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STUDY IN DEFORMATION OF LOW RIGIDITY RINGS UNDER ACTION OF INSTALLATION ELEMENTS

A modeling has been performed to assess impact of compressing devices to surface layer state of the rings made of porous composite materials during mechanical treatment.

Formulation of problem. Due to complicated conditions of operation of the low rigidity rings and impact of quality of their production to efficiency of spinners and twiners, the ring is subject to quite strict requirements as for their geometrical precision:

- Deviations from flatness of the ring butts (0,05…0,20 mm);
- Deviation from roundness of internal working surface (0,2…0,35 mm);
- Parallelity of butts within tolerances for the ring heigth;
- Perpendicularity of axis of executive surface to the main basis of the ring (0,05…0,1 mm);
- Coaxiality of working surface and main basis (0,05…0,10 mm).

They are subject to high requirements as for their hardness, wear resistance, roughness and corrosion resistance. The ring hardness has to be more than HRC50, and at the same time porosity of steel has to be minimum 18-25 %. Roughness of working areas of the ring is Ra 0,16…0,32 mkm.

Analysis of studies and published works. The rings are made of steel grades 40, 45, 40Х13, ШХ15 and fritted powders ЖНБМ GOST 49-74; ПА–ЖГрМ, ПА–ЖГрД2,5, ПА–ЖГрД1,5К0,4, ПА–ЖГрЗМ15, ПА–ЖГрН0,1К0,4, ПА–ЖГрДН0,1К0,4, ПА–ЖГрДМс, ПА–ЖГрЗЦс40,1К1 GOST 26802-86, which can be carbonitrided and tempered [3; 4].

Use of the rings made of ordinary steel has misadvantages compared to the rings made of fritted powders:

- quick wear due to friction (occurs in result of dry friction in places of contact of runner with the ring);
- increase of complexity of ring production due to execution of spiral groove of lubricating system to reduce friction of the ring-runner pair;
- contamination of fibers with lubricant.

Ordinary steel rings under conditions of wool spinning have service life of 3-4 months.

In rings of fritted materials, process of lubricant emission is regulated automatically. Thus, when increasing runner motion, surface pressure is raised, and need of lubricant as well. That’s why there is no excess of oil on the surface of the ring which could dirt the thread. When the runner is in motion, working surfaces of the ring are getting hot. Oil is pressed out from the pores to the surface and creates a thin film. During long operation unstoppable oil supply is performed by a wick-feed lubricator which is connected to oil collector.

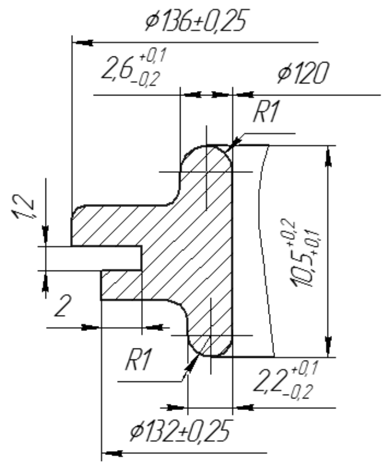


Fig. 1. Sketch of studied ring

When the machine stops, temperature of the ring lowers, lubricant is absorbed, and only a superficial, initial layer remains on the surface of the ring.

Practice of use of the ring made of rough part produced by method of powder metallurgy, has shown that wear strength exceeds the steel ones by 3÷4 times.

Purpose of the article. Study of deformation was performed for low rigidity ring (fig. 1). Material of the ring – ПА–ЖГрМ.

Four types of fixation were examined:

- in two- jaw chuck (fig. 2, a);
- in three-jaw chuck (fig. 2, b);
- in four-jaw chuck (fig. 2, c);
- in special device (fig. 2, d).

Description of main material. During mechanical treatment fixation force *Q* and moment of friction M_{mp} are acting to the ring, which are transmitted by installation elements of process equipment. During fixation in special device, force *Q* is evenly distributed over the ring surface. Under action of *Q*, reaction of bearing *N* occurs (fig. 2).

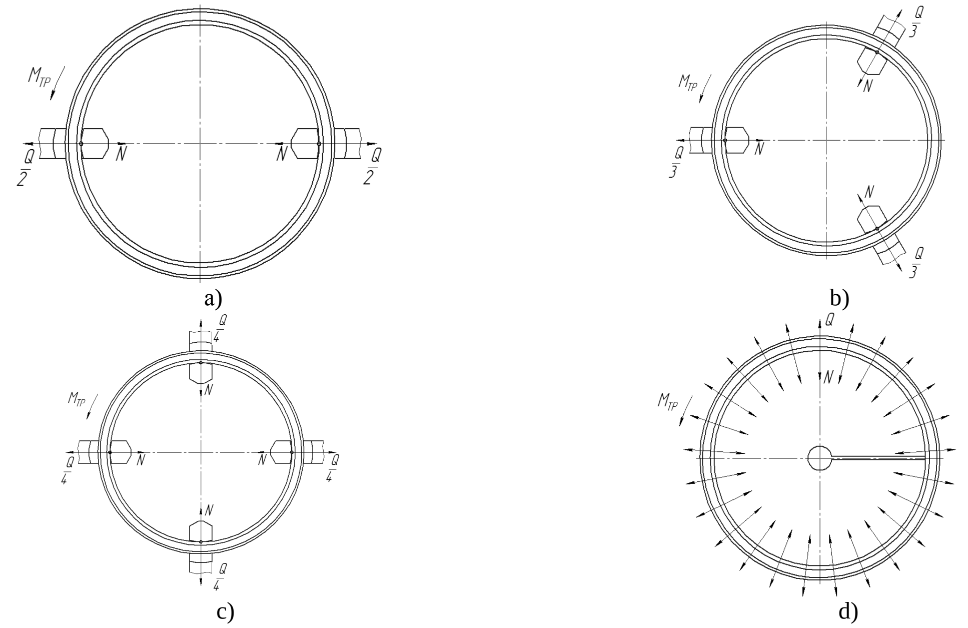


Fig. 2. Types of fixation of low rigidity rings in the process equipment
a) in 2-jaw chuck; b) in 3-jaw chuck; c) in 4-jaw chuck; d) in special device

Let us calculate force of fixation *Q* and moment of friction M_{TP} when cutting grooves with width of 1,2 mm.

As per Figure 2 [1]:

$M_{TP} = kM_{PI3} \Rightarrow M_{TP} = K \cdot R_z \cdot \frac{d_1}{2}$, by turn $M_{TP} = F_{TP} \cdot \frac{d_2}{2} = Q \cdot f \cdot \frac{d_2}{2}$, from where $Q = \frac{2M_{TP}}{f \cdot d_2}$,

where $M_{piз}$ – moment of cutting, $N \cdot m$; R_z – cutting load, N; F_{mp} – friction force, *N*; f = 0,18 – friction coefficient of working areas of installation elements; R_z – cutting load, *N*; d_1 = 132mm, d_2 = 120mm – dimensions of studied ring (fig. 1); *K* – safety factor [1]:

$$K = K_0 \cdot K_1 \cdot K_2 \cdot K_3 \cdot K_4 \cdot K_5 \cdot K_6,$$

where K_0 – guaranteed safety coefficient for all cases. K_0=1,5; K_1 – coefficient considering state of process base of rough part. K_1 = 1,0; K_2 – coefficient considering dulling of cutting tool. K_2 = 1,1; K_3 – coefficient considering shock load to the tool. K_3 = 1,0; K_4 – coefficient considering stability of power drive. K_4 = 1,3; K_5 – coefficient considering features of compressing device. K_5 = 1,0; K_6 – coefficient considering specified location of supporting points. K_6 = 1,0.

Thus, $K = 1{,}5 \cdot 1{,}0 \cdot 1{,}1 \cdot 1{,}0 \cdot 1{,}3 \cdot 1{,}0 \cdot 1{,}0 = 2{,}15$.

We take *K* = 2,15.

Cutting force R_z [2]:

$$P_Z = 10C_P t^x S^y V^n K_P$$

Value of tool advance, cutting depth, coefficients and indices of formula degrees for specified material, cutter with material of cutting part – hard alloy ВК6М [2]:

$S = 0{,}3\ мм/об$; $t = 1{,}2\ мм$; $C_P = 92$; $x = 1$; $y = 0{,}75$; $n = 0$; $K_P = 0{,}87$.

Hence: $P_Z = 10 \cdot 92 \cdot 1{,}2^{1{,}0} \cdot 0{,}3^{0{,}75} \cdot 0{,}87 = 389{,}34H$.

Moment of friction M_{TP}:

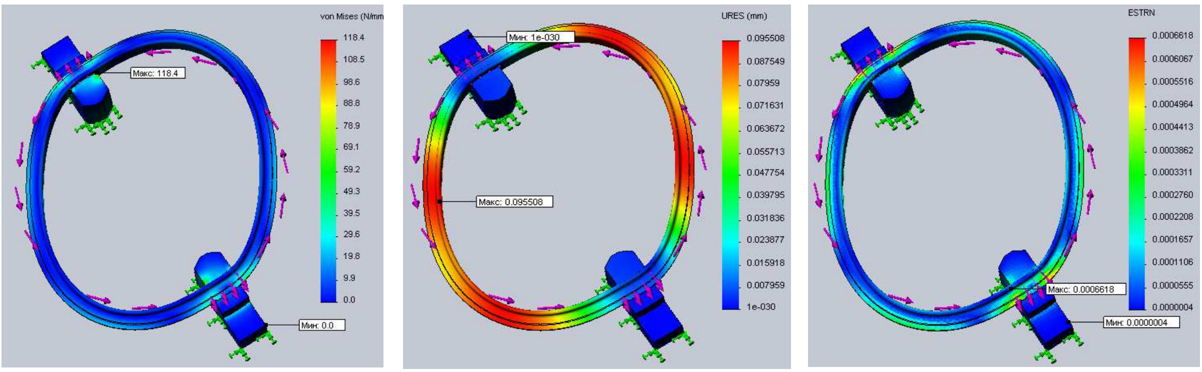
$$M_{TP} = 2{,}15 \cdot 389{,}34 \cdot \frac{0{,}132}{2} \approx 55H \cdot м.$$

Force of fixation Q:

$$Q = \frac{2M_{TP}}{f \cdot d_2} = \frac{2 \cdot 55}{0{,}18 \cdot 0{,}12} \approx 5100H.$$

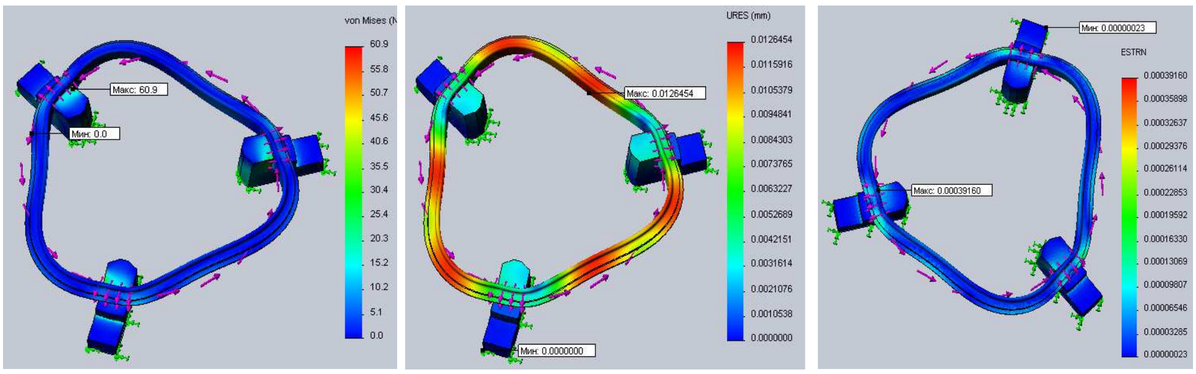
We accept for all studies: Q = 5100Н = const; M_{TP} = 55 Н*м = const.

Deformation study of low rigidity rings under action of installation element of process equipment during mechanical treatment of external outline has been performed with help of COSMOSWorks, a supplement to SolidWorks (fig.3-6).



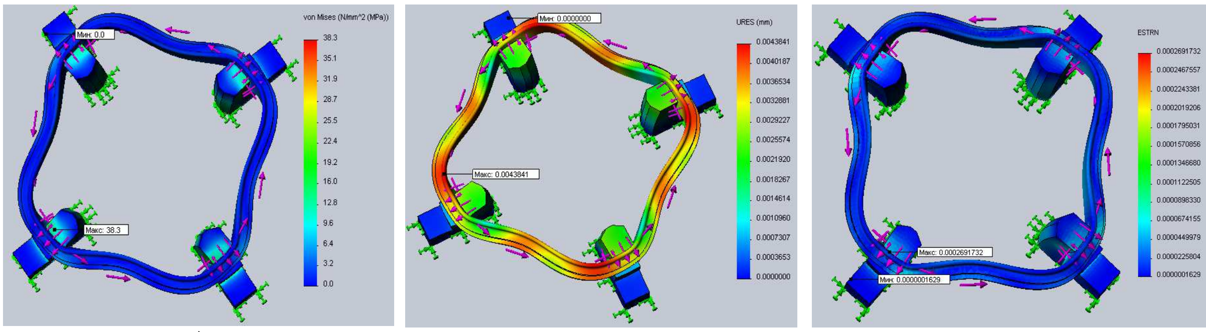
a) b) c)

Fig. 3. Deformation study of low rigidity rings when treated in 2-jaw chuck
a) evaluation of stresses; b) evaluation of displacements; c) evaluation of equivalent deformations



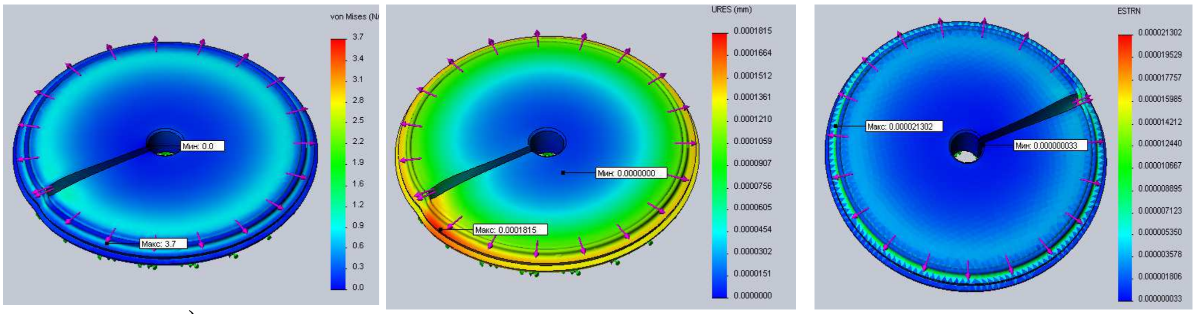
a) b) c)

Fig 4. Deformation study of low rigidity rings when treated in 3-jaw chuck
a) evaluation of stresses; b) evaluation of displacements; c) evaluation of equivalent deformations



a) b) c)

Fig. 5. Deformation study of low rigidity rings when treated in 4-jaw chuck
a) evaluation of stresses; b) evaluation of displacements; c) evaluation of equivalent deformations



a) b) c)

Fig. 6. Deformation study of low rigidity rings when treated in special device
a) evaluation of stresses; b) evaluation of displacements; c) evaluation of equivalent deformations

Table 1

Results of studies

Type of fixation	Max. stress, MPa	Max. displacement, mm	Max. equivalent deformation, %
in 2-jaw chuck	118,4	0,0955	0,066
in 3-jaw chuck	60,9	0,0126	0,039
in 4-jaw chuck	38,3	0,0044	0,027
in special device	3,7	0,0002	0,002

Conclusions. Internal stresses and shape inaccuracies impact significantly operational properties of the ring-runner pair (table).

Based on the performed studies we may conclude that use of standard fixation types fro low rigidity details of ring type leads to deformations in form of two-, three-, four-sided faceting. It also leads to occurrence of higher stresses and displacements compared to the special device.

Therefore, already on the stage of technological preparation to manufacture of low rigidity rings, it is reasonable to use special process equipment, use of which leads to reduction or elimination of deformation in radial direction.

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