THE ANNALS OF “DUNAREA DE JOS“ UNIVERSITY OF GALATI
FASCICLE XIV MECHANICAL ENGINEERING ISSN 1224-5615
2007

INFLUENCE OF THE ROAD DISLEVELS UPON THE TRACTION SYSTEM OF THE SELF-PROPELLED MACHINES

Prof.Dr.Eng. Gavril AXINTI
Lecturer Drd.Eng. Adrian Sorin AXINTI
Universitatea " Dunarea de Jos " University of Galati

ABSTRACT

The kinematic response is caused by run away about the equipment of the movement modeled in the mechanic system with degree of freedom. The kinematic excitation considered produces harmonic formally to the organ axle of resistant run moment characterized by the factor of amplification that can have very high values. The analysis in which the way of kinematic excitation influences a dynamic behavior , traction of a self - propelled equipment.

1. Introduction

The runaway irregularities for an unarrange road are from broken lines that form height outlines H_0 and s length. The profile of the road can be appreciated periodicity [6], [7]. The regular dislevels are modeled using frecvently harmonic functions [5], [6] like:

$$u(x) = u_0 \sin(\omega_0 x); \text{ and}$$
$$u(x) = u_0 (1 - \cos(\omega_0 x)); \quad (1)$$

where: $u_0 = H_0 / 2$ represents the dislevels amplitude of the road; $\omega_0 = 2\pi / s = v_0 / r$ represents the throb dislevels of the road; s - represents step the irregularities of the road; x - the movement of the estimate element of the dislevels, in the empirically can be the movement of the moving tool of equipment. (the wheel, caterpillar).

A model is a path of run close to the reality, is a representation of a function what Fourier represents a sum of harmonic components that frequencies are multiple of the fundamental frequency of angular velocity ω_0. The mathematical expression of such a representation is:

$$\begin{aligned} u(t) &= u_0 + u_1 \sin(\omega_0 t + \varphi_1) + \\ &+ u_2 \sin(2\omega_0 t + \varphi_2) + \ldots \\ &\ldots + u_n \sin(n\omega_0 t + \varphi_n); \end{aligned} \quad (2)$$

where: $u_i(i = 1...n)$ are the Fourier coefficients, which represent vibrations of the harmonic components and u_0 represents the average value function of the in part of the period $T = s / v_0$, what characterizes the bed bearer. From the relation (2) results as to speed v_0 of displace the equipment of periodic inharmonic dislevelments of the road constitute perturbators factors $\omega_1 = \omega_0, \omega_2 = 2\omega_0, ..\omega_n = n\omega_0,$ what acts concomitantly the throbs to the amplitudes $u_i(i = 1...n)$. In under consideration the constrained vibrations an important role have Harmonicals the force of disturbing, in case of girlish of kinematic excitation path disturbing the run, what it can lead to the appearance of the phenomenon of resonance [8]. For the analytic solution kinematic of excitation produced also forms by path of run can kept just fundamental harmonical definite through by term:

$$u(t) = u_1 \sin(\omega_1 t + \varphi_1); \quad (3)$$

2. The dynamic model

It is considered the equipment together its wheel mechanism, as a material point, (the centre of mass) elastic suspended viscous element of elasticity that models a mechanism of movement, as in fig. nr. 1. It is considered that the excitation produced of modeled runaway as the a function a harmonica, dependency of time u(t). The dynamic model of the equipment moving across the dislevels of the road is presented in fig. 1.

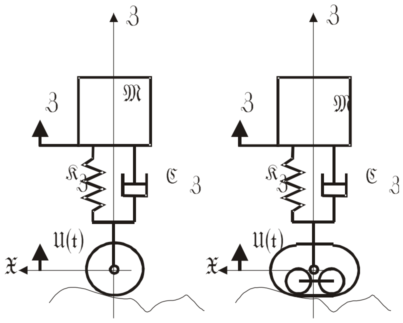


Fig. 1. The dynamic model

The motion model in z vertical axes arises from the adhibition principle D'Alembert for mass M of the equipment, considering the rigidity k_z respectively the damping factor c_z of the moving mechanism movement. The motion equation is:

$$M.\ddot{z} = c_z(\dot{u} - \dot{z}) + k_z(u - z); \qquad (4)$$

After the primness terms in (4) is obtained the motion equation of the equipment in verticall direction -z, puting the obvious factor of kinematics excitation induced by the runway, found out in the right term of the equation:

$$M.\ddot{z} + c_z\dot{z} + k_z z = c_z\dot{u} + k_z u; \qquad (5)$$

3. The solution of the model

The kinematic excitation produced by the equipment on runway modeled as a function of a formal harmonic like (3) is considerat. Replacing in relation (5) the expressions from the right limb, results in:

$$c_z\dot{u} + k_z u = c_z u_0 \omega_0 \cos \omega_0 t + u_0 k_z \sin \omega_0 t = \\ = Z_0 \sin(\omega_0 t + \theta); \qquad (6)$$

where:

$$Z_0 = u_0\sqrt{k_z^2 + c_z^2\omega_0^2}; \theta = arctg[\omega_0 c_z / k_z]; \qquad (7)$$

Replacing (6) in (5) and dividing thro by M, it results in:

$$\ddot{z} + 2n\dot{z} + p^2 z = h_0 \sin(\omega_0 t + \theta); \qquad (8)$$

$$2n = c_z / M; p^2 = k_z / M; h_0 = Z_0 / M;$$

The behavior in permanent regime of excited kinematic equipment of the bed bearer is falled across the particular solution $z = A\sin(\omega_0 t - \Gamma)$, what be due to verify the equation (8), from where:

$$A = \frac{h_0}{p^2}\frac{1}{\sqrt{(1-\Omega^2)^2 + (2\xi\Omega)^2}}; \qquad (9)$$

What represents the motion amplitude of the equipment on z vertical, and:

$$\Gamma = arctg\frac{2\xi\Omega}{1-\Omega^2}; \qquad (10)$$

What represents phase initially of motion.

In the relations (9) and (10) it noted $\Omega = \omega_0/p -$ the relative throb motion, $\xi = n/p -$ the fraction from the critical amortization.

If is noted: $A_0 = h_0/p^2 = Z_0/k_z = u_0\sqrt{1 + tg^2\theta}$ the static amplitude of excitation kinematic and $\eta = A/A_0 -$ the dinamic factor (of amplification), results in: $\eta = \frac{1}{\sqrt{(1-\Omega^2)^2 + (2\xi\Omega)^2}};$ (11)

The relations (10) and (11) put the obvious phenomens of canorous in the equal-phase what characterizes amplitude the motion of the equipment with speed $v_0 = const$.

4. The moment of the equipment

The dynamic reaction to the organ of movement of the equipment is formed from elastic force and force of absorb the equipment.

Results as the dynamic reaction on the mechanism of movement is fallen across the relation (4), that is:

$$Z_m = c_z(\dot{u} - \dot{z}) + k_z(u - z) = M.\ddot{z}; \qquad (12)$$

The variation In Temporally to the dynamic reaction arises from the expression of the acceleration $\ddot{z}$ change in the expression (12), from where through remakings of terms results the amplification **factor of the dynamic reaction**, produced of excitation kinematics inducted of the bed bearer:

$$\Re = \frac{Z_m}{Z_0} = \frac{\Omega^2}{\sqrt{(1-\Omega^2)^2 + (2\xi\Omega)^2}}; \qquad (13)$$

where Z_0-resulted from the (7) relation and it has the signification of static reaction on the mechanism of run. Because the proof moment of the movement mechanism (the wheel with his tire or caterpillar) depends on nature material of the path, through the coefficient of proof run charm, results [1], [2]:

$$M_R = f(G + Z_m).r = f[Mg + Z_m \sin(\omega_0 t - \Gamma)].r = \\ = M_{RS}\left[1 + \frac{Z_m}{G}\sin(\omega_0 t - \Gamma)\right];$$

(14)

where: $M_{RS} = Mgrf -$ represents the proof moment the run wheel or the caterpillar produced of the static shipment of the organic of movement. The term from square parenthesis represents the growth of resistant moment produce by kinematics excitation challenged of the run away. It Is defined the factor of amplification of the proof moment the organ of movement of the self-propelled equipment through:

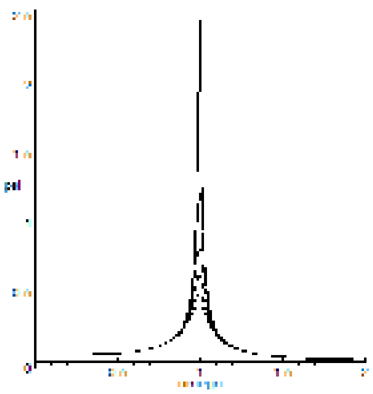
$$\psi = \frac{Z_m}{G} = \Lambda \frac{\sqrt{1+(2\xi\Omega)^2}}{\sqrt{(1-\Omega^2)^2+(2\xi\Omega)^2}}; \qquad (15)$$

where: $\Lambda = u_0 v_0^2 / gr^2$ – law coefficient the height of run away dislevels (u_0), the speed of displace the equipment (v_0), the ray of the organ of movement ($r = r_d$ dynamic tire, $r = r_0$ of gear the caterpillar) and the acceleration of the gravitation (g). For analysis dynamic behavior of the transmission of displace of a technological self-propelled what equipment is displaced across the bed bearer dislevels, modeled harmonic, is considered as the proof moment to the wheel axle with tire or wheel of caterpillar is fallen across the relation:

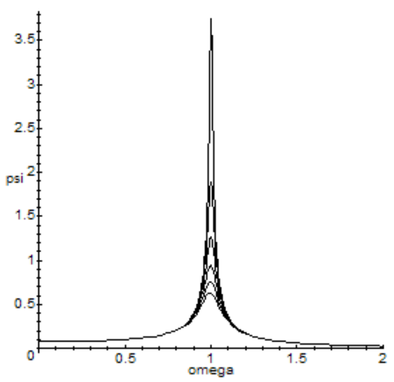
$$M_R = M_{RS}\left[1+\psi \sin(\omega_0 t - \Gamma)\right]; \qquad (16)$$

5. Results of modelation

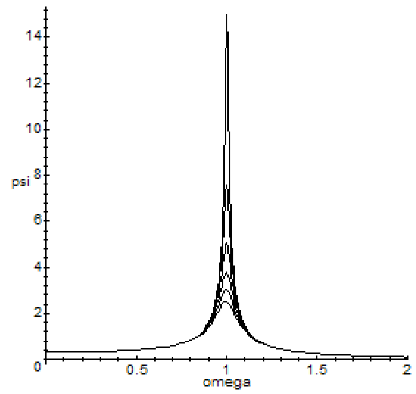
The dynamic amplification of the moment to the wheel axle is fallen across the factor Ψ, rel. 15, For which achieved analysis of hereinafter, for usual values of terms what interfere, fig. 2.



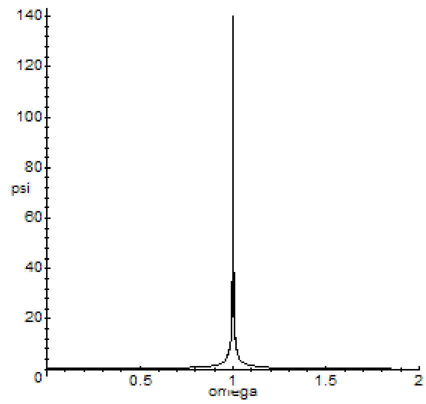
a) $u_0 = 0.2;\ \xi \in (0{,}01 - 0{,}06)$;
$v_0 = 2{,}85 km/h;\ r_0 = 0{,}5m$



b) $u_0 = 0.3;\ \xi \in (0{,}01 - 0{,}06)$;
$v_0 = 2{,}85 km/h;\ r_0 = 0{,}5m$



c) $u_0 = 0.3;\ \xi \in (0{,}01 - 0{,}06)$;
$v_0 = 5{,}65 km/h;\ r_0 = 0{,}5m$



d) $u_0 = 0.3;\ \xi \in (0{,}001 - 0{,}006)$;
$v_0 = 5{,}65 km/h;\ r_0 = 0{,}5m$

Fig. 2. The variation of the factor of the amplify proof moment of the wheel $\psi = f(\xi)$.

6. Conclusions

From consisted analysis as to the movement of technological self-propelled equipments across the run away dislevels appear the dynamic solicitations proved through vibrations in the structure of equipments but and dynamic couples demonstrated to the systems of run (wheels or caterpillar this solicitations appear pursuant to acceleration of the equipment on the vertical or road and transmitted the run away, but and the system of run, through mediums of the viscous elasticity structure wheel or the caterpillar.

It was put the obvious in a factor of amplification, named the factor of amplification of the proof moment to the organ of movement of the self-propelled equipment, dependent on factor the height dislevels, ray of run, speed of displace the equipment and the factor of amortization of the mechanism of run and path. From digital analysis undertaken in work is seen in the dynamic growth couple to the wheel of the order of tens of the hundreds of either against the moment in static regime. The amplification factor of the resistant moment scales up by the growth of the speed of movement, breed the height of the dislevels and diminish the factor of amortization.

The operating analyse for dynamic behavior of the mechanisms movement self-propeled of the equipments.

References

[1] **Axinti, A.S, Axinti, G.** *About kinematic excitation induced of the dislevelments bed bearer to the wheel of self-propelled equipments*, Romanian Journal of Acoustics and Vibration, Volume III, Number I, Icecon, Bucuresti, 2006, ISSN 1584-7284.34.

[2] **Borkowski, W., Konopka, S., Prochowski, L.** *Dynamika maszyn roboczych*, Podreczniki Akademickie- Mechanika. Wydawnictwa Naukowo- Techniczne,Warszawa,1996, pg.156-168; 172-185;

[3]. Bratu. P. P., Vibratiile sistemelor elastice. Editura Tehnica. Bucuresti. 2000

[4] **Bucur, C., Bucur, V.M.** *Railway dislevelments influence on the dynamic response of bridges*, Intersections/Intersectii. Vol.2., 2005, No.3, Transportations Research, Iasi 2005, ISSN 1582-3024.

[5] **Debeleac, N.C.** *Analiza regimului dinamic la incarcatoarele frontale rapide in vederea stabilirii performantelor de calitate*, Teza de doctorat, Universitatea "Dunarea de Jos" din Galati, 2006, pg.115-123.

[6] **Nitescu, Gh., Nastasoiu, S., Popescu, S.** *Tractoare*, Editura Didactica si Pedagogica, Bucuresti, 1974.

[7] **Sireteanu, T., Gundisch, O., Paraian, S.** *Vibratiile aleatoare ale automobilelor*, Editura Tehnica, Bucuresti, 1981.

[8] **Toader, M., Luca, Gh., Stefan, C.** *Mecanica.Vibratii. Aplicatii industriale*, Editura Politehnica,Timisoara, 2003.

[9] **Untaru, M., Peres, Gh., Stoicescu, A., s.a.** *Dinamica autovehiculelor pe roti*, Editura Didactica si Pedagogica, Bucuresti, 1981.