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Experimental Identification of Condition of Position Sensor

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Abstract Paper deals with experimental identification of condition of potentiometer position sensor. Calibration characteristic is obtained. Uncertainty of measurement also has been evaluated.

Keywords: *sensor, position, uncertainty, condition*

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1. Introduction

A Mechatronic product has integrated sensors, actuators, mechanical structures and control structures. Measurement of position is very frequently measured quantity in practice. The potentiometer sensor has a long tradition of using. Last years the using of this principle has increased, because of its disadvantage. A lot of books have mentioned about its disadvantages like noise, oxidation of wiper and resistive road, short life etc. In this days situation is changes, because the new technologies and materials have been developed. Modern potentiometer sensors have an excellent properties, low noise, long life, low uncertainty etc. This article deals with testing of one of these sensors.

Figure 1. Position sensor

2. Sensor Properties and Its Calibration

The sensor has mechanical travel 800 mm and total electrical resistance 10kΩ. Linearity error of the sensor should be less than 1%.

Calibration of the sensor has been executed in accordance with standards (EA-4-02rev01) [2]. Position of the wiper has been adjusted with length gauges. Length gauges has been composed into the block of the length gauges. Full range of the sensor has been compared with block of the gauges at every millimetre. Electrical resistance between wiper and one end has been assigned to every block of length gauges (every millimetre ten times).

It is recommended to do calibration for every millimetre ten times in industrial practise. Ten times measured every value is minimum, which enables to evaluate standard uncertainty of type A (see standards EA-4-02rev01) [2].

Two packages of the length gauges have to be used for the calibration process. The Gloves has been necessary for the manipulation with these gauges. Process needs very high attention and a lot of time. Temperature if the room has to be regulated via air condition at the 20°C. Sensor and package of the length gauges has to be placed in laboratory with stabilized air temperature all day before measurements. Every piece of the length gauges is conserved with vaseline to avoid the corrosion of the length gauges. So, every piece is necessary to unconserve with denatured alcohol before using.

Consequently, observance of every these mentioned rules causes that calibration process is very complicated and difficult for time.

Measured data have been stored into the evaluation table. It is possible to evaluate static characteristic shown on Figure 3.

Figure 2. Calibration procedure of position sensor

Table 1. Selected sensor characteristics

Property	Value
Mechanical travel	800 mm
Life	One billion operations
Linearity	0.1% from 0 to 100% of range
Resolution	Infinite
Total Resistance	10kΩ
Resistance Tolerance	±20%

Measured data has nonlinear dependence. That is difference from information mentioned via producer noted in Table 1. Dependence can be fitted with polynomial of 2nd degree. Also maximum range of the output electrical resistance exceeds the mentioned total resistance 10kΩ.

This characteristic enables to recalculate the measured electrical resistance to linear position of the wiper from the end of the sensor. The approximation regression equation (shown on Figure 3) can be inserted into the evaluation subsystem for calculation of the measured position. But, how we can believe it? How is the measured data and equation exactly? It is necessary to give answers for these questions.

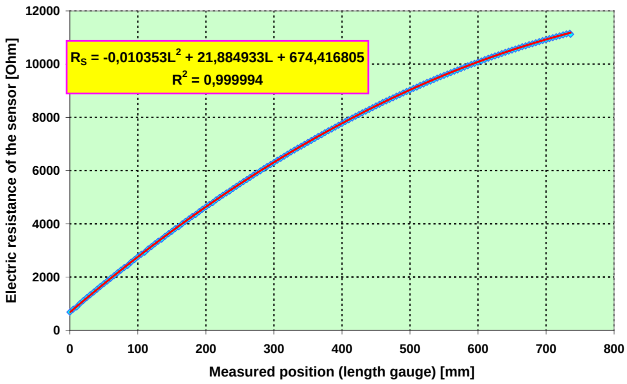

Figure 3. Position sensor static characteristic

3. Position Sensor Measurement Chain Uncertainty

The uncertainty of measurement is a parameter, associated with the result of a measurement that characterizes the dispersion of the values that could reasonably be attributed to the measurand. Term uncertainty is also used for uncertainty of measurement if there is no risk of misunderstanding.

Sensor producer doesn't note uncertainty of measurement. Consequently, it is necessary to obtain this information from calibration process.

For a random variable the variance of its distribution or the positive square root of the variance, called standard deviation, is used as a measure of the dispersion of values. The standard uncertainty of measurement associated with the output estimate or measurement result y, denoted by u(y), is the standard deviation of the measurand Y [2].

The uncertainty of measurement associated with the input estimates is evaluated according to either a 'Type A' or a 'Type B' method of evaluation. The Type A evaluation of standard uncertainty is the method of evaluating the uncertainty by the statistical analysis of a series of observations. In this case the standard uncertainty is the experimental standard deviation of the mean that follows from an averaging procedure or an appropriate regression analysis. The Type B evaluation of standard uncertainty is the method of evaluating the uncertainty by means other than the statistical analysis of a series of observations. In this case the evaluation of the standard uncertainty is based on some other scientific knowledge [2].

The Type A evaluation of standard uncertainty can be applied when several independent observations have been made for one of the input quantities under the same conditions of measurement (minimum of 10 samples of measurement). If there is sufficient resolution in the measurement process there will be an observable scatter or spread in the values obtained [2].

The proper use of the available information for a Type B evaluation of standard uncertainty of measurement calls for insight based on experience and general knowledge. It is a skill that can be learned with practice. Type B evaluation of standard uncertainty can be obtained from various sources as [2]:

- previous measurement data,
- experience with or general knowledge of the behaviour and properties of relevant materials and instruments,
- manufacturer's specifications,
- data provided in calibration and other certificates,
- uncertainties assigned to reference data taken from handbooks.

Electrical resistivity has been measured via multimeter and manufacturer provides specification for type B evaluation of the standard uncertainty of measurement. It is possible to specify equation:

$$u_B = \pm \begin{pmatrix} 0{,}0025\% measured\_value \\ +0{,}0005\% scale\_range \end{pmatrix}. \tag{1}$$

Figure 4 shows the standard uncertainty of measurement for values of electrical resistance measured via multimeter. Type B evaluation is much smaller then types A evaluation. So, it is possible the evaluation B neglected in the next evaluation process. It means that multimeter used in calibration process has been well selected.

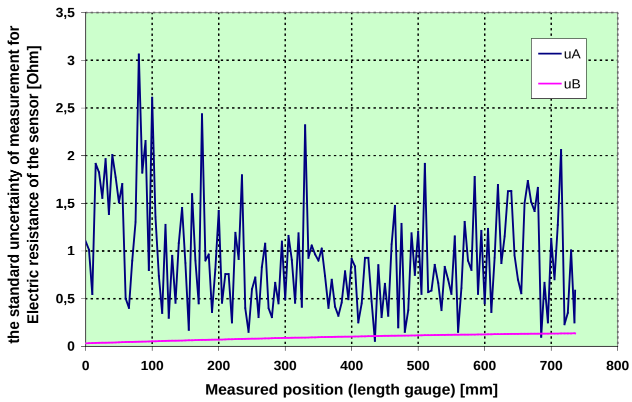

Figure 4. The standard uncertainty of measurement for electric resistance of the sensor measured in calibration process

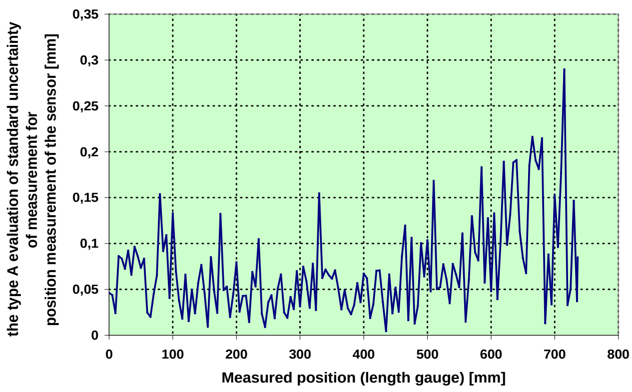

Figure 5. The standard uncertainty of position measurement

Recalculation of the standard uncertainty of electrical resistance measurement to standard uncertainty of position measurement is possible via using regression math model obtained from analysis shown on Figure 3. Figure 5 shows the standard uncertainty for position measurement.

Within EAL it has been decided that calibration laboratories accredited by members of the EAL shall state an expanded uncertainty of measurement U, obtained by multiplying the standard uncertainty u(y) of the output estimate y by a coverage factor k [2],

$$U = k \cdot u \text{ [2]} \qquad (2)$$

Coverage factor should be defined via sensor manufacturer, but datasheet has no information about it. Best way how to find value of coverage factor is experiment. It is known that coverage factor depends on measurement data distribution.

4. Identification of Measurement Data Distribution

Identification of the measurement data distribution has done for four random selected values from sensor range. Every value has been measured 100 times at the same conditions. These values have been evaluated into histograms shown on Figure 6.

All explored values are distributed according to Normal law of distribution of measured values. It means that for significance level P=0.95 is coverage factor equals to value 2.

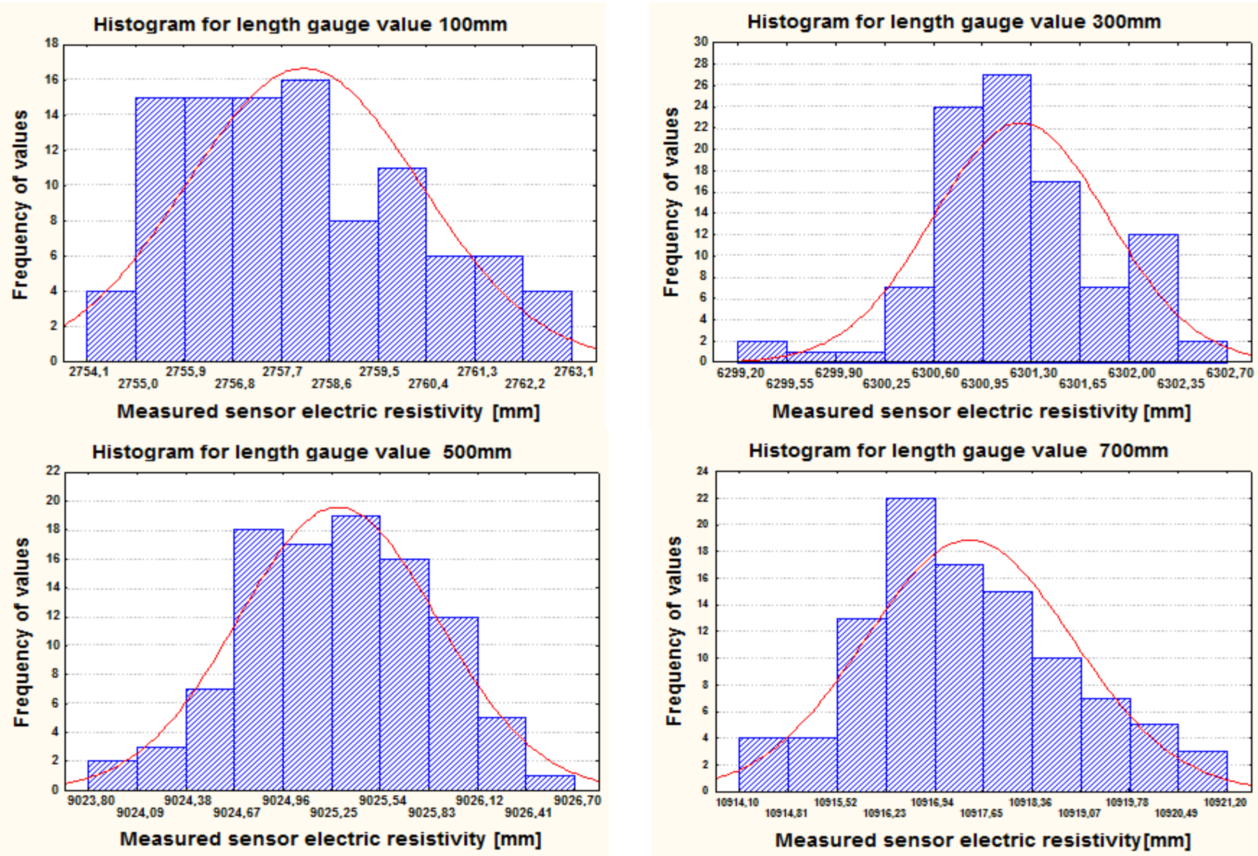

Figure 6. Sensor measurement data distribution

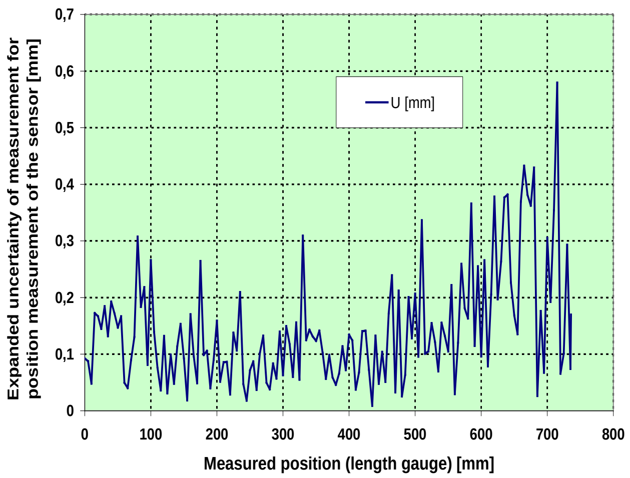

Figure 7. The expanded uncertainty of position measurement

5. Conclusion

Figure 7 shows the expanded uncertainty for position measurement. Expanded uncertainty means the interval about mean value (obtained as average of measured data) where located true value of measurement with probability 95% is.

The expanded uncertainty means how we can believe to examine sensor in measurement process. The expanded uncertainty is as inseparable part of measurement result [3,4,5,6].

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