

APPROXIMATE SOLUTIONS TO HERTZIAN AND NON-HERTZIAN CONTACT ELASTICITY

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ABSTRACT

This paper presents a new numerical method to calculate the Hertzian and Non-Hertzian contact. Results calculated with the new relations are successfully compared with data from literature. The proposed method assures a good continuity of the transition between point and modified point contact.

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

1. INTRODUCTION

To study the Quasi- Static parameters for a Non-Hertzian contact the classical methods can be uses. In this case, a computing system must allocate to that duty a large memory resources. That implies also a big consuming time. To reduce these disadvantages some interpolation functions was create. A computing code was developed in Borland Delphi and Visual Fortran for a French company and some results are shown.

2. NUMERICAL FORMULATION.

When a bearing is loaded some conjunctions can be of line contact type and others of point contact type [1]. The contact load is a function of the center of mass displacement of the rolling element (ξ). The local contact deformation for a slice "**j**" is given as the geometrical interference between the roller element and raceway geometry as:

$$\delta_j = \left(\frac{1}{Rw} - \frac{1}{Rc}\right) \cdot \frac{XR_j^2}{2} + \xi \tag{1}$$

where:

$$XR_j = \frac{2.j - N}{N} \cdot \frac{lw}{2}$$

j = is the slice index,

Rw = local rolling element radius profile,

Rc = local raceway radius.

The proposed functions to obtain the contact parameters are given by equation (2), as follows [4]:

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

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

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

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

Local load, $Q=Q(j)$

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

with:

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

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

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

and

- $\Delta x_j = \frac{lw}{N}$, length of the slice section *"j"*
- lw = the rolling element length,
- k, the contact elipticity [1, 3],
- E_o, the equivalent modulus of elasticity of the two bodies in contact [1, 3]

3. NUMERICAL APPLICATIONS

The model was applied to study the Hertz and non-Hertz contact type .

3.1. Hertz contact type

Assuming a spherical roller bearing (SRB) 22308C with

- Contact angle 14.33^o;

- Pitch diameter *dm=66* [mm];
- Roller diameter *dw=13* [mm];
- Roller length *lw=12* [mm];
- Roller radius *Rw=39.5* [mm]
- Inner raceway profile radius *Rc=40.35* [mm]

Table 1 shows some numerical comparisons between the numerical solutions gives by Hertz theory and the proposed formulas (see also figure 1).

Table 1. Numerical comparisons, SRB 22308C – roller – inner ring contact.

Contact load	Contact ellipticity	Hertz theory		Eq. 2	
Q[N]	k(Rw)	Maximum pressure [MPa]	b[mm], semi width of the point contact	max(P), [MPa]	max(b), [mm]
300	k=44,27565	730.9	0.06653	731.59	0.06652
2500	Rw=39.5	1481.8	0.13488	1483.2	0.13487
300	k=16.0082	1029.3	0.0932	1029.1	0.0932
2500	Rw=36.5	2086.9	0.1980	2086.5	0.1980

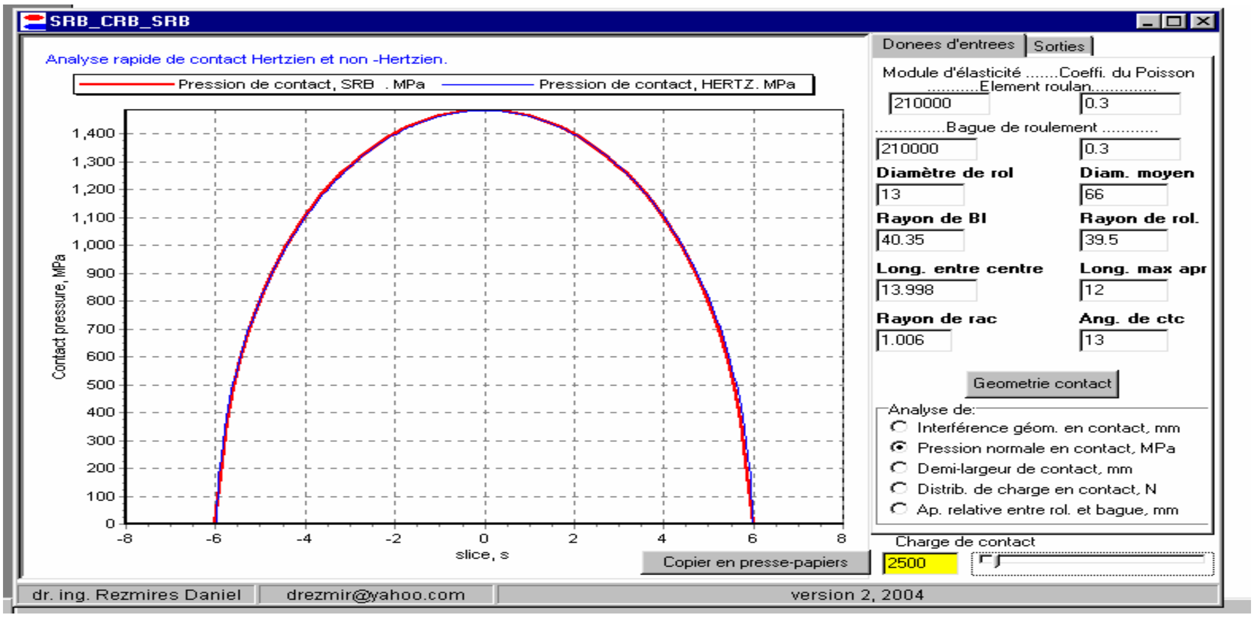

Fig. 1a. The pressure distribution according to the table 1, and geometry input data.

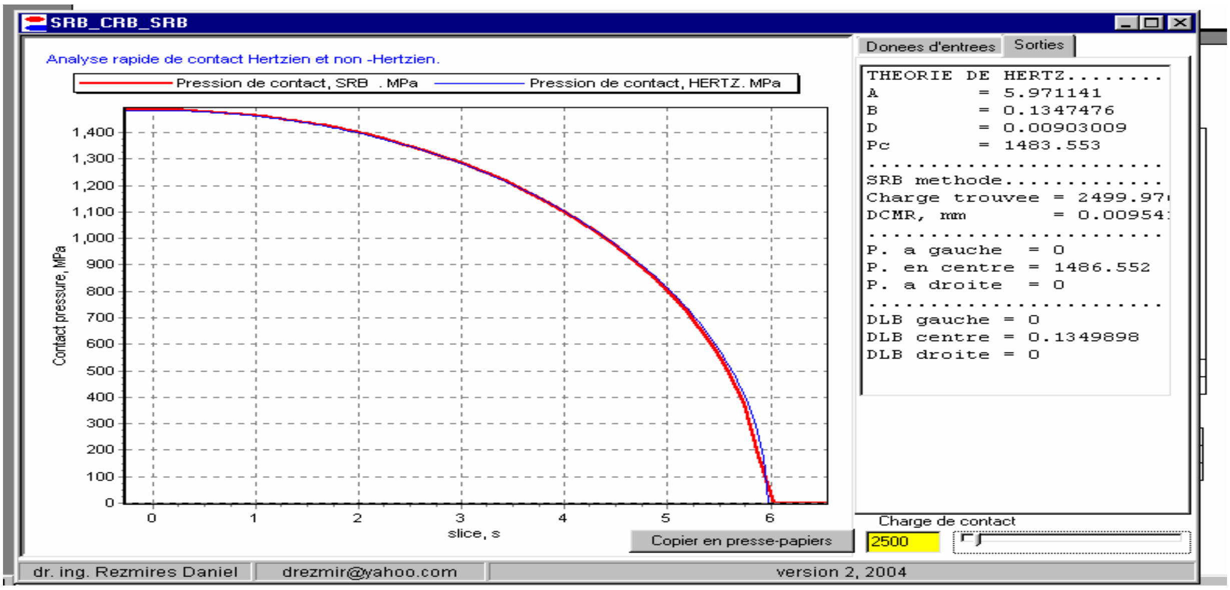

Fig. 1b. Pressure distribution – details. Numeric results for Rw=39.5.

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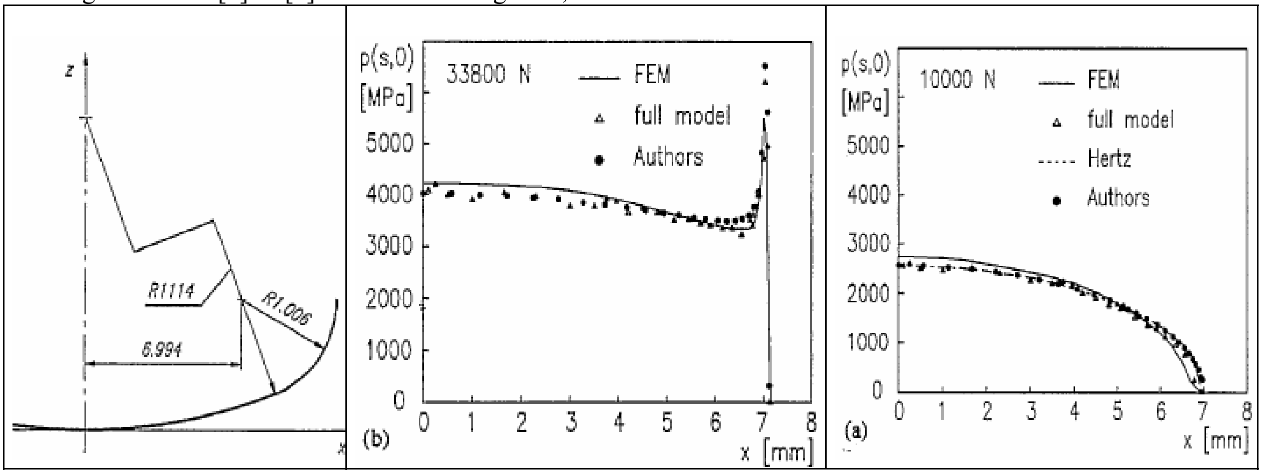
3.2. Non Hertz contact type. Example for the multi radius profile

For the case of the multi-radius profile was chosen the case given in the [2] & [3] references. In figure 2, the bearing geometry and the pressure distribution are presented for two distinct cases as a function of the external load. The numerical validation of the proposed mathematical model is assured by the results presented in table 2 and figures 3a, 3b, 3c respectively.



Multi radius profile | Pressure distribution ref [2] and [3].

Fig. 2. Ref [2] & [3]. Rroller diameter, Dw=15 mm, roller length, lw= 16 mm, the race diameter, d=58.5.

Table 2. Numerical results. Comparisons with reference [2].

Load, N	Krzeminski [2]	Half space model	FEM	Full model	**Eq. (2)**
10000	002785	0.028	0.02444	0.02482	**0.02256**
33800	0.06714	0.0675	0.0570	0.05737	**0.06653**

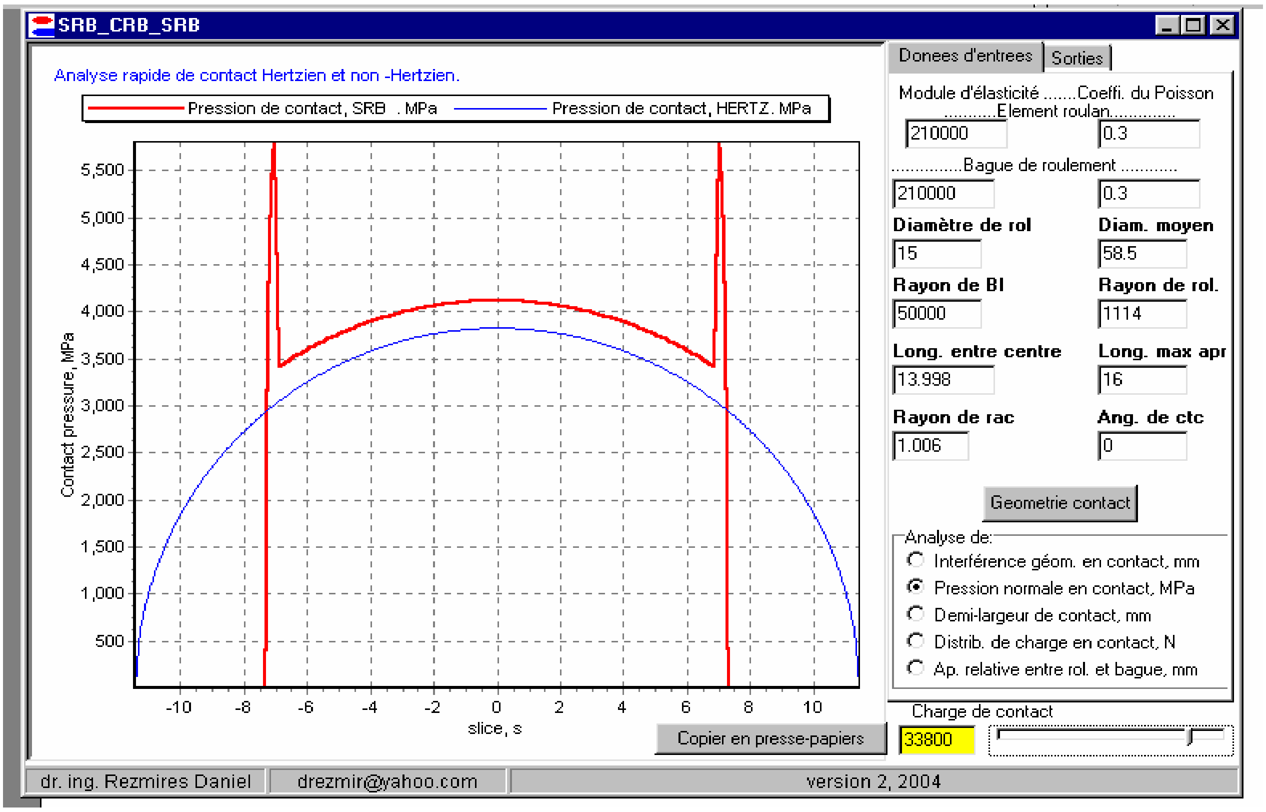


Fig. 3a. The pressure distribution imposing the contact load as 33800 N.

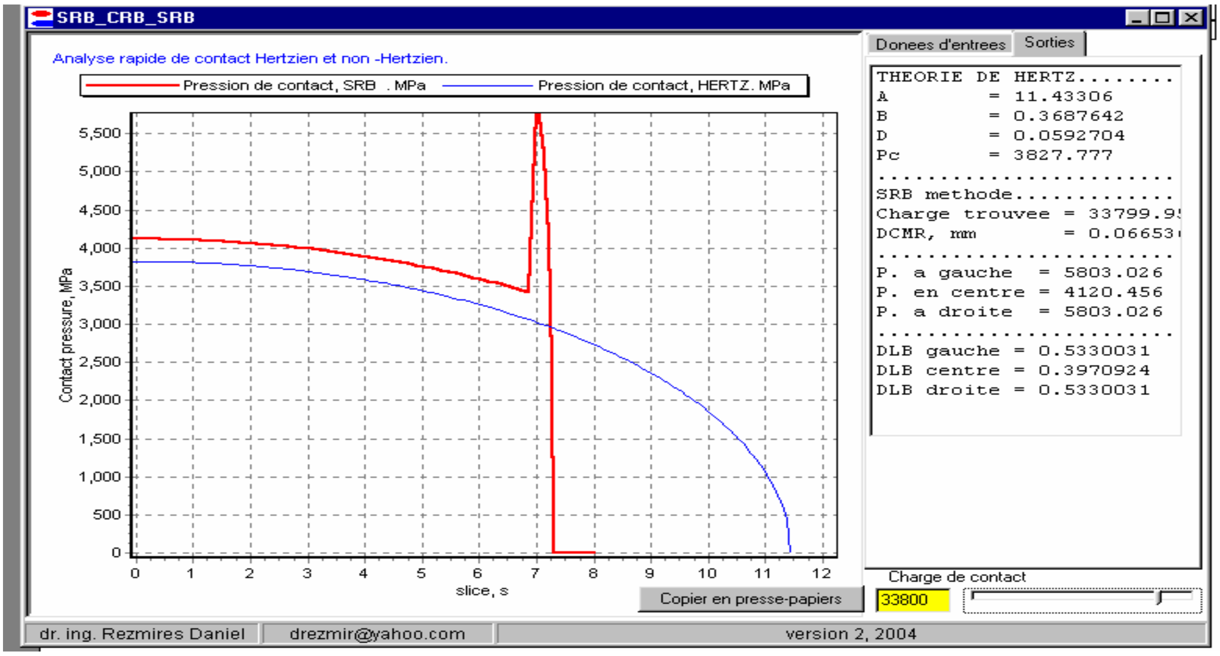


Fig. 3b. Pressure distribution – details. Numerical results.

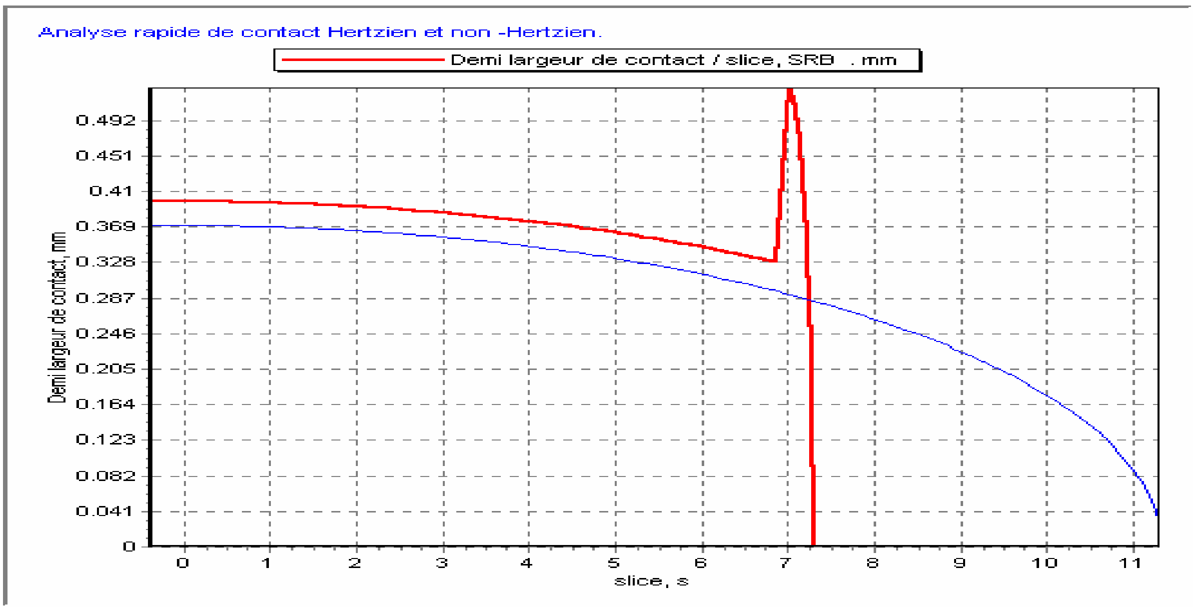


Fig. 3c. Contact demi-width

The pressure distribution presented in figure 2a, and the center mass displacement presented in table 2, give a good correlation between author's relations and references [2] and [3], respectively.

4. CONCLUSIONS

The proposed equations have been compared successfully to the different method [2] and [3], giving confidence in the new suggested method. The proposed method improves the computing speed of the non-Hertzian cutting point contact parameters and shows that the imposed hypothesis of the linear dependence between load and centre of mass displacement of the rolling element gives good results.

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