The mechanism study for changing the precision parts dimensional accuracy such as bearing rings

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Abstract. The article presents the mechanism studies results for changing the precision parts dimensional accuracy such as bearing rings, arising from the residual stress diagrams asymmetry relative to the rings transverse and longitudinal sections main axes occurring during the relaxation process. The stabilizing geometric parameters' problem is especially acute in the accuracy precision rolling bearings production classes 6 and higher, which are widely used in various machines and units. Even a slight change in dimensions over a time certain period leads to an accuracy sharp loss in these bearings. The existing technology and known methods for stabilizing geometric parameters, such as heat treatment, low-temperature tempering, artificial ageing, are ineffective since their use in practice lead to high energy costs, and the geometric dimensions and shape refinement degree is negligible. Therefore, work on improving the technology for stabilizing the precision bearings geometric indicators is very relevant.

1. Introduction
The precision engineering most important task, in particular, bearing construction, at the present stage is the more efficient technological processes development for the parts manufacture, ensuring not only the high accuracy achievement at a minimum cost but also the initial accuracy indicators' preservation throughout the product entire service life. One of the main factors leading to a decrease in the parts initial accuracy is the residual stresses relaxation. An increase in deviations in the parts' shape caused by stress relaxation inevitably leads to a decrease in reliability and a decrease in the machines service life, a decrease in their operational properties. In this regard, a residual stresses formation main regularities detailed study and the processing parameters influence on it is carried out [1-6].

In recent years, the residual stresses study has become very topical. In a mechanical engineering branches number, structures low-rigidity parts consisting are increasingly being used. Such parts must have a shape sufficiently high accuracy, which makes it possible to assemble them without creating additional stresses [7, 8].

2. Experimental studies
The research object in this work is the car belt tensioner bearing assembly rings (tension rollers) of the following types 2108-1006120-01, 2112-1006120-01. The parts investigated parameters control was carried out using the following equipment: a MAP 3 diffractometer and a FARO ARG EDGE coordinate measuring machine.
Studies show that the parts dimensions stabilization, as well as the deviation values from roundness (ovality), occurs 15 days after the residual stresses relaxation proposed method application in precision parts such as bearing rings based on the ultrasonic energy propagation through a special liquid (cavitation effect).

To determine the ultrasonic (US) processing effectiveness, four rings batches, 30 pieces each, were tested, which were randomly selected from a rings group that had undergone preliminary processing according to the manufacturing this part technological process. The parts first batch was a control one - the rings were not subjected to any processing to relieve internal stresses. The second batch was sonicated in a liquid medium. The third one was subjected to vibration treatment with a rotation of the part by 25-30° and modes A=10 µm, t= 5 µm, d=35 µm. The fourth batch is the usual thermal vacation.

2.1. *Ovality deviation indicators distribution histograms construction and analysis*

![Figure 1](image)

*Figure 1.* Bearing rings ovality deviation indicators distribution histograms the 1 group.
In the obtained data processing process, rings’ ovality deviation indicators distribution histograms were built before pouring the flange from polyamide (a), immediately after pouring the flange from polyamide (b), after the first day (c) and 15 days after pouring the flange (d), presented in figure 1.

2.2. The bearing ring groups ovality deviation indicators distribution analysis

The results for rings each group processing was carried out according to the creating control charts principle for the scattering field ($\omega$), mathematical expectation ($x$), variance ($\sigma^2$) and standard deviation ($\sigma$). A bearing rings control first group study showed that the bearing rings ovality not treated with ultrasound changes over time. The value of $\sigma$ varies within 10-15%.

Analysing the control group bearing rings ovality normal distribution curve according to $\omega$ - the scattering control group value, we can say that the ovality of the bearing rings not treated with ultrasound will not provide the specified parameters in the assembled bearings. This can be judged by the increase in $\sigma$ of the random variable and the increase in the scattering control group value on the 15th day of measurement.

The 2nd observation group rings ovality values distribution graphs show a sharp decrease in the value of $\sigma$, which in turn leads to a decrease in the scattering value. The scattering value indicates an increase in the rings frequencies concentration with the same ovality values, then the value of $\sigma$ increases (the
The value of σ becomes close to the value of σ, obtained before the flange was cast (the difference is 17%), which makes it possible to judge the decrease in internal stresses since the ovality value returns to the values obtained before the flange was filled.

The group 3 ovality distribution shows that the distribution curve after pouring the flange shifted relative to the curve obtained from the ovality values before the flange was filled; there was also a decrease in the values σ and ω, which indicates the ovality values concentration in this interval. The curve displacement indicates a change in the rings' ovality values in this group, namely, an increase in the ovality value, which indicates the stresses' presence inside the rings.

The group (c) rings ovality histogram, treated with ultrasound (no. 3), shows that the change in the deviation from roundness (ovality) continued. The stray field value also continued to change, σ increased by 20%. On repeated measurements, the following results were obtained: the curve normal distribution middle value returned to the position that was observed at the curve before the flange was filled; the value of σ increased and approached the value of σ before filling the flange, the difference is 15%. The stray field also approached the value ω, obtained before casting the flange, which makes it possible to judge the parts dimensions stabilization on the 15th day after ultrasonic treatment and a decrease in residual stresses.

The graphs for group 4 show that the normal distribution curve after filling the flange shifted relative to the curve obtained from the ovality values before filling the flange, as well as a decrease in the values of σ and ω, which indicates the ovality values concentration in this interval. The change in the deviation from roundness continued, the stray field value also continued to change, σ increased by 14%.

On repeated measurements, the following results were obtained: the curve normal distribution middle value returned to the position that was observed at the curve before the flange was filled; the value of σ increased and approached the value of σ before filling the flange, the difference is 17%. The stray field also approached the value ω, obtained before casting the flange, which makes it possible to judge the parts dimensions stabilization on the 15th day after ultrasonic treatment and a decrease in residual stresses.

### 2.3. General ovality distribution before and after ultrasonic processing

Analyzing the ovality general distribution graphs before and after ultrasonic processing, we can talk about the deviations stabilization from the bearing rings roundness (ovality). After pouring a polyamide flange, there is a sharp increase in the parts' ovality in a batch, as evidenced by a decrease in the normal distribution curve height, i.e. on the increase of σ - the random variable standard deviation, which indicates an increase in the stray field ω. An increase in the stray field indicates sizes large scatter and, therefore, a lower accuracy. In this case, the normal distribution curve top shifts relative to the scattering field middle, which indicates a change in the mathematical expectation (figure 3).

After the rings ultrasonic treatment, observations were carried out at a certain time interval. So during the first measurement (1 day), the normal distribution law curve stretched out, i.e. there was a decrease in the value σ - the random variable standard deviation. The scattering field of ω decrease, the rings' accuracy with a flange made of polyamide after ultrasonic treatment increased, but the normal distribution became not symmetrical, as a result of which we can speak of a systematic and random nature' various reasons influence.

On the 15th day after ultrasonic treatment, the bearing rings selected batch was re-measured. The normal distribution curve became symmetrical but σ decreased by 30% compared to the previous reading. Further measurements showed no changes in the standard deviation value, which indicates the bearing rings ovality stabilization. Indicators stabilization indicates a decrease in residual stresses associated with processing various stages.
3. Conclusions
A rings batch measurements results confirm the ultrasonic processing positive effect, as stabilizing the precision parts dimensions. The raceway and deviations diameter deviations in from roundness for rings treated with ultrasound are constant for the accepted time interval -15 days (raceway -0.0009 mm, deviation from roundness-0.000126 mm), which confirms their stabilization after ultrasonic treatment.

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