ADJUSTABLE LIMITING CALIBERS FOR INTERIOR SURFACES

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Abstract: *The paper presents the idea and the conception of adjustable limiting calibers for interior surfaces control. These calibers have the possibility of adjusting the dimension of the "pass" and "do not pass" sides, in a few millimeters range, depending on the value of the nominal dimension to be checked and it's tolerance and limit deviations. For small series, these instruments can be useful in order to control interior surfaces in a certain measuring range and to avoid the necessity of a big number of calibers and consequently the costs related to their acquisition.*

As two limiting calibers with two different reading systems were realized in the "Tolerances and Dimensional Control" Laboratory of the Faculty of Mechanical Engineering, Mechatronics and Management, "Stefan cel Mare" University of Suceava, a set of preliminary measurements was carried out in order to evaluate the adjustment errors of these instruments.

Keywords: *calibers, dimension, interior surfaces, control*

1. Considerations

Generally, the methods of measurement and control are extremely varied. This is why, determining the appropriate measurement method, should be performed according to the company's technical equipment, production characteristics, the batch size (individual production, small volume, large scale or mass), the required measurement accuracy, the measured parameter. In principle, the methods for measuring and controlling dimensions are simpler than those for measuring and controlling deviations of form and especially the deviations of mutual position.

Depending on the purpose and method of measurement chosen, the instrument, equipment or means of measuring and control should be chosen as well.

Limiting calibers are special means used to check (control) parts in mass and large scale production with a corresponding productivity. When checking dimensions using limiting calibers the actual values of dimensions or of dimension's deviations is not determined, the purpose being to establish only if they fall within limits. Consequently, the control time is significantly reduced and the majority of measuring errors which may appear when using other instruments are removed [1-5].

2. Adjustable limiting "pass" - "do not pass" calibers for interior surfaces

The limiting calibers mentioned, with all the listed advantages, obvious in the case of mass or large series production, may have disadvantages in the production of small series, due to high variability both of the nominal dimensions checked and of the tolerances prescribed to them and hence to the necessity of a big number of calibers and consequently to high costs related to their acquisition. Given this obvious disadvantage for small volume production, emerged the idea to design adjustable limiting calibers,

with both the “pass” or “do not pass” sides adjustable in a certain range, so only a few calibers of this kind, or possibly only one adjustable caliber together with some accessories that extend the measurement range to be enough.

Adjustable limiting “pass” - “do not pass” caliber, for interior surfaces [6-9] is shown in Fig. 1 and consists of the following components:

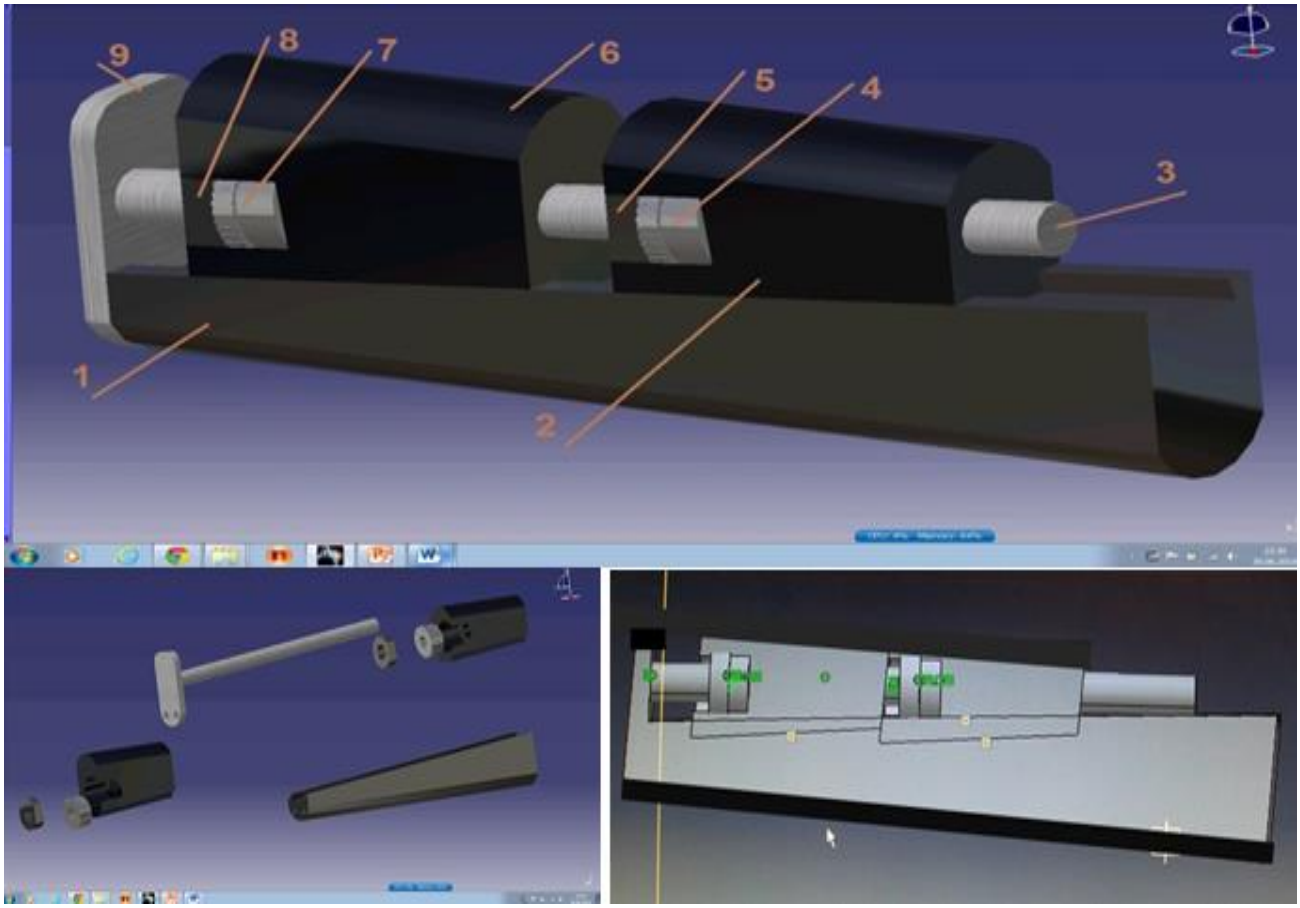

Figure 1: *Adjustable limiting caliber - components*

- 1 - fixed block;
- 2 - mobile block;
- 3 - micrometer screw;
- 4 – graduated drum;
- 5 – drum support;
- 6 – mobile block;
- 7 – graduated drum;
- 8 – drum support;
- 9 - supporting and fastening element for the micrometer screw.

Relative displacement between fixed and mobile blocks is performed by rotating the graduated drums 4 and 7 and transforming in translational motion the rotation between the micrometer and the nut.

In order to adjust with a fine tuning the caliber to the appropriate dimension, the fixed block 1 and the two mobile blocks 2 and 6 corresponding to the “pass” or “do not pass” sides were realized with a slope leading to a vertical displacement (an increase or a decrease in the active dimension of the caliber) 10 times smaller than the relative linear displacement between the fixed block and moving blocks.

According to Fig. 2, relationships 1 and 2 are used in order to determine the angle of inclination:

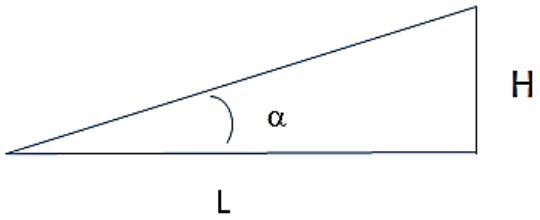

Figure 2: *Angle of inclination*

$$\sin a = H/L = 1/10 \quad (1)$$

$$a = \arcsin H/L = \arcsin 1/10 = 5{,}739170477^{\circ} = 5^{\circ}\,44'\,20'' \quad (2)$$

In order to adjust the "pass" or "do not pass" sides of the caliber to the desired size, depending on the value of the nominal dimension to be checked and it's tolerance and limit deviations, two variants were considered:

2.1 Adjustable "pass" - "do not pass" caliber with the reading system type " linear graduated scale - circular graduated vernier" ("micrometer type" reading system)

This caliber (Fig. 3) is provided with two linear scales graduated in mm attached to the fixed block (and corresponding to each mobile block, that is to the "pass" and to the "do not pass" sides) and with circular verniers, graduated in 50 divisions, as any ordinary micrometer and fixed to the drums of the mobile elements.

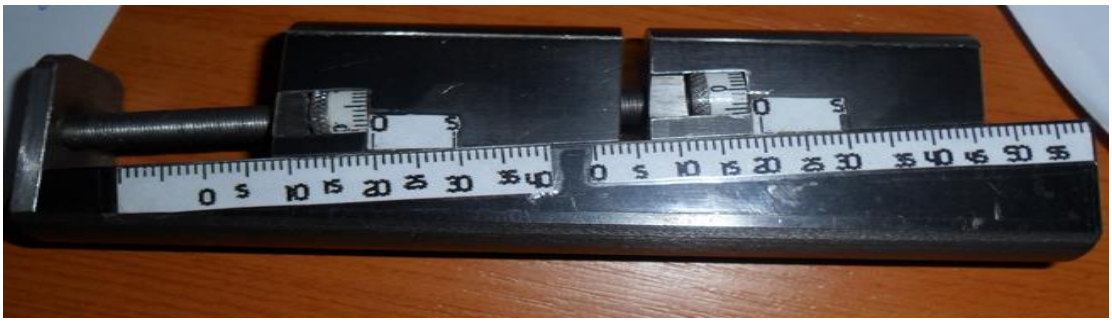

Figure 3: *Adjustable "pass" - "do not pass" caliber with the reading system type " linear graduated scale - circular graduated vernier"*

Since the micrometer screw pitch is 0.5mm, at a complete rotation of the drum the relative displacement between the fixed and the mobile elements is 0.5 mm. As the circular vernier has 50 divisions, for a rotation with only one division, the relative translational displacement is 0.5 / 50 = 0.01 mm.

Furthermore, since, as noted above, the vertical displacement corresponding to the active dimension of the caliber is 10 times smaller, will result the possibility of adjusting the size of the active part of the "pass" or "do not pass" sides of the adjustable caliber with only 0,001 mm.

For the adjustable "pass" - "do not pass" caliber with the reading system type " linear graduated scale - circular graduated vernier", the adjustment range of the active size is more than 3 mm. Fixing the scales was performed so that the value "zero" of the reading system indicated 41 mm.

Adjustment to "zero" was conducted using an orthotest graduated to 0.001 mm (Fig. 4) and a 41-mm block of gauge blocks.

Figure 4: *Adjustment to "zero" for the adjustable "pass" - "do not pass" calibers*

2.2 Adjustable "pass" - "do not pass" caliber with the reading system type " linear graduated scale - linear graduated vernier" ("caliper type" reading system)

This adjustable caliber has the reading and adjustment system similar to a regular caliper, using a graduated linear scale and a graduated linear vernier (fig.5).

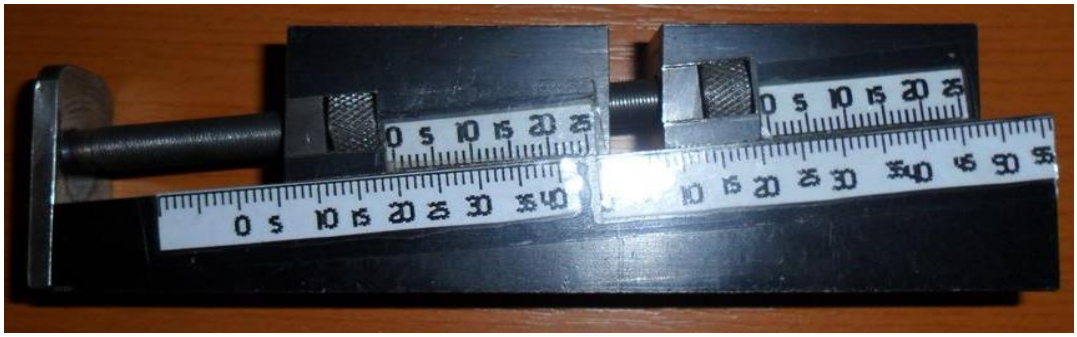

Figure 5: *Adjustable "pass" - "do not pass" caliber with the reading system type " linear graduated scale - linear graduated vernier"*

The adjustment precision of the system "graduated linear scale - graduated linear vernier" is 0.04 mm, resulting from the report:

$$Vd = \frac{Vi}{Nd} = \frac{1}{25} = 0{,}04 \quad (3)$$

were:

Vd – value of the vernier division;
Vi - the value of the interval between two divisions on the ruler scale (Vi = 1mm);
Nd - number of divisions on the vernier

The relative linear displacement of 0.04 mm will determine a vertical displacement (a possibility of adjusting the size of the active part of the caliber) 10 times smaller, namely 0.004 mm.

This adjustable “pass” - “do not pass” caliber with the reading system type " linear graduated scale - linear graduated vernier", has also the adjustment range of the active size more than 3 mm.

Fixing the scales was performed so that the value "zero" of the reading system indicated 36 mm. Adjustment to "zero" was conducted using an orthotest graduated to 0.001 mm (Fig. 4) and a 36 mm block of gauge blocks.

2.3 Experimental determination of adjustment errors

In order to evaluate the size of the adjustment errors of the calibers, a set of measurements were carried out with the orthotest.

For each caliber five blocks of gauge blocks corresponding to five values of adjustment of the calibers, that is to five different sizes, were materialized. Eventually, comparison was made between the measurements made over the blocks of gauge blocks as benchmarks and the measurements made over the calibers adjusted to the corresponding values.

The results are compiled in Table 1 and Table 2, both for the caliber with "micrometer type" reading system and for the one with "caliper type" reading system. The data in the table represent the average of five different measurements and are plotted in Figs. 6 and 7 (Series1 – errors for the “pass” side; Series2 – errors for the “do not pass” side).

caliber with "micrometer type" reading system		
Adjustment dimension	**Errors for the “pass” side**	**Errors for the “do not pass” side**
41	-0.0003	-0.0002
41.5	-0,0001	0.0003
42	0.0004	0.0007
42.5	0.0008	0.0009
43	0.0013	0.0011

Table 1: *Experimental determination of the adjustment errors of the calibers - caliber with the reading system type "linear graduated scale - linear graduated vernier" (instrument with "micrometer type" reading system)*

caliber with "caliper type" reading system		
Adjustment dimension	**Errors for the “pass” side**	**Errors for the “do not pass” side**
36	0.0002	0.0003
36.5	0.0004	0.0008
37	0.0007	0.0012
37.5	0.0013	0.0015
38	0.0018	0.0018

Table 2: *Experimental determination of the adjustment errors of the calibers - caliber with the reading system type " linear graduated scale - linear graduated vernier" (instrument with "caliper type" reading system)*

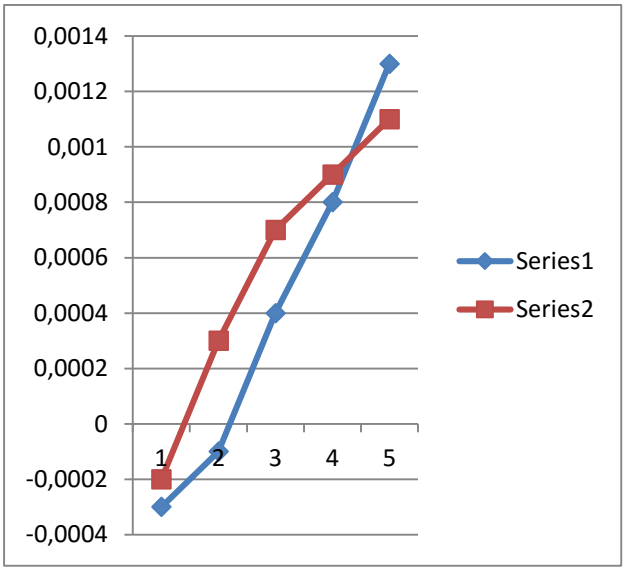

Figure 6: *Adjustment errors for the caliber with "micrometer type" reading system*

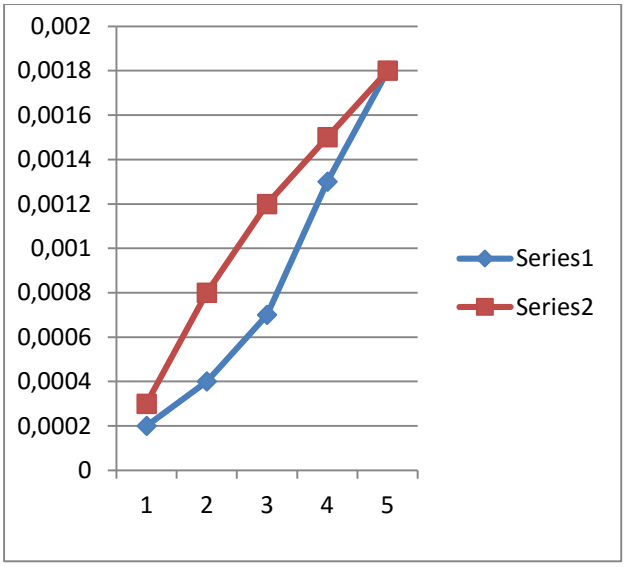

Figure 7: *Adjustment errors for the caliber with "caliper type" reading system*

3. Conclusions

These adjustable limiting "pass" - "do not pass" calibers for interior surfaces can be useful in order to materialize very precise dimensions and to control interior surfaces in a certain measuring range. Expanding measuring domain can be done either by using several calibers, either by designing accessories in order to extend the measurement range. Possible wear of the calibers active surfaces can be easily compensated through supplementary adjustment.

Experimental determinations carried out highlights the following aspects:

- an error of scale fixing was observed;
- adjustment errors are almost similar in size and trend for both calibers and are most likely determined by the fixation error of the scales, their grading errors and especially by the inclination angle error, which can cause a linear increase of errors;
- taking into account the possibility of a high accuracy in manufacturing the components of the calibers and eventually of the adjustable calibers, it is more likely that the caliber with "micrometer type" reading system is preferable, since it offers the possibility of a higher "fine tuning".

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