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NEW EDUCATION STRATEGY IN QUALITY MEASUREMENT TECHNIQUE WITH IMAGE PROCESSING TECHNOLOGIES

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Abstract – The stability of the production process and whose control technologies, is one of the major topics for the quality of the product. Therefore fast measurement technique plays an important role. Actually more than 80% of quality assurance applications are realized with image processing so the annual report of the German VDMA association 2010. So there is a need for the combination of quality assurance and image processing. On the Ilmenau university of technology a new way to educate both of them will be gone. As one of the first steps to communicate that, the name of the department quality assurance was changed into quality assurance and industrial image processing. Furthermore in the new publication quality management for engineers (Qualitätsmanagement für Ingenieure) a separate chapter for image processing was added in this new publication. To underline the need of the combination a practical application for the combination of both was given in the following paper.

Keywords: quality loop, quality control chart, image processing

1. INTRODUCTION

The department quality assurance was founded in 1990 and is integrated in the faculty of mechanical engineering. From the beginning up to now the department focuses on the use and the development of image processing technologies. In the last years the computing power of personal computers becomes attractive for the application in image processing. So the department decided to build a library Quick Image development (QID). This library contains all essential interfaces for camera based quality checks and is especially suited for the use in high precision coordinate measuring machines. The history of the department as well as the need of the new mix between quality assurance and image processing, leads to the decision teaching both topics as well. To enter this new field a short introduction of optical part inspection was given in the new publication “Quality assurance for engineers”. Furthermore several practical examples for student trainings were developed in the last years as well as the lecture called digital image processing part I and part II.

2. QUALITY ASSURANCE VERSUS QUALITY MANAGEMENT

Quality management is the overall process in a company or an institution to monitoring the quality level. Quality assurance means to manufacture material and immaterial products and processes in specified quality, to control and constantly improve processes in specified quality [2, 3, 4].

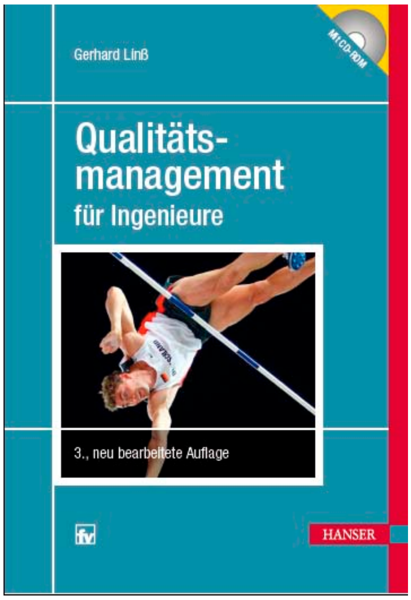

Fig. 1: New publication “Qualitätsmanagement für Ingenieure” – quality management for engineers

So quality assurance was the technical part of the quality management. To train quality assurance and give the students the possibility to get a better understanding the main book [Fig. 1], according to the given lectures and three training books were published.

3. IMAGE PROCESSING IN THE FIELD OF QUALITY ASSURANCE

To point out the strong need of the combination of image processing and quality assurance, in the following chapters an example for an industrial application is given. The methods and the knowledge to realize quality control elements like quality charts, quality loops etc. are contained in the new book. That procedures and the knowledge were applied in this example.

3.1. Quality Control Loops

In analogy to technical control loops therefore quality control loops with Quality Controlled System, Quality Controller and Quality Control Element must be developed.

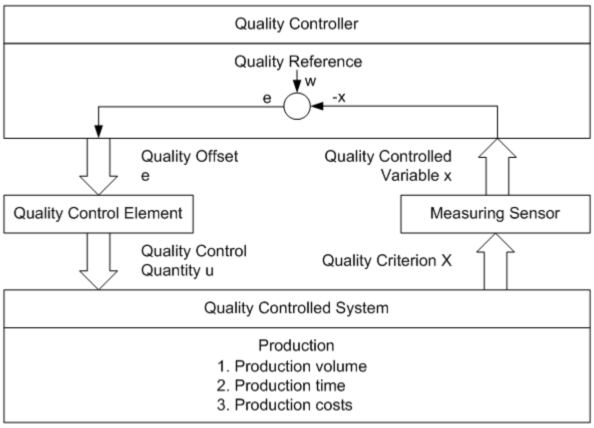

Fig. 2 Components and structure of quality control loops [2]

Quality control loops (Fig. 2) are defined as closed technological-organizational action sequence in a process for the production of a quality product. With view on the whole production process, quality control loops must be divided into small quality control loops and large quality control loops [2, 5].

Small quality control loops are used for current control in the production process by instantaneous influencing control on the individual manufacturing steps. They exert direct influence on quality criteria during their production. They include direct statistical process control (SPC) units in the form of quality control charts. As quality reference for example the desired value and the range of tolerance of a quality criterion are consulted [8].

The overall quality control loop includes all activities from the idea of the product up to the line production process. They are used for subsequent inspection and quality confirmation of the production process by delayed influence. In the application, presented in this paper, the small quality control loop is applied [8].

3.2. Statistical Process Control with Quality Control Charts

Statistical process control is a continuous accompanying monitoring of the manufacturing processes by collection of all characteristic numbers relevant for the product quality. SPC supplies the base data for the recognition of weak points and thus the condition for the constant improvement of the respective processes. SPC developed from the quality control charts technique.

Quality control charts are one of the oldest tools in the quality management and an important aid to the quality control. The quality control chart is a form for graphically representing of measured values taken up by sequential samples [Fig. 3]. They are used for the purpose of the quality control in comparison with warning and/or control limits [6]. The main objective is to recognize promptly error developments for regulative intervention. Examples of quality control charts are shewhart quality control chart, average value quality control chart and median quality control chart.

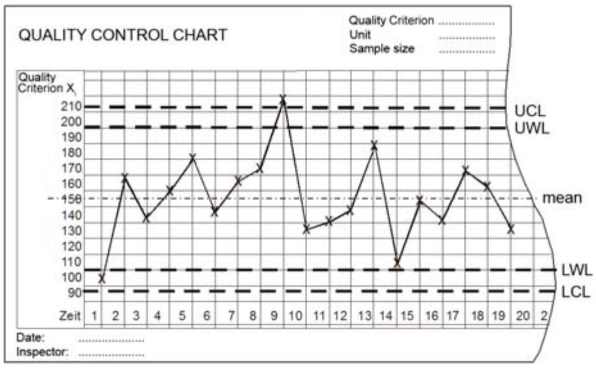

Fig. 3: Structure of a quality control chart (UCL = Upper Control Limit (or Upper Action Limit); LCL = Lower Control Limit (or Lower Action Limit); UWL = Upper Warning Limit; LWL = Lower Warning Limit)

For the definition of the interference and warning limits of quality rule maps the following error bands are used:

- $\alpha = 1\%$ → 99% error band → control limit
- $\alpha = 5\%$ → 95% error band → warning limit

In the 99% error band covers at least 99% of the values of the characteristic. With the fact it is improbable that with an unchanged process values arise, which lie outside of this range. That means, if the values lie within the control and warning limits, the process can be continued without intervention. A Violation of the warning limits leads to a monitoring of the process with increased attention. If the values fall outside the control borders, intervention must take place into the process, in order to guarantee quality of the product. In addition the causes for the change of the process must be examined.

For the successful implementation of SPC four conditions must be fulfilled: data integrity, data traceability, identify critical process parameters and real-time capability [7]. Data integrity means that the measurements must be accurate, so that fluctuations during the process are recognized surely. The traceability to the respective process and product must be secured, so that interferences in the correct place are accomplished. Beyond that the production steps must be recognized, which have a significant influence on product quality. Each intervention into a current process means a interference. The reduction of unnecessary interventions into the process is a goal of the SPC. The presented Inline measuring system on basis of image processing technology fulfils all these conditions [8].

3.2. Application for a Statistical Process Control Using Quality Assurance and Image Processing Technologies in the Quality Control of Springs [8]

In the presented application, the quality control chart represents the quality controller in the quality control loop (Fig. 3, Fig. 4). The set points for the spring production are the length and the diameter. The drives of the production machine and its mechanic system represent the control path. The entry values for the quality control chart deliver an image processing system. So the control loop is closed. Troubles during the control path can be, for example, defective wire or abrasion of the mechanical forming tools.

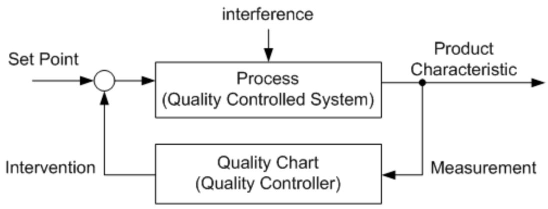

Fig. 4: Small quality control loop using quality control charts for SPC [2]

The novel approach in this application is that the ranges of the quality control chart directly controls the spring forming process. Therefore an upper warning limit and a lower warning limit were defined. Also an upper control limit and a lower control limit were to be used for the control of the process.

Beyond that, the software offers additional support to the operator. In a typical measuring scenario is assumed humans know the item under test and its situation exactly. In the field of technical recognition the algorithm must be able to detect type and orientation of the unit under test.

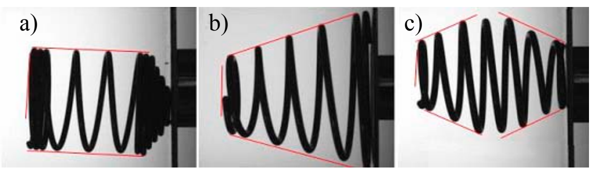

Fig. 5: Different spring types (a: cylindrical spring; b: single-conical spring; c: double-conical spring)

For humans it is relatively easy to differentiate on a single view cylindrical, single-conical or double-conical springs (Fig. 5). The different spring types cover different geometrical boundary conditions, which must be monitored during the production process. The teach-in process of these conditions for inspection is however more difficult for the operator to realize. That leads to the fact, that a manual setting-up of the individual values, depending on the type of spring, increases the danger of operator errors.

In this new approach of software the detection and the classification of the spring type works automatically. The operator only has a one button solution to set up the whole production system. The manual configuration of area of interest (AOI) for the measurement is replaced by the new algorithm. So the operator errors and the teach-in time for new geometric spring forms can be minimized.

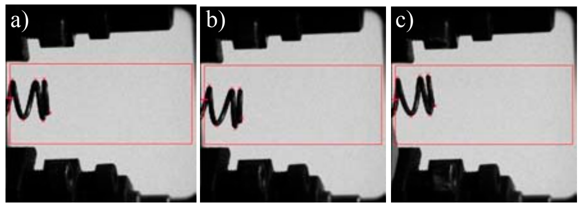

Fig. 6: Images of swinging springs (a: horizontally; b: downward swinging; c: upward swinging)

Another novel algorithm in the software realizes automatic tracking of the measuring points. That means, during the production process the spring can begin to swing and has different orientations. This leads to not deterministically assignable deviations of the spring position of two following springs during the production process (Fig. 6). From it results, that the use of static AOI is not possible in such high-dynamic processes. After the machine configuration the software is able to make a good or bad divisor identification based on the set points from the small quality loop. Furthermore the software generates new setup values for the forming tools during the runtime of the machine. In case of a bad divisor identification a sorting device is steered, in order to segregate the incorrect spring.

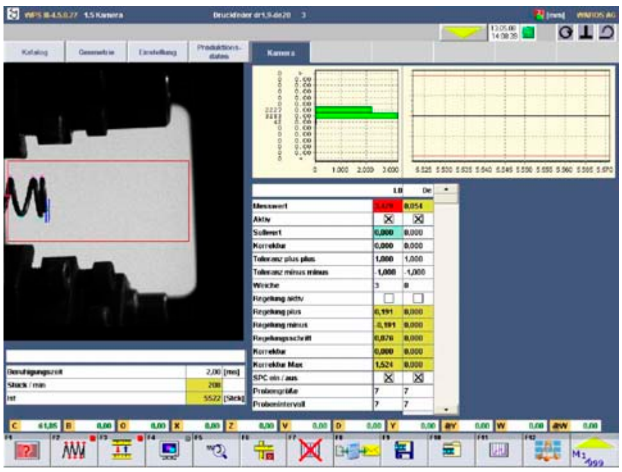

Fig. 7: Machine-integrated image processing software with analysed spring and quality control plan
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The software for statistical process control was integrated directly into the machine control software (Fig. 7). Algorithms compares the quality controlled variable determined by the measuring system (geometrical dimension) with the quality reference (nominal dimension and tolerance). In the case of a quality offset the drive control is readjusted. Different control algorithms can be realized.

4. HOW TO TEACH THE NEW STRATEGY

First of all the students have to absolve the lectures concerning to quality management. In this part quality assurance, technical reliability and quality administration are contained. Simultaneously they have to pass the lectures in industrial image processing part I and part II. If they have done it successfully, they begin with the practical training it is divided in the basic quality assurance skills and basic image processing skills [Fig. 8].

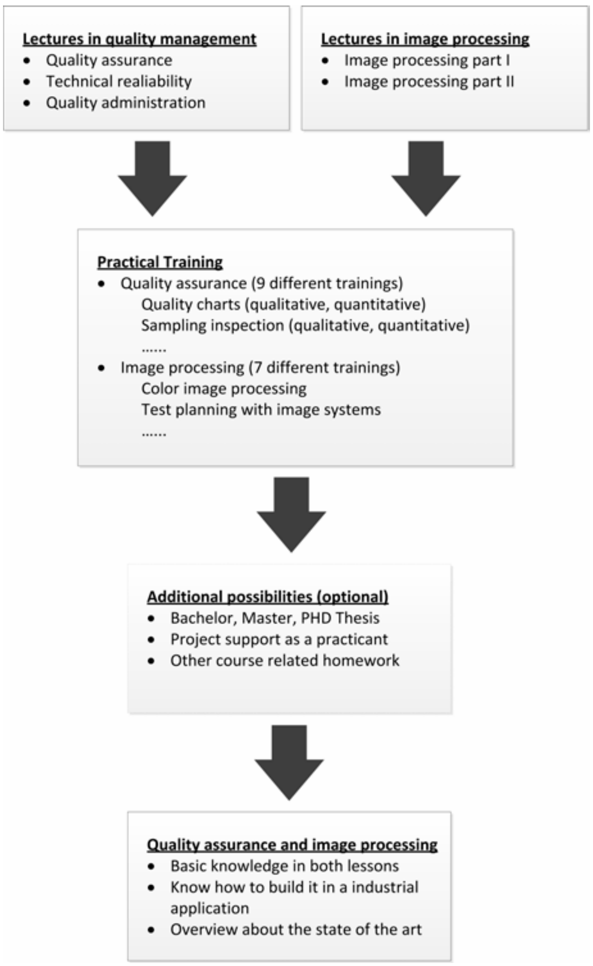

Fig. 8: Flow chart education steps in a combined strategy in image processing and quality assurance

During the practical training the students get the chance to benefit from actual research projects and realized solutions like the application in the example. To learn the theoretical knowledge after the lectures the new publications support them additionally. Afterwards they have the possibility to get deeper in that field of science, doing their Bachelor, Master or PHD degree in the department.

5. CONCLUSIONS

Industrial image processing in combination of quality assurance is a powerful method to monitor the quality of industrial processes. In the given Example a quality control chart combined with a small control loop is used to steering the spring production. The data therefore were captured with an imaging system. This application gains and shows the need of a combined education in the field of imaging processing and quality assurance. The students which pass the lectures in the department of quality assurance and industrial image processing, gets lectures of quality assurance as well as image processing. So there are able to understand the interdisciplinary working principles of both techniques.

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