XVI IMEKO World Congress
Measurement - Supports Science - Improves Technology - Protects Environment ... and Provides Employment - Now and in the Future
Vienna, AUSTRIA, 2000, September 25-28

SYNERGY OF TESTING BENCHES WITH REAL CONFIGURATION

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Abstract: Metrological rules issued from european community, and may be others countries, are imposing a limit errors regarding distances covered and speeds of the measuring installations like lorries equipped with tachographs in order to make sure public guaranty, as well as security. The standardisation of these measuring installations is generally performed with lorries empty weight rolling upon a testing bench. Installations standardised in this manner are gravely wrongs and thus far european rules; thence unuseful standardization, the inconvenience is due to the influence between reactive torsor when a lorry is rolling upon a testing bench or upon a road. It will be seen how synergy between them can be performed through softward.
Keywords: creep rolling, winkler model, software

1 INTRODUCTION

Problem to be solved is that of the measuring installations as quoted before, which should be standardised. For that purpose, the exit of the speed gear box (coefficient W) is connected to the entrance of the tachograph (coefficient k imp/km) through an adjustable mean (constant coefficient $a = \frac{W}{K}$, Figure 1).

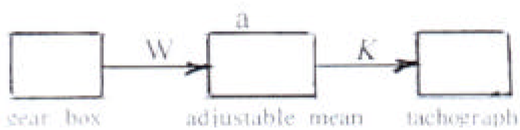

Figure 1.

To measure W before adaptation to tachograph, according to the actual procedure, lorries are generally rolling upon a testing bench like home-trainer, Figure 2. From figure 1we can see that all perturbations coming from the rolling used in the procedure of standardisation appears on W and then on K in the same ratio consequently on the used information. The reactive torsor in rolling upon a surface with curvature is different with one on a road, as well as that many others factors (tyres, empty or full weight of the lorry, aerodynamic drag, rolling drag, etc ...).

Studying the contact mechanics of the surfaces S_1, S_2 before loading, it has been set up [1] that a rolling can be seen as a combination of rolling, sliding, rotation. thus the tyres of a vehicle :

- are rolling without sliding nor rotation
- 3
- are sliding without rolling (wheels blocked up)
- are rolling and submitted to a rotation in a turning

from that time a standardisation by mean a rolling upon a testing bench with rollers is belonging to the first case.

After loading bringing some deformations it should be taken into consideration the tangential actions, for example, if it is existing a motive force transmitted by mean of the contact forces between the two surfaces S_1, S_2. From the russian literature we call " free rolling " the rolling without any tangential action, motive or friction.

The stresses of the tread are tenses when rolling upon a curve surface and compressive when rolling upon a road.

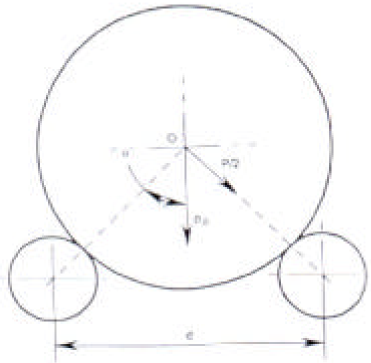

Figure 2. Home trainer

2 THEORETICAL ASPECT

Material particles of elements in contact flow away during a rolling with a speed $\vec{V}$ of the rolling plus a speed $d\,\vec{V}$ due to deformations. Speed of material elements of the deformed area can be calculated by mean of an Eulerian description.

The field of the speeds being stationary, the speed in a point is independent of the time, but a " function of the point " f (M,t) which can be followed in the moving.

$$\frac{\mathrm{df}}{\mathrm{dt}} = \frac{\text{ä f}}{\text{ä t}} + \vec{\mathrm{U}}\,\mathrm{gr\vec{a}d\,f} \qquad (1)$$

after some calculations and from (1) the no dimensional relations can be set up [2].

$$\frac{\mathrm{S'x}}{\mathrm{V}} = \mathrm{Vx}_1 - \mathrm{Vx}_2 = \text{îx} + \left(\frac{\text{ä}\,\overline{\mathrm{U}}_1}{\text{ä x}} - \frac{\text{ä}\,\overline{\mathrm{U}}_2}{\text{ä x}}\right)$$

$$\frac{\mathrm{S'y}}{\mathrm{V}} = \mathrm{Vy}_1 - \mathrm{Vy}_2 = \text{îy} + \left(\frac{\text{ä}\,\overline{\mathrm{U}}\mathrm{y}_1}{\text{ä x}} - \frac{\text{ä}\,\overline{\mathrm{U}}\mathrm{y}_2}{\text{ä x}}\right) \qquad (2)$$

In adhesion S’x = S’y = 0 being a rate of “creep” due to micro-sliding of elements in contact. We can write when two cylindrical bodies rolling one upon another regarding their speeds :

$$V_{R2}(1 + x\,\%) = V_{R1} \qquad (3)$$

V_{R2} = speed of the wheel equipped of tyres > V_1 = speed of the roller.

In an elastic transmission, the speed of the leading body is superior at that one of the led body.

Reactive torsor in a rolling upon a testing bench is different of the reactive torsor in a rolling upon a plane (road) in accordance with ξ its to say ξ_{rol}, $\xi_{pla.}$ To make a very simple example of these results :

- in a standardisation by rolling upon a testing bench, taking into no account of any tangential action, the real result regarding speed or the covered distance :

$$d_{real} = \frac{d_{measured}}{(1 + x_{rol})}(1 + x_{plane}) = d_m\{1 + (x_p - z_r)\}$$

so if we know to calculate ξ the problem will be solved.

3 CONTACT MECHANICS IN THE ROLLING

To establish Hertzian equations, we write :

$$\overline{U}x_1 + \overline{U}x_2 + h = d = d_1 + d_2$$

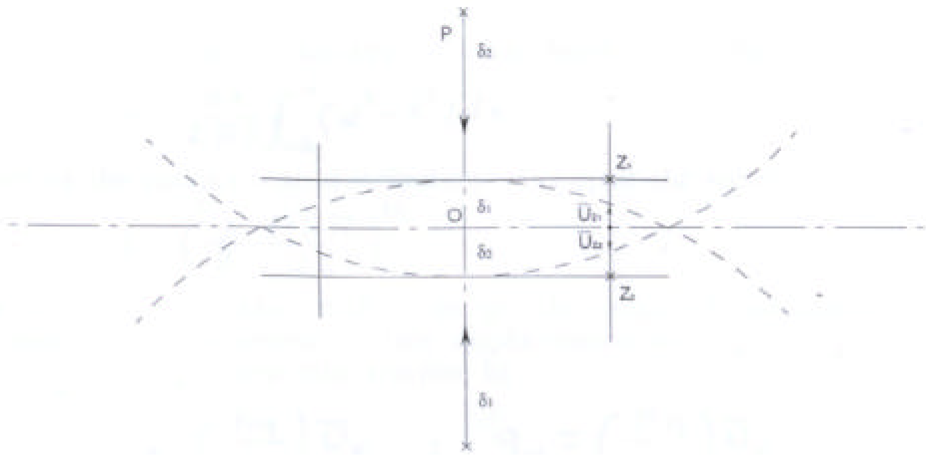

Figure 3. contact mechanics

Contact mechanics like tyre-roller is rigid-elastic

$$\overline{U}x_1 + \overline{U}x_2 = d - \frac{1}{2} X^2 = d - \frac{1}{2}\left(\frac{1}{R}\right)x^2$$

$A = \left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{1}{R}$, R_1, R_2 being the radius of the bodies in contact.
The contact to be considered being not Hertzian a Winkler model will be used. Figure 4.

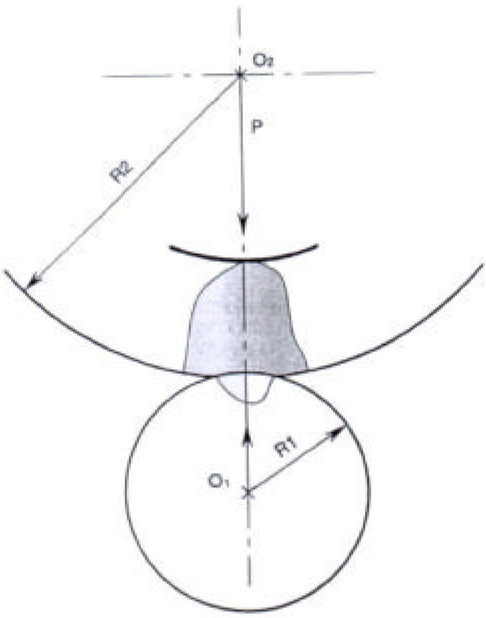

Figure 4. Winkler model

$$Uz_1(x) = 0, Uz_2(x) = d - \frac{1}{2R}x^2 = \frac{a^2 - x^2}{2R}$$

Materials in contact having constant elastic quite different, it will exist tangential placements. Calculations of stresses and displacements can be performed from the Winkler model.

$$P(x) = \frac{Kp}{2Rh}(a^2 - x^2) \qquad (5)$$

Kp = normal compression of the tyre, h = the height of its flank

$$P = \frac{Kp}{2Rh}\int_{-a}^{a} (a^2 - x^2)dx$$

1/2 breadth of the contact with distribution (x) upon the roller

$$a = \left(\frac{3}{2}\frac{PhR}{Kp}\right)^{1/3} \qquad (6)$$

The same expedient (Winkler model) can greatly simplified calculations rather than elastic-half spaces. The tangential surface displacements as u_x u_y are related to components q_x and q_y tangential traction by

$$q_x = \left(\frac{Kq}{h}\right)\overline{U}x,\ q_y = \left(\frac{Kq}{h}\right)\overline{U}y \qquad (7)$$

we consider only one direction Ox from equations (2) with the condition that the traction is zero on the leading edge as used to find the distribution of the tangential traction along contact area :

$$\frac{S'x}{V} = 0 = \text{î}\ _x + \frac{\partial \overline{U}x}{\partial x}$$

we substitute for $\overline{U}x,\ \overline{U}x = -\int_{-a}^{a} x_x dx$

$$q = -\left(\frac{Kq}{h}\right)^{-\text{á}} \text{î}\ _x(\text{á} + x) \qquad (8)$$

Traction increases linearly from the leading edge to the trailing edge to the trailing edge, thus Q would be :

$$Q = \frac{Kq}{h}\text{î}\ _x\int_{-a}^{a}(a + x)dx = \frac{2Kq}{h}\text{î}\ _x a^2 \qquad (9)$$

but, in practice a slip will occur at the trailing edge where the pressure falls to zero. It is not the case (8). For this purpose a stick region of width *2c* extends from the leading edge. At the point x = (2c-a) slip begins :

$$qx = \left(\frac{Kq}{h}\right)\text{î}\ _x(a + x) = \left(\frac{Kq}{h}\right)\text{î}\ _x 2c = \text{ì}p(x) \quad [3]$$

with a parabolic distribution upon the contact

$$p(x) = \frac{Kp}{hR}(a^2 - x^2)$$
$$q_x = \left(\frac{Kp}{h}\right)\ _x 2c = \frac{4Kp}{hR}\ (a - c)c \qquad (10)$$
$$\frac{Kq}{Kp}.\frac{R}{a}\ x_x = 2\left(1 - \frac{c}{a}\right) = \ l$$

$$\text{viz}: \frac{Qx}{\text{ì}P} = \frac{3}{2}\text{ë}\left(1 - \frac{\text{ë}}{2} + \frac{\text{ë}^2}{12}\right) \qquad (11)$$

Kp = elastic transverse modulus of elasticity.

4 ROLLING ON A PLANE - FREE ROLLING

In a free rolling (russian literature), the rate of the deformation between $\widehat{AB}$ and $\overline{AB}$ of the length of the contact gives a rate of " creep " :

$$x_{x} = \frac{\partial Ux}{\partial x} = -\frac{d}{3R}$$

δ being the crushing of the tyre, R its radius when a wheel equipped with tyre is rolling on a plane surface. The tread of the tyre is compressed when rolling on a plane, or else tense, when rolling on a rolling on a roller (curve surface) with all consequences upon the effective circumference of the rolling.

5 ROLLING ON A PLANE - TANGENTIAL ACTION

The rolling is not free regarding motive wheels. One tangential action is necessary :

- to proper the lorry
- to pulled, eventually, a trailer from the motives wheels of the lorry
- to balance the rolling-drag, Fig. 5
- to balance the aerodynamic-drag which should be taking into account

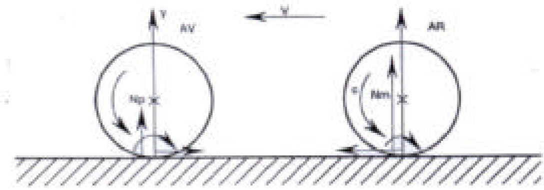

Figure 5. rolling drag

Thus from chapters (1), (4) (5) we can conclude that the actual practical work for standardisation, only in rolling on a testing bench, as analogical sensor, cannot be representative of the real configuration.

The reactive torsor of a testing. bench is riot in accordance with the reactive torsor on a road. Through calculations by mean software taking into account influential factors, a relation can be established between the two torsors (formulas chapters (2), (3), (4)). At that time, we have not a testing bench but a SIMULATOR.

We see, Fig. 6, over 50 km/h, that the errors cannot be accepted according rules.

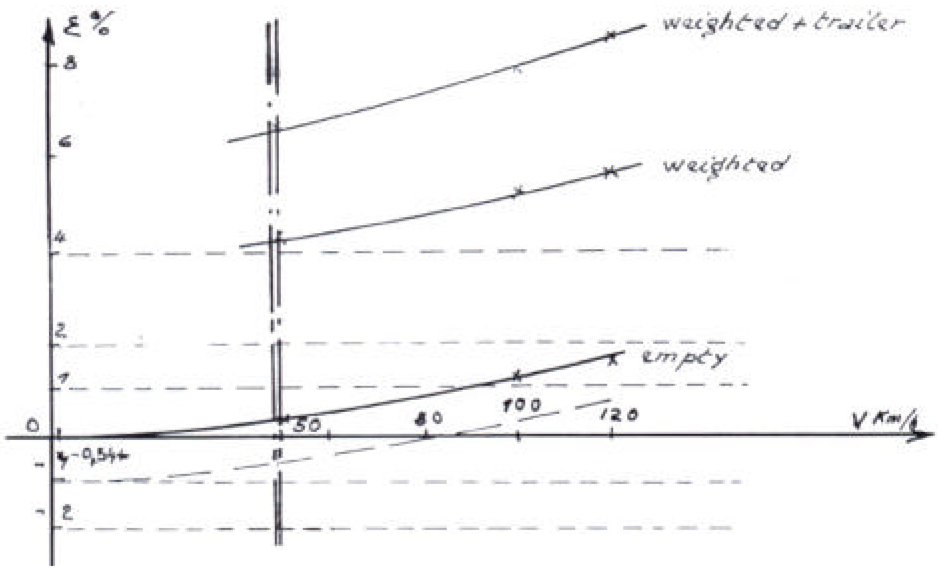

Figure 6. errors from standardisation of a lorry weight

We get data in real configuration of the material. So, the adjustable mean, Fig. 1 should not be a fixe mean, but an automatic adjustable mean with V km/h.

6 PROCEDURE TO STANDARDIZE

Fig. 7 give the mean software to standardise through several sequences of calculation by key-board characteristics of the tyres. All necessary calculations are performed to bring about W imp/km all rates of “creep" graphical solutions of errors empty of and weighted when lorries are used.

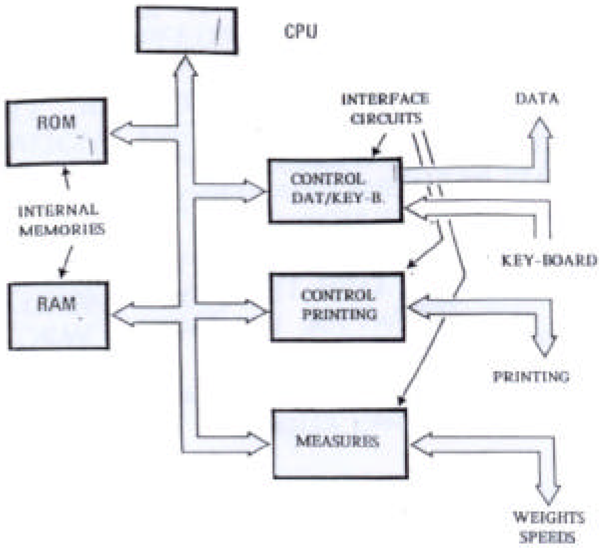

Figure 7.

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