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EVALUATION OF EFFECT OF ATTRIBUTIVE MEASUREMENTS IN A CLIME COMPARTMENT ON THE VALUE OF DIMENSIONAL MEASUREMENT UNCERTAINTY IN AN ACCRETED TEST LABORATORY

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Abstract

In the field of precision measurement and testing by state-accredited laboratories, the area of measurement uncertainty has a clear and indispensable role. This article builds on a 2018 study (The Influence of Humidity on ABS Plastic Measurement Result). This study addressed the variability in results occurring with changes in otherwise constant humidity in an accredited testing laboratory. This paper builds on the results obtained and evaluates the effect on the components of the standard uncertainty of the Type A measurement and the uncertainty of the Type B measurement). In order to understand the milestones of the process and their limitations. An analysis of the measurement system according to the VDA5 methodology was carried out and a clear limit was established beyond which the resulting values are no longer reliable. The results will lead to an increase in the relevance and accuracy of the measurements and the awareness of the professional metrology community.

Keywords: Metrology; Uncertainty; Measurement; Attributive; Clime Compartment

1. Introduction

Within the framework of the measurement methodology on a coordinate measuring machine of a state-accredited laboratory (ISO/IEC 17025 standard), measurement uncertainties represent a mandatory area of discussion between the metrology service provider, i.e. the customer, and the metrology service provider. Without at least a basic knowledge, the results are misinterpreted or at least distorted by the customer. [1], [2]

This analysis builds on a previous experiment from 2018, which was published as "The Influence of Humidity on ABS Plastic Measurement Results“. Humidity environment parameter remains a specific requirement. The standard for the CMM according to standard ISO 10360-2, however, indicates the reference value of 50±10%, but this is the recommended value for 3D measuring machines and not for the products. [3] Our follow-up paper operates one level down, where the effect that is potentially introduced when simulating environmental conditions using a climate chamber is investigated.

2. Experimental analysis

Within the accredited metrology laboratory L-1718 of the Regional Institute of Technology at the Faculty of Mechanical Engineering, University of West Bohemia in Pilsen, a comprehensive analysis was carried out to investigate the influence of clime compartment device used to simulate required air pressure condition. All measurements were subject to DIN ISO 1101 environmental conditions, i.e. a temperature of 20 °C ± 1 °C in a vibration-neutral environment and humidity. [4]

Fig. 1. Clime Compartment

The experiment was conducted under controlled conditions at a constant temperature of 20 ± 2 ° C. During the experiment only 1 operator performed measurements to eliminate the reproducibility error. This operator repeatedly measured the selected parameters on samples of ABS plastic part. Selected parameters = Inner diameter, wall thickness, length describe main metrology tasks for ABS evaluation. The measurement itself was performed on the CMM Carl Zeiss Prismo 7 Navigator equipped with a fixed sensor head with an measurement uncertainty of 0.9µL / 350µm. The measurements were carried out gradually at 30%, 45%, 60% humidity. Total of 5 samples of the same test sample being performed at each value due to the relevance of subsequent statistical data processing. [5], [6]

Fig. 2. Etalon

3. Data processing

As it is clear from the output, the resulting measurement value changes at 30%, 45%, 60%. The specified mathematical formula may be a useful tool for industrial practice, especially for the situations where measurement does not take place in a controlled environment of a metrology laboratory. [7]

3.1 Parameter length_1_Y (chosen example)

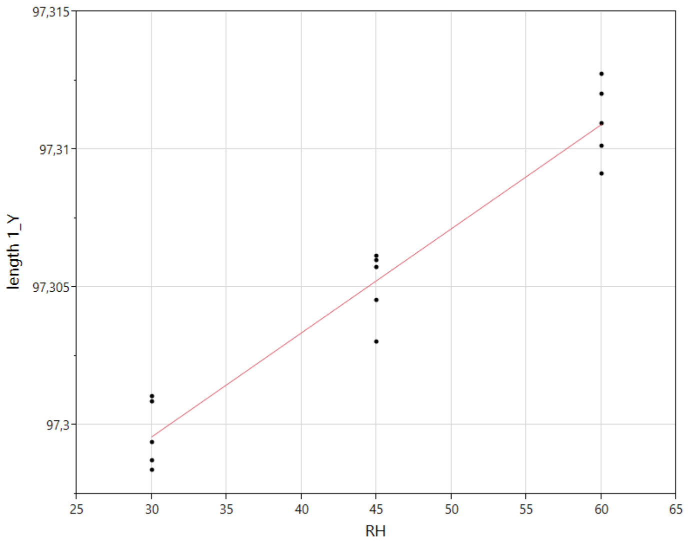

Fig. 3. Chart dependence for length_1Y

Parameter	Value
RSquare	0,937721
RSquareAdj	0,93293
Root Mean Square Error	0,001279
Mean of Response	97,30526
Observations (or Sum Wgts)	15

Table 1. Parameters of dependence for length_1Y

The predictive model of the length dependence of the change of the humidity value RH (1) describes 93.293% of the variability of the studied variable on the basis of the adjusted index of determination (RSquareAdj).[9] Therefore, the model predicts within the moisture interval 30 to 60% with an accuracy of 93.293%, with an average value of the measured quantity being 97.30526. [8]

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob> F
Model	1	0,00032	0,00032	195,7368	<,0001
Error	13	2,13E-05	1,64E-06		
C. Total	14	0,000342			

Table 2. Prediction model for length_1Y

From the ANOVA analysis table, the model used is adequate based on the Fischer-Snedecor test criterion and therefore we can say that at the selected level of significance α = 5%, there is at least one factor (predictor) in the model that varies from zero.

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	97,28827	0,001258	77338	<,0001
RH	0,000377	0,000027	13,99	<,0001

Table 3. Parameters of dependence formula

The table shows that the greatest effect on the change in the value of length 1Y is the absolute intercept. It hides all the neglected factors we have not considered in the experiment. But, at the chosen level of significance α = 5%, the RH moisture value is statistically significant. The model itself can therefore be expressed in the form of:

$$lenght\_1\_Y = 97,28827 + 3,77.10^{-4}.RH$$

4. Results confirmation

Due the fact motivation for this paper is from automotive industry, the VDA5 methodology was chosen as the uncertainty effect evaluation methodology. Considering the lengthy calculations and the need for a considerable amount of data (MSA I + II analysis was also performed as part of the validation calculations), the supporting tool Yarvyn was used. [9]

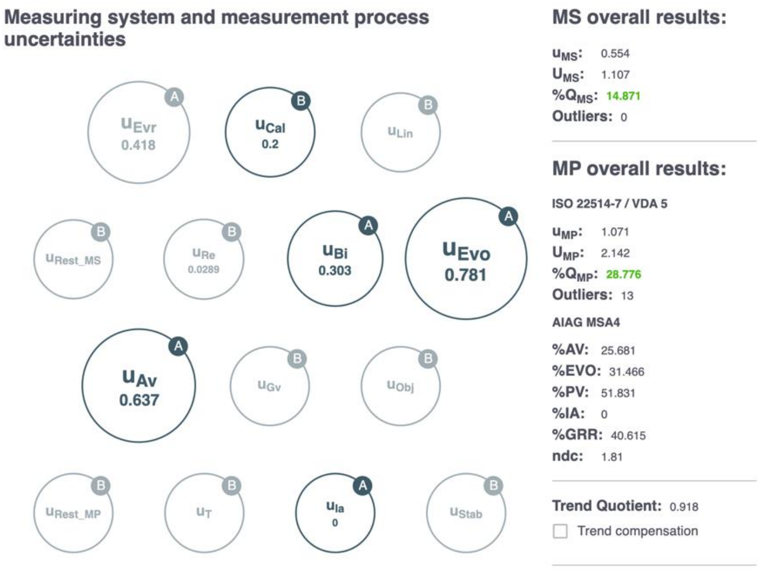

Fig. 4. Yarvyn output with uncertainties

In the case of the clime compartment: the influence and experimentally verified substantial increase of the A-type uncertainty components, namely: uEvo, uBias, uCal, uAv, has been unequivocally proven, thus leading to the degradation of the entire measuring system, including its accuracy, which drops by up to 3 orders of magnitude. [10]

5. Conclusion

The motivation for developing this paper was a consideration of the effect of the attributive clime compartment device on the parameters of measurement uncertainty. The subject chosen for testing was described in previous study “The Influence of Humidity on ABS Plastic Measurement Results“. The measurement system analysis according VDA5 methodology and evaluation of single effects on the uncertainty of the uB type and thus on the overall uncertainty of the uc was carried out to understand the process and its limits. All inspection processes are characterized in a table of result values. This paper is part of a comprehensive study of the effects of human factors on the accuracy and reliability of results. The individual sub-experiments carried out in 2021 and planned for 2022 will be published in a comprehensive method manual on workshop metrology.

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