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DEMANDS ON MANUFACTURING METROLOGY AND SOLUTIONS

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Abstract: Today's global competition causes increased demands on production processes. Workpieces with more and more complex shapes, which are toleranced very sharply, must be manufactured with a high time and cost pressure and have to fulfil highest demands on quality. That is why manufacturing processes must be optimized continuously and controlled reliably. These requirements cause new tasks and challenges for manufacturing metrology, which has to supply the needed information for optimizing manufacturing processes. Within this paper, an approach is given to fulfil the actual and the future demands on manufacturing metrology. New chances offered by the progress in metrology and information / communication technology are shown. Furthermore the article describes steps, to realize the given approach within the company using those new technological chances.
Keywords: quality management, optimization

1 INTRODUCTION

Contemporary production processes face the demand, to manufacture products in a shorter time under even more complicated conditions and meanwhile keep up with increased quality demands. In this situation unstable and disturbing processes occur to be most critical, as they lead inevitably to quality problems or production failures, which can cause a serious drop in the competitive ability. Therefore manufacturing companies are forced to control and optimize all of their processes in a sovereign and economical way, to remain competitive in the future.

Furthermore the functionality of a product or its technical features alone are no more sufficient to arouse client's emotions and to fulfil his demands. There exist further special features, whose expressions stand for a product's excellence and which are very important in competition. Those high technical products make increased demands on their components. So workpiece's shapes get more and more complex and their measures are toleranced very sharply.

Besides the increased demands on complexity and precision of workpieces also production processes themselves face requirements, which are difficult to fulfil. Product quality and process stability are taken for granted, but with high cost and time pressure, that exists, it is contemporarily hard, to fulfil these demands. One the one hand a manufacturing process must be capable and optimized, on the other hand a shortened time to market interval leaves little time for run-on of the process [1].

In this tensioned field a certain kind of manufacturing metrology is needed, which is capable to control and optimize nearly all processes, especially those of high complexity in an efficient and reliable way. Against this background manufacturing metrology plays a significant part, because of a principle, which is of general importance: We only can control and optimize, what we can measure.

2 CONSEQUENCES FOR MANUFACTURING METROLOGY

The actual situation means new demands and challenges for manufacturing metrology. Increased complexity of products and processes causes more complicated inspection tasks, which have to be measured with a high accuracy. Information, obtained by the measuring process, must be supplied immediately as the base for a subsequent process control. Since a higher local distance between manufacturing process and measuring process causes a delay time in the quality loop, measurement has to be carried out as close as possible to production.

Economic and strategic demands such as a high capacity utilization of production machines or a short production time force the necessity of an optimal integration of inspection processes into production sequences. Manufacturing metrology cannot be considered as an isolated field beside the production, it becomes an integral part of manufacturing processes and a supplier of information [2]. Application of measuring systems goes beyond pure technological aspects and becomes an interdisciplinary task. Especially the area of information and communication technology gains in importance.

Today and the future much more extensive questions occur when applying metrology. Beside the choice of the most suitable metrology it has to be considered, how the obtained results can be processed and supplied for a further use and how will inspection processes be integrated into production sequences without spoiling the production flow (figure 1).

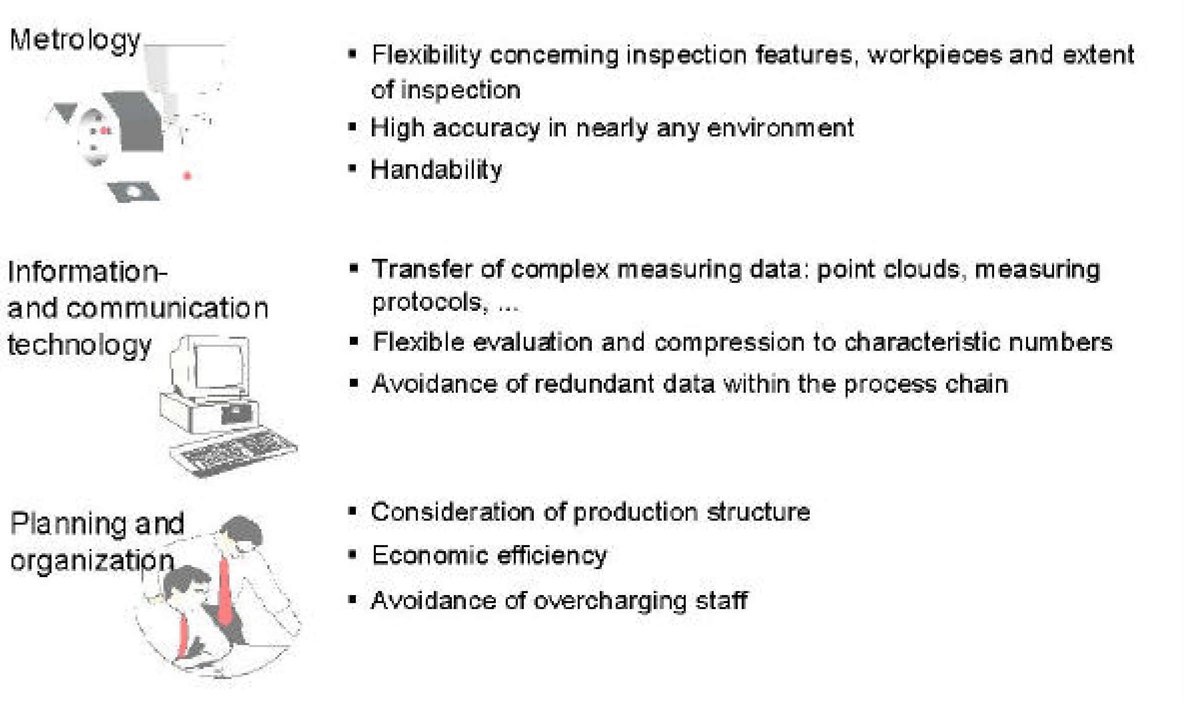

Figure 1. Demands on manufacturing metrology

3 TODAY’S TOOLS AND CHANCES

By now the market offers a variety of suitable measuring devices for tests, carried out by the worker himself or for production integrated and automated measuring. These devices facilitate a quick and close to the process capture of component’s relevant features, which is fundamental for an effective control of manufacturing processes. Decisive therefore are flexibility, the capability to measure also complex features, the integrability into production, an easy handling and also the possibility of data technical connection of the devices [3].

Modern testing devices, such as scanning coordinate measuring machines (CMM) as an example, even allow the measurement of element’s size, form and position of complex geometries with an only one fixture in a uniform reference coordinate system [4,5]. With a special capsule they meet all the requirements for a shop floor measuring system, such as no sensitivity to dirt, vibrations or fluctuations in temperature. These machines facilitate the capture of profiles or the measurement of freeform surfaces. This allows the flexible evaluation of form features.

The use of metrology for surveillance and control of production processes is mainly supported by today´s software tools. There are commercial software products for the support of essential parts of the process chain for quality inspection, such as inspection planning, data capture and data processing. Also offline-programming systems for CNC- measuring devices are constantly getting more efficient.

Further it is possible, to automate the collection of measuring results and to transfer them into any area of the company. Software systems offer the possibility to connect measuring instruments directly by standardized interfaces, or to import measuring data files of complex measuring devices by file transfer protocol (FTP) (figure 2). This facilitates a flexible connection of measuring- and testing-devices, which are located at any place in production.

By a fast transfer and processing of measuring results, CAQ-modules and software tools offer the possibility to analyze and control processes very efficiently and close to production. Statistical evaluations for example can be done so that characteristic parameters for process control are visualized. The storage of measuring results in data bases allows a flexible evaluation of those data. They can be calculated to characteristic values and decision aids for process optimization. In cooperation with network technologies, data bases offer the possibility of viewing single measuring results or parameters, which describe the quality situation in production areas. By this way the documentation of quality data can be organized more efficiently and measuring data can be assigned to production units and products.

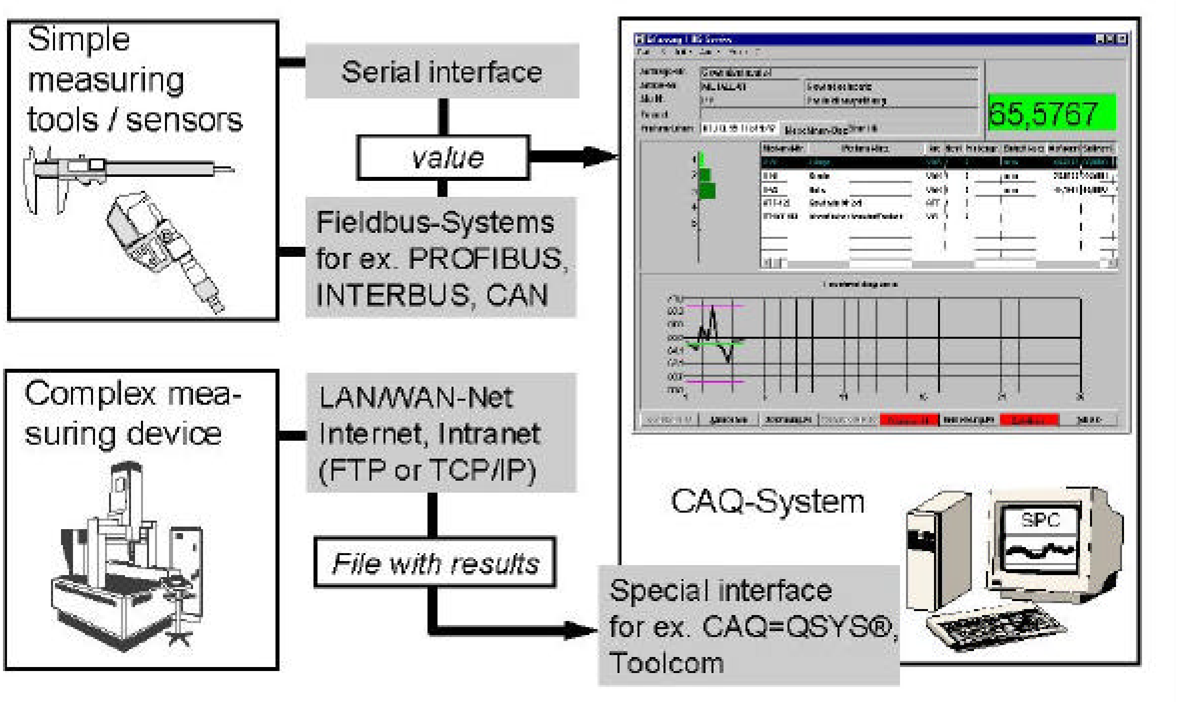

Figure 2. Automatic transfer of measurement data transfer – some possibilities.

In summary it is possible to remark, that there are suitable testing devices for a process integrated inspection of complex workpieces. Protection against and compensation of environmental influences facilitates a measurement with high accuracy in shop floor environment. Today's software tools as well as communication technology support a flexible transfer and evaluation of measuring data.

In the following, an extensive approach will be presented, which makes use of the named capabilities, to obtain an efficient quality management in today's manufacturing processes. This approach can be realized in three successive steps.

4 SCENARIOS, POTENTIAL AND REALIZATION

To obtain a high standard in product quality with today's difficult conditions, it is not sufficient to consider production processes alone. In many cases faults, which cause incapable processes and loss of product quality are made already in the pre-production phases. As an example an unpractical work planning can lead to a machine utilization, in which a critical and difficult feature is manufactured with a machine, that is not capable for this special feature. In many cases exact information about the capability of manufacturing machines for special features is missing in the phase of work planning.

For this reason, an approach must be pursued, which controls and optimizes as well the pure manufacturing process as the anticipated areas. In this context manufacturing metrology plays the part of a supplier of information, which captures the needed data and makes them available for the relevant areas.

The approach is, that all process relevant features - even those of complex components - are measured by the local workers in the production, and that the obtained measuring results are used for an optimization within the whole process chain (figure 3).

In the production itself measuring results are available without time delay and in a corresponding form to fit a process regulation. In this way a quality loop emerges close to production, which allows a quick reaction on process deviations. The correlation between the shaping of features and the process parameters must be well known, to initiate the correct measures. If necessary, the correlation must be determined in pre-investigations using methods as for example design of experiments. Furthermore processes have to be analyzed, at what manufacturing step it makes sense to apply metrology. By this way a supplementary measuring step between two manufacturing processes may first of all appear to cause expenses, but on a higher scale it leads to an optimization of the process and to cost-savings.

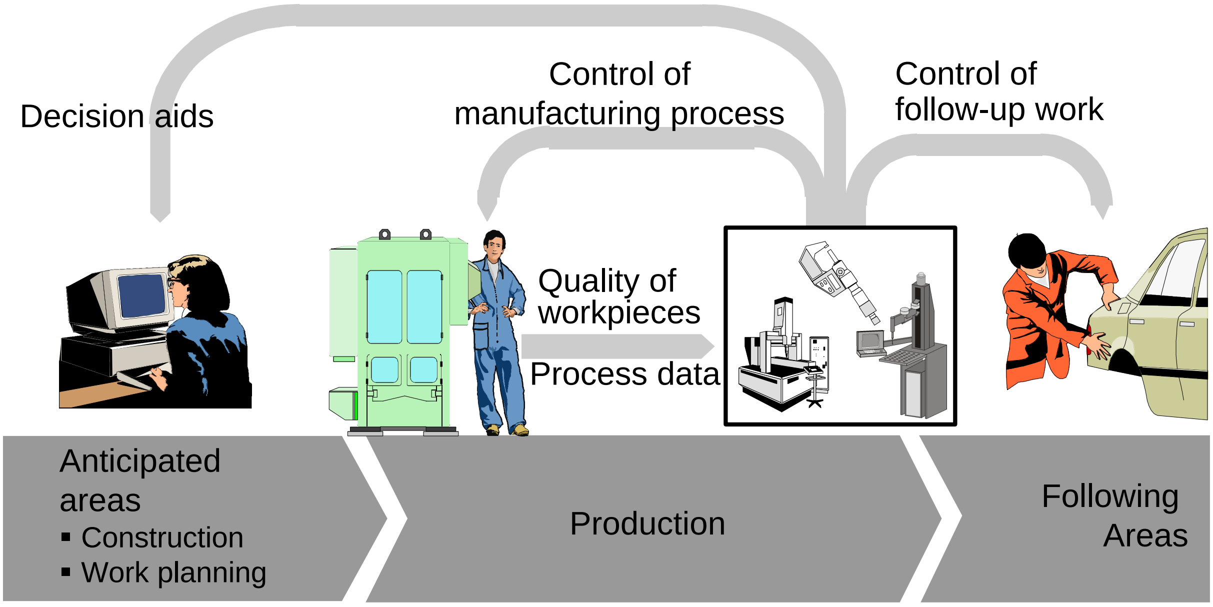

Figure 3. Approach

In addition to the regulation of the manufacturing process measuring data are prepared and transferred into pre-production phases. As an example these data can provide information for construction about the manufacture of critical construction elements or can be used for planning of machine utilization, compressed to capability indexes of manufacturing machines.

In this way a further quality loop gets closed, which includes and optimizes the planning part of the process chain. In this order metrology pays its contribution to the preventive quality assurance, as it creates a greater transparency for the constructor according to the constructability of product components. Especially in cases with a short time-to-market-interval and corresponding production initial periods, manufacture- and assembly friendly construction gets more and more important, because belated modifications come with huge costs and time delays.

In addition to the feed back into the anticipated areas, measuring data can also be used to supply information for following steps. In this manner assembly processes or working cycles can be steered, which makes them much more efficient. This allows, to use measuring results in the assembly to choose suitable construction part pairings, as it is already done in simple assembly processes such as the pair selection of two rings in the production of rolling bearings.

The described approach of a use of measuring data for the optimization within the whole process chain can be realized by several steps, gaining benefit in each step (figure 4).

By the installation of production integrated measuring centers with suitable metrological equipment, it is possible to run a test of all process relevant features and to make an evaluation of these results, for example by a statistical process control, in production. With this simple step it is realized, that the information about the quality situation is obtained close to the manufacturing process, and it is possible to reach a quick reaction on process deviations.

Within a next phase these measuring centers can be connected to a computer network by existing standards of information- and communication technology, such as the TCP/IP protocol for example [6]. In this way, an informational integration is realized, which allows a flexible measuring data transfer for further use and evaluation. So the information about the quality situation can be easily transferred to production far departments as for instance the anticipated areas. This scenario is realizable by connecting measuring systems with the use of standardized interfaces to the company´s PC-network.

The implementation of an efficient kind of quality inspection and process control, that is well integrated into production structure, demands the consideration of the corresponding manufacturing processes already in an early phase of inspection planning. This is the focal point of the third step. To integrate processes of metrology - in consideration of aspects such as machine utilization and production logistics - optimally into courses, a tight connection between inspection planning and work planning is indispensable. For such a kind of process planning there is to process a variety of information, such as data of resources or of manufacturing sequences. That is why an efficient software support of the processes for an integrated inspection and work planning is needed. As both, inspection planning and work planning base on the description of the product and its components, the starting point for these planning processes are construction data. So a continuous process chain has to be realized, that starts with the use of construction data and comprises the phases of work planning, inspection planning and NC-programming.

To avoid information redundancies within these processes and to realize a continuous flow of information, a uniform data model is needed, which is able to map all the information, which are needed and generated within these processes [7].

In contrast to the first two steps of realization, which can almost be carried out completely with systems offered by the market and existing standards, the third step still requires lots of research and development in the area of data modeling and software development. This is topic of actual activities in research and development.

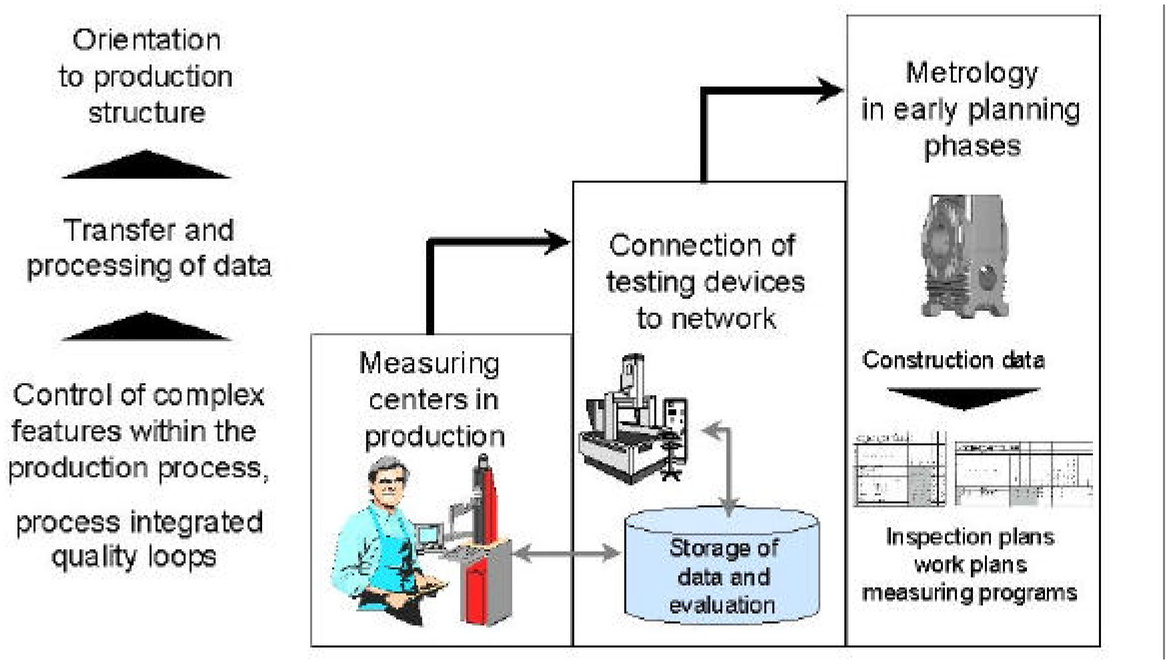

Figure 4. Steps of realization

5 CONCLUSION

New tasks and requirements for manufacturing metrology are caused by increased demands on products and processes. With today's chances in the area of metrology as well as information and communication technology we can meet those requirements. There are flexible testing devices, which allow a measurement with high accuracy in shop floor environment. Modern information and communication technology facilitates a flexible transfer, processing and visualization of measuring data.

For the purpose of an economic and effective control of manufacturing processes an approach is necessary, which comprises and optimizes the anticipated phases such as construction and work planning as well as the pure manufacturing process. For such an approach, manufacturing metrology plays the part of a supplier of information about the manufacturing process. This approach can be realized in several steps of introduction, gaining profit with each of those steps. It starts with an integration of complex manufacturing metrology into shop floor environment. In a second phase an information network can be implemented, that transfers and processes information obtained by measurement. The last phase consists in the realization of a continuous process chain basing on construction data, including work and inspection planning and using a unified data model. This last step still requires activities in the area of data modeling and software development.

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