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PORTABLE SINE RULER

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Abstract: The paper presents basic necessary notions for the design and manufacturing of a portable sine ruler. Two types of portable sine rulers are described: non-adjustable and adjustable, in order to improve the measurement accuracy and measurement range. Moreover, increased productivity of the measurements, convenience data sampling and the possibility of statistical processing of obtained data (using a digital depth micrometer) are intended. Comparative tests were made using the mechanical protractor from the Technical Measurements and Dimensional Control Laboratory and the results were plotted. Finally, some conclusions, on the validity of the method and the specific results obtained were drawn.

1. INTRODUCTION

Conical assemblies and conical machine parts are more complicated than cylindrical ones, both in terms of execution and control, as their precision depends on supplementary parameters. Conical assemblies are, however, often used in mechanical engineering due to the advantages provided (precise centring, sealing capacity and clearance adjustment possibility).

Two methods of prescribing the accuracy of a conical assembly, namely nominal taper method and tolerated taper method, are used

Amongst the instruments used to measure angles directly, protractors are the most accepted. Existing protractors work in two modes: mechanical and optical, with a measuring range of 360 °, but an accuracy of 5 '/ division. Indirect measurement of angles can be made using a sine ruler (with one or two tilted planes), [2].

The measurement method using sine ruler, Figure 1, assumes a control table, a dial indicator with the division value Vd=0.01 mm/division and a magnetic support for the indicator, a size gauge set and a stand. Dial indicator can be replaced by a precision indicator with Vd = 0.001 mm/division or a minimeter gauge with Vd=0.001 mm/division, [3].

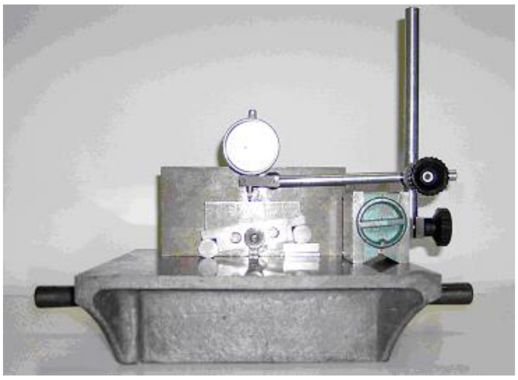


Figure 1: Measurement method using sine ruler

The dial indicator is locked through the magnetic support on the measuring table. Beneath one of the sine rule rollers a parallel precision gauge of a certain height "H" is positioned, so that the indication of the dial indicator is "0", Fig. 1. This is practically impossible in all practical situations and for every dimension and therefore the deviation indicated by the dial indicator is added or subtracted from the height H of the gauge (depending on its sign) and the angle is recalculated. All these steps and all these complementary calculations are increasing the difficulty of the measurement process and are lowering its productivity.

The aim of the paper is to combine the two types of instruments into a single one, called portable sine ruler, that will have an increased measurement accuracy and an extended measurement range.

To this end two types of portable sine rulers, namely one non-adjustable and one adjustable were conceived, designed and manufactured. The precision and accuracy of the sine rulers was evaluated in comparison with some existing instruments of the Technical Measurements and Dimensional Control Laboratory, through a series of measurements.

2. NON-ADJUSTABLE PORTABLE SINE RULER

The classic sine ruler has some disadvantages such as:

- limited accuracy due to errors introduced by each gauge of the parallel precision gauge block of height H;
- low-productivity due to the time required for finding the height of gauge block and positioning it;
- Increased time needed for the extraction, processing and interpretation of data resulting from measurement;
- Impossibility of setting the gauge block at the desired height due to the limited size gauges kit and to their dimensions.

In order to eliminate these disadvantages, it is proposed to replace the gauge block with a micrometric device, [4].

By using this device the following advantages are attained:

- High precision (0.01 mm/division - 20 ");
- high productivity by eliminating the gauge block (not necessary to calculate the height H and to position the size gauges).

For these reasons, the construction of a non-adjustable portable sine ruler is proposed, consisting of a fixed frame, a mobile sine ruler and a micrometric device instead of the gauge block.

The permanent portable sine ruler, Figure 2, has the following elements:

1. fixed frame;
2. joint ruler
3. pin;
4. roller;
5. locking screw;
6. depth micrometer;
7. helical traction spring;
8. joint - roller.

The joint ruler subassembly 2 is fixed through the joint roller 8 onto the fixed frame 1. The joint roller has a dual role: it is one of the rollers from the sine ruler and at the same time it serves as the pivot for jointed ruler 2. The other roller of the sine ruler 4 is in direct contact with the tracer stylus of depth micrometer 6, which is fixed to the frame by the locking screw 5. The helical traction spring 7 is fixed by two pins 3, both to the fixed frame and to the joint ruler, intended to maintain the contact between the roller and micrometer detecting element.

The distance between the rollers of the sine ruler is 100 mm, in our case, representing the constant of sine ruler. Given this value and the value of 0.01 mm/division of micrometer, we conclude that the precision of non-adjustable portable sine ruler is excellent, specifically 20 ''/ division.

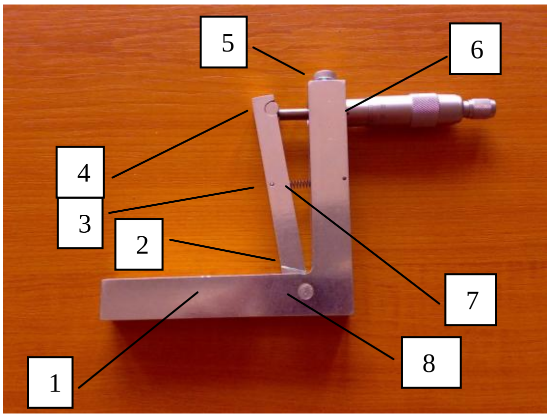


***Figure 2**: Non-adjustable portable sine ruler*

To validate the measurement results, a test of sine ruler is made, using for this purpose, a mechanical protractor available in the Technical Measurements and Dimensional Control Laboratory. It has a measuring range of 360"and an accuracy of 5 '/ division, Fig. 3.

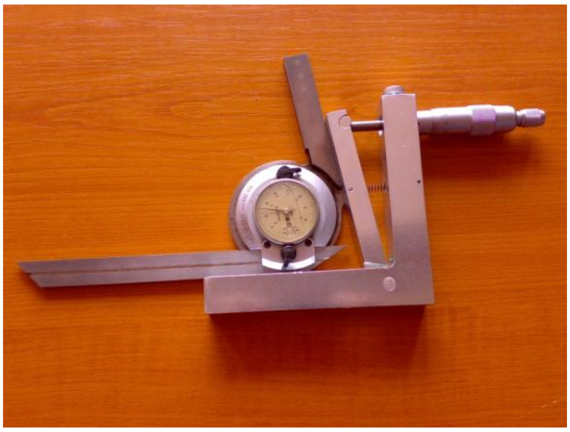


Figure 3. Testing the non-adjustable portable sine rule

The experimental data are plotted in the graph from Figure 4.

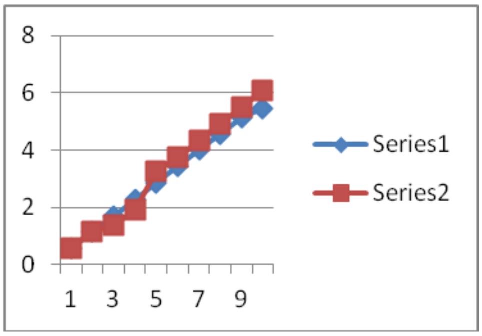


Figure 4: Plot of testing results

Data obtained using the protractor available in Technical Measurements and Dimensional Control Laboratory were plotted in blue colour (series 1), while data corresponding to the non-adjustable sine ruler were plotted in red colour (series 2).

From the values and graph analysis, a good qualitative agreement of results is noticed. Quantitative differences are quite large, up to 7%, what is considerable. The errors occurred due to low precision of execution: distance between rollers deviation, dimensional deviations, shape and position of the rollers deviation. The methodology is captured in Fig. 5.

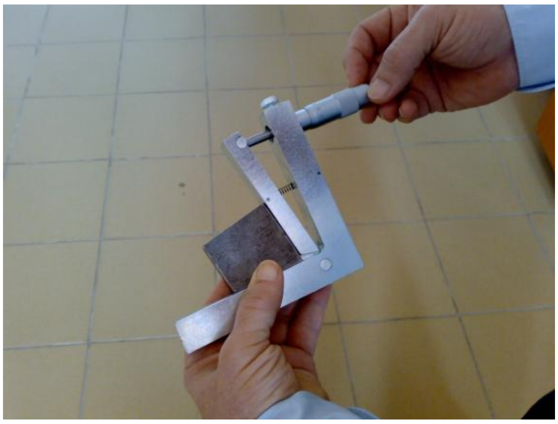


Figure 5. Non-adjustable portable sine rule measurement methodology

Before the actual measurement, the protractor is fixed to "zero", using an angle gauge of 90°. The part to be measured is afterwards fixed with one side on the fixed frame and with the other side in contact with the joint ruler. The micrometer screw is operated until the two sides of the measured element are in contact with the surfaces of the measuring set. This is made by the slit of light.

3. ADJUSTABLE PORTABLE SINE RULER

Non-adjustable portable sine ruler has the disadvantage of a measurement range lower than 15º. In order to increase the measurement range, there are two possibilities: either use a set of fixed frames working from 15 ° to 15 °, or make a frame covering a measuring range of 180 °. Portable adjustable sine ruler is the latter option.

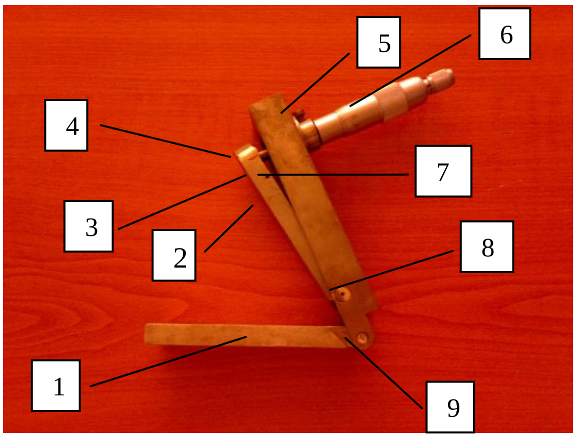


Figure 6: Portable adjustable sine ruler.

For this reason, a portable adjustable sine ruler is proposed, consisting of a joint frame, a portable sine ruler and a micrometric unit instead of the slip gauge block.

Portable adjustable sine ruler, Fig. 6, is composed from the following parts:

1. adjustable frame;
2. joint ruler;
3. pin;
4. roller;
5. locking screw;
6. depth micrometer;
7. blade spring;
8. joint-roller;
9. joint-pin.

The entire joint ruler unit 2 is fixed through the joint roller 8 on the adjustable frame 1. The joint roller has a dual role: as one of the sine ruler rollers and at the same time as the joint for joint- ruler 2.

The other roller of the sine ruler 4 is in direct contact with the sensing element of the depth micrometer 6, which is fixed to the fixed frame by the locking screw 5. The blade spring 7 is fixed by two pins 3 both to the fixed frame and to the joint ruler, as to maintain the contact between the roller and micrometer tracer. The distance between the rollers of the sine ruler is, in the presented case, 100 mm, and represents the constant of sine ruler. Given this value and the value of 0.01mm/division of the micrometer, we conclude that the protractor has a high precision that is 20"/division.

In order to validate the measurement results, a prior test of portable adjustable sine ruler is made, using for this purpose, an existing mechanical protractor from Technical Measurements and Dimensional Control Laboratory.

The instrument has a measuring range of 360 "and an accuracy of 5'/division. The mechanical protractor is able to materialise high precision bevel angles and is set for 10 values. The corresponding indications are red, in the same time, on the adjustable portable sine ruler, as seen in Fig. 7.

Figure 7: Testing portable adjustable sine ruler

The obtained data are plotted in Fig. 8. With blue (series 1) are represented the data measured with the mechanical protractor from Technical Measurements and Dimensional Control Laboratory and with red (series 2) are plotted the data corresponding to the portable adjustable sine ruler conceived, designed and manufactured. The values analysis and obtained plots show a good qualitative agreement of results. Quantitative differences are quite large, up to 6'(5%) and therefore, significant.

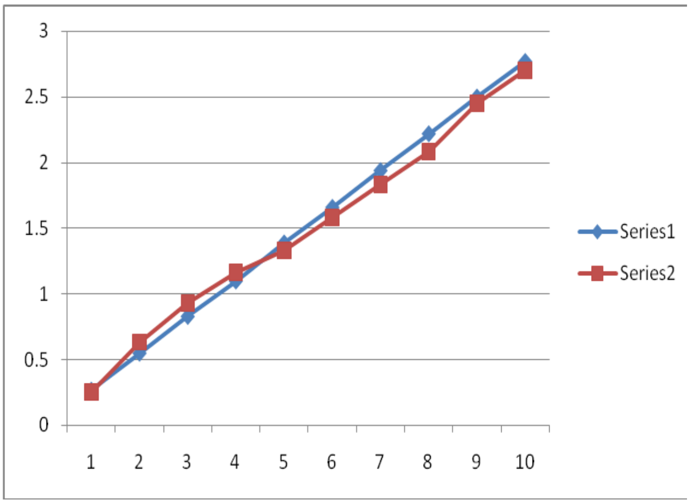


Figure 8: Graphical representation of testing results

The errors are due to low precision of execution: distance between rollers deviation, dimensional deviations, shape and position of the rollers deviations, the joint clearance. The working method is presented in Fig. 9:

Figure 9: Measuring method using portable adjustable sine ruler

Before the actual measurement, the bevel angle is fixed to "zero" using an angular gauge of certain value, according to the nominal value of the measured angle.

The part to be measured is placed one side on the fixed frame and the other side in contact with the joint-ruler. The micrometer screw is operated until the two sides of the measured part are in contact with the mentioned measuring surfaces. This is verified to the slit of light.

4. EXPERIMENTAL RESULTS

In order to determine the actual average value of the measured angle α_{efmed}, three measurements were made for three values α_{ef} of the measured angle (one angle with the non-adjustable portable sine ruler and two angles with the adjustable portable sine ruler), using the existing mechanical protractor from Technical Measurements and Dimensional Control Laboratory for comparison. The final result was considered the mean value. Note that the use of mechanically adjustable bevel angle, that is of the adjustable sine ruler, allows precision including seconds. Graphical representation of measurement results (actual values) is given in Fig. 10 (for non-adjustable portable sine ruler) and Fig. 11 (for portable adjustable sine ruler).

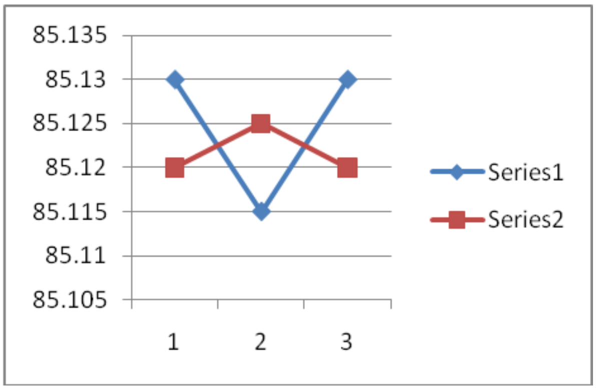
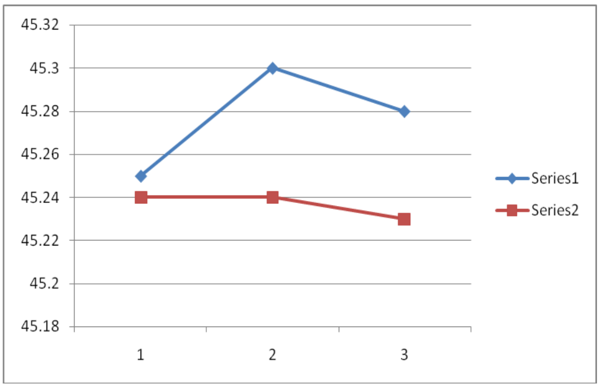
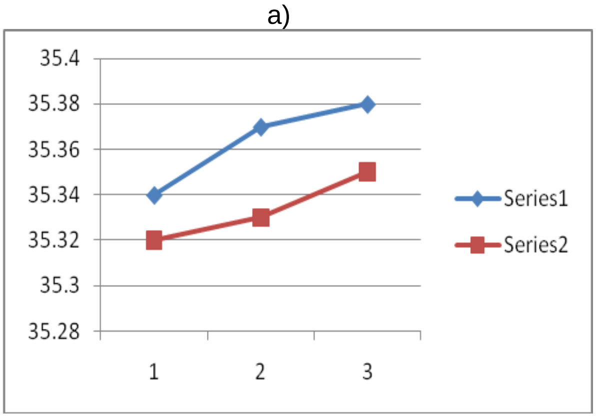


Figure 10: Plots of measurement results (actual values) for non-adjustable portable sine ruler



a)



b)

Figure 11: Plots of measurement results (actual values) for portable adjustable sine ruler

5. CONCLUSIONS

Measuring bevel and tilting angles (tapers) with portable sine ruler non-adjustable or adjustable) is an indirect measurement method, which uses the principle of sine ruler, namely the height H is obtained using a depths micrometer.

The precision of the measurements made using portable sine ruler (non-adjustable or adjustable) is 20''/division, given by the scale of the used mechanical depth micrometer (0.01 mm/division). This can actually be increased further by using additional gradations on the micrometer scale.

The measuring range of the mechanical depth micrometer is 25 mm, which corresponds, for the (non-adjustable portable sine ruler, to a measurement range of 15°. For portable adjustable sine ruler the measuring range is extended to 180 º by creating a joint frame.

One can also use digital depth micrometers that increase the accuracy of bevel angles. In addition, devices like digital micrometers can be connected to statistical calculus and printing units. They can also be connected to simple computing devices able to display directly the measured value of the angle without requiring additional calculations.

The devices designed and described in this paper present a degree of novelty, and are not proposed by catalogues of measuring instruments.

Finally, the following conclusions were drawn:

- using both methods, the results obtained were close to actual values;
- the difference between average values is however significant, due solely to the execution errors, as the measurement instruments were manufactured locally, in a didactic workshop;
- should this instrument be improved, it can be used in many practical situations due to its degree of universality and increased productivity.

References:

[1] **Lepădătescu, B., Popescu, M. – Tolerances and dimensional control, Universitatea “Transilvania” Braşov, 2002**
[2] **MITUTOYO – Instruments de Precision, Mecanique-Optiques-Electronique, B-4001, Edition 2000**
[3] **Sturzu, A., Bădescu, Gh., Militaru, C., Brăgaru, A., Îndrumător practic uzinal şi de laborator pentru controlul preciziei de prelucrare în construcţia de maşini, Editura Tehnică, Bucureşti, 1976**
[4] **www.ttonline.ro (mitutoyo-românia-803).**