

COMPUTER PROGRAM FOR THE DETERMINATION OF THE MEASUREMENT BIAS USING THE INDEPENDENT SAMPLE METHOD

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Abstract: The paper presents a computer program for the determination of the measurement bias, using the Independent sample method. The program was developed using MS Excel and calculates: the average of the measurements, the repeatability standard deviation, the bias, the bias standard deviation and the $1-\alpha$ confidence bounds around the bias value. Using these values, the program makes the decision about the acceptability of the measurement bias.

1. INTRODUCTION

The paper presents a computer program for the determination of the measurement bias, using the independent sample method.

Bias is the difference between the observed average of the measurements and the reference value, on the same characteristic on the same part [1] (Figure 1).

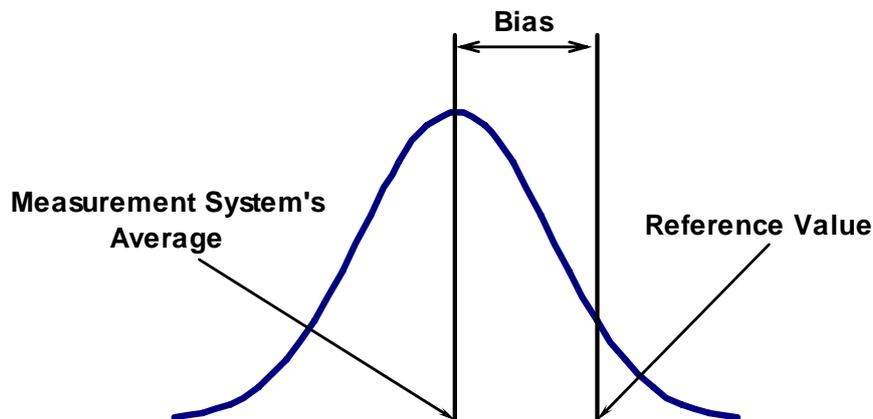


Figure 1. The definition of Bias

In order to determine the reference value, it is used a production part that falls in the mid-range of the production measurements.

The part will be measured $n \geq 10$ times in the tool room. The average of these measurements will be considered the reference value [2].

2. PRESENTATION OF THE PROGRAM

The program was developed using MS Excel, according to the procedure presented in [2].

The input data are: the measurements, the reference value, the constants d_2^* and d_2 , the degrees of freedom ν and the risk α .

Using the measurements, the program calculates (Figure 2):

- The smallest and the largest of the measurements;

- The range R, which is equal to the difference between the largest and the smallest of the measurements;
- The number of classes k, by means of the relation (1):

$$k = 1 + 3.322 \lg(n), \quad (1)$$

Using the formula (1), it will be obtained a real number, which will be rounded to the nearest integer by means of the Excel function **ROUND**;

- The size of the classes, a, by dividing the range by the number of classes;
- The limits of the classes (the first limit will be equal to x_{\min}).

The program will plot the histogram (Figure 2) and the program's user will determine if any special causes or anomalies are present.

Further, the program will calculate:

- The average of the measurements, by means of the Excel function **AVERAGE** (Figure 3);
- The repeatability standard deviation (Figure 3). The Excel function **MAX**, calculates the largest value in a set of values, and the Excel function **MIN**, calculates the smallest value in a set of values;
- The bias, which is the difference between the observed average of the measurements and the reference value (Figure 4);
- The bias standard deviation (Figure 4). The Excel function **SQRT** is used for calculating the square root of the number of measurements;

x min	19.93
x max	20.04
R	0.11
k	5
a	0.022

Limits	
1	19.93
2	19.95
3	19.97
4	20.00
5	20.02
6	20.04

<i>Bin</i>	<i>Frequency</i>
19.95	1
19.97	3
20.00	6
20.02	3
20.04	2
More	0

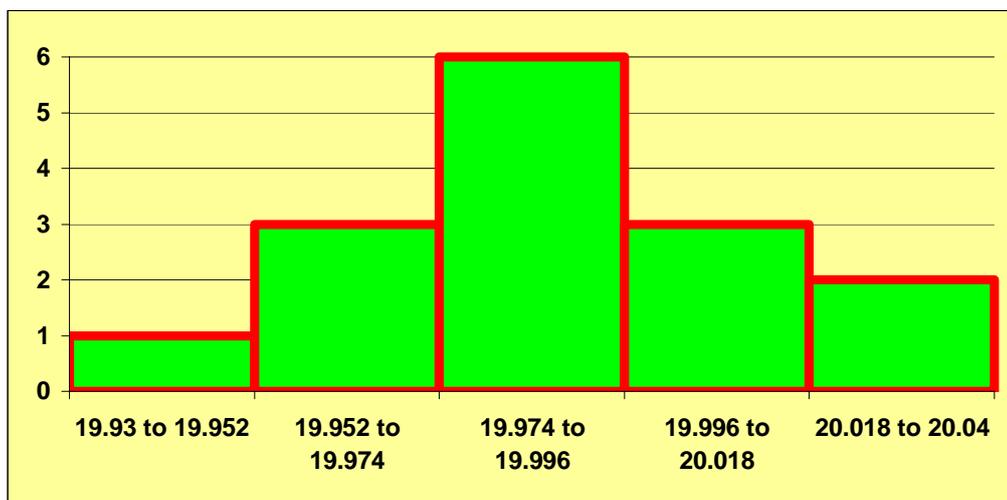


Figure 2. The histogram

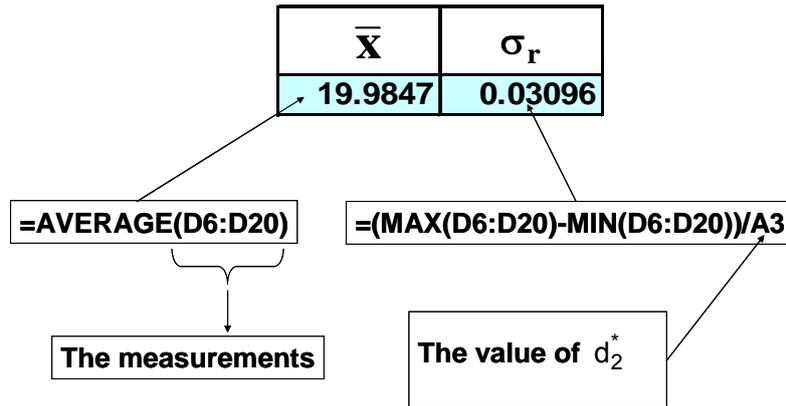


Figure 3. The average of the readings and the repeatability standard deviation

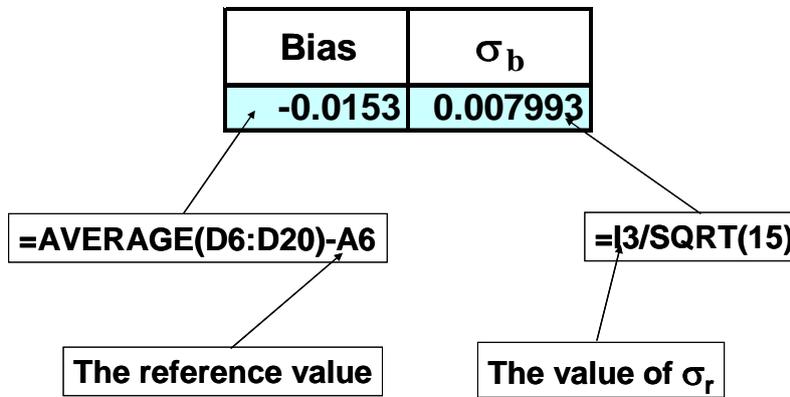


Figure 4. The bias and the bias standard deviation

- The significant t value (2-tailed) (Figure 5), which is calculated by means of the Excel function **TINV** which returns the inverse of the Student's t-distribution;

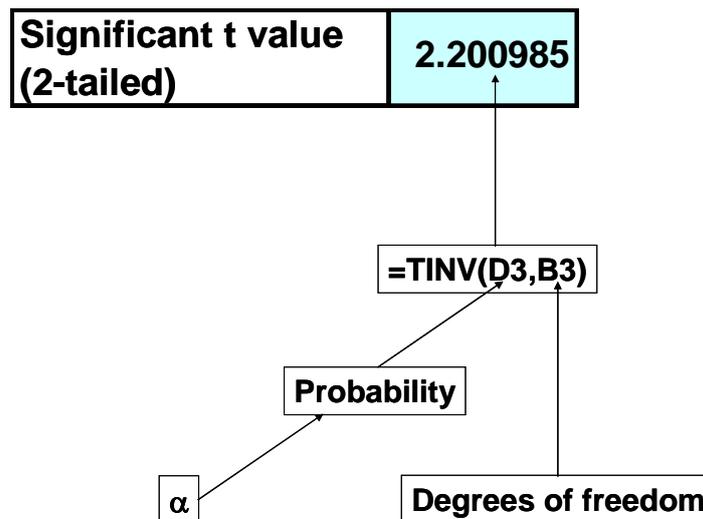


Figure 5. The significant t value

The $1-\alpha$ confidence bounds around the bias value are calculated by means of the relations presented in [2] and there are presented in Figure 6.

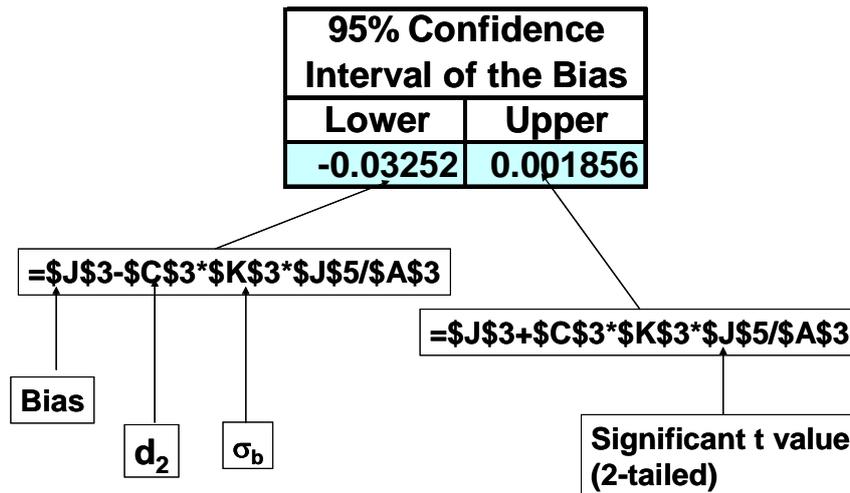


Figure 6. The bounds of the confidence interval

Bias is acceptable at α level if zero falls within the confidence limits [2]. In order to make the decision about the measurement bias, the program uses the Excel function **IF(logical test, value_if_true, value_if_false)**. In the presented case the measurement bias is acceptable (Figure 7).

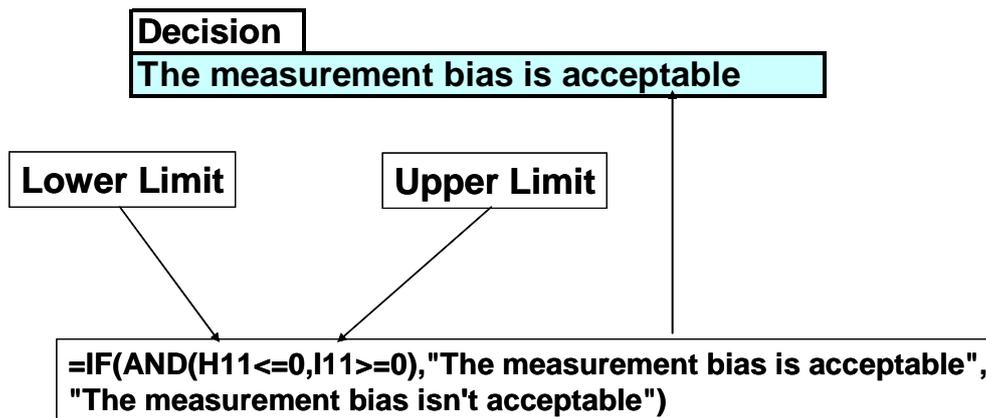


Figure 7. The decision about the measurement bias

3. CONCLUSIONS

The presented program can be used as a Computer Aided Quality tool, at the Measurement Systems Analysis.

The program calculates: the average of the readings, the repeatability standard deviation, the bias, the bias standard deviation and the $1-\alpha$ confidence bounds around the bias value. Using these values, the program makes the decision about the acceptability of the measurement bias.

REFERENCES

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2. *** Measurement Systems Analysis (MSA) – Reference Manual, Third Edition. 2002, Automotive Industry Action Group. Chrysler Corporation, Ford Motor Company, General Motors Corporation, p85-87, 195.