Towards a Practical Approach to Cost-Oriented Automation and Smart Metrology in Advanced Fabrication

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ABSTRACT

Thanks to the information age, the manufacturing sector faces very critical problems at present and in the near future. The entire value chain is blown up by new data, network, automation, digital customer interfaces. Creation of nanoscale workpieces requires high-quality integration in line with manufacturing processes and micro-Nano metrological evaluation and assessment. There is a multidisciplinary approach of nanotechnology. Modern metrology of production and its industrial implementation began based on the science, technical and organizational research of E.Abbe, William Taylor and Frederick Winslow Taylor and the development of the "Quality Control Generation" at the end of the twentieth century has entered nanotechnology and is progressing towards pico-and femto-technology. In order to meet potential high-level demands from both industrial and private customers, manufacturing companies must be versatile and agile enough to adapt quickly to changes in product demand, particularly in the field of micro, nano and pico-scale precision engineering. Dynamic cost-effective customer-driven design and production can be realized with the help of AI and dynamic IT.

Keywords
Advanced Production, Integrated Management Systems, Intelligent Quality System, Intelligent Metrology, Robotics

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Introduction

Industry 4.0 is an revolutionary framework and model for future companies that is implemented with the intention of offering cost-effective, efficient, flexible and optimized ways of delivering customer-led goods. Such new models can be built on the basis of smart design, lean manufacturing, parallel engineering and the use of common data technologies for the product.

The move to Industry 4.0 includes models to be implemented as part of automated and robotic systems, networked intelligent machines and instruments, using advanced information processing, artificial intelligence and interconnected Industrial Internet of Things (IIoT).Intelligent manufacturing systems based on multi-functional integrated factory model (Osanna et al., 2009) as well as extensive use of IT, AI, simulation, smart quality automation, robotics, advanced metrology and advanced data exchange techniques would be able to operate more effectively, collaboratively and sustainably, making an agile and optimized industrial environment feasible[1]–[3].

The new forms of collaboration between research institutions and the manufacturing industry should include high-quality and creative goods with capacity to grow.The growth of knowledge highway, technology and advanced data exchange techniques render global information systems in a collaborative and interactive environment.

With regard to processing techniques, due to improved material selection, material property, efficiency, and quality, additive manufacturing is gaining broader acceptance as a process of "direct production'.' Additive manufacturing, however, should not be seen as a pure processing process. In addition to improving how products are made, additive manufacturing also affects how products are delivered (i.e., supply chain and logistics effects, as well as how products are constructed (e.g. topology optimization or component consolidation). The GE 90 jet engine fuel nozzle exemplifies a well-known and effective application to additive manufacturing to component consolidation.The fuel nozzle not only integrates all 20 parts of the old system into one package using an additive manufacturing technique, but also weighs 25 per cent less and is more than five times as solid. The nozzle topped the wildest expectations of the manager. Additive manufacturing makes the cost of the unit far less sensitive to lot sizes in production. This isolates product cost from lot size factors, which have been a manufacturer 's problem from the beginning of the practice. As a result, one day parts may be made in batch sizes of a few or even one — anywhere, anytime, and at a reasonable cost.This notion of stack-wide convergence with a massive scale of a single pro-duct — anywhere, anytime — will destroy several current market models and generate fresh, more advanced ones. As far as the business model is concerned, manufacturing-enabled operation is the key driving force with value creation. Manufacturing initiates value production in these situations and technology makes this. Most industrial firms have discovered that production and distribution intersect, as technology has moved from product delivery to constant customer engagement.With several manufacturers, innovative and competitive services that are allowed by intelligent sensors and communications slowly become the business model of choice. The number of effective blended manufacturing-service business models is growing. For example, Rolls-Royce uses sensors in its jet engines to help track the output and identify problems. In reality, this organization transforms commodity into a business by paying its consumers for engine use instead of letting customers purchase an engine right away.For another example, Babolat makes tennis racquets with sensorsthat can produce data to monitor the player 's tennis strokes, whichsubsequently helps the company to provide coaching services. Some John Deere equipment can collect and submit data on weather and soil conditions in order to inform consumers about when and when to plant seeds.3. Hybrid production Nearly three decades ago, when invention led to a heavy use of automation in industries, many people expected that all industries would be packed with robots within 10 years, and that no human operators would be available. Decades later, human workers are already active in factories and will continue to be there in the near future.Today, people expect that all machining methods will be replaced by additive fabrication. It won't. The future factory will be a network of robotics and humans hybrid devices, additive and subtractive fabrication, composites and plastics, digital and analog processes, cyber and physical structures, nano and macro sizes, and so on. Robots are not going to completely replace humans, just as additive manufacturing is not going to completely replace subtractive production. Rather, they'll work towards a fair sharing of accountability in partnership. Of course the study of individual systems is important.The analysis of the interface and the technological and financial equilibrium between various systems is similarly or perhaps more important — that is, the interface between robots and humans, additive and subtractive processing, and composites and metals. Standardswill also be important for safe and productive operation of the integrated systems system. Forming, machining (subtractive), and additive manufacturing are three main manufacturing groups. Notional map showing the relationship between cost of the unit and quantity (or lot size) construct.The analysis of the interface and the technological and financial equilibrium between various systems is similarly or perhaps more important — that is, the interface between robots and humans, additive and subtractive processing, and composites and metals. Standardswill also be important for safe and productive operation of the integrated systems system. Forming, machining (subtractive), and additive manufacturing are three main manufacturing groups. Notional map showing the relationship between cost of the unit and quantity (or lot size) construct.Clearly, shaping is ideally suited for very large lot size production to achieve low unit cost by amortizing high initial capital expense over a vast number of parts in equipment and machinery. The lot size for machining may be smaller compared to shaping but it is also comparatively higher than that of production additives. This makes the manufacturing of additives more cost-effective for further applications.

Modern Integrated Intelligent Management In Advancedproductionsystems

Modern Integrated Intelligent Management System-MIIMS with modern quality methods is an integral part of manufacturing enterprises and, in particular, of advanced production climate. These systems will also play a central and most important role in factories of the next decade. Fig.1 shows that integrated smart management and quality control needs to be explored in the individual operations of next generation factories. The goal is to ensure that production is realized in the future through intelligent production systems focused on the automation of integrated management and quality systems in order to develop, realize and present features such as concurrent, interactive, collaborative,Modern Integrated Intelligent Management Systems for Efficiency, Climate, Energy, Risk, Health and Safety, Information Security (ISO 9001:2015, ISO 14001:2015, ISO / DIS 50001:2017, ISO 31000:2018, ISO 45001:2018, ISO / IEC 27001:2017) inside the manufacturing system and focused on intelligent quality control, provide an opportunity to prevent process errors and discover this as early as possible[4]–[7]. Quality control and automation actually perform essential roles of industrial production design

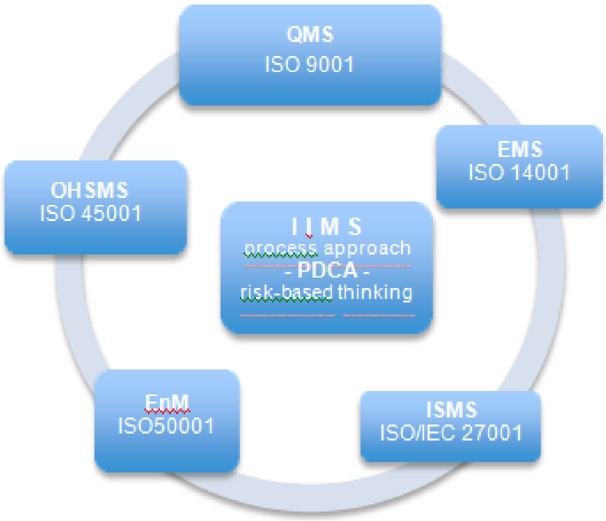

Fig.1: Integrated Management System

The production processes of advanced manufacturing technology can only fulfill consistency specifications using easy measuring technologies. International standards guide this framework approach through the specifications discussed by ISO 9001, ISO 14001, ISO 45001, ISO 31000, ISO 27001, and ISO / DIS 50001 (ISO 9001: 2015, ISO 14001: 2015, ISO / DIS 50001: 2017, ISO 31000: 2018, EN ISO / IEC 27001: 2017, ISO 45001: 2018):

- Defining the system objectives
- Establishing, implementing and maintainingthe management system as a set ofprocesses
- Describing the system
- Continualimprovement
- Risk basedthinking
- Interconnection, interrelation and sequence of processes
- Maintaining the integrity of thesystem
- Establishing measurementprocesses

The current methods of integrated intelligent management systems in manufacturing organizations have been developed and improved, and thus there is close contact with intelligent metrology and industrial and technological innovations. Essential measurement know-how is built on the basis of metrology and organizations are provided with this know-how.

Cooperation between the next-generation manufacturers and technology developers has been an important prerequisite for the creation of solutions to automation trends and metrology in production environments.Implementing both of these assets in an intelligent quality management and assurance system is a major challenge, and open, autonomous, self-organized and self-optimized principles would be the key approach to this objective[8]–[11].

Geometrical Product Specification And Verification

Intelligent design method describes the shape (geometry), dimensions and surface properties of the workpiece under consideration on a technical drawing. In this way, given other manufacturing tolerances the optimal function of the respective component should be guaranteed. Nevertheless, workpieces which do not meet these requirements will be made. Workpieces are therefore measured to compare them with specifications according to the specification and verification of the Geometrical product.

The geometrical requirements will be set up during the design stage according to a workpiece's functional requirements, which are derived from the functional need.The area of permissible deviations of a set of characteristics of a component will be specified in this first step to the product realization at a factory. It shall establish a high standard of quality in accordance with the manufacturing processes, the limits permitted for manufacturing and the concept of workpiece conformity (Fig. 2) that the optimal function of the respective component should be guaranteed in the light of such manufacturing processes.

The geometric deviation description is used to modify production cycle. To know the required characteristics, the metrologist begins by reading the specification, taking into account the non-ideal surface model.

Integrated Management Linked To Advanced Production Supported By Artificialintelligence

The design activities can be carried out intelligently, interactively and concurrently within the Intelligent Integrated Management System (IIMS). Using the quality assurance for the design can be assured to share quality data and quality assurance data for design work. The engineers and experts will work on parts of a design assignment using parallel-processing technology but the substance of the design as a whole is a corporate resource to be handled and protected[7], [12].

In next-generation factories, the quality assurance process will be carried out simultaneously in all product realization steps-from the design process to the assembly procedures.

Multimedia transmission of terms, figures and sound can also be incorporated into these interactive CAD systems that can recognize manual drawings, learn the product design process, also understand the natural language instruction for design, and improve the design process and design quality. Modern data processing systems and intelligent quality control and quality assurance will ensure this sort of operation. The basis for modern production is a complete 3D model of a workpiece, particularly in the 3D printing process, whereby this data set can be generated either by direct 3D CAD modeling or by physical modeling and in reverse engineering.The data sets may be produced from existing workpiece measurements (Fig. 2). A facet based representation is then generated by polygon triangulation from a volume or surface model and transmitted in STL (stereo lithography) or VRML (Virtual Reality Modeling Language) format to the additive manufacturing process (ISO 17296-4: 2016).

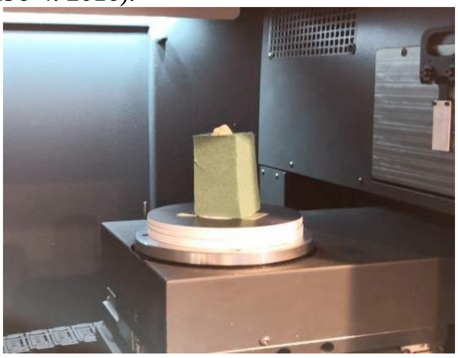

Fig. 2: 3D Coordinate metrology, measurement of free form surfaces using a CT

Manufacturing companies need to radically modify or improve their design strategy to ensure that the final product meets the functional needs of its application. It can be a challenging concept to realize and to do so will mean that there is substantial investment in practical testing to realize the criteria required to ensure that the design and its realization by construction, taking into account the chosen materials and their manufacturing yields the desired conditions. His reliability, functionality, efficiency and corrosion resistance are the most important criteria when evaluating the suitability of a technical component.

Information collections and handbooks related to the task support design engineers. Most products are not designed and tested to such a high degree of rigour, but there are many instances where such extensive functional testing has been carried out and the manufacture of micro-components and nano-structures in precision engineering are instances where the regular implementation of such testing is extremely necessary to ensure the functional functionality of the products. The manufacturing of aircraft parts and automobile engines as well as the extensive testing of medical devices are related examples.

The geometrical requirements will be defined during the design stage according to the functional specification of a workpiece, which is derived from the functional need. The area of permissible deviations of a set of characteristics of a component will be specified in this first step to the product realization at a factory. It shall identify a high quality standard in accordance with the manufacturing processes, the limits permissible for manufacturing, and the workpiece conformity specification.

Conclusion

The challenges of adapting to the new manufacturing industry can be solved by incorporating interconnected intelligent metrological technologies into integrated models of management to achieve agile and efficient growth. Cooperative laboratory practices enable systematic transfer of information and the creation of data. Every process is

performed step by step in accordance with the appropriate standards.
Under such a method the quality control process should be used in all stages of product development-from the design stage to the final assembly.Within such a collaborative environment, quality management and quality assurance in the individual activities of various functional companies-large factories as well as SMEs-play a fundamental role in ensuring the realization of the idea, e.g. through smart production processes focused on quality management and quality assurance in the framework to develop, realize and present features.

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