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The impact of sustainablemanufacturing on Industry 4.0

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Abstract: The paper seeks to highlight the strict rules of production, in a framework necessary to carry out the evaluation and examination of the aspects within intelligent manufacturing systems. The role of Industry4.0 is to revolutionize industrial production processes to ensure sustainability by combining state-of-the-art technologies. Sustainable development in Industry 4.0 according to the specialized literature, is incorporated by following the sustainability concepts of Industry 4.0. Some benefits and impact of implementing sustainability in Industry 4.0 are presented. The paper provides decision-makers with techniques and a vision for adopting sustainable concepts in Industry 4.0.
Keywords: manufacturing system, Industry 4.0, sustainability

I. INTRODUCTION

For the elaboration of the work, have chosen a section that has been little analysed, relatively expensive, but which can contribute to ensuring the sustainability of the manufacturing system, whatever it may be. By ensuring the maintenance, it is possible to intervene for an easy readjustment to modern technologies over time.

Maintenance for industry 4.0 is a method of preventing failures, with a role in ensuring sustainability, by analysing production data to accurately identify problems that may arise. In Industry 4.0, maintenance has emerged rapidly, so implementing industrial technologies to optimize maintenance schedules and obtain real-time risk alerts can reduce costs, maximize uptime, and improve production efficiency(Chesworth, 2018).

The advantages offered by such a system are:

- Real-time monitoring of conditions.

Technologies help create the availability and processing of the necessary information. Data is recorded and displayed in real time. Data visualization is not limited, so it is accessible on screens, dedicated stations and in the cloud.

- Flexible evaluation and analysis possibilities.

The data are evaluated using customized rules and methods depending on the equipment, the type of manufacture, so that the limit values are eliminated, these being considered unimportant.

- Notifications.

During the maintenance process all condition measurements are collected and transmitted to a centralized unit, and then the measurements are processed centrally based on diagnostic, prognostic and maintenance scheduling failure models and algorithms for future analysis. A cloud-based maintenanceand shown in Figure 1 is exposed as a vital part of cloud manufacturing, it is a next-generation service-oriented technology with the aim of supporting more enterprises to implement and manage maintenance services, including machine condition monitoring, data analysis and diagnosis, forecasting and maintenance planning on the Internet(Wang, 2017).

The role of cloud-based maintenance at the machine control and execution level is to improve the reliability, availability and safety of cloud manufacturing. Among the challenges, the following can be highlighted:

(1) automatic service provisioning: it has long been a problem to allocate cloud resources to satisfy its service while reducing operational cost;

(2) energy management: designing energy-efficient data centers and improving system energy efficiency has become a major issue;

(3) traffic management and analysis: how to manage cloud data and reduce cloud data traffic is an important issue;

(4) storage and data management technologies: software frameworks can introduce compatibility problems with the file system and legacy applications due to non-standardized interface and storage structure;

(5) new cloud architectures: large data centers come with limitations of high energy expenditure and high initial investment to build data centers.(Wang, 2017)

These aspects will be treated in another research paper, in which the advantages of cloud systems will be analyzed and where even new architectures will be proposed.

Accordingtospecializedliterature, maintenanceisalsorequired for cloudmanufacturingsystems. Thisactionwasbased on theinformationalsofound in figure 1.

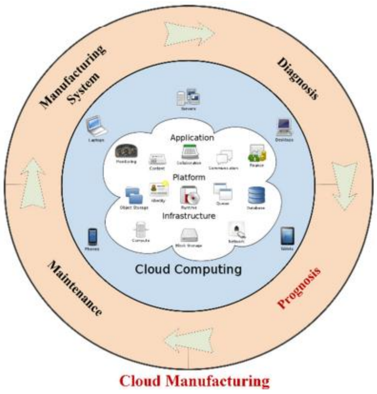

Figure 1: Cloudmaintenance as an integral part of cloudmanufacturing (Wang, 2017)

Sincethemanufacturingprocessismonitored at cloudlevels, there are a number of factorsthatinfluencehandling: quantities of materialstransported, transport times, layout change. A very important role istoensurethemaintenance of thesysteminfluencedbyfaultsthatmayoccurandimplicitlythetimetorepairthe fault.

Industry 4.0 implies a major transformation of the entire production by unifying digital technologies and the Internet with classic industry. The new dedicated industry solutions are specially designed to give manufacturers flexibility in the integration of Industry 4.0 technologies - computing, processing and display solutions. An interconnected production is based on an integrated system of equipment, machines, employees, mobile devices and IT systems, able to communicate to fulfill the purpose (Ciortea, 2021).

Challenges for condition-based maintenance include: determining equipment information, evaluating and analysing information; transmission and quick visualization of information. We grouped these three challenges in the paper as managed in the cloud and analysed with technologies and equipment provided by IoT, after which normal production flows can be resumed. Thanks to the modern technologies offered by Industry 4.0, maintenance can be easily done without significantly disrupting the production flow.

New IT solutions and means used during production processes bring four major advantages related to:

- time can be allocated to activities that produce value. Employees become more productive in the context of an optimized system.
- cost, data is correct, resulting in well-documented information and good planning.
- flexibility, any change can be easily adopted thanks to the flexible system open to new opportunities, which allow the optimization of processes based on data analysis.

By considering and analysing the technological flow, we customize our case study the access of IoT systems to the organizational architecture. Many IoT servers provide functions such as databases, storage, and security management. Today there are many companies offering IoT servers as enterprise software, cloud software or services. Selecting the right IoT server is a challenging proposition as no market leader has emerged. IoT servers provide dedicated databases, storage, and security management features, but there are also IoT servers that provide enterprise software or cloud services. These servers are more useful considering tiered cloud-based production systems.IoT servers require setup and operation, knowledge of how to program all basic functions, how to configure interfaces with IoT applications, and how to monitor the entire production flow (Ciortea, 2018).

Unlike a web server, which is basically a file system with a database interface, an IoT server is a complex system that requires trained personnel to manage and operate. Since this system needs to be integrated with all other IOT functions, it is necessary that businesses are first considered as complex stochastic systems after which the current systems are modified to use the purpose for which it was created. In this case, it is considered a complex stochastic system that allows the management of the entire transport system and can identify any error that it transmits to the IoT system (Ciortea, 2018).

IoT does not introduce new components to the enterprise architecture, but uses existing parts of the Internet application: web server, Internet browsers, and web browsers and phone applications. They must be adapted so that they can serve a wider set of internal and external applications developed as part of new business opportunities and the object of Internet operations (Ciortea, 2018).

II. METHODOLOGY

By observing all the recommendations and indications that can be found in the technical documentation of each component, machine, equipment and by achieving concordance in operation, a sustainable action for the future can be established. The method is difficult to implement because the system is complex and each piece of equipment has different technical prescriptions, but through a well-developed action and a sustained evolution of all components, a sustainable manufacturing can be reached by ensuring maintenance(Jamwal, 2021).

Since maintenance plays a very important role, regardless of the system that is adopted it must be taken into account that revisions, checks and maintenance must be carried out. An important condition must be met, which is that during the maintenance process, the technological process must not be disrupted and no significant gaps in production must occur.

Analysis of the failure modes of a certain production process provides important information about:

- functional analysis of the production facility;

- any generic "failure" or "failure", with a list and description of all potential failure modes for the process/product being analysed;

- the probability, severity and detectability of the occurrence of each defect;

- a classification of all failure modes in order of importance (Bertolini, 2006).

This information is managed using big data systems, performed, in separate cloud manufacturing locations and can provide real information on all the necessary details. In this study, only the functional analysis of the production facility is analysed.

To represent the entire system proposed for analysis, a general representation is used. Thus, the base, according to figure 2, consists of the manufacturing system with two processing centers, also equipped with a robotize system, a cloud system for collecting information and an IoT system that allows a monitoring and control system of the entire system. For the entire complex assembly, this study proposes to carry out the maintenance process. It is a heavy, sophisticated process, which wants to interfere negatively in the entire manufacturing process, it being applied only to a structure from the entire manufacturing system of the enterprise, and which has the role of maintaining the entire installation from processing centers, collection of information and ending with the monitoring and control system on this section.

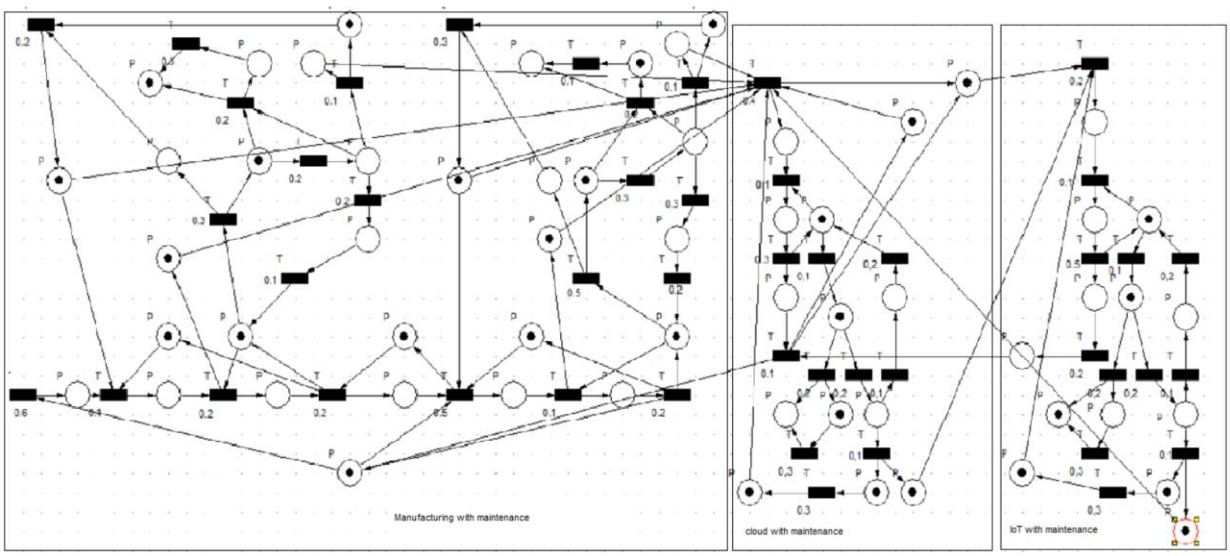

Figure 2: Petri net control system maintenance with the two processing centers, cloud, IoT

The modelling of distributed systems with the help of Petri nets is performed at the state level: it is determined which actions occur in the system, which states precede these actions, and which states the system will go into after the actions occur. By simulating the state model through Petri nets, the description of the system's behaviour is obtained.

The graphical tool can simulate and analyse the behaviour of discrete systems, efficient events. This tool is widely applied in information protocols, software engineering and for flexible manufacturing systems to help reduce processing time and improve the process of error determination and system reliability management, leading to a development of sustainability. This is a tool that allows detection and counting of failures, with a view to replacing components after successive failures, describing the state of the system and automatic shutdown to reset the monitoring and preventive maintenance system.

In the production system mainly used as handling systems: linear automatic lines, transfer of pallets to processing centres, industrial robots for material handling.

The advantages of Petri net modelling and analysis systems used in production are: explicit relationships between events. the same modelling language can serve to describe the system abstract at different levels. analysis of system properties to validate the solution.

For the chosen manufacturing system, will model and evaluate based on the data collected from the factory but reduced so that a full simulation can be done. Because it is theoretical research, the modelling of Petri nets is attempted, which with the help of dedicated technologies can be realized with IoT devices.

The diagrams that result after the introduction of the time intervals mentioned in the technical documentation of the machines lead to the optimization of the transport by removing from the system the machines that are being repaired. The analysis of the time intervals required for the maintenance of the machines resulting from the simulation and taking into account the optimization of the system in terms of the layout leads to the optimization of the transport for the entire manufacturing system.

These maintenances can be managed, carefully time-controlled and tracked with the help of the control subsystem implemented at the level of the production line or processing centers, so that there are no large losses in the development of the manufacturing process, for example by stopping the entire production lines.

By performing the appropriate maintenance operations, a sustainable operation can be ensured for a relatively long period of time.

III. PERFORMANCE EVALUATION

Result diagrams obtained by introducing time intervals specified in the technical documentation of the machines, optimizing the transport system by removing the machines that go in for repair. Analysis of equipment maintenance times resulting from simulation and optimization of the system considering the optimization of the transport aspect to reach the entire production system.

This maintenance can be managed carefully controlled in terms of time and tracked by the control subsystem implemented in the manufacturing line or processing centers so that losses are not high during the manufacturing process, for example by stopping the entire manufacturing line.

The following diagrams show the flow of information that takes place during maintenance for the entire selected system. Maintenance only for the manufacturing system was highlighted in a previous paper.

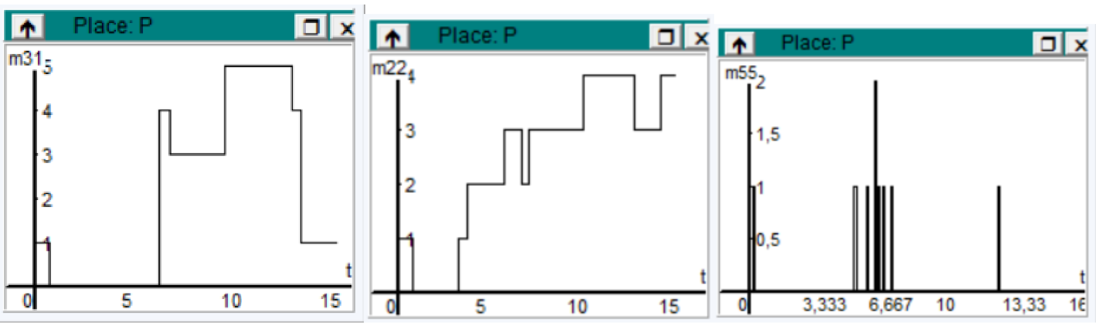

Figure 3: Monitoring the flow of information from the manufacturing system and IoT

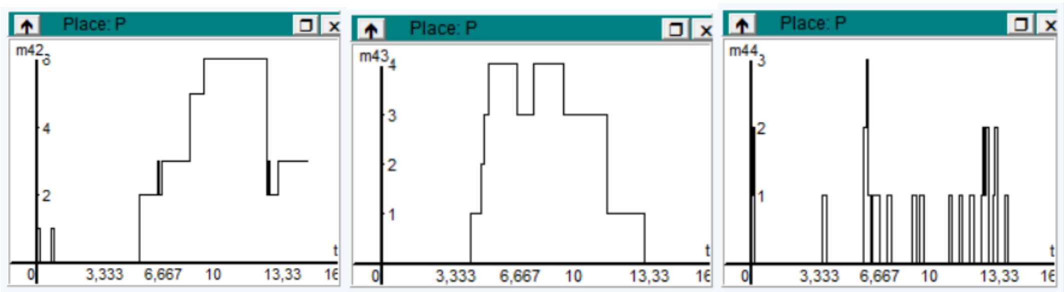

Figure 4: Representation of the flow of information from the cloud direction - IoT, IoT Cloud and the flow of information from the cloud

These diagrams, figures 3 and 4, are considered to ensure a flow of information for which the variation is followed during maintenance. It is observed that the flow of information does not vary according to the amount of information accumulated, but according to the amount of information that must be processed. Cloud and IoT information is processed very varied and discontinuously. While the flow of information from the manufacturing system and the connection between the cloud and IoT are relatively continuous, they largely depend on the parameters introduced by the manufacturing system.

From these diagrams, considered representative, the necessary information can be gathered to be stored and to contribute successfully to the sustainability of manufacturing.

Along with the development and implementation of new solutions, maintenance must be considered. It has a well-defined role in the manufacturing process and, if paid attention to and followed, can lead to process optimization. If it is considered insignificant, it can lead to big losses both by damaging the machine or even the manufacturing cell, but it can also attract costs due to production losses.

After the automatic identification of the maintenance task is based on the preset parameters, the information is sent as digital information. All notifications are automatically recorded, stored and analyzed in order to analyze the flow of information and the flow of production to manage any additional costs.

IV. CONCLUSION

In the case study, we had a Petri net for maintenance, capable of analyzing the monitoring and recovery tasks of manufacturing systems with real-time information analysis.

When a malfunction occurs, it is important to be able to intervene in real time to maintain productivity and ensure system safety. Knowing all the variables of time, distance and process are very important because it makes the supervision more effective by early detection of a possible error of any kind. This is quite useful for maintenance task.

This approach is necessary and must be considered as a very important step in the entire technological flow, because it can lead to production losses, non-compliance with manufacturing deadlines and many other errors that can introduce maximum time constraints.

The study assumes that the system is modeled by Petri nets. Modeling and analysis of manufacturing systems based on Petri nets is a productive field for researchers. Research problems must deal with large-scale, configurable, and complex production systems. Several combinations of production objectives should be considered to study their effects on system performance.

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