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EXPERIMENTAL DETERMINATION OF THE RINGING SPRINGS STIFFNESS

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ABSTRACT:
Circular arcs are machinery falling within the elastic assembly and have the property to deform very little in high load conditions, he have high stiffness. The present study shows aided design of these springs, aided design of a special device to calibrate the spring ring, respectively their stiffness experimental determination and their results in tabular and graphical form.
KEYWORDS: Ringing spring, stiffness, deformation, calibration

1. INTRODUCTION

Ringing springs are machinery falling within the elastic assembly and have the property to deform very little (tens of mm) in high load conditions, ie have high stiffness (thousands of N).

Ringing springs are however a disadvantage namely requires very precise mechanical adjustments, respectively correction on conical surfaces (exterior and interior) that come into contact.

Justification for use circular arcs can be in situations where lack of space can not be used compression coil spring.

A specific case to use these spring ring is automatic protection devices overturning mechanisms of construction type bluming rolling lines, where they have press role of body blocking. The device is designed to yield to a force of 530100 [N], ring springs being compressed with a maximum force of 46000 [N], their deflection being only 19 [mm].

2. RINGING SPRINGS DESIGNING

Ringing springs scheme with its main dimensions is shown in Figure 1, and 3D model, made in Autodesk Inventor, in Figure 2.

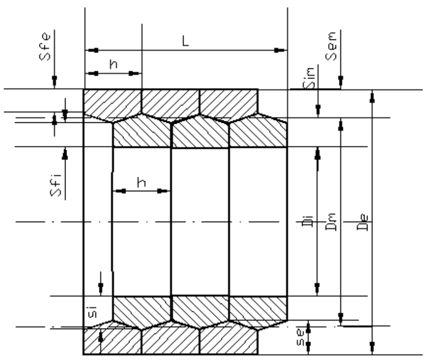

Figure 1. Arc dimensions

Figure 2. 3d model of the arc

To design the ringing spring, as provided in the bibliography the following entry sizes are accepted:

- inclination angle of work sides of the rings: α = 14[degrees]
- compressive stress from inner ring: σ_{ci} = 1200 [MPa]
- friction angle between the rings: φ = 7[degrees]
- tensile stress from outer ring: σ_{te} = 800 [MPa]
- contact pressure between the rings: p = 14 [MPa]

- arc average diameter Dm = 50 [mm] (Rm = Dm/2 = 25 [mm]
- longitudinal MOE E = 2,1x105 [MPa]
- arrow bow ring thing f = 18 [mm]

With the above sizes can making following calculations, presented in Table 1:

Table 1

Size	Relation	No. of relation
areas fraction of the two rings	$\frac{A_e}{A_i}=\frac{\sigma_{ci}}{\sigma_{te}}=\frac{120}{80}=1{,}5$	1
spring repulsion force	$Q'=Q\cdot\frac{tg(\alpha-\varphi)}{tg(\alpha+\varphi)}$	2
Outer rings dimensions		
outer ring area	$A_e=\frac{Q}{\pi\cdot\sigma_{te}\cdot tg(\alpha+\varphi)}$	3
average thickness of the outer ring	$s_{em}=R_m\cdot\frac{p}{\sigma_{et}}$	4
ring height	$h=\frac{A_e}{s_{em}}$	5
average radius of the outer ring	$R_{em}=R_m+\frac{s_{em}}{2}$	6
Inner rings sizes		
inner ring area	$A_i=\frac{A_e}{1{,}5}$	7
average thickness of the inside ring	$s_{im}=\frac{s_{em}}{1{,}5}$	8
height of the inner ring	$h=\frac{A_e}{s_{em}}=\frac{A_i}{s_{im}}$	9
average radius of inner ring	$R_{im}=R_m-\frac{s_{im}}{2}$	10
elemental arrow (the arrow on the ring)	$f_o=\frac{R_{em}\cdot\sigma_{te}+R_{im}\cdot\sigma_{ci}}{E\cdot tg\alpha}$	11
the total number of rings	$z=\frac{f}{f_o}+1$	12
the work stored in the spring	$L=\frac{Q_{\max}\cdot f}{2}$	13
blocked arc length	$L_B^{'}=\frac{1}{2}\cdot[(z+1)\cdot h+(z-1)\cdot e]$	14
distance between two same rings on the undistorted spring	$e=\frac{1}{100}\left(\frac{D_{em}+D_{im}}{2}\right)$	15
free arc length without load	$L_o=L_B'+f$	16
Ring thickness		
outer ring in the middle	$S_e=s_{em}+\frac{1}{2}\cdot h\cdot tg\alpha$	17
outer ring in the ends	$S_{fe}=s_{em}-\frac{1}{2}\cdot h\cdot tg\alpha$	18
inside ring in the middle	$S_i=s_{im}+\frac{1}{2}\cdot h\cdot tg\alpha$	19
inner ring in the ends	$S_{fi}=s_{im}-\frac{1}{2}\cdot h\cdot tg\alpha$	20

Relations [1]...[20] are solved using MECANISME01 program designed and written in Visual Basic programming environment. Interface with which is designed ring spring, respectively the input mode chosen sizes by the designer is shown in Figure 3.

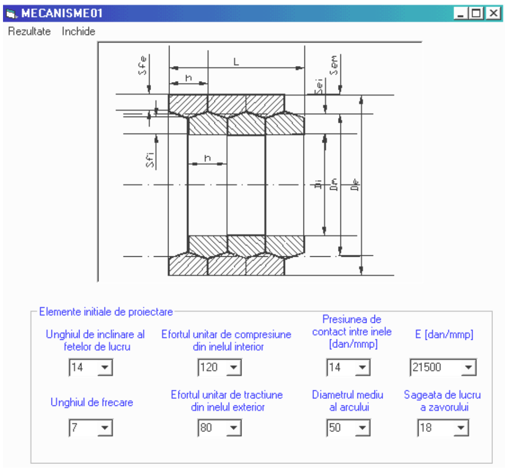

Figure 3. Mecanisme01 programming interface

Dimensiuni arc inelar

Dimensiuni arc	Valoare
Inclinarea fetelor alfa [grd]	14
Ughiul de frecare [grd]	7
Inaltimea inelelor [mm]	16,59667
sem [mm]	4,375
sim [mm]	2,92
se	6,44
sfe [mm]	2,31
si [mm]	4,99
sfi [mm]	1,53
Numar inele z	21
Dm [mm]	50
Di [mm]	44,16
De [mm]	58,75
Lung. arc blocat [mm]	187,7088
Lung arc liber Lo [mm]	205,7088
Sageata elementara fo [mm]	0,9332322

Figure 4. Showing results

Showing results based on calculations is made by the software as a table, this is shown in Figure 4.

3. EXPERIMENTAL DETERMINATION OF RINGING SPRINGS STIFFNESS

Ringing springs, according to figures 1 and 2, consisting of outer and inner rings, tapered guide, internal and external surfaces. These rings require specific processes (grinding surfaces tapered inner and outer) and hardening heat treatment (tapered contact surfaces).

Therefore, before using circular arcs is proposed to follow their functioning, ie their calibration.

In the ringing spring calibration was designed and executed a device, adaptable to universal test machine from the laboratory of resistance material.

Figure 5 presents 3D model of the device designed in Autodesk Inventor, and in Figure 6, the photo device made with some of the annular rings arc executed.

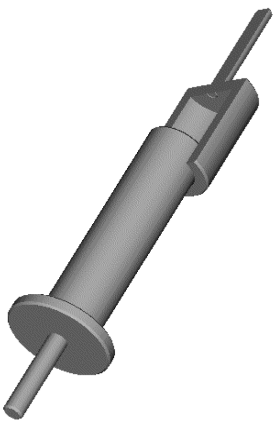

Figure 5. 3d model of the device

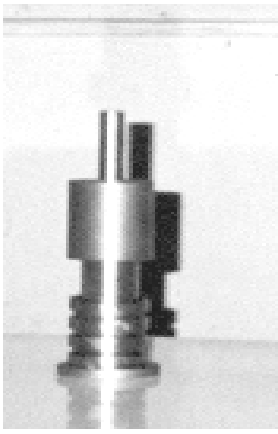

Figure 6. Test device

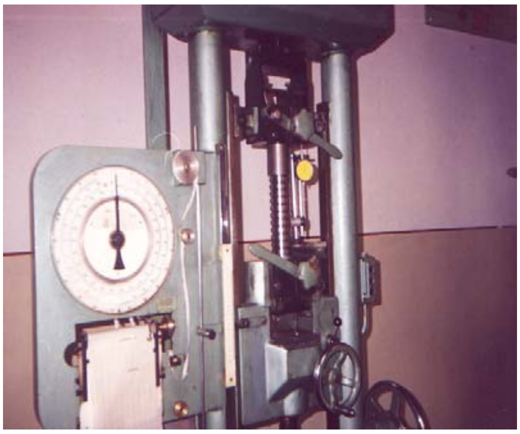

Figure 7. Stiffness experimental determination

The device is mounted on universal test machine and will be compressed. Deformation force value is read from the machine dial (in daN) and the deformation value to a comparator adapted to device. The picture from Figure 7 shows how to determine the stiffness, ie the deformation measurement.

In Table 2 pairs of values (force - deformation) obtained, and in Figure 8 are presented the calibration curve of the spring rings with trend line equation (y = 314, 54x).

Table 2

No.	f[mm]	F[daN]	No.	f[mm]	F[daN]
1	4.09	1490	8	10.97	3480
2	5.00	1730	9	11.99	3773
3	6.03	2050	10	12.98	4062
4	7.09	2340	11	13.98	4350
5	8.05	2620	12	14.97	4638
6	9.01	2910	13	15.96	4927
7	10.02	3200	14	16.95	5215

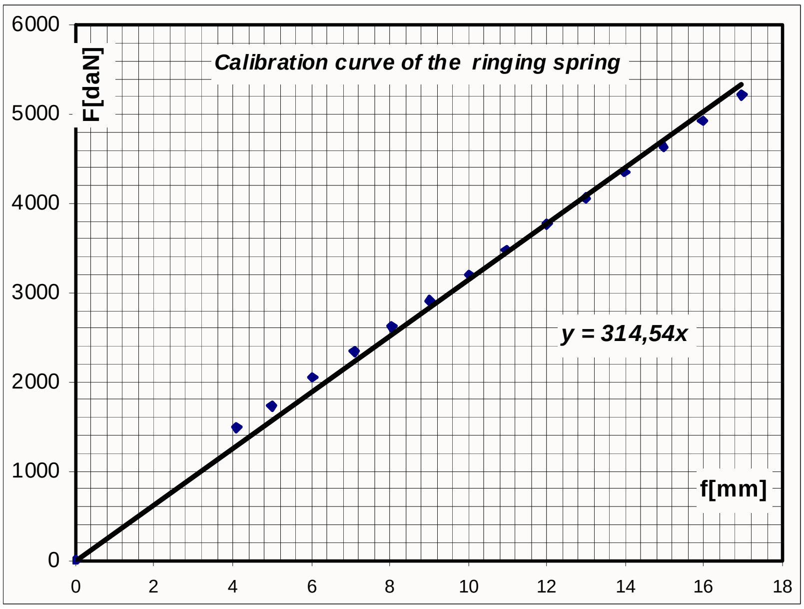

Figure 8. Calibration curve of the arc

4. CONCLUSIONS

Analyzing the calibration curve of the arc ring (Figure 8) shows an arrangement of points corresponding pair of values, force - deformation, very close to the linear trend curve, which passes through the origin of axes, so it may be considered that the ring arc functioning properly.

Calibration line slope is exactly ring spring stiffness calibrated, respectively: C = 314,54 [daN/mm]

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