THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI
FASCICLE XIV MECHANICAL ENGINEERING, ISSN 1224 – 5615
2003

THEORETICHAL CONSIDERATIONS ABOUT THE MAXIMUM VIBRATION LIMITS FOR WHEEL LOADER AFFECTED BY THE GROUND CONDITIONS

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ABSTRACT

In this paper, the author make a study of vibration (vertical acceleration) into wheel loader who is affected by the ground conditions. It is known from many studies and investigations, that the drive vibrations are mainly responsible of the driver's performance perception and the vehicle's driveability.

1. Surface profiling

There are a large number of different techniques, which can be used in modelling the surface roughness.
The principle is to find out certain regularities of the surface profile (figure 1) so that, adequate information on obstacle heights and densities are available for trafficability and mobility analysis.

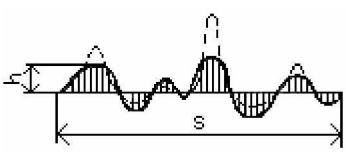

Figure 1. Surface profiling

An average equivalent obstacle slope factor k_0 is as follows, Eq (1).

$$k_0 = \frac{\sum h_s}{s} \qquad (1)$$

2. Modelling the vibration

There is a large number of special programs to analyse the vibration of a machine, but they are too resource demanding for the purpose of the study.

For special analysis, dynamic modelling must be adopted; but a simple wheel/obstacle approach seems adequate to develop a constraint model to limit the predicted velocity close to the levels obtainable in the field. When a tractor wheel is passing over an obstacle, it changes its trajectory, which causes the vertical acceleration, vibration in plane z, Figure 2.

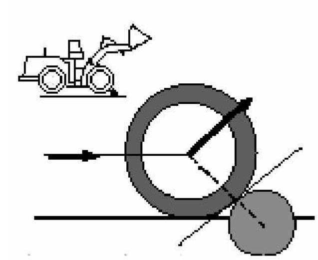

Figure 2 A wheel overcoming an obstacle

From a simple plane geometry (figure 3), and using static loads, the following model for horizontal velocity v_z, can be derived, Eq (2).

$$v_z = v_x \cdot tg\alpha = \frac{x}{z} v_x \qquad (2)$$

where:
v_z is the vertical velocity, Z-plane, [m/s];
v_x - horizontal velocity, X-plane, [m/s];
α – trajectory angle, [°].

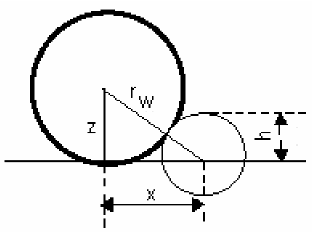

Figure 3 Wheel geometry for modelling the vertical acceleration

As the acceleration is the derivate of the velocity, and by using simple plane geometry, the following vertical acceleration model can be developed.

$$a_z = \frac{(r_w + h)^2}{(r_w)^3} \cdot v^2 \qquad (3)$$

3. Vibration constraint velocity

By letting a certain maximum allowable vibration acceleration, technical, efficiency or comfort, the maximum horizontal velocity for a wheel can be calculated, Eq (4).

$$v_{maz} = \frac{\sqrt{a_{max} \cdot (r_w + h)^3}}{r_w} \qquad (4)$$

where: $r_w = r_1 + r_2$;

v_{max} is the maximal attainable horizontal velocity, [m/s];

a_{max} - limiting vertical acceleration, [m/s];

$r_{1/2}$ - radius of the wheel/obstacle, [m];

h - height of the obstacle, [m].

4. Vibration limits

The maximum acceleration depends on the frequency and plane, and on the exposure time.

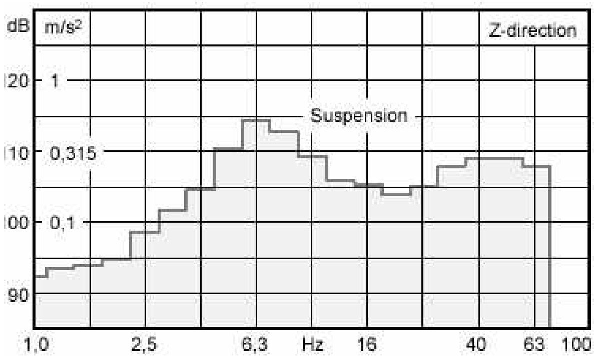

Figure 4 The maximum acceleration of wheel loader

For forwarder traffic the low frequency, passing over obstacles, becomes the limiting factor. The maximum vibration limits at the drivers seat are given in ISO norms see Table 1

Table 1

Frequency [Hz]	Z - level			X - and Y - level		
	1 min	4 h	24 h	1 min	4 h	24 h
	Acceleration, $[m/s^2]$					
Tolerance limit						
1	11.2	2.12	0.56	4.0	0.71	0.20
4	5.60	1.06	0.28	8.0	1.42	0.40
63	44.8	8.50	2.24	126	22.4	6.30
Efficiency limit						
1	5.60	1.06	0.28	2.0	0.35	0.10
4	2.80	0.53	0.14	4.0	0.71	0.20
63	22.4	4.25	1.12	63.0	11.2	3.15
Comfort limit						
1	1.78	0.34	0.09	0.63	0.11	0.03
4	0.89	0.17	0.04	1.27	0.22	0.06
63	7.11	1.35	0.36	20.0	3.56	1.0

In Figure 5 the different velocity limits as a function of obstacle height are depicted for a bogie with 1.330 m tyres.

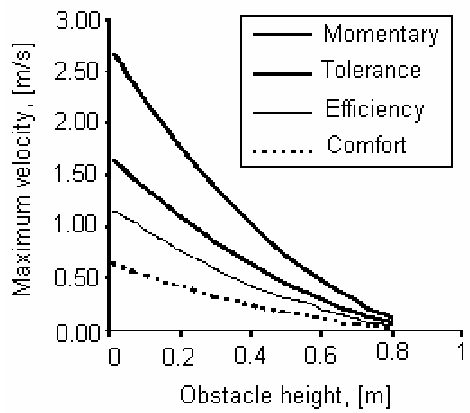

Figure 5 Constraint velocity as a function of obstacle height

The used maximum vertical limits are:

- Momentary, a=5.60 m/s^2, duration 1 min;
- Tolerance, a=2.12 m/s^2, duration 4 h;
- Efficiency, a=1.06 m/s^2, duration 4 h;
- Comfort, a=0.36 m/s^2, duration 24 h.

References

*** *Human Vibration, Bruel & Kjaer Sound and Vibration Measurement A/S*, BA 7054-14, 2002.

*** *National Institute for Occupational Safety and Health (NIOSH)*, National Occupational Exposure Survey (1981– 1983). Cincinnati, Ohio: NIOSH, 1998.