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Supervision over technological and measurement processes

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ABSTRACT

Purpose: of the paper has been an attainment of the thesis: "If there is something we can define, we can measure it. If there is something we can measure, we can analyse that. If there is something we can analyse, we can supervise that. If there is something we can supervise, we can improve that [1]".

Design/methodology/approach: used for the analysis has covered proposition of the supervision over measurement processes system that can be applied in quality assurance.

Findings: of analysis are as follows: system of supervision over measurement processes performed (in compliance with real), realised in an organisation processes, can assure the achievement of the accurate and reliable results that, being the base of any feedback in any process, have fundamental meaning in making appropriate decisions.

Practical implications: can be applied in case of any organisation, wanting to demonstrate the conformity of processes in the range of requirements that apply to: products, workers, natural environment and others by supervision over measurement equipment.

Originality/value: of the presented paper has been obtained by working out the design of supervision over measurement system, also measurement system capability, which should be supplement for supervision over processes system in the assurance of processes and products quality.

Keywords: Improvement of process; Measurement processes; Supervision over measurement; Calibration; Measurement capability

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1. Introduction

Entrepreneurship means kind of activity aiming at fulfilling the needs of other entities of social life by producing goods and providing services based on innovative usage of changes that emerged in the environment. The activity is motivated by intention of obtainment of material profits or personal benefits and it is realised with taking into account owner's risk [1].

It seems that the definition of entrepreneurship excludes the implementation in any organisation of the systematic improvement of the processes based on the Deming cycle (P-plan, D-do, c-check, A-act) – on one hand, and on the other – it registers permanently in the improvement of the system of processes of the whole organisation not only by effective by also efficient activity [2,3].

Technological processes are main processes, when products and services are delivered; control processes, being the supportive processes, are the base of decision making in the frames of management processes. That is why any feedback should be treated as informational-decisive process reflecting completely continuous improvement cycle [2,4,5].

2. Supervision role

"If there is something we can define, we can measure it. If there is something we can measure, we can analyse that. If there is something we can analyse, we can supervise that. If there is something we can supervise, we can improve that [6]". Those words, that have been said by quality gurus J.J. Dahlgaard, K. Kristensen, G.K. Kanji, explain the meaning of supervision and measurement of processes in increase of their ability to fulfill quality requirements.

ISO 9000 standard defines measurement control system as "set of interrelated or interacting elements necessary to achieve metrological confirmation and continual control of measurement processes", where metrological confirmation is "set of operations required to ensure that measuring equipment conforms to the requirements for its intended use" and measurement process is "set of operations to determine the value of a quality". Relations between metrological processes in the range of measurement control system have been shown in Figure 1 [7].

Measurement plays the main role in the management of every organisation especially in the context of quality, environmental and occupational safety integrated management systems [8-11].

Organisation, in accordance with ISO 9001 standard, should define monitoring and measurement for realisation as well as monitoring and measurement equipment being necessary to submit a proof of conformity. Standard's guidelines say that, where it is necessary measuring equipment should be: "calibrated or verified at specified intervals […], adjusted or re-adjusted as necessary, identified to enable the calibration status to be determined, safeguarded from adjustment that would invalidate the measurement result, protected from damage and deterioration during handling, maintenance and storage" [12].

Every organisation, according to the requirements of ISO 14001 standard, should monitor and measure the key characteristics of the processes being realised, which can significantly impact the natural environment. The organisation should ensure that monitoring and measurement equipment is calibrated or verified. The identification of environmental aspect should consider especially: emissions to air, releases to water, releases to land, use of raw materials and natural resources, use of energy, energy emission, waste and by-products and physical attributes [13].

The aim of monitoring the occupational health and safety in the organisation, in accordance with PN N 18001 standard, is to check the progress in compatibility of the realised processes with legal requirements as well as occupational health and safety politics. Monitoring the occupational health and safety conditions can be realised as reactive or proactive. Independently on the kind of monitoring, organisation, to assure its effectiveness, should realise the monitoring with use of measurement equipment that is properly maintained, calibrated or verified accordingly to the instructions based on legal and standards' requirements [14].

To make the data, being achieved via measurement, the base of accurate decisions, it must be realised in the environment that is supervised or known to the degree necessary to assure the reliable measurement's results. According to the PN EN ISO 10012:2003 standard 'Measurements management systems", requirements connected with measurement processes and measurement equipment's requirements concerning measurement processes and equipment should include [15]:

- use of verified equipment,
- application of validated measurement procedures,
- availability of information resources,
- maintenance of environmental conditions,
- employment of competent personnel,
- reporting the results,
- implementation of monitoring.

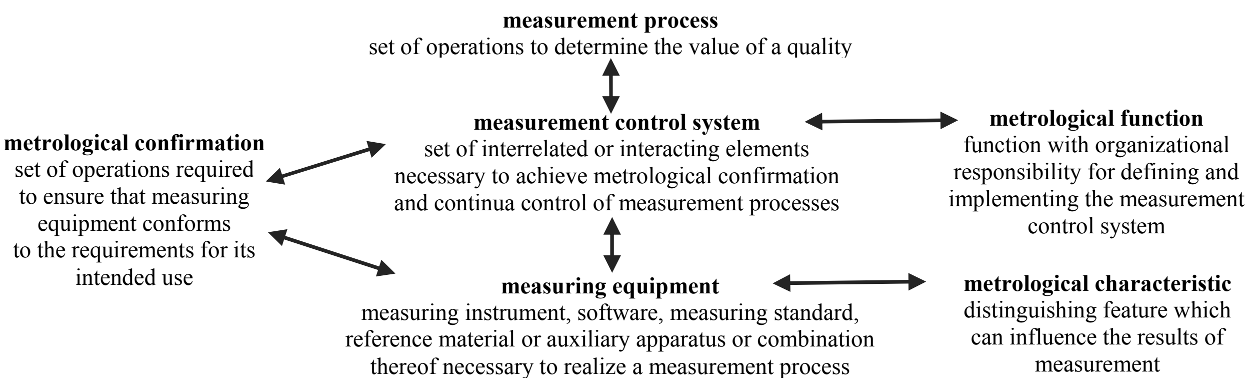

Fig. 1. Scheme of relations between metrological processes in the range of measurement control system [7]

3. Measurement errors

Very often, due to various reasons, results of measurements reveal dissimilar values. These are errors, which are defined as discrepancy of the result with the real value of the measurement. True value of the measured quantity seems to be impossible to estimate, that is why the achieved results are treated as more or less precise approximation. Reporting the results should include the information about accuracy degree to the true value. Lack of such information makes the definition of measurement reliability as well as their comparison impossible [16-23].

Among measurement errors one can differentiate systematic and random errors [16-23].

3.1. Systematic error

Systematic error takes on constant value during measurements of the same value in the same condition. One can say about conditions repeatability, when measurement is conducted by the same person, with use of the measurement equipment, by the same method and in the same place. To remove systematic error one should identify and eliminate source of their occurrence. It can be done by [16-23]:

- examination of equipment symmetry,
- identification of influences connected with the sequence of measurements,
- analysis of changeability of environmental conditions (temperature, atmospheric pressure, air humidity),
- change of measurement method.

3.2. Random errors

Random error is caused by the impact of different factors that change in the unpredictable manner. Its occurrence is unavoidable and usually leads to the measurement unrepeatability. Difference in the results can be observed in the time of multiple measurements conducted in the same way [16-23].

The most popular causes of random errors creation are [16-23]:

- mechanical vibrations,
- temperature and pressure changes,
- rush of air,
- reading inaccuracy.

3.3. Measurement uncertainty

Measurement results are characterised by dispersion of values in relation to the measured value, which is why they are treated as uncertain ones. The uncertainty shows lack of accurate knowledge of true value. As the most popular causes of measurement uncertainty one can qualify [16-23]:

- inaccurate definition of the measured value,
- lack of the knowledge of environmental factors that influence measurement,
- realisation of the measurement in seemingly identical conditions,
- incorrect results reading indicated by analogy equipment,
- attribution of values to reference standards and reference materials.

One can use two basic methods to determine measurement uncertainty. First one is connected with statistic analysis of series of simple results and expresses measurement uncertainty by the standard deviation. Second one is grounded on accessible information about factors concerning measurement uncertainty that can be: phenomenon accompanying the measurement, properties of measurement equipment or data achieved during calibration [16-23].

4. Own research

The research have been conducted to attain the confirmation that only the properly designed system of control of test and measurement equipment is capable of obtaining accurate and reliable results of measures.

In the planning of the supervision system one has taken into account:

- analysis of technological operations of internal ring of conical bearing taking into account all information, where properties of the product had been specified,
- interoperation verification in the aspect of monitoring and measures,
- control of test and measurement equipment,
- test of measurement capacity R&R.

Process of internal ring of conical bearing, being analysed, includes: forging, annealing, turning, hardening and tempering, grinding and superfinish [24].

4.1. Methodology

Methodology used for the analysis has included establishment of the equipment needed for verification, measurement and test during production process of bearing elements. The plan has been done on the basis of constructional and technological documentation.

Supervision over measurement equipment has been based on the grounds of:

- calibration of measurement equipment,
- measurement system capability.

Calibration of measurement equipment

The most important criterion analysed during undertaking decision about length of intervals calibration is minimization of: the risk of loosing the compatibility of the measurement equipment during usage as well as costs of calibration. During definition of the intervals between any another calibration, factors being taken into consideration are:

- recommendations of a manufacturer,
- tendencies to wear and tear of measuring surfaces,
- importance of measured parameters in technological process,
- environmental conditions.

Test of measurement system capability

Test of measurement system capability is realised in the real conditions, it means: on the work position where the measurement tool is used, with usage of the original details by the operators being competent to conduct the measure.

Measurement is carried out independently by tree operators in the same sequence and using the same method. Results of measurement are analysed with usage of statistical methods; in measurement system capability estimation tree groups of qualification are receipted:

- R&R ≤ 10% - measurement system is capable and can be accepted,
- R&R ≥ 10% and ≤ 30% - measurement system is capable for special usage and can be accepted dependently on importance of usage,
- R&R > 30% measurement system is incapable and can't be accepted.

4.2. Practical analysis

Turning treatment is realised with usage of two automatons. First of them assures proper realisation of the internal diameter and the height of the ring and the second one - bearing way width, runner brick depth, phase suspension. Parameters being under control after second stage of turning treatment have been shown on the Fig. 2 and listed in the technological card in the Table 1.

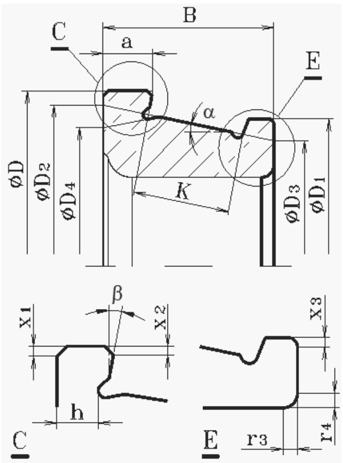

Fig. 2. Drift of the internal bearing ring simplified to the parameters being controlled

Measurement of the flanges and the diameter of the main bearing way is made with the usage of MT_3 tool that has the measurement nosepiece set up dependently on the flange or bearing way measurement and it is based on the location of the internal ring on the measurement plate between the measurement nosepieces of the measurement sensors (Figs. 3-7).

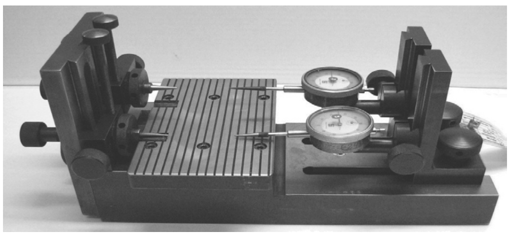

Fig. 3. Photography of MT_3 tool

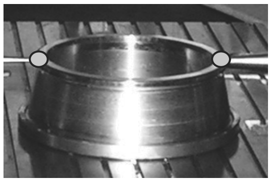

Fig. 4. Photography of the measurement of diameter of the small flange [D_1] made by MT_3 tool

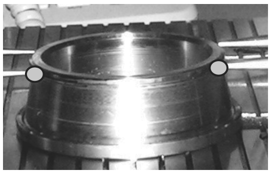

Fig. 5. Photography of the measurement of diameter of bearing way near the small flange [D_3] made by MT_3 tool

Fig. 6. Photography of the measurement of diameter of the big flange [D] made by MT_3 tool

Fig. 7. Photography of the measurement of diameter of bearing way near the big flange [D_2] made by MT_3 tool

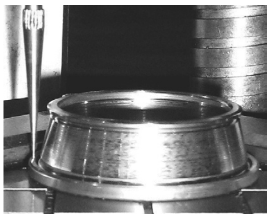

Fig. 8. Photography of the measurement of height of ancillary bearing way [a] made by MT_1 tool

Measurement of diameter of runner brick is done by MT_4 tool accordingly to the rules of MT_3 measurements; measurement frequency is six units every ten minutes, without any record.

Next parameters exposed to the control are: height of bearing ring, height of ancillary bearing way and depth of runner brick. Measurements are made with making use of MT_1 and MT_2 tools (Figs. 8-10); measurement frequency is six units every ten minutes, without any record.

Table 1.
Technological card of the second stage of the turning treatment

Parameter	Value [mm]	Tolerance [mm]	Measurement tool	Quality control in the work time		Kind of control card
				Unregistered [unit/min]	Registered [unit/min]	
Diameter of big flange [D]		±0.06	MT_3	6/20	-	-
Diameter of small flange [D_1]		±0.05	MT_3	6/20	-	-
Diameter of bearing way [D_2]		±0.05	MT_3	6/10	6/30	self-control
Diameter of bearing way [D_3]		±0.05	MT_3	6/10	-	-
Diameter of runner brick [D_4]		-0.24	MT_4	6/10	-	-
Height of bearing ring [B]		±0.05	MT_2	6/10	-	-
Width of bearing way [K]		±0.08	MT_5	1/20	-	-
Depth of runner brick [h]		-0.05	MT_1	6/10	-	-
Height of ancillary bearing way [a]		±0.05	MT_1	6/10	-	-
Suspension of radius [r_3]		±0.40	MT_6	1/20	-	-
Suspension of radius [r_4]		±0.20	MT_6	1/20	-	-
Suspension of trim [x_1]		±0.10	slide calliper	1/20	-	-
Suspension of trim [x_2]		±0.10	slide calliper	1/20	-	-
Suspension of trim [x_3]		±0.10	slide calliper	1/20	-	-

Table 2.
Specification of calibration intervals of measurement equipment in the turning treatment

Measurement tool		Calibration intervals
MT_1	Measurement of: height of ancillary bearing way, depth of runner brick	365 days
MT_2	Measurement of height of bearing ring	365 days
MT_3	Measurement of: diameter of big and small flange, diameter of bearing way	365 days
MT_4	Measurement of diameter of runner brick	365 days
MT_5	Measurement of width of bearing way	365 days
MT_6	Measurement of suspension of radius	730 days

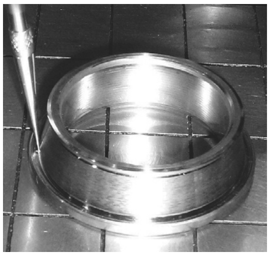

Fig. 9. Photography of the measurement of depth of runner brick [h] made by MT_1 tool

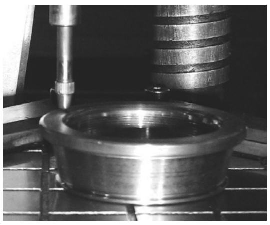

Fig. 10. Photography of the measurement of height of bearing ring [B] made by MT_2 tool

Last parameters being verified after second stage of turning treatment are: width of bearing way - with usage of the standards, suspension of radiuses r_3 and r_4 - by MT_6 tool as well as suspension of trim x_1, x_2, x_3 - making use of slide callipers; measurement frequency is one unit every ten minutes, without any record.

Supervision of measurement equipment realised in the turning treatment reflects the rules that govern all of the processes in the organisation. Measurement tools are signed with the card including information with the date of the last and the next verification, place of the usage as well as technical condition.

All the sensors are identified by the colour label informing about expiring the calibration. One of the most important elements of the measurement equipment supervision is R&R capability examination.

Calibration of measurement equipment

Intervals between any another calibration, undergo continuous supervision by the measurement laboratory at an angle of loss of measurement capabilities of the measurement equipment; that's the base for making appropriate correction. Calibration intervals for measurement equipment used in the turning treatment have been shown in Table 2.

To afford possibilities for a reconstruction of every measurement in similar conditions it had been done at the first time results of calibration are recorded in details.

Test of measurement system capability

Test of measurement system capability in the turning treatment operations is based on determination of Repeatability&Reproducibility indictor. It makes the estimation of usefulness of every measurement tool (MT-1MT-6) in the planned measurement tasks taking into account all of the influences possible.

The test of measurement system capability in the range of MT-2 tool is conducted by 3 operators, the test items are ten internal bearing after turning treatment.

The following activities during the test of measurement system capability are:

- preparation of MRa standard (properly to the KJL6934 ring) that is necessary to appropriate arrangement of the tool,
- identification of the deviation as a standard dimension and nominal dimension:
  - nominal dimension (from the process) - 17.00 [mm]
  - standard dimension - 16.90 [mm]
  - standard deviation – 0.10 [mm],
- arrangement of the tool taking into account calculated deviation (Fig. 11).

Accordingly to the accepted test methodology taking into account both changeability of equipment (repeatability) and judging operators (reproducibility) the result of the test is 9.8%, which means, that MT-2 measurement tool is capable of measurement tasks (%R&R $\leq$ 10).

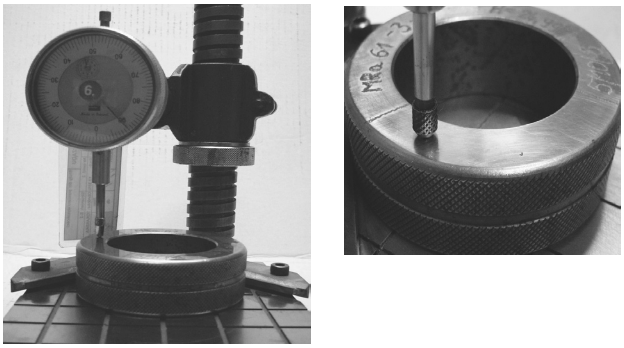

Fig. 11. Photography of the arrangement of MT_2 tool by the MRa standard

Measurement certificate of Repeatability&Reproducibility test has been shown in Table 3.

Simultaneously, the majority of the results' averages achieved by every MT-2 operator lies on the control card of averages outside the control limits, which confirms the adequacy of the measurement system to the used control process.

Table 3.
Measurement certificate of Repeatability&Reproducibility test

Repeatability&Reproducibility test
Measurement certificate

Type	KJI693	Resolution	1
Detail	internal ring	Unit	0.01
Parameter	height of ring	Date	25.03.2010
Measurement tool	MT_2		

Test by	**No**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Galus	1	-3.0	-7.0	-3.5	-5.0	-6.0	-7.0	-6.0	-8.0	-6.0	-7.0	-5,85
	2	-3.0	-7.0	-3.0	-5.0	-6.0	-7.0	-6.0	-8.0	-6.0	-7.0	-5,7
	3	-3.0	-7.0	-3.0	-5.0	-6.0	-7.0	-6.0	-8.0	-5.0	-7.0	-5,7
Average		-3,0	-7.0	-3.166	-5.0	-6.0	-7.0	-6.0	-8.0	-5.333	-7.0	Xa = -5.750
Spread		0	0	0.5	0	0	0	0	0	1.0	0	Ra = 0.150
xyz	1	-3.0	-7.0	-4.0	-5.0	-6.0	-7.0	-6.0	-8.0	-6.0	-7.0	-5,9
	2	-3.0	-6.5	-4.0	-5.0	-5.0	-7.0	-6.0	-8.0	-6.0	-7.0	-5,75
	3	-4.0	-7.0	-4.0	-5.0	-6.0	-7.0	-5.0	-8.0	-6.0	-7.0	-5,9
Average		-3,333	-6.833	-4.0	-5.0	-5.666	-7.0	-5.666	-8.0	-6.0	-7.0	Xb = -5.85
Spread		1,0	0.5	0	0	1.0	0	1.0	0	0	0	Rb = 0.35
zyx	1	-3.0	-7.0	-4.0	-5.0	-6.0	-7.0	-6.0	-8.0	-6.0	-7.0	-5,9
	2	-3.0	-7.0	-4.0	-5.0	-6.0	-7.0	-5.0	-7.0	-6.0	-7.0	-5,7
	3	-4.0	-7.0	-4.0	-5.0	-6.0	-7.0	-5.0	-7.0	-6.0	-7.0	-5,8
Average		-3.333	-7.0	-4.0	-5.0	-6.0	-7.0	-5.333	-7.333	-6.0	-7.0	Xc = -5.8
Spread		1.0	0	0	0	0	0	1.0	1.0	0	0	Rc = 0.3
Average (details)		**-3.222**	**-6.944**	**-3.722**	**-5.0**	**-5.888**	**-7.0**	**-5.666**	**-7.777**	**-5.777**	**-7.0**	**Rp = 4.56**

R'' = (Ra' + Rb' + Rc') / 3 = 0.267	n = 10 r = 3
X'' = maxX' – minX' = 0.100	K_1 = 3.54 K_2 = 3.14 K_3 = 1.89
$UCL_R = R_x D_4$ = 0.7	D_4 = 2.57

5. Conclusions

Broadly minded management of the processes based on the quality criterion should be realised to fulfil client's expectation not only in the context of products' quality assurance but also in the meaning of interested parties' safety. The tasks should be performed both to:

- demonstrate the conformity of processes in the range of requirements that apply to: products, workers, natural environment and others, and
- ensure conformity and continuous improvement of quality, environmental, occupational health and safety management systems and other.

In compliance with the established aims every organisation should implement monitoring, measurement, analysis and improvement system to assure to the processes not only effectiveness, but also efficiency.

The most important operation seems to be the application of well-planned measurement and over-measurement supervision system. First of them should be concentrated on the selection of measurement equipment properly to the realised processes and should take into account introduction of the measurement equipment to the use and equipment identification.

Over-measurement supervision system should be focused on the verification of measurement equipment quality and it can take advantage of system of calibration of measurement equipment as well as measurement system capability, also the proposed Repeatability&Reproducibility test.

Both the measurement system and the measurement supervision system ought to be characteristic of every organisation - planned in accordance with the established aims and conducted processes.

Always the superior aim of supervision over measurement processes should be the rule: "If there is something we can supervise, we can improve that" [6].

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