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SUPERVISION AND CONFIRMATION OF COMPLEX MEASUREMENT SYSTEMS BY USING OF INTELLIGENT TECHNOLOGIES

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Abstract – The permanent increasing of quality standards, world wide competition, as well as the legislation of regulation of the product responsibility, require not only a proper documentation of the measurement data of the production, but also the continuous supervision of measuring and test equipment. Especially in modern flexible and intelligent production environment, measuring devices are often connected directly with the manufacturing process. This causes direct or indirect influences on the quality level, therefore the supervision and management of measuring and test equipment is becoming a significant part of the quality management for the entire production.

The supervision of measuring equipment is an essential quality requirement for modern production especially at the higher demands of micro and nanotechnology. The efficiency of the confirmation can be increased and expenses can be reduced substantially through computer assistance with flexible checking intervals. A special method developed for this purpose allows increasing of the flexibility level and efficiency of a system for the intelligent management and supervision of measuring devices.

Keywords: supervision measurement systems, optimum checking interval, artificial intelligence

1. INTRODUCTION

In modern industrial production system it is often necessary and important for the quality of products and processes to confirm and control measuring and monitoring devices. The international standards in the field of quality management systems ISO 9000: 2000 family also require to establish a comprehensive control and confirmation system for the measuring devices [1, 2, 3]. Measuring and monitoring devices shall be used and controlled to ensure that measurement capability is consistent with the measurement requirements. Measuring and test equipment connected with the production flow, are subject to a relatively high wear through constant use. Therefore a universal function capability for the entire production flow is absolutely necessary. This confirms the necessity of regular examination and documentation of these measuring devices. But it is possible that unused measuring and test equipment lose their fitness for use through physical or chemical influences. Also new measuring and test equipment may have errors and they are subject to wear at later stages of use.

The monitoring and measuring equipment shall:

- be calibrated or verified at specified intervals, or prior to use, against measurement standard traceable to international or national measurement standards.
- be adjusted or re-adjusted as necessary
- be identified to enable the calibration status to be determined

The validity of the previous measuring results will be assessed and recorded when the equipment is found not to conform to requirements. The organization shall take appropriate action on the equipment and any product affected. Records of the results of calibration and verification shall maintained.

2. INTELLIGENT SUPERVISION OF COMPLEX MEASUREMENT SYSTEMS

All measuring and test equipment according to the scope are to be examined in determined distances. The examinations are to be determined in virtue of type, stability, intended purpose and utilization frequency of the measuring and test equipment. The intervals are to be determined in that way, that a calibrating ensures, before a change of the precision, which is for the use of the instrument of meaning, enters. Legal instructions (e.g. law of adjustment) determined checking intervals might be overstepped thereby in no case.

On the basis of results of preceded calibrations the intervals are to be shortened if necessary, to secure the precision continually. They can be also enlarged, if it from the results of calibration clearly emerges, that this measure the trust in the precision does not hurt the measuring and test devices. The system must ensure, that the measuring and test equipment will be calibrated according to the determined timetable [3]. If the checking interval is overstepped, the measuring devices have to be marked and blocked for the further application.

If instruments are used without any practical experiences, so the interval can be determined only approximately. In that case it should be considered the experiences of the similar instruments as well as the different factors appearing at the measurement elements. In case of doubt, the interval is to set shorter as it is anticipated and to correct in virtue of the next examination if necessary [4].

"Optimal Interval" is that one where the total costs is a minimum. If the interval is chosen too small, the checking costs goes up, because there are more checking in the equal period than necessarily. If the interval is chosen too large, there raises the probability to find the measuring and test equipment as "inadmissible" at the next checking. This means in other words, that longer time would be examined with an inadmissible measuring equipment and sank thus the quality of the delivered products. Poor quality is joined always with a rise of the costs [5].

The size of the optimal interval depends on a number of different elements: frequency of utilization, mode of using, behavior of abrasion, consequences at lapses, permissible tolerance range, number of the users, status in the calibration chain, etc [6]. Since these elements are not temporal constant, the optimal interval cannot be a constant size.

Through the dynamification of the checking interval is possible to arise the level of flexibility from the measuring equipment management system. Taking distance from stare checking interval, means of course an increased expense for fixing the interval. However the dynamification allows optimizing the measuring expenditure and to increase the reliability of the measuring and test equipment.

The supervision and confirmation of complex measuring equipment is an essential quality requirement for modern production especially at the higher demands of micro and nanotechnology. The efficiency of the confirmation can be increased and expenses can be reduced substantially through intelligent confirmation systems with flexible testing intervals.

For this purpose has been a special method developed, which is based on the artificial intelligence [8]. This method is based on the demand, to consider on the environment conditions of the past as well as of the expected future. This happens exclusively through the application of fuzzy-logic, a polyvalent logic, which operates mainly with linguistic variables [9].

Three input variables shall result an output variable, which means that there is a three-dimensional model shown in “Fig.1”. In this case the curves of the affiliation functions become a surface. However the graphic representation of such surfaces is difficult. Furthermore the handling is unclear and extensive. Therefore the model is analyzed into two-dimensional subsystems. The two input variables “application” and “abrasion” are associated with each other and result the output variable “operating conditions”. These two variables are the inputs of the second logic sequence. The output variable will be determined as an “optimum interval”.

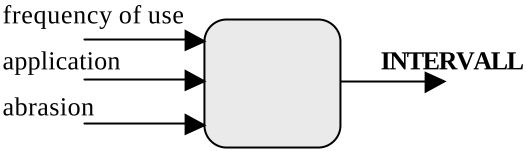

Fig. 1. Three-dimensional model

Measuring equipment management systems also can assist in the lending of the measuring equipment from the store. Furthermore each measuring equipment will be marked according to its whereabouts such as:

- blocked,
- in operation,
- in the store,
- under repair,
- scrap,
- not traceable.

As a first step, checking plans for groups of measuring instruments shall be prepared. These can be associated with the basic data of the individual measuring equipment. Checking plans for certain groups of measuring equipment should be stored under the respective group number, so that they can apply to all measuring equipment of this group.

The intelligent confirmation and management of measuring equipment provide a specific record of checking results to each measuring device. For each measuring equipment recorded in the database control charts displaying the results and the judgment of the finally accomplished test shall be laid out. At variable features values appear in their nominal value with relevant specification of tolerance. The actual deviations are to be entered with a corresponding sign. A more automatic variance comparison produces a finding in the form "ok" or "not ok". The automatically prepared finding should be changeable by the user. At attributive features only an entry of the form "ok" or "not ok" appears.

The evaluation function of the system should give an overview of the individual history of the measuring equipment. This allows the observation and analysis of the development of a measuring device according to its characteristics. The results of the last test as well as the entered deviations should be indicated. At variable features the measuring behaviour can be presented additionally in the form of a graph.

3. DETERMINATION OF FLEXIBLE OPTIMUM CHECKING INTERVAL

A very sensitive criterion for the continuous monitoring of the measuring instruments is the checking interval. Checking interval is the distance between two tests following each other. It is also important to determine the confirmation intervals of measuring equipment, because all relevant influence quantities, e.g. intended use or claim, should be taken into account. In general the checking intervals can be determined as time interval, as limit of the number of the uses or as combination of both. All measuring and test equipment according to the scope are to be examined in determined distances. The examinations are to be determined in virtue of type, stability, intended purpose and utilization frequency of the measuring and test equipment.

On the basis of results of preceding calibrations the intervals are to be shortened or lengthened to secure the continuous precision. To get an adequately small uncertainty of measurement, the confirmation intervals should be chosen as short as possible but, on the other hand, this will lend itself to a high rate of equipment utilization [10]. The system must ensure, that the measuring and test equipment will be calibrated according to the determined timetable. If the checking interval is exceeded, the measuring equipment has to be marked and blocked for further application.

If instruments are used without any practical experience the interval can be determined only approximately. In that case the experiences of the similar instruments as well as the different factors appearing at the measurement elements should be considered. In case of doubt, the interval is to be set shorter than anticipated and to be corrected in the next examination if necessary [5].

"Optimum Interval" is one where the total costs are a minimum. “Fig. 2” shows the costs development as a function of checking interval. If the interval is chosen too small, the checking costs go up, because there is more checking in the equal period than necessary. If the interval is chosen too large, there raises the probability to find the measuring and test equipment as "inadmissible" at the next checking. This means, that longer time would be used with an inadmissible measuring equipment and thus the quality of the delivered products would be low. Poor quality always implies an increase of costs.

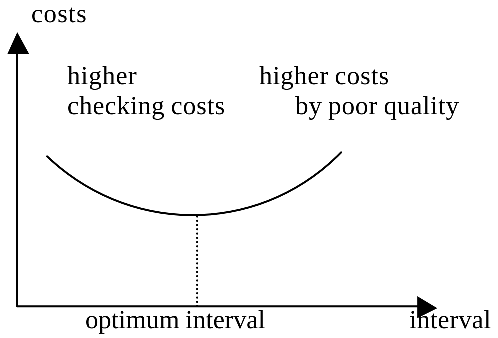

Fig. 2. Optimum interval

The size of the optimal interval depends on a number of different elements: frequency of utilization, mode of using, behavior of abrasion, consequences at lapses, permissible tolerance range, number of the users, status in the calibration chain, etc. Since these elements are not temporal constant, the optimal interval cannot be a constant size.

4. INTELLIGENCE MODIFICATION OF CHECKING INTERVALS BY USING FUZZY LOGIC

Through the dynamification of the checking interval it is possible to increase the level of flexibility of the measuring equipment management system. Refraining from fixed checking intervals naturally means an increased expense for fixing the intervals. However the dynamification allows optimizing the measuring expenditure and to increase the reliability of the measuring and test equipment. The construction of the fuzzy system for the evaluation of a measuring instrument is shown in “Fig. 3”.

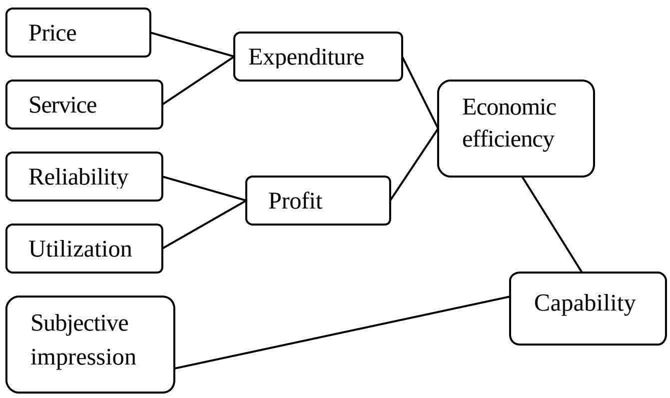

Fig. 3. Fuzzy system construction for measuring instrument evaluation

For this purpose developed method for the determination of the testing interval is based on expert knowledge [7]. This method makes the estimate and the insertion of the experiences unnecessary, since all "estimate"-processes are accomplished using computer aid and practical knowledge (experience from earlier tests, experiences from the testing, etc.) is implemented in mathematical algorithms. This method is based on demand of the environmental conditions of the past as well as of the expected future. This happens exclusively through the application of fuzzy logic, a polyvalent logic, which operates mainly with linguistic variables [6].

Central characteristic within the computer aided interval dynamification is the so-called test-characteristic. This characteristic describes the condition of the testing equipment at time of testing. The test-characteristic is a result of the considered testing. The range of results of the test-characteristic is the interval in number between 0 (inadmissible condition of measuring device) and 1 (optimum condition).

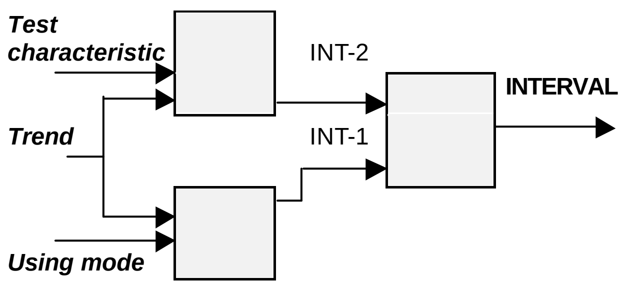

Fig. 4. Substitute model

The sizes necessary for the dynamification of the interval are shown in “Fig. 4”. There is one recognize, that beside the test-characteristic two further input sizes: the trend, which is determined again by the test-characteristic, and the mode of use. This trend indicates the temporal course of the test-characteristic-curve. The trend will be at constant environmental conditions a linear slope. The mode of use implies the behavior of abrasion, frequency of utilization, pollution degree, operation temperature, the storage at not on the operation etc. This becomes thereby exclusively the expected mode of using until the next checking.

Since there are more then two input sizes, reference shall be made to a substitute model in "Fig. 4", which consists of two subsystems with only two input sizes. The testing interval will be given as an output size in the range of 3 and 24, which indicates a number of months. For the establishing of the fuzzy sets INT-1 and INT-2 the five linguistic terms will be divided up according to the standard form. In the fuzzy set of testing interval, the INT-1 and INT-2 are other combined with each other to produce the optimum interval. "Fig. 5".

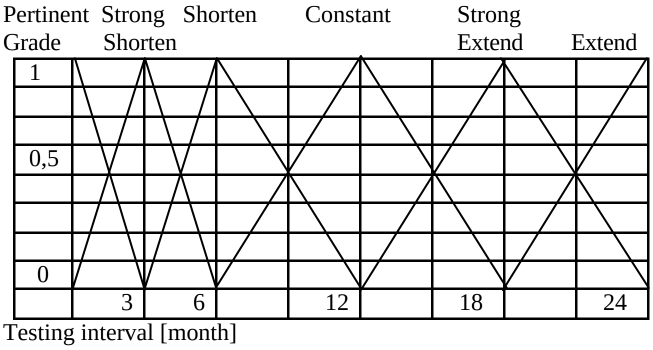

Fig. 5. Fuzzy set of testing intervals

The control basis will be created by iterative method. Figure 4 shows the control basis. All sizes are in complex interaction with each other. The method of fuzzy logic provides for a reproducible system to find the optimal interval. Requirement is that the internal fuzzy algorithms are formed in virtue of reliable expert knowledge.

5. CONCLUSION

The supervision and management system of complex measuring equipment should ensure that the measuring instruments are capable and in function at all times. Through computer assisted systems the expense of documentation because of the multitude of use of measuring equipment, as well as the expenses concerning the establishment of the checking plans are reduced. These systems should provide for complete and orderly checking and for the traceability of measuring and calibration results.

By means of fuzzy logic it is possible to create a system, which allows the quantitative evaluation of the quality of measuring equipment. Because of many relevant influence quantities, this system can be used for optimising the confirmation intervals.

Further, through the use of this systems within the management of manufacturing equipment the checking expense climbs only conditionally, while the profit gains increase in greater proportions and the estimate of the testing intervals based on subjective impressions are objectified and made reproducible. The economic benefits and the quality of the confirmation of measuring and test equipment will increase substantially.

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