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RESEARCH

Some Considerations Regarding the Stress Parameters in Ball Bearings Rings Contact

The paper presents some considerations about the parameters σ, δ, τ, p, a, b obtained in ball-bearings rings contact. The determinations are realised on a concrete example (the 6305 ball-bearing) where r_{11}=29.500 mm, r_{21}=16.590 mm, r_{12}=5.159 mm and r_{22}=5.263 mm. Also there are presented comparatively some results obtained using different bibliographical studies.

***Key words**: wear, ballbearing, geometry, stress.*

1. *INTRODUCTION*

There are some papers [1, 2, 3, 4] where there are treated aspects concerning the rolling contact which is specific to ballbearings.

This paper presents some experimental results obtained in the case of the tribomodel roll-ring, using different materials (f.e. RUL1, RUL2 and 15Cr08Mo).

2. *HERTZIAN ELEMENTS CONTACT*

The dimensions of the tribomodei used in the experiment are (see fig. 1):

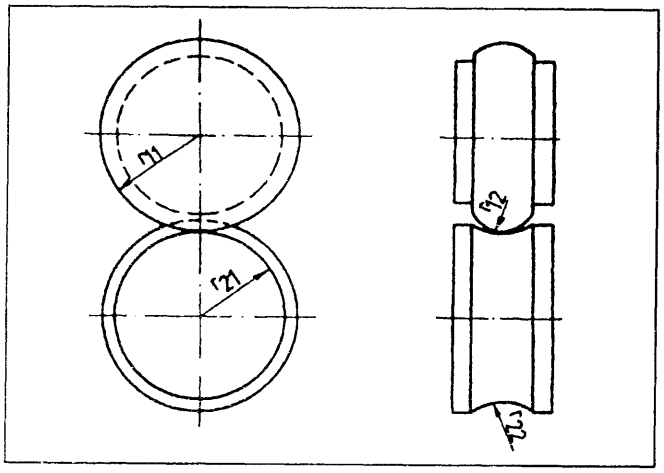

Figure 1. Rolls dimensions

The contact curvature are:

r_{11}=29,500 [mm]; r_{21}=16,590 [mm];
r_{12}= 5,159 [mm]; r_{22}= 5,263 [mm].

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Using the relations from the literature [1, 3] it is possible to establish the contact area dimensions *a*, *b*, the maximum pressure p_{max} , and also the elastic compression δ:

$$a = \alpha (F\rho/K_0)^{1/3} = 0{,}02022\ F^{1/3} \quad [mm] \quad (1)$$

$$b = \beta_0 (F\rho/K_0)^{1/3} = 0{,}01799\ F^{1/3} \quad [mm] \quad (2)$$

$$\delta = \lambda (F^2/K_0^2\rho)^{1/3} = 3{,}454\ 10^{-4}\ F^{1/3} \quad [mm] \quad (3)$$

$$p_{max} = 3F/2\pi ab = 137{,}45\ F^{1/3} \quad [mm] \quad (4)$$

where the values of the α, β, λ, ρ, K_0 coefficients are done in the table 1 [1, 3].

Table 1.

α	β	λ	ρ	K_0
1,061	0,944	1,996	2,1015	1,15 10^5

Admitting the Huber-Mises-Henky hipothese it is possible to establish the depth of the maximum $\sigma_{ED(\lambda)}$ and τ_{45D} tensiles, in function of the rapport β=b/a = 0,8897.

$$\sigma_{ED(\lambda)} = 0{,}6291\ p_{max} \quad [N/mm^2] \quad (5)$$

$$z_{\sigma ED} = 0{,}4991\ b \quad [mm] \quad (6)$$

$$\tau_{45D} = 0{,}2166\ p_{max} \quad [n/mm^2] \quad (7)$$

$$z_{\tau 45D} = 0{,}3611\ b \quad [mm] \quad (8)$$

From K.L. Johnson [4] the a and b dimensions, the maximum pressure p_{max} and the compression δ are:

$$a = 0{,}014265\ F^{1/3} \quad [mm] \quad (9)$$

$$b = 0{,}015039\ F^{1/3} \quad [mm] \quad (10)$$

$$p_{max} = 3F/2\pi ab = (6FE^{*2}/\pi^3 Re)^{1/3} \quad [N/mm^2] \quad (11)$$

$$\delta = (9F^2/16ReE^{*2})^{1/3} = 2{,}823\ 10^{-4}\ F^{2/3} \quad (12)$$

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where the equivalent radius

$$Re = (R'R'')^{1/2} \quad (13)$$

and the equivalent elasticity module is:

$$1/E^* = (1-\upsilon^2_1)/E_1 + (1-\upsilon^2_2)/E_2 \quad (14)$$

From Palmgreen [2, 3], the specific force K_0 is establish in function of the Vickers hardness.

$$K_0 \leq 1,8\ (Hv/750)^3\ (\xi/\psi)^{3/2}\ \delta^{1/2} \quad (15)$$

From Stribeck [2, 3] the maxim elastic hertzian pressure is

$$p = (KE^2/4,28)^{1/3},\ [N/mm^2]$$

where are:

$$K = K_0/\delta\varphi$$

$$\varphi = \delta^2(\xi\eta)^3.$$

The ξ, ψ, δ and φ values are given in table 2 [2, 3].

Table 2.

ξ	ψ	δ	η	φ
1,088	1,0825	0,3628	1,9263	0,1347

For the usual values of the hardness, obtained for the ballbearings, between 59...66 HRC the pressures values K_0 and p are given in table 3.

Table 3.

HRC	HV	K_0 [N/mm^2]	p [N/mm^2]
59,2	680	8,016	8726,78
60,1	700	8,744	8983,45
61,0	720	9,515	9240,12
61,8	740	10,707	9610,78
62,5	760	11,191	9753,46
63,3	780	12,098	10010,013
64,0	800	13,053	10266,80
64,7	820	14,057	10523,47
65,3	840	15,110	10780, 14
65,9	860	16,216	11036,81

Using the relations (5...12) it is possible to establish the contact geometric elements and the tensiles in this case (the tribomodel roll - interval ring) (see table 4).

Table 4.

F	1000	2000	3000
0	1	2	3
2a	0,30008	0,37801	0,44203
2b	0,28591	0,36013	0,41214
p_{max}	2221,57	2798,369	3202,893

Table3'.

0	1	2	3
ρ	2,816	3,547	4,061
σ_{ED}	1397,59	1760,44	2014,93
$z_{\sigma ED}$	0,0713	0,0898	0,1028
τ_{45D}	481,19	606,12	693,74
$z_{\tau 45D}$	0,0516	0,0651	0,0744

Table 4'.

F	4000	5000	6000
2a	0,47629	0,51289	0,54491
2b	0,45367	0,48866	0,51923
p_{max}	3524,912	3796,804	4034,46
ρ	4,469	4,814	5,115
σ_{ED}	2217,51	2388,56	2538,08
$z_{\sigma ED}$	0,1131	0,1219	0,1295
τ_{45D}	763,49	822,38	873,86
$z_{\tau 45D}$	0,0818	0,0882	0,0937

2. EXPERIMENTAL RESEARCH

The experimental researches where be done using a machine with 4 contact points, as you can see in figure 2 and 3.

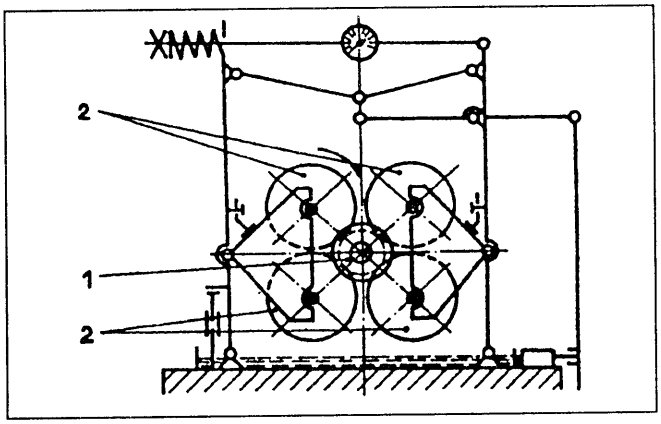


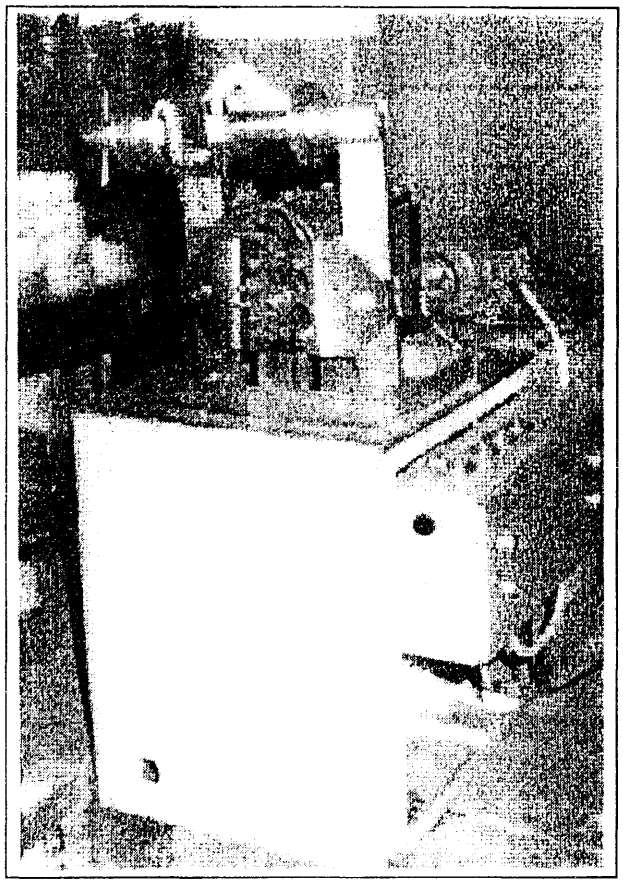
Figure 2. Machine scheme

This machine has 5 rolls, 4 loading rolls and one the tribomodel.

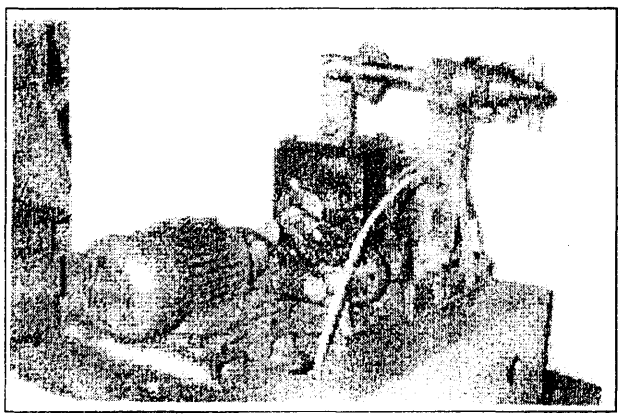
Where built 5 internal rings with the dimension of the 6305 ballbearing, using different materials (RUL 1, RUL 2, 15CrO8Mo) and with the hardness between 62...63 HRC.

The testing conditions:

- th force. F = 4000 N;
- the contact frequency: υ_c =35160 contacts/min;
- oil: M30;
- oil temperature: t_u = 67 °C.



a)



b)

Figure 3. The machine

The obtained results are given in table 5.

Table 5.

Testing	Number of contacts					
	RUL 1		RUL 2		15CrO8Mo	
1	865	3,04	520	1,82	830	2,91
2	920	3,23	683	440	1125	3,95
3	984	3,45	855	3,02	1250	4,39
4	1294	4,54	1190	4,18	1525	5,36
5	1445	5,08	1274	5,32	1772	6,23
	time [min]	x 10^7 working cycle	time [min]	x 10^7 working cycle	time [min]	x 10^7 working cycle

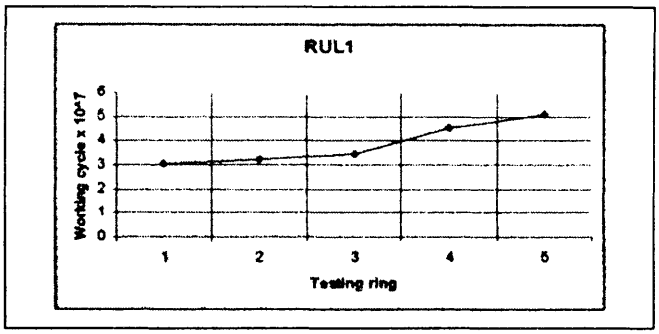


Figure 4. Durability variation for RUL1

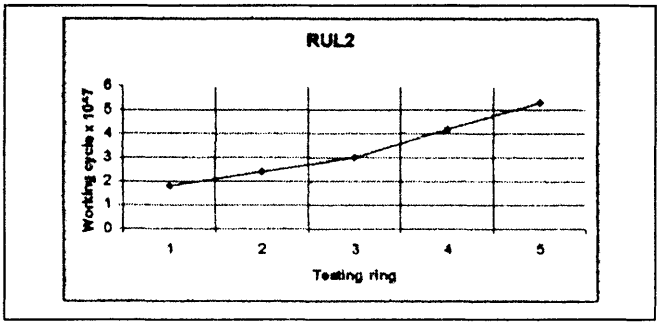


Figure 5. Durability variation for RUL2

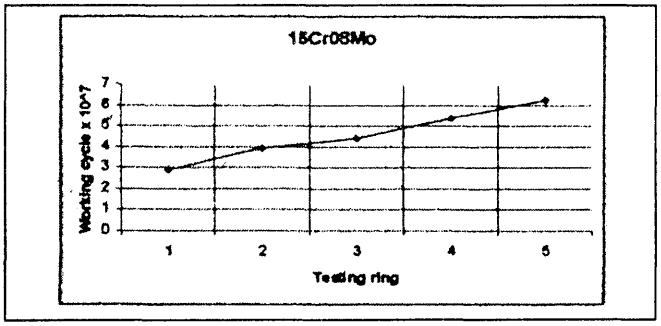


Figure 6. Durability variation for 15CrO8Mo

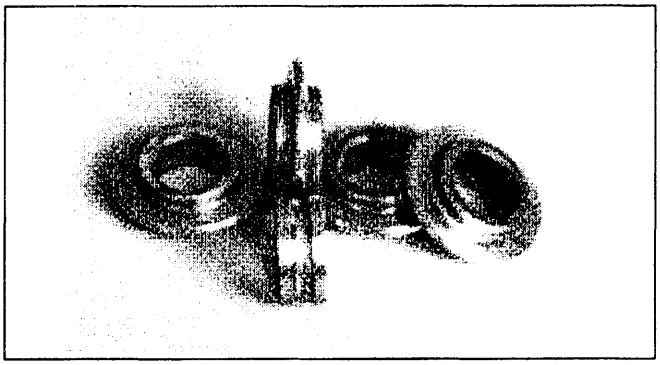


Figure 7. Testing rolls

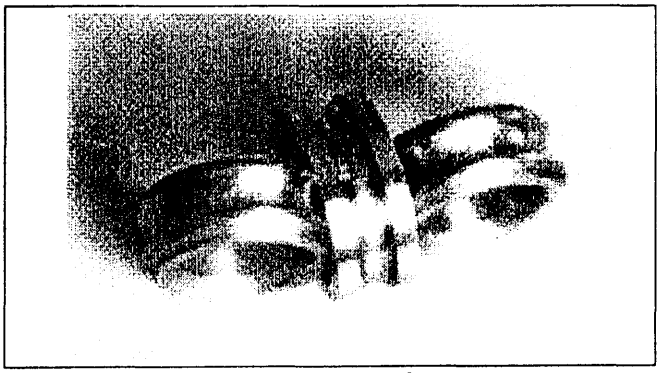


Figure 8. Pitting forms

In fig. 7 and 8 are presented the testing rolls and some pitting forms obtained on rings.

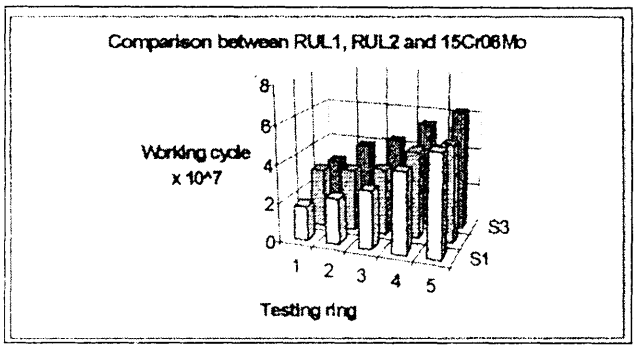


Figure 9.

4. CONCLUSIONS

This paper presents some experimental results obtained for different materials in the case of hertzian contact specific to ballbearings rings. For in concrete example, the 6305 ballbearing internal ring, was constructed a tribomodel roll-ring.

Using the relations from the literature . it was possible to establish the contact area dimensions, the maximum pressure and the elastic compression.

Using a testing machine and some testing conditions were obtained experimental results for rings and for materials RUL 1, RUL 2 and 15CrO8Mo.

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