DIGITIZATION OF METALLURGICAL PROCESSES

[1]Miloslav BEČKA, [1]Tomáš SIRNÍK, [1]Martin MENŠÍK, [1]Ivana BARČÁKOVÁ

[1]VSB - Technical University of Ostrava, Ostrava, Czech Republic, EU,
miloslav.becka.st@vsb.cz, tomas.sirnik.st@vsb.cz, martin.mensik.st@vsb.cz, ivana.barcakova.st@vsb.cz

https://doi.org/10.37904/metal.2022.4521

Abstract

The paper deals with the processes of digitization of metallurgical processes, its possibilities and limitations caused by the specifics of these operations. Digitization is the process of introducing the use of digital technologies in various areas of production and society. In general, digitization seeks opportunities based on digital technologies that streamline and improve the operation of processes and services.

Most companies, and therefore also in metallurgy, are today overwhelmed by a number of routine, often repetitive activities and processes. They often consume valuable (and expensive) human resources, which then do not have time for conceptual work with higher added value.

Keywords: Digitization, business processes, models, metallurgy

1. INTRODUCTION

With the approach of the Industry 4.0 concept, it is necessary to change the point of view to new technologies, modernize the production process and the overall approach in the field of heavy industry. The use of an ever-increasing volume of data, and especially their processing, is critical for companies in this field. This can be achieved, for example, by changing commonly used computational models for newly implemented options such as: digital twin model, machine learning, artificial intelligence, etc. This can streamline the production process, faster retraining, or direct training of new / existing employees to the customer up to the already mentioned production or improvement of the system of predicting the consumption of production materials together with the production of castings [1,2].

2. INDUSTRY 4.0

Since the first mention in 2011, over 11 years the date of the fourth industrial revolution has enjoyed increasing interest from a number of researchers, companies, but also individuals without technical background. This idea supports the emergence of so-called "smart factories" to replace systems that use human activity in repetitive and simple production processes / tasks for robotic work together with automatic production lines, etc. The aim is to improve production processes through ever-increasing levels of digitization and combine it with business factors (storing a smaller amount of material, only for a given order; streamlining maintenance; monitoring of all possible production processes) [1,2].

Internet of things

Almost every second, more than 200 devices connect to the Internet, which no longer use people as intermediaries for their own communication. This trend of digital change is being followed by more and more companies in the world, and of course the number of devices is constantly increasing. By 2025, their growth is expected to exceed 75 billion [3].

Data processing can be solved in the device using machine learning, which is built directly into it or are collected and analyzed by an external device, or sent to the cloud, where further work with data takes place. Connection and communication are taken care of by communication and interconnection protocols, e.g. (AMQP, DTSL, DDS or CoAP) wireless (RFID, LPWAN, NFC, Bluetooth), but it is also possible to use satellite connection and mobile networks [3,4].

Administration of IoT

Of course, these devices must not have their security, power options, availability of integration in the given environment, remote administration and organization forgotten. This is safely solved by the device management functions:

- Activation with registration
- Authorization / verification
- Configuration
- Establishment
- Monitoring and diagnostics
- Firmware update
- Troubleshooting

The companies that provide software and services for the administration include (Microsoft, Google, Amazon, Siemens, etc.).

3. ARTIFICIAL INTELLIGENCE TOOLS USABLE IN DATA PROCESSING AND ANALYSIS

The issue of deeplearning and its application lies in the need for practice, not programming on big data and how to behave in different situations. The disadvantage of these applications is the tendency to misinterpret data and the necessary presence of a team of specialists in the issue to determine the correctness of the application output [4].

For the correct analysis of the text, it is necessary, as with other analyzes, to create the largest possible database of precisely given documents, in which the content is explained systematically (occurrence of words, vector description of the language, etc.). The system can then cope when the same word or sentence appears, but in a completely different context [4].

Even in the case of spoken word recognition, artificial intelligence must first learn to understand through big data an audio recording along with a textual one that corresponded to the same content. For even better results, the audio track is masked and distorted differently so that it can be recognized from all kinds of sources and in different environments (personal assistant on mobile, Google, Siri, etc.) [4-6].

Other analyzes include image processing. Recognition of the letters of a distressed text can be realized even without deep learning, the challenge here comes only from the analysis of handwritten text. Nowadays, this discipline is mainly used for face recognition from camera recording. The image is usually divided into appropriate levels, which can then be further evaluated and used to identify clear trends [5,6].

4. DATAMINING METHODOLOGY IN METALLURGICAL INDUSTRY

The method of processing operational data can be described in the following steps:

Definition and understanding of the problem, subsequent definition of required data, data collection, data preparation including their qualitative control, data processing using SW, evaluation together with understanding of the obtained results, their interpretation, and finally further use of knowledge (for the control model).

First, it is necessary to specify the requirements as accurately as possible (series of questions to obtain requirements for output requirements, etc.). These include analysis of material, energy and information flows, environmental costs, this information can be obtained from already established management systems, SCADA systems, predictive maintenance, or operator management. All data is now assessed for the purpose. Data collection mostly depends on the metallurgical technology we research. Data preparation means their transformation, selection, cleaning, formatting, integration or even supplementing certain missing elements. The software used for data processing can be divided into three categories: specially developed (adapted to various assignment specifics), general (KNIME, MATLAB, WEKA, etc.), commercial. Last but not least, the evaluated data can be used for the interpretation of the identified deficiencies and their elimination, optimality of the state of control systems, field instrumentation and given technologies, sufficiency of storage of operational data [5,6].

5. VIRTUAL MODEL OF FOUNDRY

Creating a virtual model practically means converting real things, in our case a foundry with its processes into a simulation. Everything should work as it really is, but only as their image.

Digital twin

The biggest advantage of the digital twin is the ability to simulate, diagnose, monitor, control and predict the behavior of selected physical objects. The foundry's digital twin would include not only the actual representation of the real foundry, but also the elements of its production process, whether we are talking about logistics, financial planning, maintenance, time management and other sub-processes. **Figure 1** shows all these processes. As this virtual model of the foundry will be hardware intensive, the use of the cloud is recommended here.

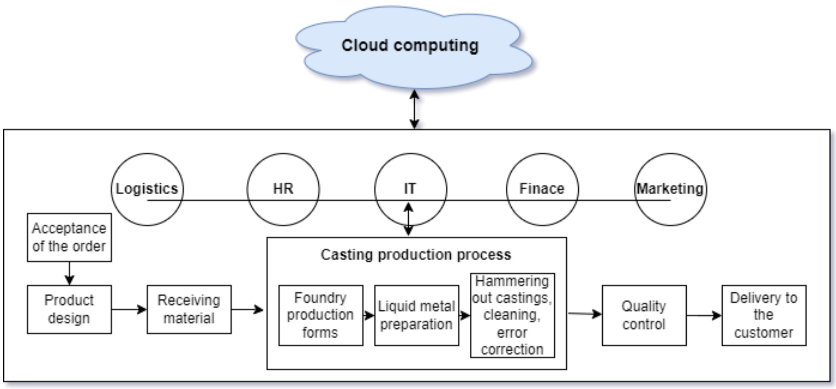

Figure 1 Process of virtual foundry [own elaboration]

6. APPLICATION

To select a suitable solution, it is always necessary to gather as much information as possible. Thanks to this, the whole procedure can be simplified and possible situations that would lead to redesign or, worse, the creation of a completely new solution can be eliminated.

To create a virtual 3D model of a real foundry could be achieved in various ways (scanning equipment, modeling software).

The interactive software application was eventually created by a combination of the Blender modeling program, Unity software and the C # programming language. The display takes place on a computer monitor and is controlled using keyboard and mouse inputs. The main goal is not only to display the 3D model of the foundry, but also the possibility of interaction with the foundry's objects with a real simulation of physical laws similar to those on earth.

After creating the terrain, it was necessary to add the equipment and the foundry building according to the photo documentation (**Figure 2**), each component had to be modeled separately in the Blender program and then imported into the Unity scene.

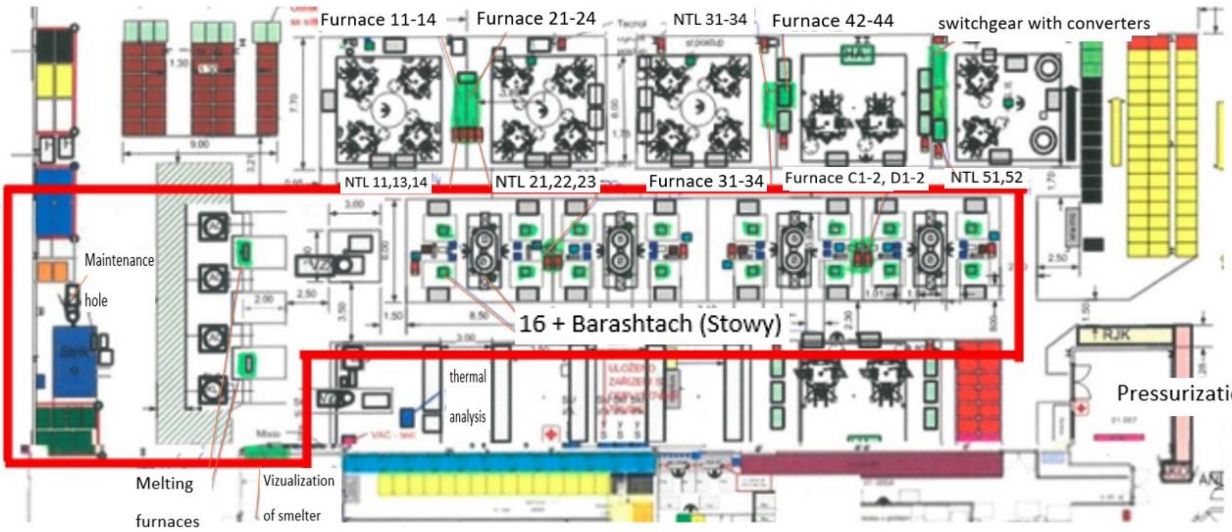

Figure 2 Plan of foundry [own elaboration]

The resulting device models in the virtual foundry application are interactive according to the specification (**Figure 3**). Click on the melting furnace to display information about the furnace, temperature, melt size and its purpose. Furnaces are regulated by thermocouples using PLC. Other equipment includes: Casting molds for casting aluminum alloys, holding furnaces (same regulation as melting furnaces), gravity casting table and NTL casting mold, and finally an adjoining office building.

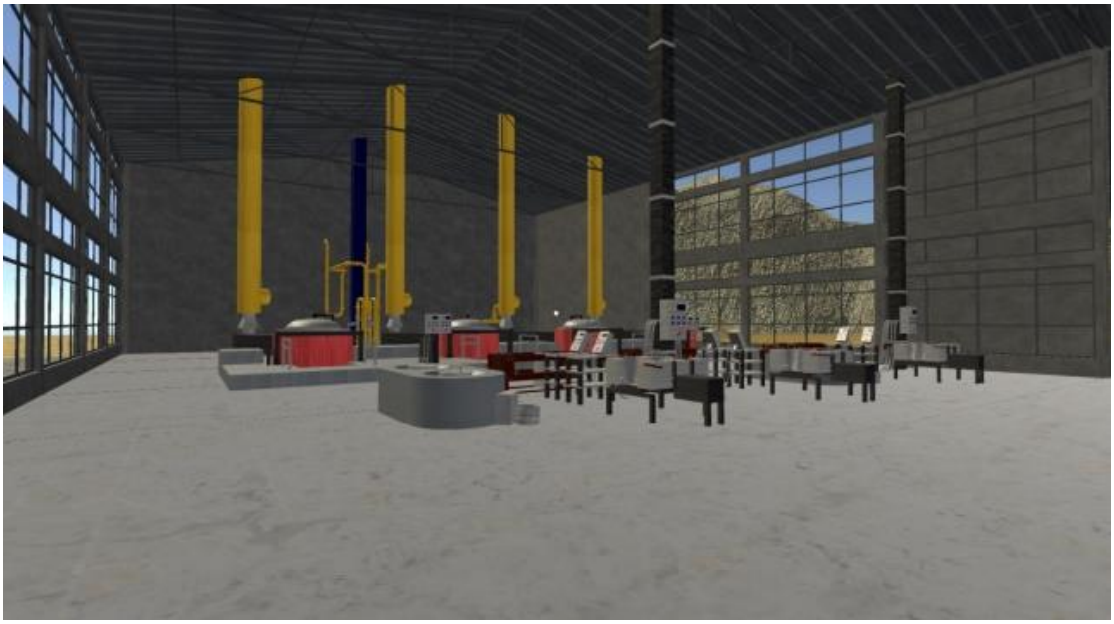

Figure 3 Virtual Foundry [own elaboration]

7. CONCLUSION

The theoretical part contains a description of the key topics for this work. There is a general description of Industry 4.0, and there is also a mention of the Internet of Things. The following chapters approach the issues of artificial intelligence, deeplearning and the digital twin. The last part focuses on the actual production of a virtual model of a real foundry, which was created by a combination of Blender and Unity programs. With this application, you can facilitate the training of new employees, or use the connection of a virtual foundry with real data mining to improve production processes or just read real data. The advantage of this application is its ease of use and interpretation using a keyboard / mouse and a computer with a screen.

ACKNOWLEDGEMENTS

The work was supported by the specific university research of Ministry of Education, Youth and Sports of the Czech Republic No. SP2022/74 and SP2022/80 and SP2022/86.

REFERENCES

[1] TYKVA, T. *Pokročilé metody analýzy dat v řízení průmyslových systémů*. [online]. Ostrava, 2020. Disertační práce. [cit. 2022-05-04]. Dostupné z: http://hdl.handle.net/10084/145395. Vysoká škola báňská – Technická univerzita Ostrava.

[2] FRIDRICH, M. *Pokročilé metody zpracování dat procesního řízení v metalurgii.* [online]. Ostrava, 2021. Disertační práce. VŠB – Technická univerzita Ostrava. [cit. 2022-05-04]. Available from: http://hdl.handle.net/10084/145393.

[3] GILAD MAYAAN, D. The IoT Rundown For 2020: Stats, Risks, and Solutions. *Security Today*. [online]. 13. leden 2020 [vid. 2021-05-06]. Available from: https://securitytoday.com/articles/2020/01/13/the-iot-rundown-for-2020.aspx

[4] DAVID, J., ŠVEC, P., GARZINOVÁ, R., KLUSKA-NAWARECKA, S., WILK-KOLODZIEJCZYK, D., REGULSKI, K. Heuristic modeling of casting processes under the conditions uncertainty. *Archives of Civil and Mechanical Engineering.* 2016, vol. 16, Issue 2, pp. 179-185. Available from: https://doi.org/10.1016/j.acme.2015.10.006.

[5] DAVID, J., POLLAK, M., TUHÝ, T., PRAŽÁKOVÁ, V. Modern communication technologies usage for controlling metallurgical processes. *METAL 2014: 23rd International Conference on Metallurgy and Materials*. Brno: TANGER Ltd., 2014, pp. 1678-1683.

[6] DAVID, J., ŠVEC, P., PASKER, V., GARZINOVÁ, R. Usage of real time machine vision in rolling mill. *Sustainability.* 2021, vol. 13; Issue 7, ArN. 3851. Available from: https://doi.org/10.3390/su13073851.