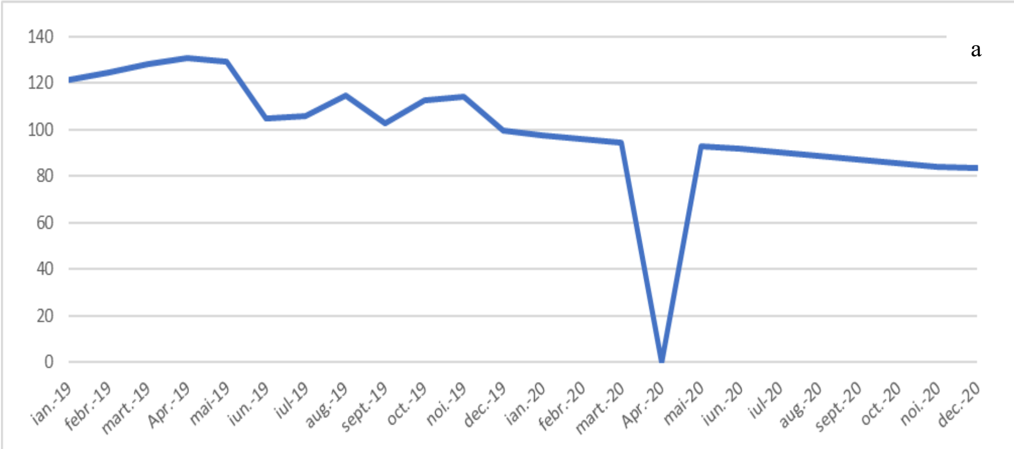


Fig. 3. Optimization of the Digital Model: *a* − number of defective products resulting from the pilot workshop (defects/ vehicle); *b* − number of defective products entered in the pilot workshop (defects/ vehicle).



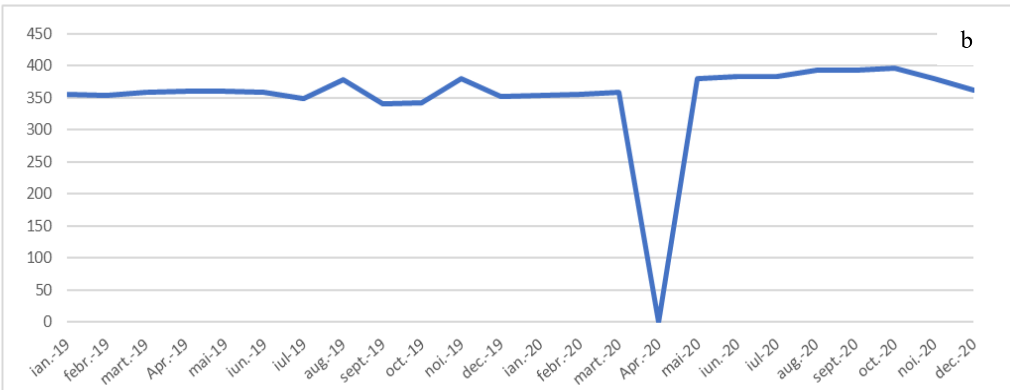


Fig. 4. Optimization of the Digital Model: *a* − number of defective products resulting from the Factory (defects/ vehicle); *b* − number of defective products entered in the Factory (defects/ vehicle).

The value 0 from April represents the month in which the manufacture did not work (due to COVID 19).

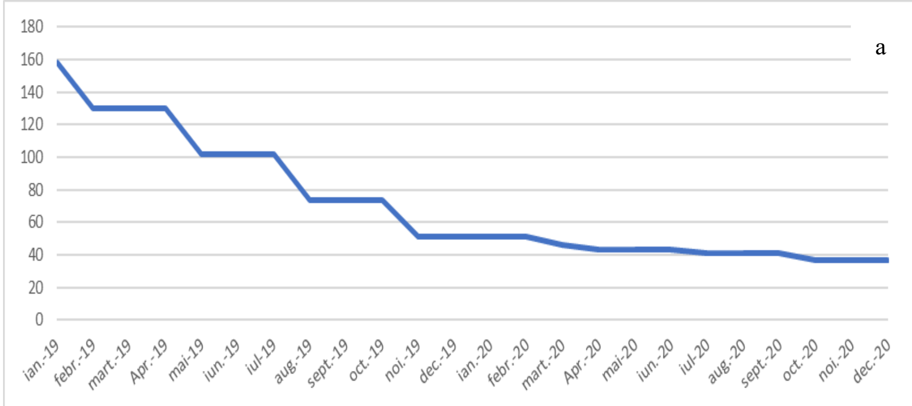
Also, in the Figs. 4,*a* and 4,*b* one can list the evolution of the two indicators at the factory level (the impact of a single workshop is significant; by applying the digitization project throughout the factory is expected that the results improve significantly (good results represent with an improvement of the product quality and the decrease of the terms; a manufacturing department consists of several workshops − around 250−300 workstations and a factory comprises several manufacturing departments).

At the end of the digitization of the pilot workshop we identified the following benefits:

- establishing the responsibilities of each team/ operator;
- improving the results when exchanging teams (operators who replace each other at the end of the program/ new entrants know the anomalies that appeared during the work of the other operator);
- transmission of data on anomalies to all work teams;
- rapid reaction to eliminate nonconformities;
- anticipation of parts with stock risk;
- declaring a quality defect, automatically alerting the operator who can remedy the defect in the area of malfunction;
- identification, from all instances of quality analysis, of the position that generated a manufacturing problem, with the signaling of the managers responsible for the respective area;
- the first line manager can send quick messages to other parties interested in the occurrence of anomalies in the manufacturing process (maintenance, quality, upstream / downstream manufacturing, etc.).

Among other indicators followed in the development of the workplace digitization project, one can also mention the indicator that follows the occurrence of non-conformities to the products resulting in the distribution network (customer complaints).

The indicator (Fig. 5) represents the number of incidents reported per 1000 vehicles manufactured and delivered and allows the study of the occurrence of incidents in different driving months (after 1, 3, 6, 9, 12, 15, 18, 21, 24, 30 and 36 driving months, from the date of manufacture). An improvement of the notifications from the distribution network can be observed with a favorable impact on the brand image and the satisfaction of the final customer.



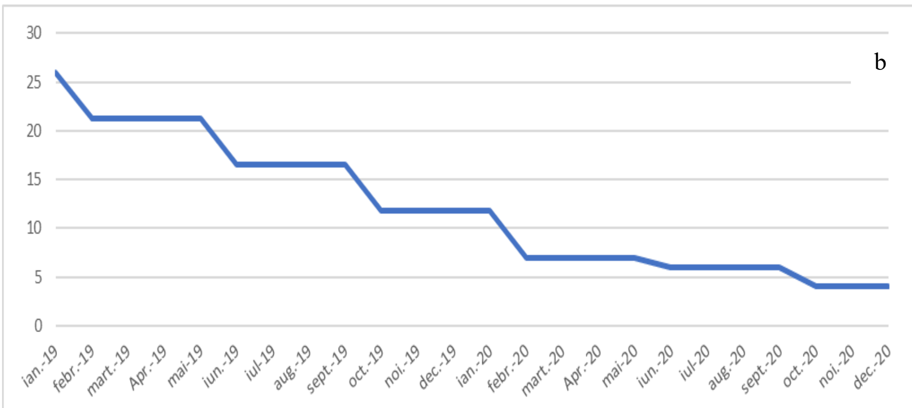


Fig. 5. Optimization of the Digital Model: *a* – Sales quality network indicator (no. of incidents vehicle/ a thousand) (K / ‰ vehicle); *b* – Sales quality network indicator costs (€/ vehicle).

7. CONCLUSIONS

The paper tries to provide an explanation for the term "Industry 4.0" and new implications for the concept of intelligent industry, principles of design and operation of new technologies. It is intended to help identify areas / activities with rapid implementation potential by facilitating access to information that will inevitably come, whether we like it or not.

Besides standardizing equipment, installations, products and processes to meet a high security standard, all will be required to have a "security passport" containing unique electronic codes that will store details of the risks that have been taken in calculation and those that should be analyzed by the one who implements the new solutions.

Intelligent factories will be forced to identify and implement ways to reduce the resources consumed during industrial production processes and to optimize them permanently, this being a necessity in the struggle to keep the gained / won markets.

Starting with 2004, since the brand renewal, the manufactured vehicles have been increasingly performing, this being possible with large investments in manufacturing technology and human training.

The digitization of the activities consolidates the communication between the manufacturing processes and the related subsystems (1500 suppliers, of which 16 are implanted inside the factory), through an intelligent and integrated management of data resulting from each component of the system.

Industry 4.0 defines a new level of organization and management of value chains during the product life cycle and is defined by the integration of complex machines and physical devices with network sensors and software, used to anticipate, control and plan, for increasing performance and end customer satisfaction. In the implementation of this new concept, the necessary software solutions are needed to optimize the operational processes and to digitize the production, leading to self-organization and self-optimization and the demonstration of resource savings.

Research results should be aggregated and discussed to eliminate discrepancies, examples of good practice should be promoted at all levels of values to encourage technology transfer; The Industry 4.0 Implementation Initiative should aim to mobilize the market potential for industry in general, by adopting strategies including the implementation of SPC in production and marketing in order to facilitate the transition to the new concept.

The case study shows the influence of a small sector of the automotive industry when implementing digitization solutions, how technology can influence labor productivity by reducing cycle time in the manufacturing process and how important it is to have access to information. real time.

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