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# Improving the Assembly of Ballscrews Using Analysis of Interactions between the Working Parts

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**Abstract**

The research considers the conditions for the rational dimension ratio of ballscrews with design parameters of screws and nuts, which allow the increasing the carrying capacity without upgrading the accuracy of the details in the assembly set.

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*Keywords:* ball; screw; nut; gearing; clearance; distribution; carrying capacity

## 1. Introduction

Ballscrews are widely used in present-day engineering. Improvement of their operating characteristics is achieved by upgrading the accuracy of the component parts. However the any possibility for further enhancement of accuracy of the processing equipment has been practically exhausted. Among the unimproved opportunities for increasing the load-capacity of multilink connections is development of a science-based method for formation of rational stochastic dimensional ties between the working parts when manufacturing the parts and assembly.

## 2. Determination of size of a gap between the screw and nut as a result of assembly

The gap setting between the balls, and turns of screws and nuts in ballscrews can be found from the expression [1]:

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$$h_v = \frac{n_g^2}{2k^2}(v-1)^2\left(e_g - e_v\right) + (v-1)\frac{n_g}{k}\left[S_g - S_v - 0{,}5e_g + (1{,}5-\lambda)e_v\right] + h_\lambda + \xi + (r_v + r_g - d_s)\sin\beta, \quad (1)$$

where $n_g$ is the number of nut turns, $k$ is the number of balls in the working area, $v$ is the sequential number of a link, $e_v$ and $e_g$ are the systematic errors of the helix lead in accordance to screw and nut, $S_v$ and $S_g$ are the helix leads in accordance to screw and nut, $\lambda$ is the sequential number of an element, $h_\lambda$ is the amount of clearance in the first turn, $\xi$ is random error fraction, $r_v$ and $r_g$ are the shapes of the turns of a screw and a nut having a circular arc form, $d_s$ is the mean diameter of a ball, $\beta$ is the angle of a helix.

Let us assume that the value of random error fraction of screw manufacturing is the difference between the dimensional tolerance – in this case it is the tolerance of the screw pitch – and systematic error of screw manufacturing:

$$\xi_v = T_v - \Delta_v, \quad (2)$$

where $\xi_v$ is the random error of a screw pitch; $T_v$ is the tolerance for pitch of a screw; $\Delta_v$ is the systematic error of a screw pitch;

The cross-section of contacting bodies is shown in Fig. 1. The instantaneous axis of relative pivotal point in contact surfaces occurs in the course of rolling. It is placed in the cross-section of the contact zone and crosses it in the points A and B, where no microslip in the contact surfaces is found.

In addition, let us assume that the systematic error of a screw pitch $\Delta_v$ is equal to permissible error of the workpiece installation and working that can be found from expression:

$$\Delta_v = \sqrt{T_v^2 - \Delta_s^2}, \quad (3)$$

where $\Delta_s^2 = \sum\left[\Delta_f^2 + \Delta_C^2 + \Delta_H^2 + 3\cdot\left(\Delta_T^2 + \Delta_I^2\right)\right]$, $T_v$ is the pitch tolerance of a screw; $\Delta_f$ is the total form error of the workpiece surface; $\Delta_C$ is the machine inaccuracy in accordance with the machine certificate (if the machine is after repair, then using test machining for workpieces); $\Delta_H$ is the machine setting error which is determined from expression:

$$\Delta_H = 1{,}2\cdot\sqrt{\Delta_p^2\cdot\Delta_{iz}^2\cdot\Delta_r^2}. \quad (4)$$

Using (2) for the equation (1), we get the expression for determination of random error fraction of the helix lead in the screw:

$$\xi_v = T_v - \sqrt{T_v{}^2 - \Delta_S^2}. \quad (5)$$

In a similar way, we get an expression for the value of random error of the helix lead in a nut:

$$\xi_g = T_g - \Delta_g, \quad (6)$$

where $\xi_g$ is the random error of the screw pitch; $T_g$ is the pitch tolerance of the screw; $\Delta_g$ is the systematic error of the screw pitch.