

HERTZIAN AND NON HERTZIAN CONTACT ANALISYS IN BALL BEARINGS

Daniel REZMIREŞ[1], Daniel NELIAS[2], Cezar RACOCEA[3]

[1]S.C. FORPRES S.A. Iasi, [2]INSA – Lyon, [3] Technical University "Gh. Asachi" of Iasi
drezmir@yahoo.com

ABSTRACT

This paper presents some aspects of Hertzian and Non-Hertzian contact specific for the ball bearings with 2, 3 or 4 contact points. The analysis uses the slice technique and show the possible contact types form the ball bearings taking into account the raceways geometry.

KEYWORDS: Hertz contact, non-Hertz contact, cutting point contact analysis, Borland Delphi, Compaq Visual Fortran

1. INTRODUCTION

The pressure distribution on the ball - ring contact depends by the local geometry. In the ball bearings can appear non-Hertzian or / and Hertzian contact types. To study these aspects, a computing code was developed in Borland Delphi and Visual Fortran for a French company. Some results obtained with a specific Borland Delphi application are shown.

2. MATHEMATICAL FORMULATION

The load distribution, the contact angle and the raceways geometry can give non-Hertzian contacts in ball bearings. The contact parameters are expressed as function of the center mass displacement of the ball, notted (ξ). The local contact deformation for a slice "*j*" is given as the geometrical interference between the rolling element and raceway, (see equation (1) and fig. 1), as [1, 2]:

$$\delta_j = \left(\frac{1}{Rw} - \frac{1}{Rc}\right) . \frac{X_j^2}{2} . f(x) + \xi \tag{1}$$

with:

- $x = 2.X_j/Dw$; $x = [-1\ldots1]$
- Rw = local rolling element radius profile
- Rc = local raceway radius
- j = represents the slice index

and

$$X_j = \frac{2.j - N}{N} . \frac{Dw}{2}$$

$$f(x) := \sqrt{\frac{0.999960688 + x^2 \cdot (-1.58345115444314 + x^2 \cdot 0.593671524)}{1 + x^2 \cdot [-2.085234052466021 + x^2 \cdot (1.33188545905796 + x^2 \cdot -0.2441052041698022)]}} \tag{2}$$

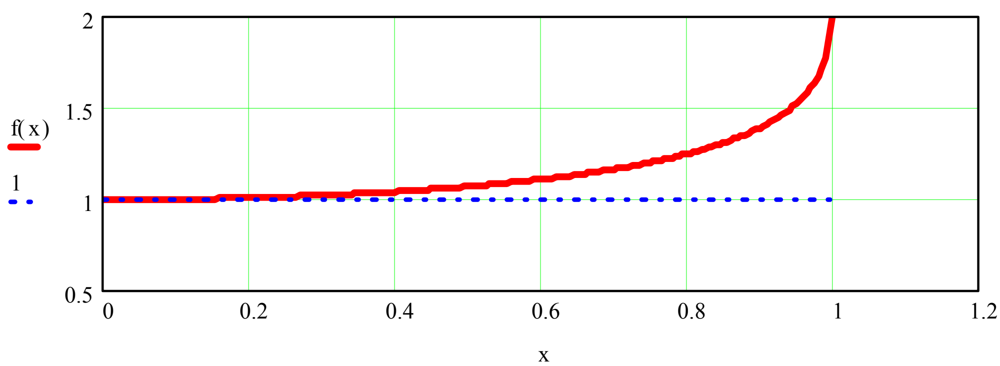

Fig. 1.

According to [1] the quasi-static contact parameters are:

- Local contact pressure, $P=P(j)$

$$P_j \approx \frac{0.282.E \cdot k^{-0.11}.\delta_j \cdot 2}{\pi \cdot b_j}.fp(k) \quad (2a)$$

- Local semi-width, $b=b(j)$

$$b_j = R_{y_j} \cdot \sqrt{\frac{\delta_j .k^{-0.11}}{Ry}}.1.15617 \cdot fb(k) \quad (2b)$$

- Local load, $Q=Q(j)$

$$Q_j = E0.k^{-0.11}.\delta_j.\Delta x_j.fQ(k) \quad (2c)$$

with:

$$fp(k) = \frac{3.2821 - 0.3322 \cdot ln(k)}{1 + 0.42877 \cdot ln(k)}$$

$$fb(k) = \frac{1.21386 - 0.07678 \cdot ln(k)}{1 + 0.115078 \cdot ln(k)}$$

$$fQ(k) = \frac{0.94896 - 0.09445.ln(k)}{1 + 0.45412 \cdot ln(k)}$$

$\Delta x_j = \frac{Dw}{N}$, the length of the slice section *"j"*,

Dw = the ball diameter,

k, the contact elipticity,

E_o, the equivalent modulus of elasticity of the two bodies in contact [1, 3].

3. BEARING GEOMETRY MODELISATION.

To describe the contact parameters we use the parameters shown in figure 1a. These parameters are taken into account to describe any type of the ball bearing raceways. With these parameters a Delphi software was developed. For this study the bearing geometry elements are shown in figure 2. Using the track bar properties attached to the main program results some derived geometry as in figures 3, 4 and 5. The elements shown in figure 4 and figure 5 are specific to radial-axial ball bearings and to the 3 or 4 contact.

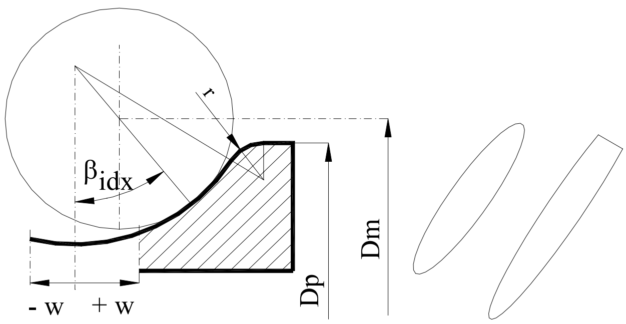

Fig. 1a. Ball bearing geometry elements uses to contact analysis..

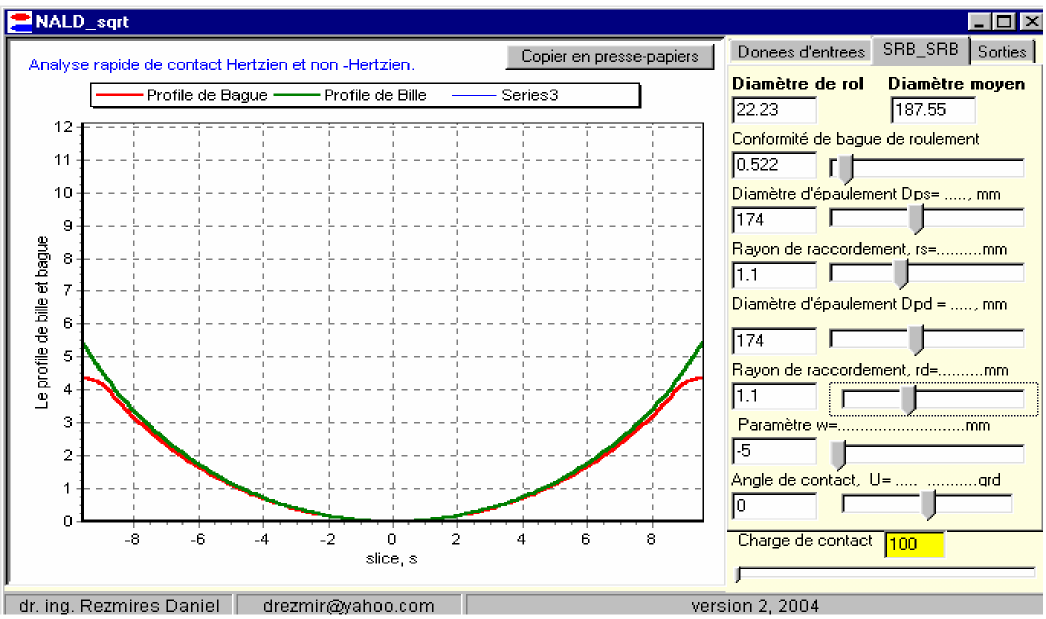

Fig. 2. Symmetric geometry example.

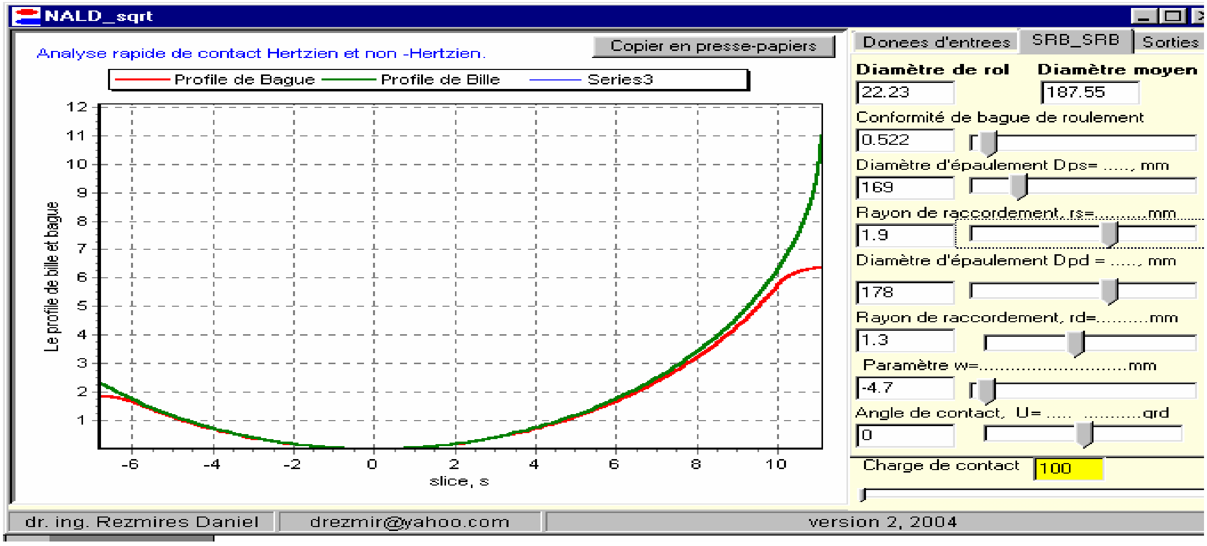

Fig. 3. Non symmetric geometry specification for the radial-axial ball bearings

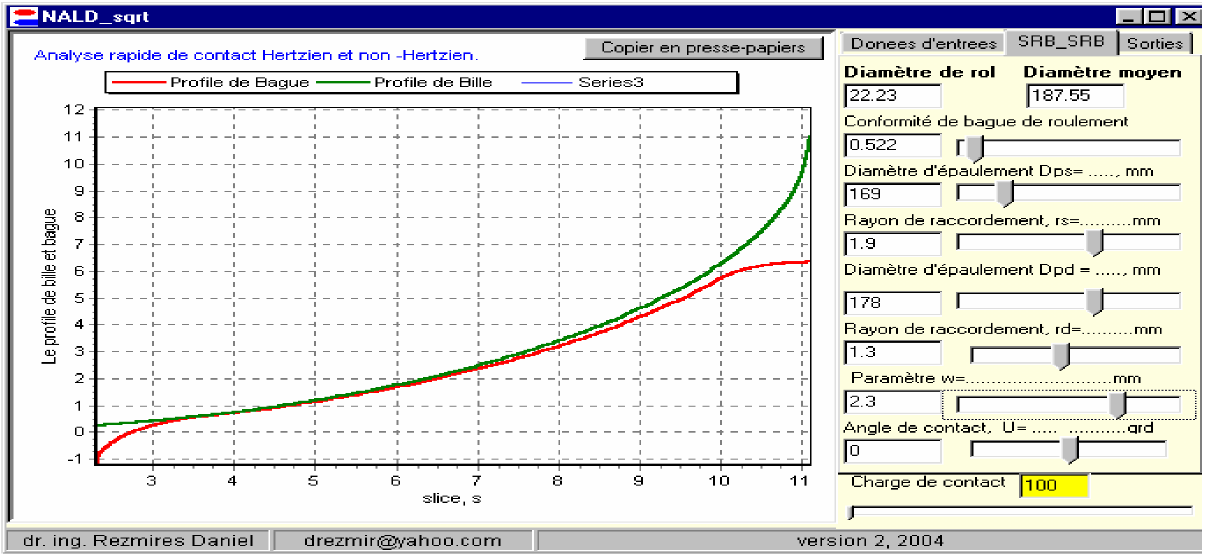

Fig. 4. Non symmetric geometry specification for the ball bearings with 3 or 4 point contacts.

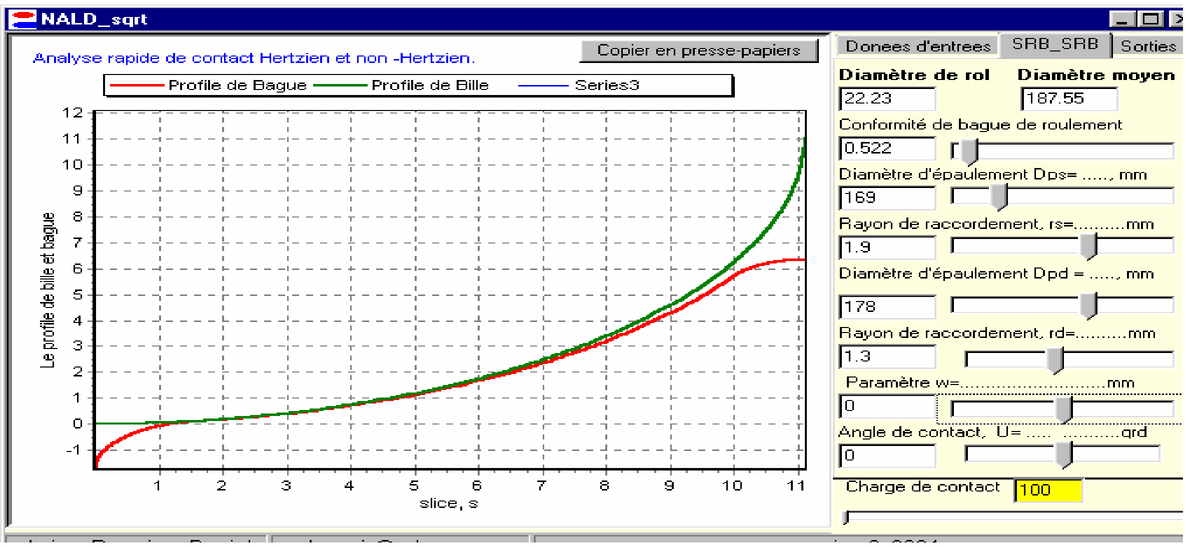

Fig. 5. Non symmetric geometry specification for the ball bearings with 3 or 4 point contacts.

The differences between figures 2, 3 and 4, are effect of *w*, parameter modification process.

4. NUMERIC RESULTS

The effect of the combination between the external load and the raceway geometry are shown in figures 6 to 9.

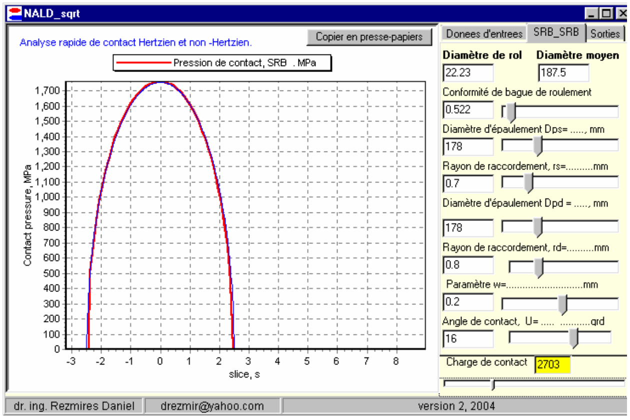

Fig. 6. Pressure distribution example.

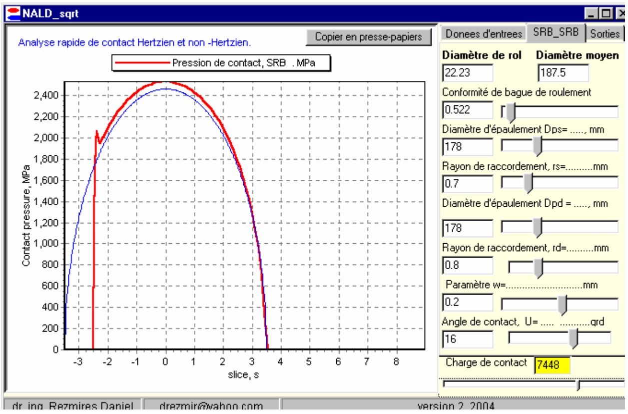

Fig. 7. Pressure distribution example.

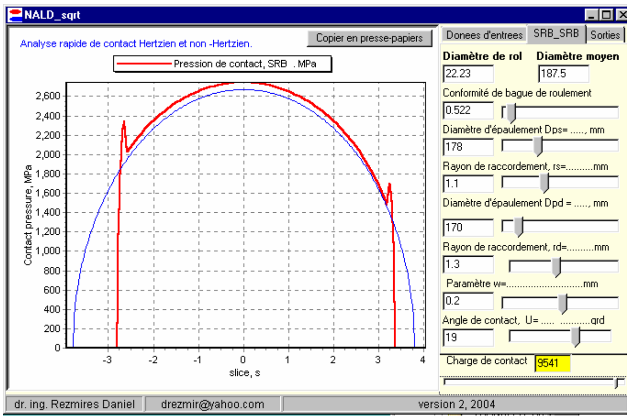

Fig. 8. Pressure distribution example.

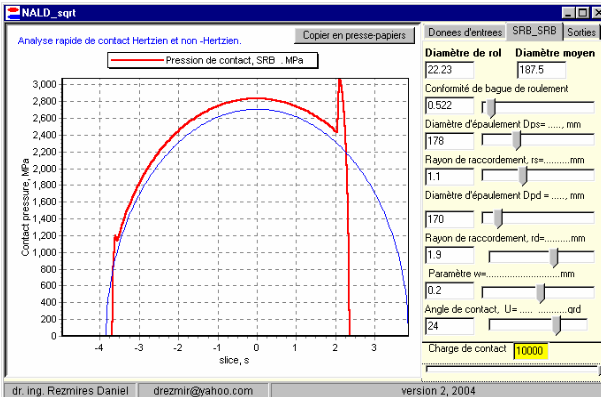

Fig. 9. Pressure distribution example.

5. CONCLUSIONS

A numeric approach has been developed to approximate the Hertzian and non-Hertzian contact parameters in the ball bearings. The proposed equations retrieves the Hertz contact type and offer some realistic information about the cutting point contact.

REFERENCES

1. **Rezmires D.**, 2003, Research about Dynamics and Kinematics Optimization of the Spherical Roller Bearings, Iasi, PhD Thesis.
2. **Rezmires D., Nelias D.**, 2002, Logiciel BB20, Convention de stage, INSA de LYON- SNECMA Moteur – France,
3. **Harris T. A.**, 1991, Rolling bearing analysis, 3rd *edition.* John Wiley & Sons Inc., New York.
4. **Eschmann, P.**, 1985, Ball and Roller Bearings, John Wiley & Sons, New York.