On the question of determining the moment of resistance in the bearings vertical spindle

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Summary.
The article is devoted to the calculation to determine the moments of resistance in the spindle poles in the areas of braking and acceleration of vertical spindle cotton-th unit, depending on the speed limits and types of spindles.

Keywords: vertical-spindle cotton harvesting machine, harvesting machine, spindle, spindle bearings, forces acting on the spindle, the working zone, removal of the moments of resistance in the bearings, the zone of inhibition and acceleration, alignment supports.

It is known that vertical spindle cotton pickers have a lack of technological and structural reliability. To improve these indicators need to improve the quality of manufacture of basic components and parts cotton machine. Spindle drum is the main operating unit, the quality of whose work depends largely on the efficiency of cotton machinery in general. In turn, the spindle drum consists of a number of details, quality of manufacture and assembly of which determines the stability of the technological process of the whole cotton-picking machine. Hos ¬ novnoy working body of the cotton machine - Spindle to ensure ¬ pechivat speed stability, as in the work area, and in the area of removal. To comply with this condition need quality work spindle drive elements and the bearing assemblies, ensuring alignment of upper and lower supports, as well as the minimization of loads and moments of resistance acting on the spindle in the working zone and the zone of removal, the highest values occur in the reverse of the spindles.

The spindle, with its reverse side is affected by these forces (Fig. 1):
centrifugal forces of inertia of the drive spindle and roller and

\[ R_q = m_w \cdot R_6 \cdot \omega_6^2 R_q = m_p \cdot R_6 \cdot \omega_6^2 \]
where $m_w$ - massweight spindle;

$m_p$ - mass of the roller;

The normal $F_n^p$, $F_n^c$, and tangential $F_f^c$, $F_f^p$ force component of the district-ing efforts on the axis of the roller caused by the driving device-properties, respectively, in the work zone and the zone of removal of the spindle drum.

In Fig. 1. Diagram of forces acting on the spindle

(a - in the work area, b - zone removal)

These forces cause the top and bottom of the spindle poles of the reaction, which, taking into account the coefficient of friction in the bearings make the power of resistance to rotation.

First we define the moment of resistance in the bearings A and B, the spindle in the work area, for which we find the reaction $R_{hy}^p R_{ey}^p R_{hx}^c$ and $R_{hy}^c$. We form the equation is the sum of the moments of forces about the axis $AY$. 

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\[-F_f^p \cdot a + R_u^a \cdot a - R_u^a \cdot \left(\frac{l}{2}\right) + R_{nx}^p \cdot l = 0\]

Hence

\[R_{nx}^p = \frac{F_f^p \cdot a - R_u^a \cdot a + R_u^a (l/2)}{l}\]

The equation of the sum of the moments of forces about the axis of the BY

\[R_u^a \cdot (l/2) - R_{nx}^p \cdot l - F_f^p \cdot (l + a) + R_u^a (l + a) = 0,\]

hence

\[R_{nx}^p = \frac{R_u^a \cdot l/2 - F_f^p (l + a) + R_u^a (l + a)}{l}\]

The equation of the sum of torques about the axis AX

\[F_f^p \cdot a + R_{ny}^p \cdot l = 0,\]

hence

\[R_{ny}^p = -\frac{F_f^p \cdot a}{l} .\]

The equation of moments relative to the amount of BX:

\[F_f^p \cdot (l + a) - R_{ny}^p \cdot l = 0,\]

hence

\[R_{fy}^p = \frac{F_f^p \cdot (l + a)}{l} .\]

Then the resulting reaction on the upper and lower spindle bearings will be equal

\[R_u^p = \sqrt{(R_{nx}^p)^2 + (R_{ny}^p)^2} = \frac{1}{l} \sqrt{\left[R_u^a \cdot (l/2) - (F_f^p - R_u^a) \cdot (l - a)\right]^2 + \left[F_f^p \cdot (l + a)\right]^2} .\]
\[ R_n^p = \sqrt{(R_{n1}^p)^2 + (R_{n2}^p)^2} = \frac{1}{l} \sqrt{\left[ (F_n^p - R_n^p) \cdot a + R_n^p \cdot \left(\frac{l}{2}\right) \right]^2 + \left[ F_n^p \cdot a \right]^2}. \]

If the upper pole rolling radius \( r_c \) and the coefficient of friction quality of \( f_k \), on the bottom - the radius \( r_c \) and the sliding coefficient of friction \( f_c \), the total moment of resistance in the working area

\[
M_p = R_n^p \cdot r_k \cdot f_k + R_n^p \cdot r_c \cdot f_c = \\
= \frac{1}{l} \sqrt{\left[ R_n^p \cdot (l/2) - (F_n^p - R_n^p)(l + a) \right]^2 + \left[ F_n^p \cdot (l + a) \right]^2 \cdot r_k \cdot f_k + \\
+ \frac{1}{l} \sqrt{\left[ (F_n^p - R_n^p) \cdot a + R_n^p \cdot (l/2) \right]^2 + \left[ F_n^p \cdot a \right]^2 \cdot r_c \cdot f_c.}
\]

Similarly, one can obtain an expression for the total moment of resistance in the area of removal:

\[
M_c = \frac{1}{l} \sqrt{\left[ R_n(l/2) + (F_n^c - R_n^p)(l + a) \right]^2 + \left[ F_n^c \cdot (l + a) \right]^2 \cdot r_k \cdot f_k + \\
+ \frac{1}{l} \sqrt{\left[ (F_n^c - R_n^p) \cdot a \right]^2 + \left[ F_n^c \cdot a \right]^2 \cdot r_c \cdot f_c.}
\]

The results of calculations of moments of resistance in the spindle poles in the areas of braking and acceleration for mass cotton apparatus that are listed in the table.

### Calculated values of the moments of resistance in the spindle poles serial device

<table>
<thead>
<tr>
<th>Type of number</th>
<th>Spindle torque</th>
<th>resistance Nm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>The working area</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Serial</td>
</tr>
<tr>
<td>1</td>
<td>Serial-metal: Ø 24 mm, ( m_w = 1.4 ) kg</td>
<td>0.0079</td>
</tr>
<tr>
<td>2</td>
<td>Spindle larger the diameter: Ø 29,5 mm, ( m_w=1,72 ) kg</td>
<td>0.0086</td>
</tr>
<tr>
<td>3</td>
<td>The composite spindle Ø 29,5 mm, ( m_w=1.8 ) kg</td>
<td>0.0086</td>
</tr>
<tr>
<td>4</td>
<td>Spindle larger the diameter and increased length: ( m_w = 2.15 ) kg</td>
<td>0.0096</td>
</tr>
</tbody>
</table>
At the same time as the initial parameters were accepted: the mass of spindles - 1.4, 1.72, 1.80 and 2.15 kg, $f_k = 0.02$, $f_c = 0.05$, the radius of the drum - 0.146 m, the frequency of rotation of the drum - 16, 8 and 18.8 s$^{-1}$, the load on the seat forward and reverse rotation of blocks: $F_H = 15 \ldots 25 N, F_h = 36 \ldots 313 N, F_h = 8 \ldots 18 N, F_H = 7 \ldots 64 N$ (adopted mean values).

Thus, it was found that the moments of resistance in the cotton spindles supports the device, its speed limits and types of spindles ranged from 0.008 to 0.0565 Nm.

In Long life bearing misalignment can lead to that moment of resistance is greatly increased (up to 0.5 - 2.5 Nm), respectively, increases the friction torque, rotational speed of spindle is sharply reduced and the quality of the cotton-picking machine deteriorates.

Moments of resistance to spindle poles as a function of the form on the cotton system, it speeds and types of spindles ranged from 0.010 to 0.0565 Nm. In Long life bearing misalignment result in that moment of resistance may increase to 0.5 - 2.5 Nm.

**Conclusion:** In the normal course of the process of spindles is necessary to ensure the quality of manufacture and assembly of the spindle drum in compliance with the alignment of upper and lower bearings and grease them mandatory.

**References:**