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THE POSSIBILITIES OF INTELLIGENT MANUFACTURING METHODS

PÉTER FICZERE–NORBERT LÁSZLÓ LUKÁCS

Budapest University of Technology and Economics,
Department of Vehicle Elements and Vehicle-Structure Analysis
1111 Budapest, Stoczek u. 2.
ficzere@kge.bme.hu

Abstract: Additive production technologies made the realization of individually designed, highly complicated geometric structures in practically all fields of industry and human therapy (implantation) possible. In order to minimalize the risk of failure originating from production technology the continuous development of measurements technologies provides the possibility to track the parameters of production and if necessary to ensure their modification. The great number of recorded production data (big data) at the same time can be used in the quality control of the product.

Keywords: *Additive manufacturing, methodology, IoT, i4.0, Remote control for manu-facturers*

1. INTRODUCTION

Nowadays we can hear that we have been living in the fourth industrial revolution. The first industrial revolution was the transition of new manufacturing methods, the transition from hand production to machines, the second was the time of the mass production and the third was time of automation [1]. In case of fourth industrial revolution more technical feature can be highlighted.

Tracking of individual products, monitoring and analysing process of manufacturing conditions and autonomous failure detection can be possible with machine monitoring systems with high quality sensors (for example RFID systems or different measuring systems) and smart industry networks. With assistance of these tools and devices the synergy between smart production lines and information technologies can be put in practice. It means the collection, storing and dispersing of high complexity data which can be set in industrial service by intelligent analysing software. The high volume of data can provide multivarious analysis for different aspects of production [2].

The industrial measuring and data collecting methods have numerous advantages. Places of failures can be predicted and these methods have a significant role in quality assurance (QA). Tracking of products life cycle is a highly recommend task during the production and logistical process. Full transparency in material flow, tracking of production can provide great traceability. With evidence record and store of production data, the identification and certification of individual product can remain after the delivery. Quality assurance and magisterial tests can be done more economically and quicker [2].

Analysis of data can highly support the sufficient maintenance process and the quick intervention either. The real time online data collection and autonomous failure detection can help the precise manufacturing. For these reasons the amount of waste product can be highly reduced. Continuous data collection can help the verification of certifications.

In the last few years, futurologists and scientist who are involved in the education of design have been studied that which parts of the industry can achieve breakthroughs in the next few years and can affect to everyday life: AI (artificial intelligence), autonomous cars and autonomous manufacturing were predicted as the fifth industrial revolution [3], [4], [5]. Participants of the sixth industrial revolution may can be cyborgs, which means the cooperation of cybernetic and organic beings. In this case we can speak about the hybrids of bits, atoms, gene and nanotechnology.

2. The possibilities of additive manufacturing

Remarkable part of Industry 4.0 is the IoT (Internet of Things) where the equipment is connected in common networks and these instruments can communicate to each other, the big data, where all of data are collected and a more complex analysis is possible with them [6]. Big data can help to time maintenances and some failure can be predicted. The human-machine connection (cobots) come into prominence with the Industry 4.0. Additive manufacturing technologies also must be mentioned, which manufacturing technologies can provide nearly infinite possibilities and produce complex parts in an economical way. [7], [8].

2.1. Additive manufacturing with AI

The newest 3D printers are not bounded to a frame. It means that these machines can change their position, therefore there are no limits with size. These experimental machines can preannounce how will the future look like.

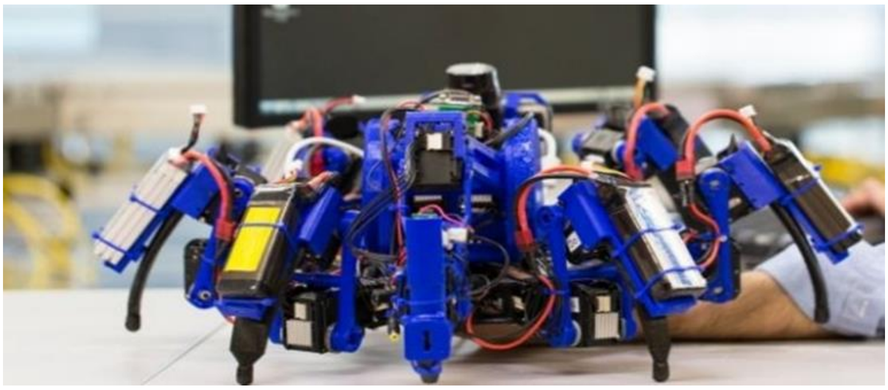

Figure 1. 3D printer spider [9]

In the first picture there is an autonomous 3D printer which operates with the help of artificial intelligence (AI). Every single leg has a 3D printer head and these legs can communicate to each other. These "heads" can solve individual problems and this method is optimised by the communication of them. The sensors in legs can help them to avoid hazards and they also can inform other machines about them. The cooperation of these printers can create functioning products. They can control their own energy consumption and charge themselves if it is needed.

Modern software can optimise the 3D printers and at the same time these systems can pay attention to mechanical properties, accuracy and aesthetics [10]. *Figure 2* shows the influence of adaptive layer height. This function can reduce layer height where it is needed, for example where rounded or complex shaped areas are and allow higher layers for the quicker manufacturing where the resolution is not important.

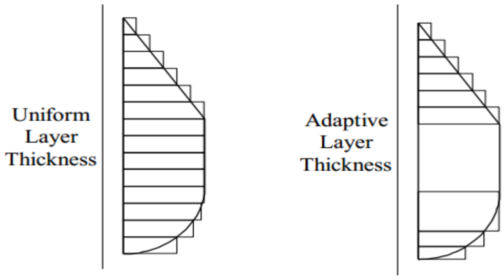

Figure 2. Adaptive layer height [11]

2.2. Diagnostics during the production

As it was mentioned earlier, the certifications during the production are important in quality assurance. For example, EOS can check (metallurgy) and certify every layer during the manufacturing process and therefore these data can be conclusive.

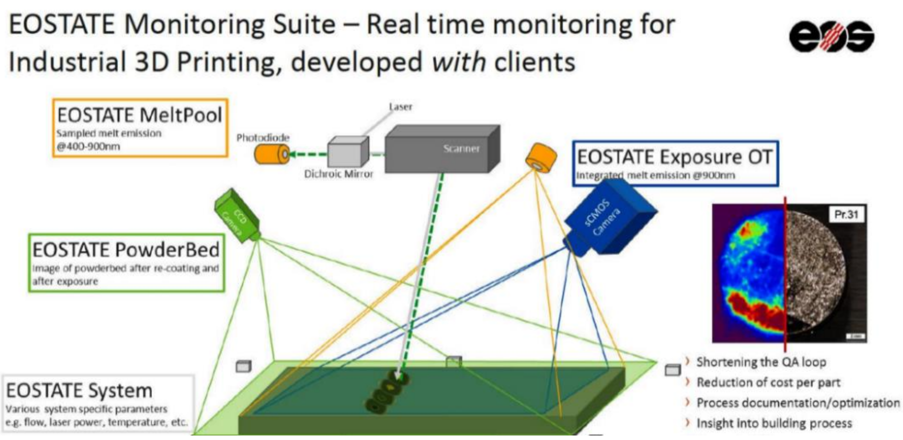

Figure 3. Levels of layer quality control [12]

Nowadays we have the possibility to check and measure the geometrical parameters after every layer, to compare them to the original CAD file. The actual height can also be measured, compared to the actual position, therefore the absolute inaccuracy can be determined and necessary modifications can be executed (i.e.: layer height or temperature can be modified). This possibility can help the intervention and the failures can be prevented automatically. Measuring and intervention methods produce a huge number of data (Big Data) and this is also a part of the Industry 4.0.

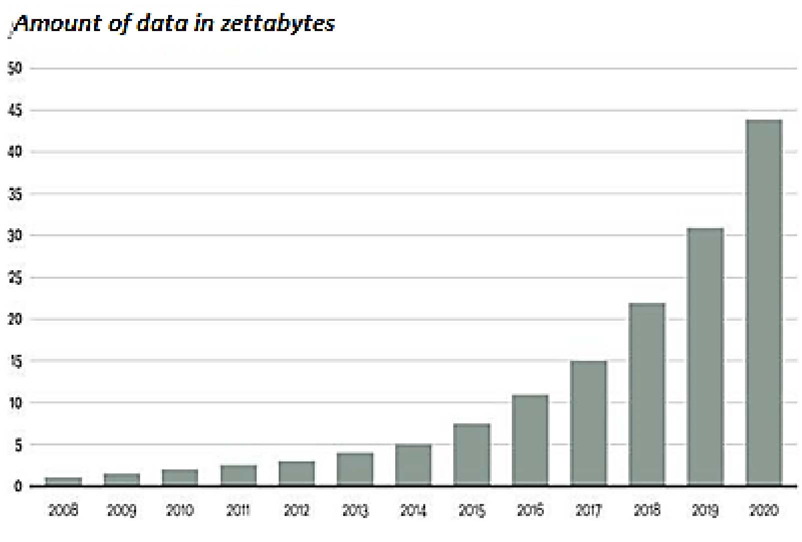

Figure 4. Stored data in each year, in zettabyte [13]

It is also a possibility to measure the amount of material and change it if it is needed. Furthermore, the operator can also choose from the ordered parts depending on the available material and start a print without the risk of material shortage.

2.3. Coordination of machines

Additive manufacturing companies work with more and more 3D printers. In this case it is an enormous challenge to control parallel projects. Nowadays the 3D printers can easily run for 70–80 hours without human intervention, they cannot work independently, without human surveillance. Print endings (if these are not in the working hours) can produce idle time. Remove or of finished products need operators. Complex CAM software can exactly predict the printing time and therefore the projects can be added for proper machines. This assignment can be done online, where the company members can see the status of printers and also can start a new project if the selected machine is available. Furthermore, operators can prevent idle time and provide more profit if the projects will be finished in working hours. In this case, online availability is also useful. This feature is not a privilege of big companies. Some of these systems are available for free for everyone. The actual printing process can be monitored and possible failures can be detected and solved in real time. This system requires one and more camera and internet (IoT, Internet of Things) what is also a feature of the Industry 4.0. In this case we can intervene during the manufacturing.

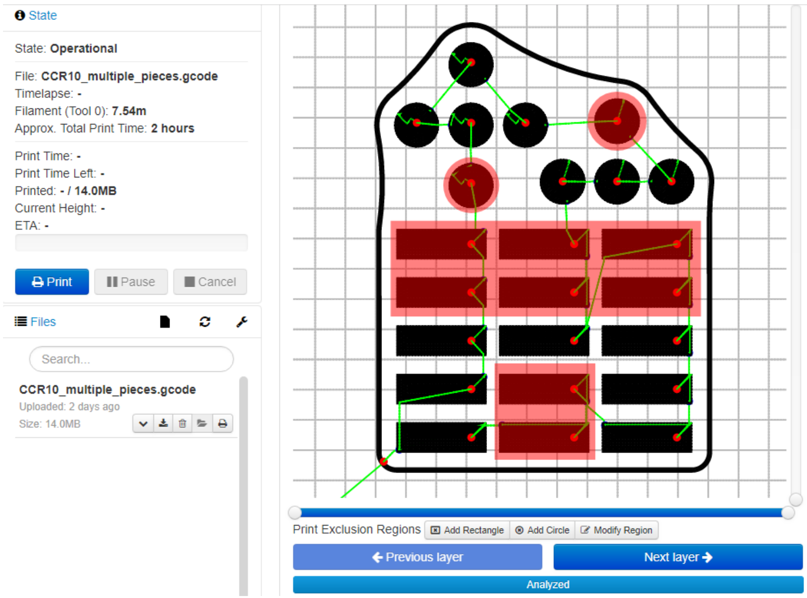

Figure 5. Octoprint [14]

For example, a warped or over crashed part can ruin the whole stack of parts. With the help of this software the failed part (area) can be assigned, then the software can rewrite the g-code and the other parts can be printed uninterruptedly. *Figure 5* shows the software during operation. Assigned areas where the parts will not be printed (red) and parts what will printed normally (black) are noticeable. It can provide less waste, because without this function the complete stack of parts would be spoilage.

3. SUMMARY

Consequently, it is noticeable that just the Industry 4.0 can deal with the more complex demands. For this application the most modern technologies needed. One of these technologies are the additive manufacturing technologies which nowadays more widespread and used are and provide more and more possibilities. Additive manufacturing technologies can utilize the possibilities of Industry 4.0 and production can be more flexible and efficient. These possibilities (IoT, Big Data, etc.) produce more data and these data must be evaluated before storing and using for development.

It is observable that the infrastructure is often available but the human mentality needs recreation. Nowadays the industry needs more flexible thinking for quicker and economical reactions for challenges of Industry and Economy. It means the use of acquired knowledge is not enough but continuous renewal and development is needed not just for the machine side but for the human side either.

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