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THE MODELLING OF THE SMALL DIMENSION PROBES DEFORMATIONS SUBMITTED TO THE DIMENSIONAL CONTROL WITH CONTACT PRINCIPLE

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ABSTRACT
In the paper there is described the way in which it was materialized a study on the analysis with finite element of some small dimension probes behaviour, which are submitted to the dimensional control. The measuring was made with devices which principle ensures the permanent contact with the tested surface. The research was made to determine the lower limit dimensional value of the measured probes, until theirs deformation degree do not influences the measuring precision.
Our paper presents the study applied to the annular small dimension probes, which compose the miniature bearings, insisting on the radial miniature bearing coils. The analysis with finite element was made using the ANSYS software environment, for different typo-dimensions, for dynamic variable measuring forces.
Key words: ball micro-bearing race, ANSYS

1. ON THE MICROCOMPONENTS MANUFACTURING
Nowadays the micro-electroncs and the nano-technology play a more and more role on ordering and command systems optimisation. It could be considered as integrated part of the MEMS technology. Due to the fact that medicine, environment, industry are important domains in which the micro-robotics plays a key-role, it is important to ensure a high quality in functioning of this kind of micro-systems.
Some microelements in MEMS as micro-bearings, micro-engines, micro-shafts require a very high precision in functioning; that invokes to ensure a very high quality in micro-components manufacturing. The surface quality control, the dimensional inspection the micro-flaw detection are some representative examples to insure the high quality in MEMS functional micro-elements manufacturing.

2. THE MICROCOMPONENTS DIMENSIONAL INSPECTION IMPROVEMENT
Our research was concentrated on the dimensional control of some functional micro-components in MEMS technology. As an example we referred to the micro-ball bearing races. The aim of the study is to find the optimum-measuring device reported to the micro-component’s geometry.
To choose the proper measuring device, the main aspect is to find the lowest dimensional limit for which the form deviation control accuracy is not affected. The way in which the dimensional control precision can be influenced is due to the micro-strains that appear in case of the contact between the displacement transducer and the tested micro-component. In this order we founded the micro-ball bearing race dimensional limit for which the non-contact measuring device is strictly required [1,2].
As a solution for our study, we choose to use the finite element to determinate the strains of the ball micro-bearing race, knowing the constraints and the measuring force that act to the micro-probe submitted to be measured.

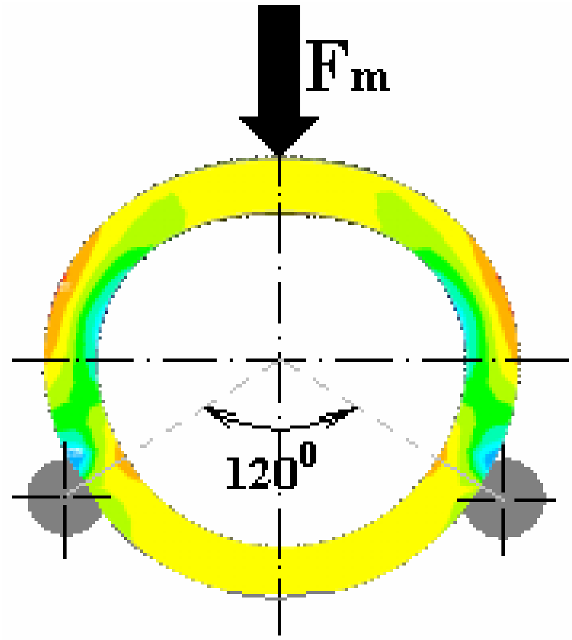

Figure 1. External micro-ball bearing race submitted to be measured

As an example it was taken into account the most frequent case, in which the micro-ball bearing race is supported by two rollers which layout directions form an angle about 120° reported to the instantaneous centre of revolution of the ball bearing race. The measuring force due to the contact between the displacement transducer and the inspected bearing race surface is disposed along the symmetry axis of the micro-ball bearing race.
Knowing the constraints and the measuring force, the problem is to determine the micro-probe maximum strain (along the measuring force axis) reported to the maximum accepted tolerance. Grace to the fact that the form deviation tolerance is specified in bearings catalogues, it is easy to find the maximum accepted form deviation, in the dimensional control accuracy (relation (1)).

$$\delta_{max} = 20\% \cdot T \tag{1}$$

where δ_{max} is the maximum accepted form deviation and T represents the dimensional tolerance of the ball bearing race.
The strain of the ball bearing due to the contact forces being the object of the study, we considered that it could be associated with the form deviation during the dimensional control.

3. THE RESULTS ON THE STRAINS USING THE FINITE ELEMENT

To evaluate the strains for different measuring forces, we used ANSYS as environment for finite element calculus. The strains determination for different measuring forces was made for different dimensions of micro-ball bearing races.
The measuring force variation for the same tested micro-probe is due to the dynamic mode during the dimensional control. It could vary from 1.5 to 2.8 N in case of displacement transducers.
The results on external and internal micro-ball bearing having different dimensions are presented in the tables 1 and 2.
The geometric dimensions of the studied external and internal micro-ball bearings are presented in the figure below:

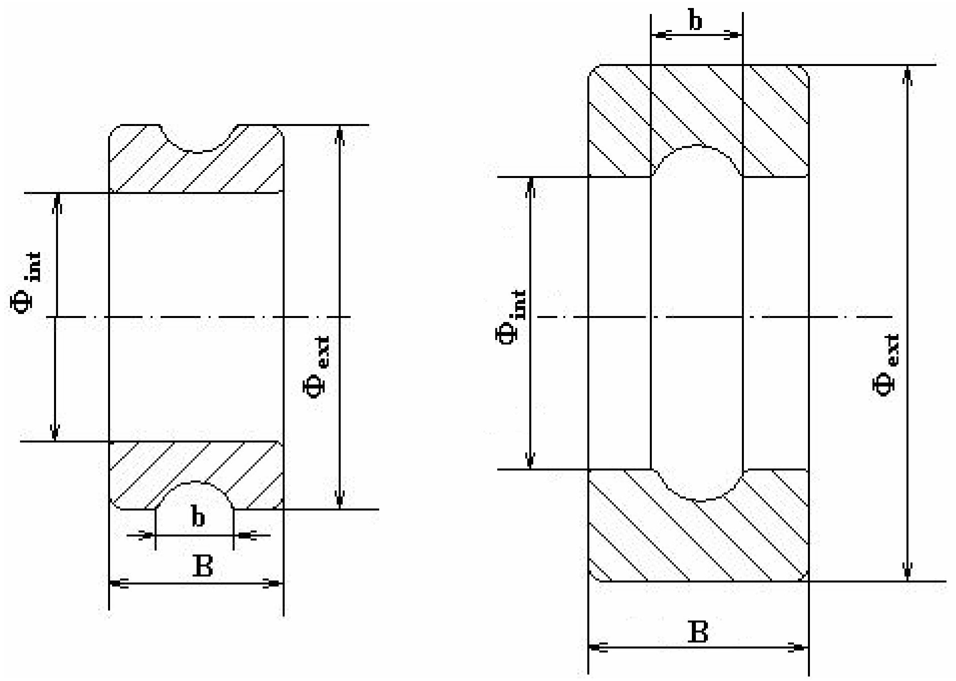

Figure 2. The dimensions of the internal and external micro-ball bearings for which our study was referred

Table 1. The calculated strains for known measuring forces, via ANSYS

Type of ball bearing	Geometric dimensions [mm]	Measuring force values [N]	Maximum accepted dimensional tolerance T (STAS) [μm]	Maximum accepted form deviation δ_{max} [μm]	The calculated strains values [μm]
External radial ball bearings	$\phi_{ext} = 1.3$;	1.5	5	1	5.5
	$\phi_{int} = 1$	2			6.5
	B = 1.5	2.5			8.9
	b = 0.75	2.8			11
	$\phi_{ext} = 8.5$;	1.5	8.5	1.7	1.02
	$\phi_{int} = 6$	2			1.5
	B = 3	2.5			2.04
	b = 1,8	2.8			2.45
Internal radial ball bearings	$\phi_{ext} = 1.3$;	1.5	5	1	4.85
	$\phi_{int} = 1$	2			6.46
	B = 1.5	2.5			8.08
	b = 0.75	2.8			9.05
	$\phi_{ext} = 2.7$;	1.5	7	1.4	4.96
	$\phi_{int} = 2$	2			6.61
	B = 2	2.5			8.27
	b = 1.2	2.8			9.26
	$\phi_{ext} = 5.5$;	1.5	8	1.6	1.26
	$\phi_{int} = 3$	2			1.9
	B = 3	2.5			2.02
	b = 1.8	2.8			2.31
	$\phi_{ext} = 6$;	1.5	8.25	1.65	0.97
	$\phi_{int} = 3.5$	2			1.52
	B = 3.2	2.5			1.6
	b = 1.9	2.8			1.75

3. CONCLUSIONS

The main issue of the study was to obtain concrete and precise information about the optimal condition for use of different measuring devices, with or without contact with measured surface principle. First of all the research serve to obtain some information on the without contact measuring displacement transducers principle using requirements, which completes the information referring to the price. Besides, the technical data on the measuring precision imposed for each measuring probe prototype is an important parameter to be improved.

4. REFERENCES

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