XVII IMEKO World Congress
Metrology in the 3rd Millennium
June 22–27, 2003, Dubrovnik, Croatia

DIAGNOSTICS AND MEASYREMENTS SYSTEMS IN MANUFACTURING PROCESSES

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Abstract – The paper presents the quality control and quality assurance problems during manufacturing. The main components of the proposed system are: automated manufacturing process control and monitoring of multi-measurements block process.

Keywords quality, manufacturing, diagnostics

1. INTRODUCTION

Quality control is ordinarily associated with manufacturing.

A high level of products quality depends on the monitoring of the whole manufacturing process at every stages of production. In first phases of product formation the activity connected with the quality design gathers the essential meanings. In the following stages of production a part of quality planning decreases.

One of the most important statistical applications for engineers is statistical quality control. This importance is due to the nature of engineering itself, which is largely concerned with the creation of things, the operation of processes or the design of public works and facilities.

Final products must adhere to the engineer's specifications, the components and materials from which they are fabricated.

There are two major groups of statistical method for quality control. Acceptance sample is usually concerned with items obtained from vendors or suppliers, although manufacturers often apply the same methods to production batches. The objective of acceptance sample to production should be accepted or rejected. A manufacturer also wants to ensure that the production process operates as intended. For this purpose control charts are used to monitor current production on a real time basis [1].

The fundamental background for understanding of statistical quality control has been provided in the earlier publications [2]. Statistical quality control embodies many of the basic concepts and methods of descriptive and inferential statistics. As in earlier applications, parallel methods are employed, depending on whether the data are qualitative or quantitative. In evaluating qualitative data the proportion is used, whereas several measures are employed with quantitative data, including the mean, standard deviation and range.

A high level of products quality depends on the monitoring of the whole manufacturing process at every stages of production. In first phases of product formation the activity connected with the quality design gathers the essential meanings. In the following stages of production a part of quality planning decreases. The quality control dominates. A classification of main functions realized in system of quality assurance is:

- Quality designing.
- Quality planning.
- Quality control.

Three main areas, separated here relate as well to the traditional and to computer aided manner of quality assurance.

A very important activity is to keep the continuous flow of information in all phases of production. It should assure that quality of realization responds to quality of design. In the control process the quality control should be conducted not only after process (off-line), but also during process (on-line). In this manner the control circuit is realized, directly connected with production process on the machine tool. That permits the enrichment of information used in the phase of product and process planning and designing.

Practically, the realization of information flow in the Quality Assurance Systems relies on the integration of CAQ module with other modules of system. Measuring data can be introduced to computer by hand, from keyboard in the interactive mode, automatically from devices operated by hand or in the full automatic cycle, where computer controls the whole process. In the modern quality control systems the orders of inspection and measurements plans computer, connected with measuring system receives by net with CAQ system. After carrying the analysis out the measurements results are sent in the inverse direction.

The main components of the presents in the paper system are:

- Automated manufacturing process control.
- Monitoring and multi-measurements block process .

In the computer integrated automated production systems the identification and prediction become the essential factors of the technological quality assurance of products [3]. The properly comprehended quality control is a collection of the ordered monitoring of the present obtained state and the expectation of a changing trend of its state for the purpose to the quality improve.

2. MULTI - MEASUREMENT SYSTEM

Fig.1 presents the computer aided system for certain shape and position surfaces errors analysis for quality assurance.

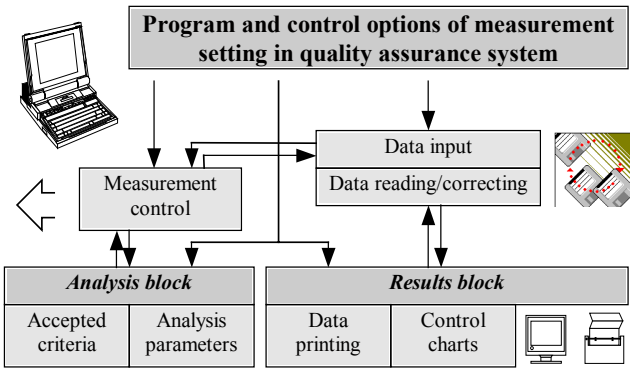

Fig. 1. Block diagram of the monitoring and controls system

At least two subjects have to be analysed to obtain full information on real geometry of elements:

1. Criterion of shape errors assessment.
2. Assessment of measurement method accuracy.

The first item has been analysed from the point of view of optimisation of at least two independent elements assembly.

The last item is essential in tests of very precise elements e.g. relating to CMM. Both subjects are considered in the work.

Computer analysis of basic geometric parameters of precision elements are presented in the paper.

Shape deviations were analysed: contour, geometrical structure, straightness or flatness of supporting surface and its position deviations in the accepted reference system, mutual position. The computer program hereby developed makes possible to estimate on accepted criterions.

Mechanical design of CNC machine tools (especially machining centres) and measuring machines (CMM) are fairly similar. In both cases there are slide ways enabling displacements of machine units along axis (usually perpendicular to each other). It is therefore obvious that description of errors caused by not ideal displacements of moving units will be also similar. So the techniques and measurement methods aiming to identify these errors will be applied. In both cases accuracy of displacements of moving units can be determined, taking advantage of position errors in measuring points.

The position error has both „spatial" and „vector" aspect although displacement is carried out theoretically only along one axis of a co-ordinate system. Position error is mainly caused by manufacturing errors of slide ways and units which move on them. Consequently, a tool or a measuring probe actually moves along a spatial profile instead of a straight line (assuming one axis motion). Deviation from a straight line is characterised by the position error.

Measurements of the above mentioned errors have to feature high accuracy if the results are to be used as a basis for a machine tool settings correction or a CMM software correction of errors.

The main functions of the measurement setting system are as follows:

- Communication with the measuring CCD camera or laser systems through the interface for automatic data collection (measurement results for processing).
- Data analysis basing on accepted geometrical criteria for elements.
- Graphical representation of the obtained results (correction values).

The block diagram of the measurement analysis system is shown in fig. 2.

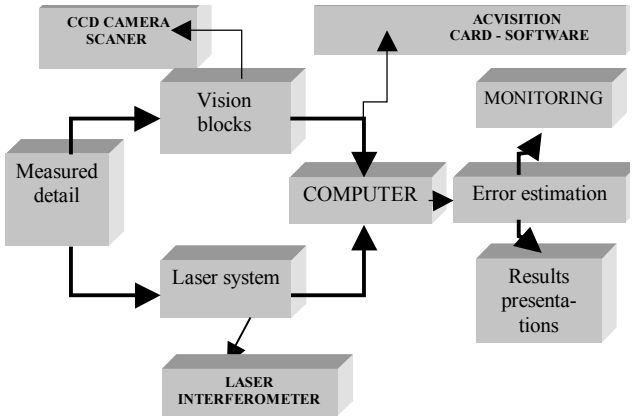

Fig. 2. Analysis block diagram

The block of the measuring system is responsible for:

- Measuring system control.
- Setting the task parameters (kind of shape error to inspect, way of determining positioning error of the travelling unit, travelling unit movement control parameters).

General version enables to evaluate the shape contour errors, geometrical structure of straightens and flatness of elements surfaces, their distance variation (including relative orientation), movement velocity, its fluctuation of orientation of the travelling unit, (in two perpendicular directions) during its linear motion. The above can be measured with the usage of specially designed measuring system with the laser multiaxis interferometer.

Other options of this part of the program are used for data input and corrections, forming analysis files and creating base measuring line, e.g. in the case of flatness errors, the base measuring line parameters are given at first, then each measuring point coordinates the shape of the relevant segment.

Procedure „analysis" comprises of two main pairs. The first one concerns shape and position errors, whereas the second one includes positioning and movement parameters.

Shape and position errors are represented by: contour, geometrical structure, flatness, straightens, parallelness, orthogonality. The above are the subject of the analysis. Nominal conditions and assessment criteria are determined by the design and manufacturing requirements, including the shape of the element. Straightens and flatness errors are calculated in accordance with the relevant standard, parallel ness errors is directly connected with the reference surface

in the measuring sub-area. Measuring points which determinate the reference coordinate system and the non - parallelness vector are evaluated. The non - parallelness is defined as the variation of the distance between the surfaces or the planes representing them. Having the sub-area on the plane F the point P on the plane f (fig. 3), and the vector OS of the measurement direction, the distance from the point P∈f from the plane F in the OS direction can be calculated (1):

$$NP = \alpha x_0 + \beta y_0 + \gamma z_0 + \delta \quad (1)$$

where:

α, β, γ - direction cosines of the vector $\bar{n}$

δ - vector measure in OS axis

The values of flatness and parallelness deviations depend on the choice of the reference. Depending on requirements, functions and kind of the translation kinematics pair, various reference planes can be taken, differing in respect of spatial orientation to the inspected surface. The program is designed to perform analysis related to the following planes: mean, adjacent, nominal or user's (defined mathematically).
The second part of the program using the obtained data (angular and linear position of the travelling unit in time function) and basing on accepted criteria evaluates the following parameters:

- Linear and angular positioning in a given point.
- Velocity and its variations, distances in definite time intervals.
- Angular and linear position of the travelling unit in definite time intervals.

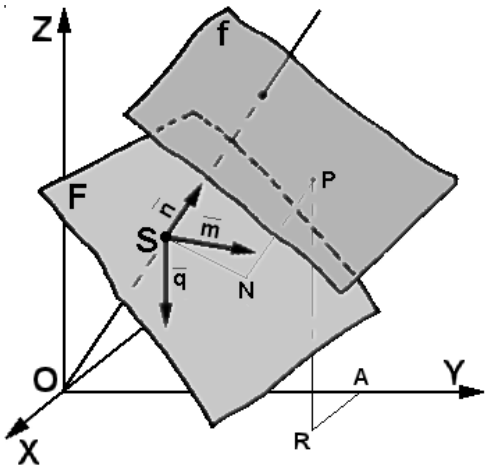

Fig. 3. Determination of the distance between surfaces

3. REPRESENTATION OF THE RESULTS

The research-measurement set-up for the precision analysis of the defined positions is shown in fig.4.

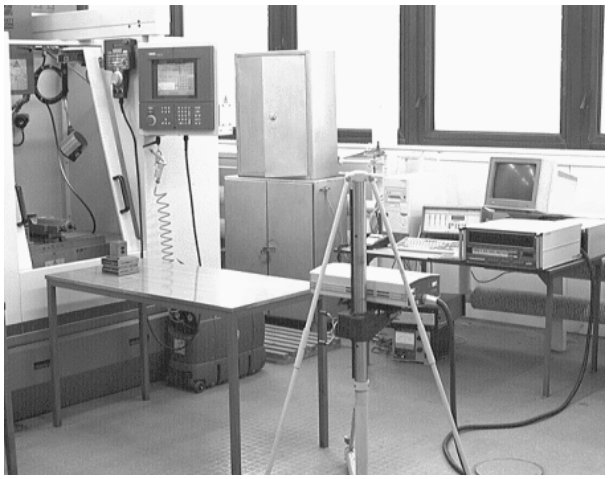

Fig. 4. Research-measurement set-up

The results of performed analysis are presented in graphical form as 2D or 3D graphs. Shape errors of contour and geometrical structure of the diagnosis element are presented as deviation in axis X or axis Y (fig .5), and position deviation in fig. 6.

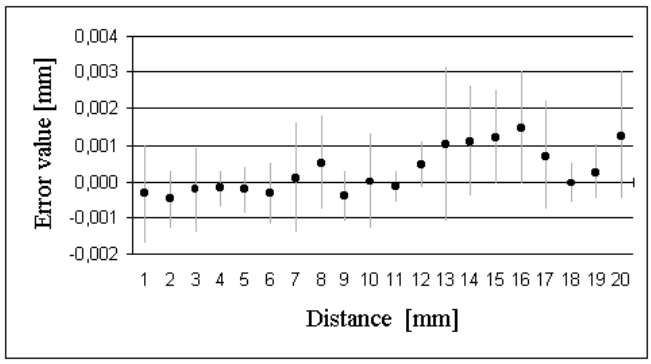

Fig. 5. Shape errors of contour and geometrical structure of the diagnosis element in axis X

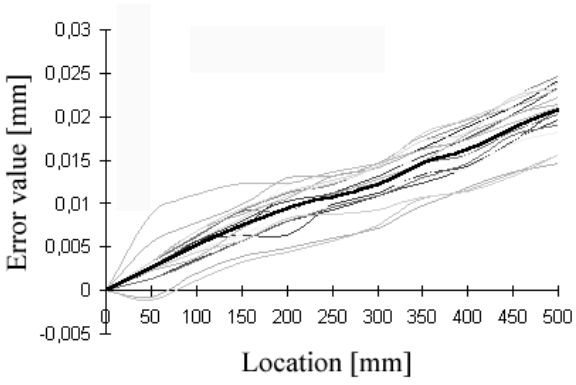

Fig. 6. Position deviations for table movements of the machine tool

Additionally, the program generates a 3D picture of the analysed elements, taking into account their actual mutual position and orientation in space.

3. CONCLUSIONS

The main functions of the proposed control system are:

- Automation and communication with the measurement system.
- Control and communication with units or elements, drives of inspected machine.
- Programming data for analysing based on accepted criteria.
- Machine tools or units data correction verification.
- Calibration and quality assurance (guides position correction, calibration of travelling units).
- Representation of obtained results.

The system makes possible quality assessment of processing devices elements. The system of assessment may be applied for various type of processing devices (machines) with free configuration of assembly elements (unit) and its task is to improve operational properties of the equipment at the stage of final technological inspection in quality ensuring systems.

Full description of both CMM or machine tools units error requires determination of 18 components of the error. These component errors can be measured with the usage of laser interferometer systems.

The program may cooperate with any measurement control device and makes on essential link in the system of quality assessment and control of high precision machines.

Basic functions of the program are:

- Data collection from measurement device and formation of relevant files,
- Data analysis based on adequate describing functions,
- Assessment of assembly elements or moving structure basing on accepted criterions,
- Assessment of measurement method accuracy,
- Results presentation in the graphic or analytic form.

Program controls the measurement system and co-operates with analysis and correction data blocks.

The developed computer analysis system based on assumed criteria, enables to perform a qualitative and quantitative analysis of the moving elements of certain processing machines and robots.

The assessment criteria were based on existing shape and position elements errors and assumed permissible tolerances of kinematics parameters.

The presented setting system also provides an automatic control of measurements and data analysis with graphical presentation of results.

The control measuring system permits cooperation with the different measuring blocs. The received pictures in the form of digital files can be compared between themselves and superimposed with the detection of the outside outlines and calculation distance between characteristic points. The worked out system cooperates with the CCD cameras in the 3D arrangement. It can be applied in the wide range in biomechanics for the analysis of the natural biological mechanisms, particularly the non-contact measurements of the elements' shape of nature.

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