The expert evaluation by the use of group of experts with established competence of the state of inductance measurements

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Abstract
Measurement of inductance is widely used in metallurgical industry, therefore requirements to measurement accuracy and data accuracy is very important for industrial process. The results of expert evaluation of the real state of inductance measurements group of experts with established competence are considered. The self-assessment of expert competence was conducted that showed that all less competent experts over-estimated own qualification. Special and universal software is used for processing obtained expert data. The obtained results show small variation of expert evaluation and quite good consistency.
Key words: GROUP EXPERT EVALUATION, EXPERT EVALUATION, METROLOGICAL ASSURANCE, MEASUREMENT, INDUCTANCE

In science and industry, measurements are one of the main means for extraction of measurement information. The science of measurement is pursued in the field of metrology. The measurement of a property may be categorized by the following criteria: type, magnitude, unit, and uncertainty. The magnitude is the numerical value of the characterization usually obtained with a suitably chosen measuring instrument. Accurate measurement is essential in many fields therefore a great deal of effort must be taken to make measurements as accurate as possible.

Measurement of such electric quantities is used as inductance at determination of specific fate of metal in ore, conductivity of liquid metals, corn-floors of Foucault, high temperature measuring, express control of quality of weld-fabricated wire, products of powder-like metallurgy, inflicted coverages from a metal, properties of intermetalloids and alloys and others like that.

Electrometallurgy is industry of metallurgy, which embraces the processes of receipt, affinage and treatment of metals and alloys from ores and concentrates by means of electric energy. The electric measurements are widely used in this industry, in particular measurements of the impedance. In the technological processes of receipt of metals from ores, the changes of chemical composition, structure, aggregate state and properties of metallic alloys, are widely used for control methods, including, and noncontact, that is based on measurements of electrical quantities.

The increase of requirements to quality of eventual products of metallurgy envisages the increase of requirements to exactness of measuring instruments that, in turn, envisages the presence of national standard base of certain physical quantities, and also row of measures from providing of the metrological traceability measurements from international standards to every measuring instrument.

Metrological assurance of inductance measurements should be considered in two approaches: traditional approach (verification and calibration of equipment with the determination of the metrological characteristics) [1] and not traditional approach (group expert evaluation of state of inductance measurements). The expert evaluation is widely used in the various spheres of activity with the aim of receipt of decisions in relation to overcoming of certain problem on the basis of opinion of skilled experts that have the special skills or knowledge in the concrete sphere of activity [2-10].

Methodology of evaluation of expert competence in group taking into account the data uncertainty is expedient to apply as useful instrument for the comparative estimation of expert competence on the basis of their objective data on the set criteria for the different fields of activity. This allows us to carry out more reasonable selection of the most competent experts for forming of group from the evaluation of certain problem questions in certain fields of activity and to decline experts, and objective data that does not confirm the certain level of set criteria.

The main aim of expert evaluation in metrological activity is to assess the quality of a metrological work and specialists on metrology. This aim is implemented by the method of expert evaluation, the essence of which is to set out a quality level on the basis of the common criteria for quality evaluation and expert questionnaires (prepared for the particular measurements).

1. Measurement standards base of inductance measurements

National Standard of the unit of capacitance and loss factor (Figure 1) is the most precision measurement standard of the unit of inductance (DETU 08-09-09), which is kept in State Enterprise “Ukrmetrteststandard” (Kyiv).

Figure 1. General view of National Standard of the units of inductance and tangent of loss

Transfer of the unit of inductance is going by the State verification scheme in accordance with national standard GOST 7161. Each year from 20 to 50 working standards (measures of inductance and tangent of loss, RLC-meters) are verified and calibrated by using National Standard DETU 08-09-09.

The evaluation of real conditions of the state of inductance measurements on national level is of extreme importance. An important issue for calibration of measuring instruments of inductance is of provision metrological traceability to National Standard DETU 08-09-09. Ukraine has internationally recognized calibration and measurement capabilities for calibration of measuring instruments of inductance. Those capabilities on inductance measurement were obtained by positive results of international comparisons of National Standard DETU 08-09-09 in project of European regional metrology organizations [11].

2. Results of expert's competence evaluation

In [12], the offered methodology of evaluation of expert competence is taking into account descriptions of data uncertainties that belong to the sphere of comparative evaluation of level of expert competence in various fields of activities. For implementation of the suggested methodology corresponding criteria are set for the numerical score of expert competence of certain field.

Within the framework of implementation of GTT of the metrological assurance of inductance measurements on the specially worked out criteria, the evaluation of competence was also conducted for 14 attracted experts on questions of metrology. Quantitative descriptions of competence of these experts were appraised by means of universal (Microsoft Excel 2010) and special (Competence ND 1.1) statistical software. All evaluations were done on the same criteria: K1 – education; K2 – total work experience; K3 – experience in field of metrology; K4 – experience of expert work in field of metrology; K5 – work status.

Windows of the marked special software with final evaluation results are shown in Figure 2 (Competence ND 1.1).

Figure 2. Appraised expert competence with the use of the software Competence ND 1.1

On the basis of all present results it is possible to talk about a rejection on the whole 4 experts (declined even by one of the program). Percent of the declined experts on evaluation results folds these programs: 29 % (4 experts out of 14 for software Microsoft Excel 2010 and Competence ND 1.1). On the whole it is possible to establish the high consistency of evaluation results.

The values of the got evaluation results of expert's competence in the rationed average values (in a range from 0 – minimum to 1 – maximal) for all 14 experts are shown in the Table 1.

Table 1. Competence coefficients for all experts

Expert	01	02	03	04	05	06	07
Relative average value	0.72	0.67	0.67	0.92	0.69	0.85	0.90
Expert	08	09	10	11	12	13	14
Relative average value	0.87	0.97	1.00	0.56	1.00	0.54	0.77

9 experts from 14 involving experts in field of metrology (64 %) have overestimated their competence according to the results as compared with the specific objective estimates and including 4 the least competent experts (100 %). 5 experts from 14 involving experts in field of metrology (36 %) have underestimated their competence according to the results as compared with the specific objective estimates and including 4 the most competent experts (57 %). Lighter column on a diagram shows the data uncertainty for a concrete expert.

Also experts were asked to make their own assessment of their competence during conducting mentioned questionnaire (Figure 3).

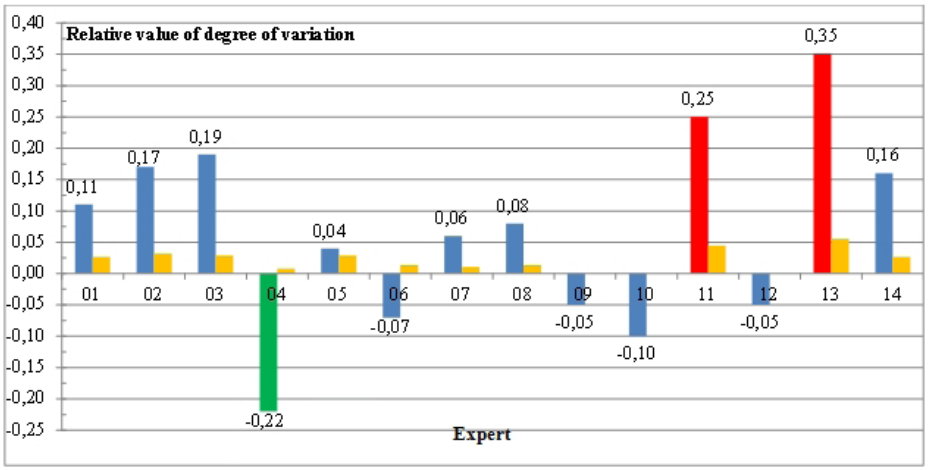


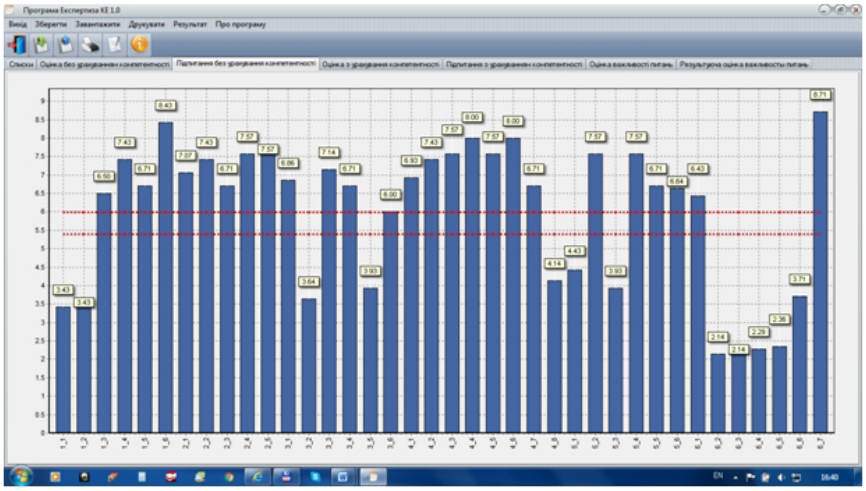
Figure 3. Self-assessment of expert competence

3. Results of expert evaluation

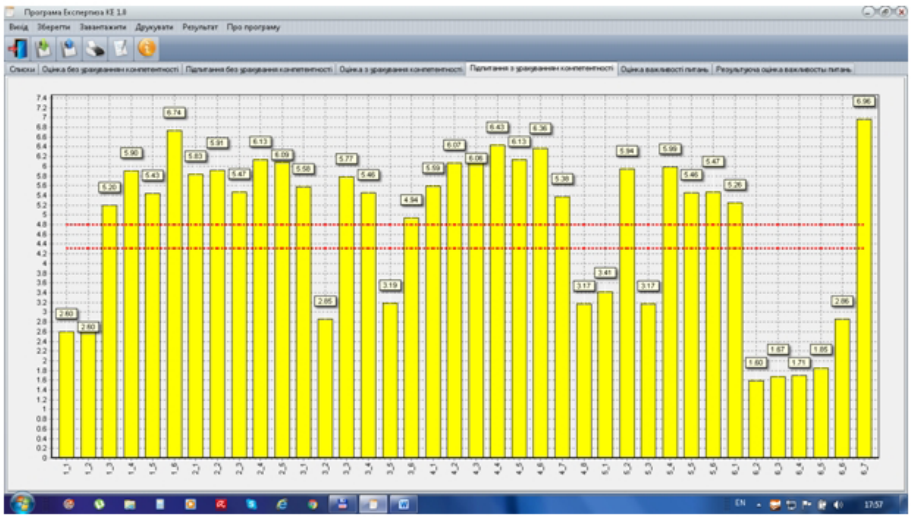
The expert evaluation of the state of inductance measurement was conducted by the methodology described in [12]. For expert evaluation involved a group of 14 experts in field of metrology whose competence was previously estimated (Table 1).

Evaluation was conducted for 6 problematic questions of the state of inductance measurement: personnel involved in metrology works (X1); conditions of implementation of metrology works (X2); normative and methodical documents (X3); standard base and adjuvant equipment (X4); procedures and documents for implementation of metrology works (X5); metrological traceability (X6), which contain total 38 subquestions taking into account the established grade evaluations. It was calculated by using universal (Microsoft Excel 2010) and special (Competence ND 1.1) statistical software taking into account the competence of experts.

These software windows are shown in Figures 4 (Expertise CE 1.0) with evaluated average grades. Reference values of expert evaluations (evaluated average grade without/with taking into account the competence of experts are 5.99/4.80) are shown as dashed lines in Figure 4 (a, b).



a)



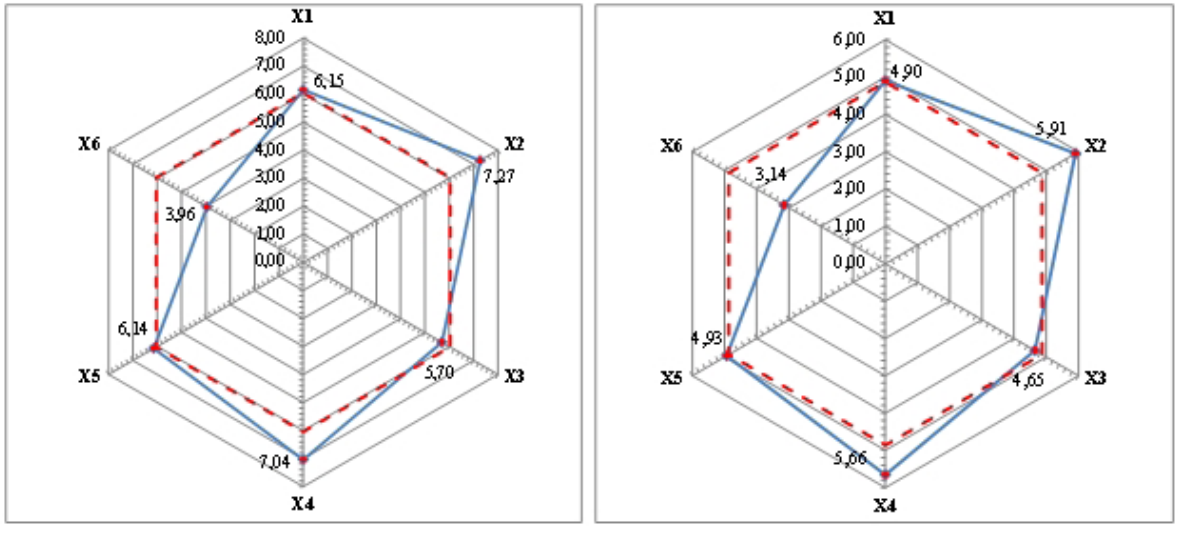
b)

Figure 4. Evaluated average grades by using special software (Expertise CE 1.0) without (a) and with (b) taking into account the competence of experts

Also analysis of the results (Figures 4) showed that in all cases 12 sub-questions (32 %) were priority for further detailed analysis in order to take the necessary decisions. But 26 sub-questions (68 %) did not have priority or not matter at all for their further analysis.

By the results of analysis of the resulting evaluation of the importance of questions, chart for average grades of expert evaluations for with and without taking into account the competence of experts was built by using universal (Microsoft Excel 2010) and special (Competence ND 1.1) statistical software (Figure 6).

Overall analysis of these results has shown that the least important questions for consideration are: X2 (average grade without/with taking into account the competence of experts are 7.27/5.91); X4 (7.04/5.66); X1 (6.15/4.90); X5 (6.14/4.93). Without and with taking into account the competence of experts, questions X1 and X5 switch places. But the most important questions are: X6 (3.96/3.14) and X3 (5.70/4.65).



a) b)

Figure 6. The chart for average grades of expert evaluations by using special software (Microsoft Excel 2010) (a – without taking into account the competence of experts; b – with taking into account the competence of experts)

By the results of analysis, degrees of deviation of the evaluated average grades from the reference value with/without taking into account the competence of experts were also evaluated for questions (X1–X6) by

using special software (Expertise CE 1.0) (Figure 7). The least important questions for consideration are: X2 (degrees of deviation without/with taking into account the competence of experts are 1.28/1.09); X4 (1.06/0.85) and X5 (0.15/0.11). The most important questions are: X6 (-2.02/-1.67), X3 (-0.27/-0.16) and X1 (-0.001/-0.05).

The results obtained show small variation of average grades of expert evaluation for questions (X1–X6) that testifies to its quite good consistency. Considering competence coefficient of experts did not influence the result of evaluation on problematic questions that were discussed.

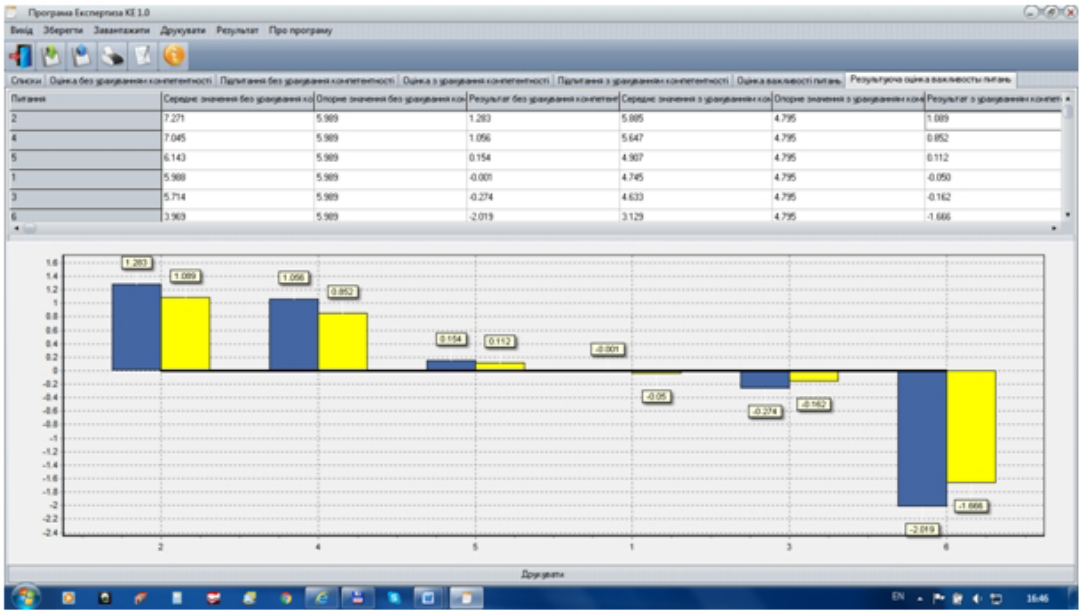


Figure 7. Degrees of deviation of evaluated average grades from the reference value with/without taking into account the competence of experts by using special software (Expertise CE 1.0)

4. Problematic questions for improvement of the state of inductance measurements

Only the problematic question of the state (X6) is attributed for further more detailed researching by the results of expert evaluation on problematic questions of the state of inductance measurements.

The following sub-questions are attributed for further more detailed researching by the results of expert evaluation (in order of importance):

- calibration of working standards (X6_2);
- correlation between the number of verified and calibrated measuring instruments by the enterprise (X6_3);
- the use of calibration methodologies of measuring instruments (X6_4);
- status of evaluation uncertainty during calibration of measuring instruments (X6_5);
- total amount of specialists that work in metrology (X1_1);
- number of experts who conduct or participate in testing (X1_2);
- used methodologies of verification of measuring instruments (X3_2);
- estimation of suitability of software for the automated collection and processing of the obtained data at the verification (calibration) of measuring instruments (X6_6);
- availability on the enterprise of the movable laboratories manned by working standards, measuring instruments and equipment (X4_8);
- use of verification protocol forms (X5_3);
- availability methodologies that require development or review (X3_5);
- authority or accreditation of enterprise on implementation of metrology activities (X5_1).

The other problematic questions of the state of inductance measurements are referred to the ones that have no primary importance.

Conclusion

Inductance measurement is widely used in metallurgical industry, therefore requirements to measurement and data accuracy is very important. The expert evaluation by the use of group of experts with established competence of the real state of specific measurements, for example inductance measurements, can be established. Special software (for example, Expertise CE 1.0) and universal software (for example, Microsoft Excel 2010) can be used for mathematical processing of obtained expert data.

The real state of inductance measurements by the

results of the expert evaluation can be stated generally. However, it should be noted that there are some problematic questions regarding calibration of working standards; correlation between the number of verified and calibrated measuring instruments by the enterprise; the use of calibration methodologies of measuring instruments.

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