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SOME POSSIBILITIES OF USING SPC IN CAQ SYSTEM

Summary. The main features of a computer program designed to aid the machine tool operator and other staff involvents in quality assurance system has been described. The program can be applied for data acquisition, data processing, process stability analysis and data transfer to other parts of enterprise information system. A proposal of a several levels CAQ system with different competencies about decision-making towards process improvement has been presented as well.

1. Introduction

Until quite lately Statistical Process Control (SPC) was a term used only by a small group of specialist being in charge of Quality Assurance in various factories. In connection with modern understanding of quality assurance SPC achieves nowadays importance and general meaning with respect both to production technology and different fields of human activity [3]. But to the rapid development of SPC contributes first of all the more and more common use of PC's.

SPC allows the organisations to confirm customer requirements closed in international quality standards (ISO 9001-9004). However, the need of using SPC in the production results not only from the outside market requirements. The other and perhaps the most important reason is that SPC may contribute to a substantial increase of production efficiency. SPC is a strategy for reducing variability, the cause of most quality and productivity problems. The majority of technological processes consist of sequences of different operations, e.g. plastic working, heat treatment, machining e.t.c. during which the form, dimension and mechanical properties of the input material are changed. Inevitable heterogeneity of material characteristic, variation of environment factors, tool wear and inaccuracy of machine tool cause, that the above stated process outcomes show a variability, which finally deteriorate the product's quality.[1,2]

The scattering of process outcomes may be due to random and assignable or special causes (sources of variation for which an explicit reason exists). The typical reaction of machine tool operator when he finds that certain outcome lies outside a specified tolerance limit consist in machine tool setting correction. Only in few cases, as result of his experience, such behaviour is proper and improves the process stability. In the majority of cases however, the exceeding of the specification limit is rather accidental and its revelation should be considered in categories of probability. It means, that the straight operator's reaction is not useful and may cause an increase of process outcomes displacement outside the field of tolerance range. After several groundless corrections of the machine tool setting a destabilization of the process may occur. It may cause scattering of results in whole range of the tolerance or even to increasing the risk to get a value outside from tolerance area.

The situation described above does not appear if the corrective actions of the machine tool operator's will aided by information arising from control charts, which are one of the most important elements of SPC. A control chart is a graphical method of recording data in order to readily distinguish between random and assignable causes of variation. The characteristic feature of control charts is that the recorded data is not a single measuring point but a mean value of a sample. These elements are tested after a fixed period of time.

There are so called control limits plotted on the chart which separate the zones of process stability, Fig 1. The formula for setting these limits are:

$$UCL, LCL = \overline{X} \pm K \cdot \frac{s}{\sqrt{n}}$$

where:

LCL, UCL	- lower (upper) control limit
$\overline{X}$,s	- mean value (standard deviation) of the stable process (variability due to random causes only)
n	- sample size (usually n=4÷5)
K	- factor fixing the risk of not detecting the mean value change (usually K=3).

From the above equation it is easy to notice, that sensitivity of control chart to detect the shift of process mean values depends on process standard deviation (s), sample size (n) and control limits setting (K). The two last factors are chosen arbitraly by the control chart designer or directly by the machine operator. If the control limits are too wide and the sample size too small, an undetected non conformance may occur (the individual process output parameters lie outside the specification limit without detection it on the control chart). An situation, in which the distribution of the individuals just touch the lower specification limit, has been illustrated in Fig. 1.

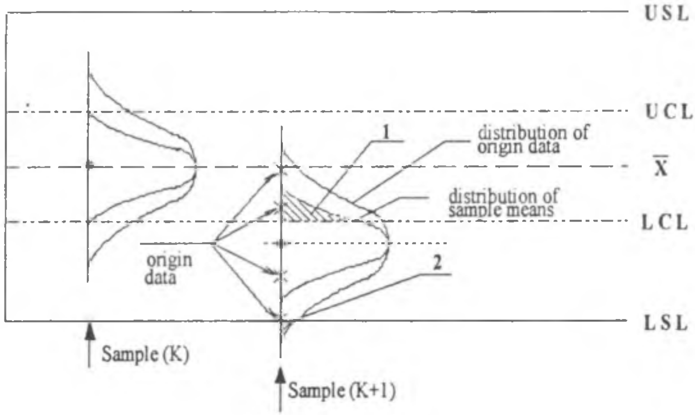

Fig. 1 Principle of mean control chart

1. The risk of not detecting the mean value shift
2. The risk of non conformance process outcome

With narrow control limits and large sample size, the mean value tends often to exceed the specification limits. In consequence of that the process has often to be corrected, what is not advantageous for the process stability.

2. New procedures for SPC

It is not easy to find an optimal set-up of the control chart. The are no general rules for calculating the sample size (n) and the factor K. They are theoretical a function of the process condition and quality requirements. In practice, independently of process performance condition, the sample size n =5 and factor K = 3 are common use. Such arbitrary choosing of setting parameters do not allow to utilise the full possibilities of SPC towards process control and improvement [3].

The setting of the control chart parameters can be effectively aided with the use of a purposeful computer program. Such computer program is described bellow. Its flowchart diagram has been shown in Fig. 2. It is destined to the aid of various actions performed by the machine tool operator and other staff involved in quality assurance system. The program can be used for data acquisition, data processing, process stability analysis and data transfer to other parts of quality systems.

Apart from the possibilities offered commonly through computer SPC software, the presented program contains some additional tools. The procedures of checking the distribution of the measured population are an important part of the program. They allow to find a distribution best conformed to the current measured data-set. Knowledge of distribution parameters of such allows to choose an optimum value of sample size (n) and UCL and LCL limits. A special analysis method - worked out by author - make possible, that the sample size and limits setting can be calculated according to permissible risk level of exceeding the specification limits by the individual process outcomes (compare Fig. 1). It is very useful, specially for processes with unstable processing conditions, that the control limits and sample size can be corrected very easy at any time during the process performance in order to minimise the risk of deficiency occurring. The current control chart parameters are estimated with consideration of the value of capability indices (Cp and Cpk).

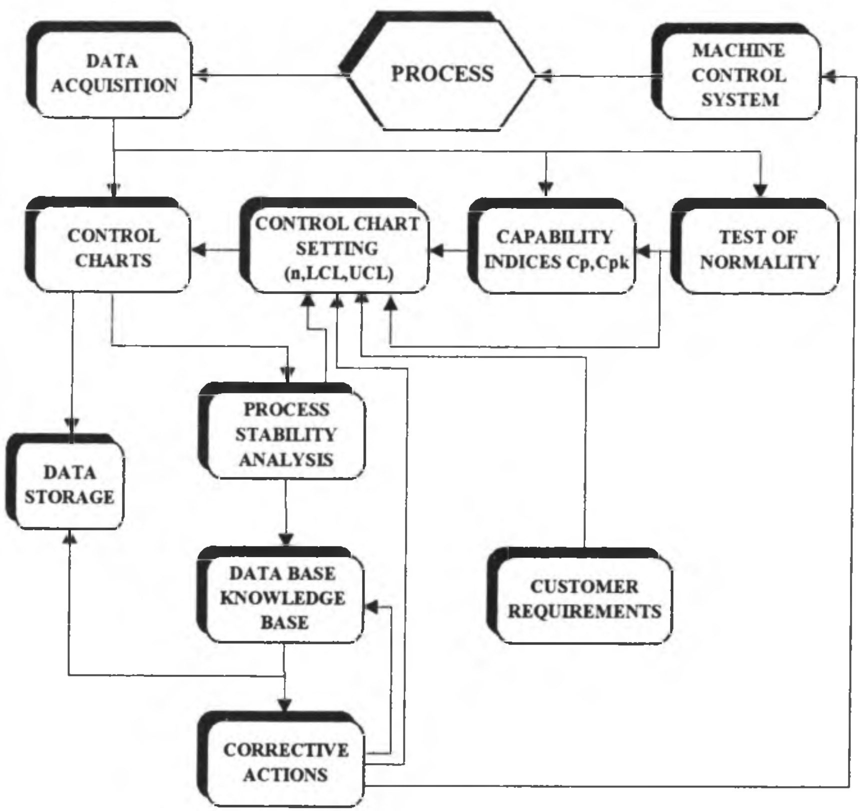

Fig. 2.Flowchart of the program for SPC

Efficiency of SPC application depends on ability to create the feedback between the SPC station and machine control system. It is connected with possibility to find the connections between symptoms revealing on the control chart (e.g. mean value which lies outside the control limit, trend of values of the sample means etc...) and the reason which caused the process instability. Only a few cases it is possible to find without a considerable investigation a causal connection between a symptom on the control chart and a assignable cause disturbing the process.

In many cases to create a data base containing the description of all events recognising during the process performance seems to be a best solution. An event means here each process non conformance with any aspect of the specification limit. The presented program allows to gather all the events in a data-base, which has a structure given below:

Data	Hour	Feature	Symptom	Reason	Response	Efficiency
03:03:94	08:00	03	05	03	10	3
.....	....	.....	....	....	.....	....
03:03:94	10:30	01	02	02	09	0

The two first record fields contain the information about the time at which the event occurred. In the following field there is the code of the feature saved (e.g. code 03 means dimension deviation), for which the event was identified . The next field contains description of the symptom appearance on the chart which allows to recognise the process instability (for example the low probability of occurrence of the current values sequence of sample means). Into the next field the reason of the recognised event is written down (for example the code number 03 describes the maladjustment of the on-line measuring instrument). In the field titled "response" the code number of the action taken through the operator in order to eliminate the assignable causes of process instability is placed. The response can mean for example the exchange of the tool or machine resetting. The last field "efficiency" is filled up by the operator with his evaluation - in a 5 -degree scale - of efficiency of undertaken action.

Data base defined in that way describes the process history and is continuously complemented. The five factors: feature, symptom, reason, response and efficiency are ranked (using Pareto Analysis) in order to distinguish the vital few and the trivial more relationships. In this way the operator is in possession of an useful tool for supporting him while decisions making towards process improvement.

3. SPC as an element of CAQ-system

Enterprises using SPC have often considerable problems with reasonable utilisation of the processed data. Usually the information received from control chart are used purely for creating the feed back, mostly with a human operator as the intermediary between SPC-station and machine control system. In other words the area of SPC influence does not step over a single SPC workstation and is limited to common machine tool corrections. Many users say they are helpless trying to use the processed and collected information for making strategic decisions about such actions as: partial re-equipment, change of suppliers of semi-finished blanks or materials, additional staff training etc.

Making of such decisions, based on information arising in SPC system, would be particularly efficient in a computer system, consisting of several levels with different and various competencies about recommendation towards process improvement. Hardware structure for a three levels system is showed in Figure 3

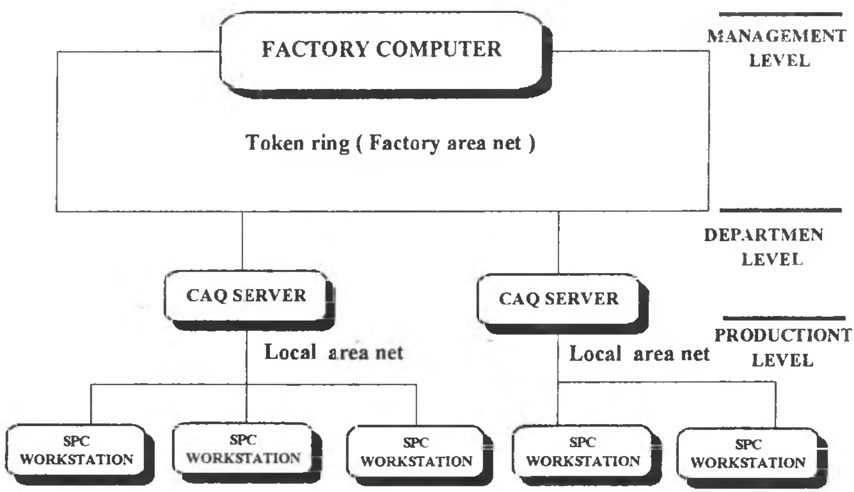

Fig. 3. Structure of three-level CAQ system

The tasks which are performed on each system level are described in the scheme in Fig.4.

The lowest level concerns the direct production and relates e.g. to: a short production line, work centre or single machine tool. It contains simple SPC stations adapted to machine tool operator's qualifications with common servicing, simplified keyboard and user-friendly menu program. The symptoms reveal on the control charts and messages connected with them are projected -if necessary - on the screen and used for the human operator to undertake suitable actions such as: machine tool setting correction, tool changing, machine stopping, consulting the problem with department supervisor etc. To maximise the efficiency the operator can use the knowledge base, described in the previous chapter.

A very important feature of SPC stations is the form of data acquisition. The simplest way of that is the data read-out by classical measuring instruments (with analog or digital reading) and then manually input the data to the system from key-board. In the future automatic data acquisition should be preferred. Computer and measuring devices can be connected by using standard cards with analog -to-digital converters, filters, measurement device controllers etc.

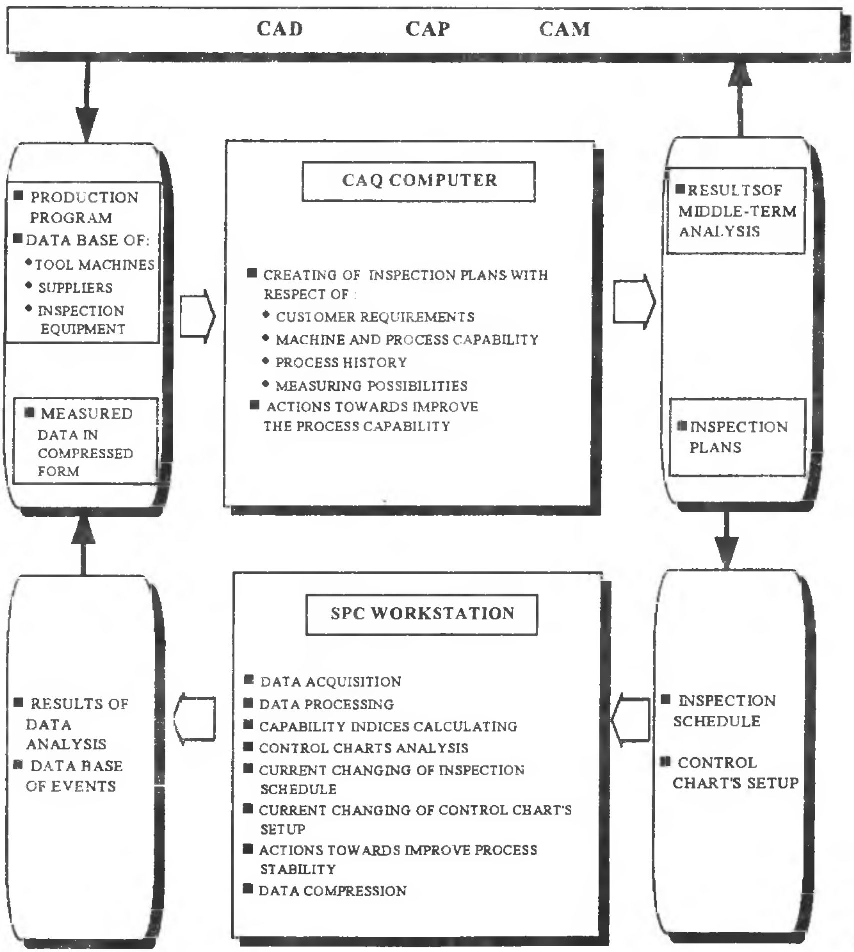

Fig. 4.Tasks being performed at various levels of CAQ system

From the CAQ - host computer, located on the middle system level, inspection plans and all necessary information connected with them are transmitted to SPC workstations. In CAQ host computer the data from SPC workstations connected to them are stored as well. They are used further for performance the middle term analysis. The computer software at this level uses the results of these analysis to make decisions which a machine tool operator cannot make directly, because of lack of information and skills. This may be such decision as: recommendation to modernise the machine, measuring instrument validation etc..

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The results of middle term analysis are transmitted in a compressed form to the factory host computer at the highest system level. The management uses them for making strategic decisions such as: machine tool stock changing, materials supplier changing or semi finished products supplier changing. Outside information (for example from customer) is also collected on this level as well. It allows to verify design parameters of the product or production methods.

The presented several-levels CAQ system is only one of the possible solutions. It should be adapted to specific enterprise conditions . For example, for SPC using within a simple production system, all system levels may be combined into a single workstation. If production conditions are not noxious for computer, special SPC workstation can be replaced with PC equipped with a special software.

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