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PROCEEDINGS BOOK

EDITOR
Dr. Fatma Gül SAKLAVÇI

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CONTENT

ABSTRACTS

PROBLEMS OF HAZARDOUS LIQUIDS TRANSPORTING IN TANKS OVER ROUGH ROADS

Volodymyr HOLOTA (ORCID: 0009-0005-7461-4376)

National University of Civil Defence of Ukraine, Kharkiv, Ukraine

D.Sc., Olena SIERIKOVA (ORCID: 0000-0003-0354-9720)

National Scientific Center "Hon. Prof. M.S. Bokarius Forensic Science Institute" of the Ministry of Justice of Ukraine, Kharkiv, Ukraine

D.Sc., Elena STRELNIKOVA (ORCID: 0000-0003-0707-7214)

A.M. Podgorny Institute for Mechanical Engineering Problems NAS of Ukraine, Kharkiv, Ukraine

PhD, Kyryl DEGTYARIOV (ORCID: 0000-0002-4486-2468)

A.M. Podgorny Institute for Mechanical Engineering Problems NAS of Ukraine, Kharkiv, Ukraine

Abstract.

The paper treats the influence of road surface irregularities on the dynamics of the hazardous liquids movement in tanker trucks. The features of the occurrence of liquid sloshing under the vertical and horizontal vibrations of the vehicle, as well as the conditions for the occurrence of resonant and parametric resonant phenomena, have been considered.

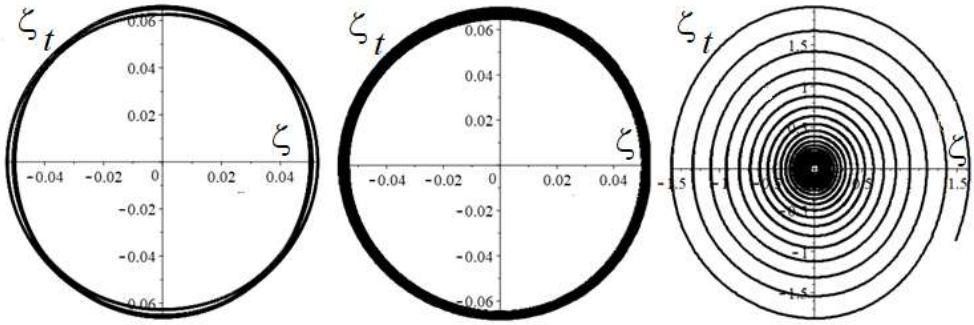
Keywords: tanker truck, liquid sloshing, environmental safety, environment, hazardous effects of liquid, transportation of hazardous liquids.

In transporting process of dangerous liquids in tanker trucks, the vibrations of the liquid inside the tank have a significant impact on traffic safety. In driving on an uneven or wavy road, the vehicle is subjected to vertical and horizontal vibrations, which cause sloshing of the liquid and could lead to the occurrence of resonance phenomena [1-2].

Of particular danger is the combined vertical-horizontal excitation, in which additional resonant modes and subresonances arise, accompanied by an increase in the amplitude of oscillations of the liquid free surface. To study these processes, the paper considers the movement of a liquid in a rigid cylindrical shell under harmonic excitation:

$$a_x(t) = a_h \cos(\omega_h t), \quad a_z(t) = a_v \cos(\omega_v t),$$

The shell-fluid system was at rest at the beginning of the motion. Calculations of the free surface motion have been carried out for different values of the excitation parameters: amplitudes a_h, a_v and frequencies ω_h, ω_v. Initially, purely vertical excitations were considered, i.e., it has been assumed that a_h=0. Phase portraits of motion in coordinates $(\zeta, \dot{\zeta})$ have been shown on Fig. 1.

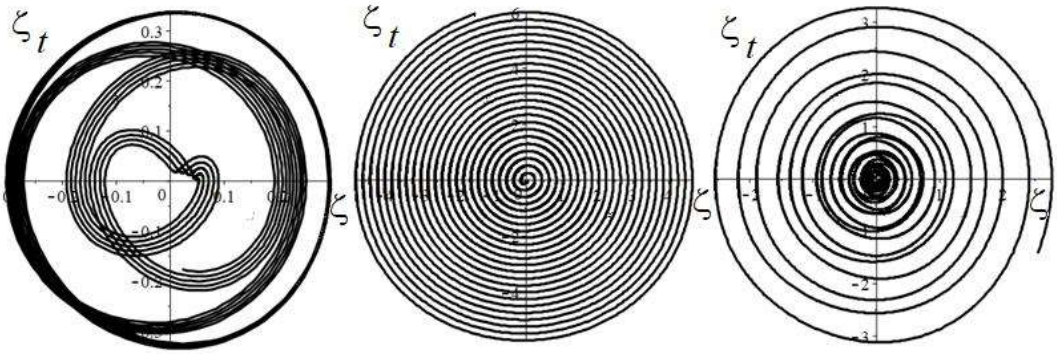


a b c

Fig. 1. Phase portraits of fluid motion under vertical load for 200 s.

Fig. 1.a) corresponds to a_h=0, a_v=1, ω_v=1 Hz, while Fig. 1. b) and 1.c) correspond to a_h=0, a_v=1, з ω_v =0.65959 Hz and ω_v = 1.31918 Hz respectively. The results show that in the first two cases the movements are stable, while for ω_v = 1.31918 Hz the amplitude increases without limits, which corresponds to the case of parametric resonance (the excitation frequency is equal to twice the fundamental frequency) [3].

Next, combined vertical and horizontal excitations were considered, i.e., a horizontal load has been added. As a result of the calculations, phase portraits have been obtained in the coordinates (ζ, $\dot{\zeta}$), which have been shown in Fig. 2.



a b c

Fig. 2. Phase portraits of fluid motion under combined load for 200 s.

The following combined excitation parameters have been applied: Fig. 2a): a_h=0.1, a_v=1, ω_h= ω_v =1 Hz; Fig. 2b): a_h=0.1, a_v=1, ω_h= ω_v =0.65959 Hz; Fig. 2c): a_h=0.1, a_v=1, ω_h - ω_v =0.65959 Hz.

It should be noted that in this case another resonance associated with horizontal excitation has been observed. ω_h =0.65959 Hz, as well as sub-resonance associated with ω_h - ω_v =0.65959 Hz.

Note also that certain combinations of vehicle speed V and wavelengths of the path L_r could lead to parametric instability.

The enhancement of sloshing could occur even with small road irregularities.

Vertical excitation could indirectly enhance sloshing in taking into account the nonlinear modal coupling [4-5].

Thus, driving on an undulating road causes a parametric excitation of sloshing modes due to the modification of the gravity force.

This effect must be taken into account when assessing the safety of transporting tanker trucks containing hazardous liquids.

Conclusions. Paper investigates the effect of vertical oscillations that occur in a tanker truck moving along a wavy road surface on the dynamics of the fluid in the tank. It is established that vertical accelerations of the vehicle lead to a change in the effective gravitational force acting on the fluid, resulting in parametric excitation of free surface sloshing modes.

It has been established that certain combinations of vehicle speed and road roughness wavelength could lead to parametric instability of fluid motion even with minor road surface irregularities. Vertical excitation could also enhance fluid sloshing in the presence of a nonlinear modal relationship.

Thus, the movement of a tanker truck along a wavy road causes parametric excitation of fluid sloshing modes due to a change in the effective gravitational field. The results obtained indicate the need to take this effect into account in assessing the safety of tanker truck operation and transportation of hazardous liquids to ensure the environmental safety of storage and transportation of such liquids.

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