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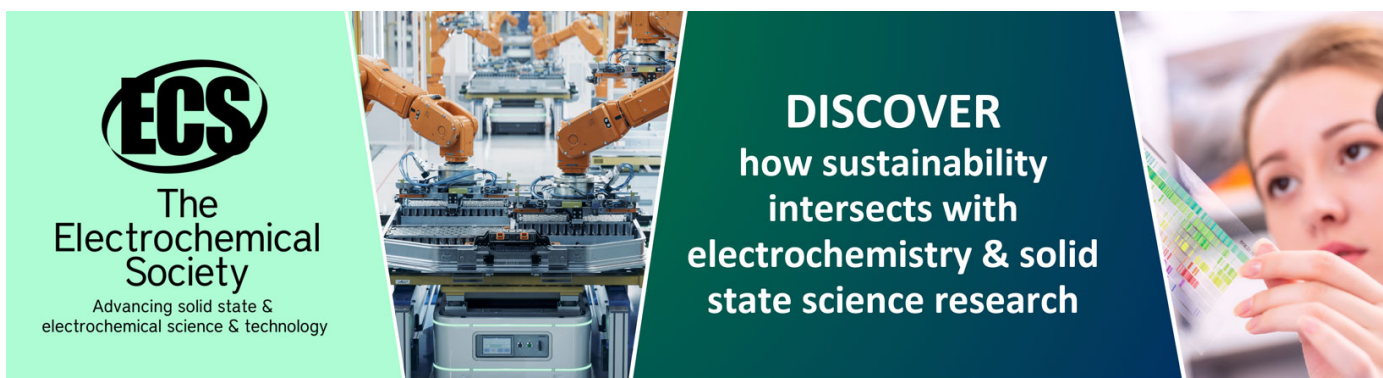
The coordinate measuring machines, essential tools for quality control of dimensional and geometrical specifications of technical components, in the context of the industry 4.0

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The coordinate measuring machines, essential tools for quality control of dimensional and geometrical specifications of technical components, in the context of the industry 4.0

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Abstract. The industry, as part of the economy, focuses its activity on the production of technical parts which are highly mechanized using sophisticated and automated machines. Over the years, the ability to innovate has proved to be an important factor in industrial development, especially in technological development in line with different requirements of the industry and the efficiency of production processes, reflecting in the quality improvements of the technical components produced. For control of dimensional and geometrical requirements of the technical components, companies use the 3D coordinate measuring machines. These sophisticated measuring machines follow the effectiveness of the latest production systems according to the requirements of industry 4.0, using information technology that promotes quick and easy inspections with large data acquisition, which facilitates the interaction of the entire production process. This paper aims to give an overview of the importance of the measuring processes, using coordinate measuring machines, the large data acquisition of the dimensional and geometrical characteristics, how to export this data to the production machines in order to correct the machine parameters and to obtain technical components in accordance with the technical requirements.

1. Introduction

The globalization process that the world has been experiencing, has contributed to introduce in the world economy a troubled and complex period which has led many countries to face very difficult economic conditions.

Nowadays the industry based on modern and smart production systems has brought new improvements in production management, elimination of waste and increase of the investment in research and development processes.

However, the production processes in industrial environments continue to be affected by several factors. The production processes of individualized products in industrial environments are exposed to several factors that (in a more or less significant way) affect the expected specifications, forcing constant adjustments in the parts and in the production control means. These factors must be considered to not compromise the quality of the final product.

The inevitable introduction of digital technologies into the industry and the need to produce sophisticated technical components has helped innovation processes to reduce development time, introduce new products in the market and improve the management of the short product life cycles.



Industry 4.0, based on new concepts of smart factories where all the machines are connected in a network, allows performing operations in real time, taking as a starting point the data obtained and processed instantly.

In order to control the production process, the support of the metrology is fundamental to ensure the technical specifications of the products.

The metrology, widely recognized as one of the most important areas of knowledge to support innovation processes, presents itself as one of the sciences that has the greatest applicability in scientific and industrial environments, maintaining itself as a strong pillar for scientific and technological development, contributing to the competitiveness of the companies in the world economy, and contributing largely to their sustainability.

2. The support of the 3D metrology to the production processes

Coordinate measuring machines are machines that allow to locate point coordinates on three-dimensional objects. They allow integration of both dimensions and orthogonal relationships.

Normally, these machines are used to eliminate difficult and time-consuming measurements with traditional single-axis devices such as calipers, micrometers and height gages.

Complex parts can be measured quantitatively, and data can be stored for later or immediate use.

The more complex the part to be controlled and measured, the more useful the coordinate measuring machine becomes.

The coordinate measuring machines have taken a lead role in many industries such as aerospace, automotive, electronics, plastics, and semiconductor, and are an equipment that is perfectly in line with the new trends of the industry 4.0.

“In the context of the Industry 4.0 concepts, the importance of measurement technology and its digital integration into production processes becomes increasing significant. Measurement technology plays an essential role in capturing the real world.”[1]

The measurement technologies are nowadays required to be more fast, accurate, reliable and flexible. In fact, the coordinate measuring machines are measuring instruments that integrate the mentioned characteristics and can carry out fast measurements.

The integration of coordinate measuring machines into production processes allows for faster measurement results and facilitates a faster delivery of measurement results. The reduction of lead time occur because the displacement time of the parts between the production areas and the control laboratories are eliminated, since robots are used to place the parts on the coordinate measuring machine (figure 2) and the measurement processes are already optimized.



Figure 1. Example for faster metrology due to the automated integration of a coordinate measuring machine into material flow by robot loading. [2]

Through the accredited calibration of the coordinate measuring machines, the accuracy of the measurements as well as their traceability are ensured.

This type of metrology equipment is very reliable, presents measurement uncertainties that cover the accuracy of most of the produced parts and is very flexible as it allows the use of different measurement techniques (figure 2).

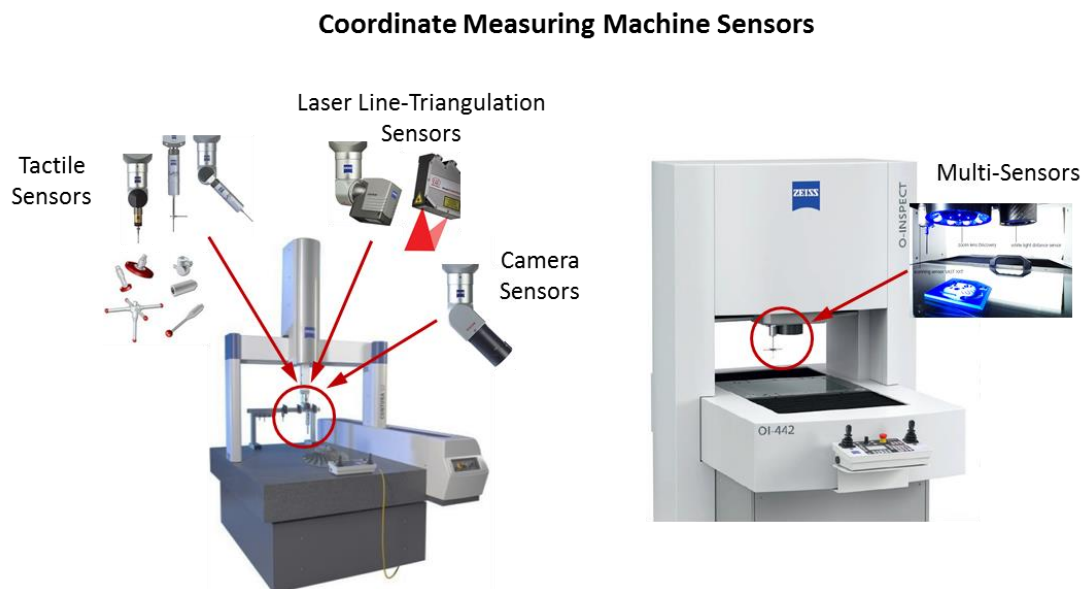


Figure 2. Examples of multi-sensor implementations in coordinate measuring machines.

In the field of dimensional and geometrical metrology, the coordinate measuring machines in industrial environments are an important resource for the quality systems, since they monitor manufacturing processes, contribute to reduce errors during the manufacturing process and contribute to the inspection of technical specifications, which ensure the quality of the final product.

Considering the need to establish increasingly tight controls on the parts produced in order to control the whole process, the coordinate measuring machines are the means used that support the productive processes, in particular the automated processes.

Once project and technical drawing with all dimensional and geometrical specification of a part is completed, it is sent to the production and using automatic production machine to obtain the real part, which is subsequently sent to dimensional and geometric control in coordinate measuring machines from which a measurement report is obtained that allows validating the part (figure 3).



Figure 3. Production and control process.

The control of the technical components, using coordinate measuring machines (refined measuring instruments that work with contact and non-contact probes systems), has become widespread in the most diverse areas of the industry, with special relevance in the demanding automotive, space and aeronautical industries, following the rhythm with the production of automated machines.

3. The data acquisition and the need to establish communication between coordinate measuring machines and production machines in order to correct failures and control the process in an automatic way

Measurement processes, as we understand them today, work offline and in laboratories, being almost exclusively dedicated to the evaluation of the technical characteristics of the manufactured components.

The existing interaction with the coordinate measuring machines and the automatic production machines is still very small and passes through human performance most of the times.

However, the coordinate measuring machines that track the effectiveness of the latest production systems according the requirements of the industry 4.0, the new business paradigm, use information technology that promotes quick and easy inspections with the acquisition of large volume of data, which will facilitate the interaction of the entire production process efficiently, ensuring compliance.

In an expected model of a smart production system all resources must be connected (figure 4). In this model, all dimensional and geometrical specifications of the technical drawing of a part are sending to automatic production machine and the cycle begins.

The technical specifications are inserting in to the software of the automatic production machine and the part is produced. The produced part is placed in to the coordinate measuring machine, especially by automation means (robots), then the measurement process occurs and the measurement report is generated regarding the state of the part, the analysis and processing of this data are directly available in production allowing automatic adjustments in the automatic production machine, if necessary. All generated data is stored on servers for future evaluation and consultation. These data are accessible to all stakeholders.

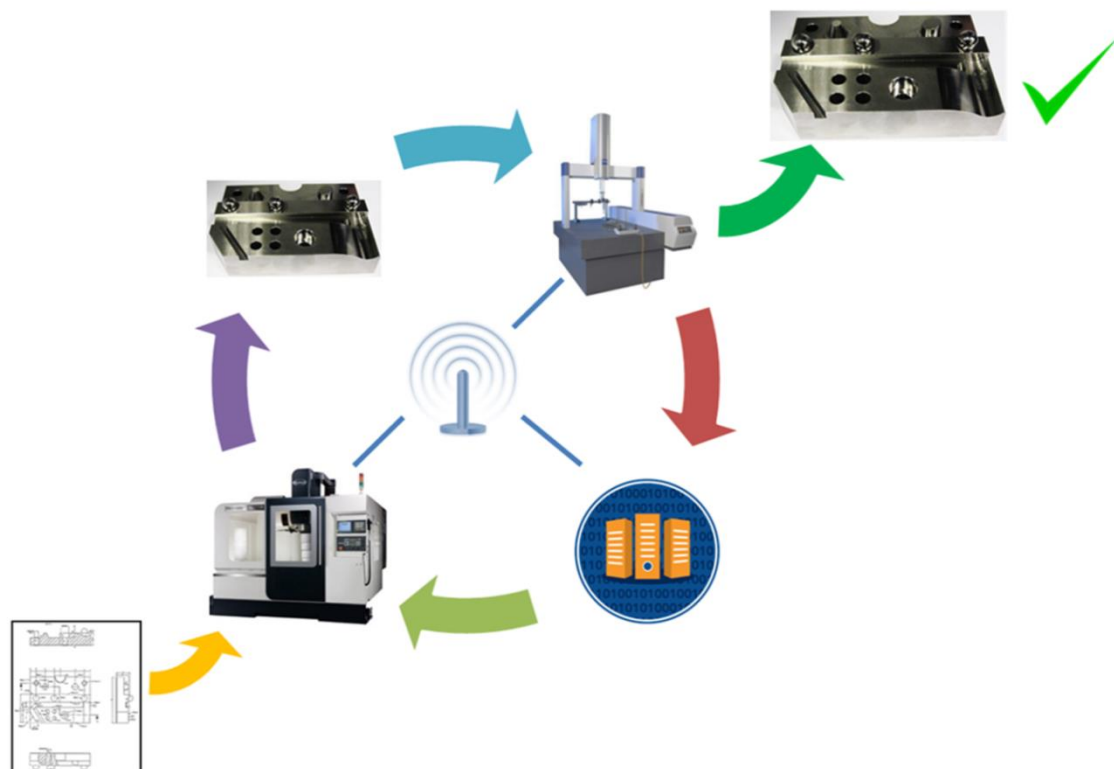


Figure 4. Production and control process in accordance with industry 4.0.

One of the great challenges for the industry 4.0 concept is dealing with the amount of data acquired in a dimensional and geometrical analysis performed on the products, i.e. how to file and process all the information acquired by the measuring instruments, contemplating the associated uncertainties so that this information be disseminated on the network for that all stakeholders have access in real time.

“Measurement technology and the information thereby gained is rather the pacemaker in the concept of industry 4.0, and this is made clear in particular by its role in the cyber-physical production system of linking together the “cyber-world” and the “real world” (Figure 5)”[1]

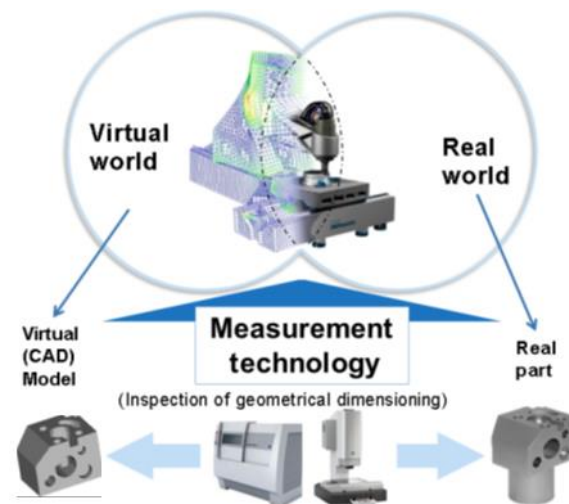


Figure 5. Measurement technology for linking the virtual and real worlds, with an example from coordinate metrology for comparing the nominal (CAD model) and actual product shape.[1]

4. Added value for companies

In the industry 4.0 context, manufacturing intelligence provides that all the information that comes from different sources allows connecting different management systems of quality control of the company with the manufacturing process, therefore improving the analysis and the product.

For the industry 4.0 paradigm, a real-time and smart metrology with online communication between the coordinate measuring machine and the production machine is absolutely necessary.

This connection allows direct measurement in production to become a reality, which means that the costs of measure and produce tend to fall and this trend will lead to the fundamental characteristics of products being controlled 100%, which generates data used in statistical controls.

Since test results and statistical controls are available to all stakeholders in the manufacturing process and to the customer as well, decisions are no longer centralized, which means that change decisions are made by the customers themselves.

It is expected that with the implementation of industry 4.0 concepts in companies, these can have significant increases in productivity and efficiency should be significantly improved.[3]

With increased efficiency and productivity, companies will have a return on defects reduction, optimization of the costs and, above all, the full satisfaction of customers.

5. Conclusions

The coordinate measuring machines are in fact an essential tool for quality control of dimensional and geometrical specifications of technical components in the context of the industry 4.0. This equipment allows to control the production process, measure the production parts, save the large volume data,

control the autonomous machines, send large volume data to do simulations and provides the integration of all systems.

This process allows to control the stability and the good performance of the industrial production, facilitates the interaction of the entire production process, optimizing the existing resources in a company and improving the efficiency and sustainability.

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