Acoustic estimation of substance capacity into cylindrical container

Vitaly Kolykhalin
cap-07@mail.ru

Abstract

The acoustic measurement of liquid and solid substance capacity in cylindrical motor transport tanks are considered. The knock acoustic source of sound pressure is installed on the outside cylindrical container. The relative sound pressure levels of "free" air volumes into tank are corresponded of different substance capacity into cylindrical container and controlled by a microphone. The knock spectrums and sound level meter signals considerably differed from each other in low frequency band are analyzed.

1 Introduction

The volume of black oil transportation on highways of the Russian Federation has considerably increased therefore a process of loading and the unloading of motor tanks should be accelerated for exception of stoppage. The automatic remote control of oil product quantity in a motor transport during loading and unloading is very important especially at night. It will be noted that the hardware has been developed with relative acoustic measurements of oil products mass with consideration for "free" air volume by sound pressure measurement with compensation for influence of variable external and internal technological conditions [1]. The knock acoustic source is installed on the outside cylindrical container. The relative level of sound pressure of oil volumes is registered by the microphone fixed inside of air phase of tank and the sound level meter installed with computer in the driver's cab (Fig.1). The microphone Mk, the sound level meter Sm, the computer PC, knock acoustic source S and cylindrical motor tank Mt are shown on Fig.1.

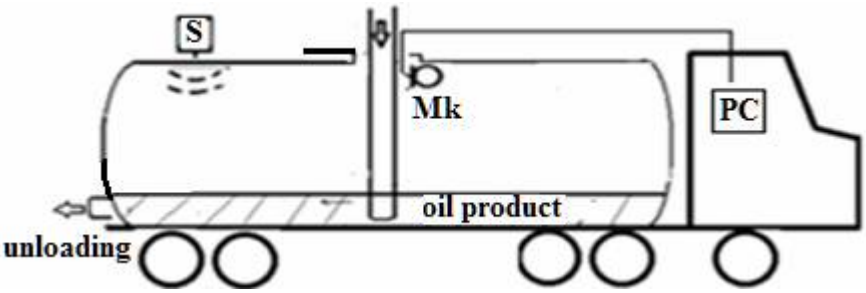

Figure 1: The measuring installation of the motor tank: Mk is the microphone, S is the knock acoustic source and PC is the computer

The eigen frequencies into cylindrical tank air space are excited by oscillation of the metallic tank border when the knock acoustic source S at regular intervals is switched on.

The complication of acoustic field measuring finds out so encompass factor for analysis as acoustic oscillation in a fluid, acoustic oscillation of air, oscillation of a cylindrical metallic border witch is installed on a foundation with damping elements of construction and having an open sight hole .

Uniquely to solve the problem in view of these factors is very hard. There is a problem to select of a physical analog to describe those regularities quantitatively. The mane purpose of the work is to describe on the relative spectrum method using data witch was obtained experimentally.

2 Measuring spectrum of levels of sound pressures

2.1 The sound source is located in the outside cylindrical container

The level of pressure Po is measured in the frequency band 63. . . 10000 Hz in the empty tank and the level of pressure Pi is measured in the frequency band 63. . . 10000 Hz in the partially filled tank (Fig.1). The attitude of pressure levels Po/Pi are disposed on the ordinate axis and the substance capacities Vm are shown on the abscissa axis (Fig.2).

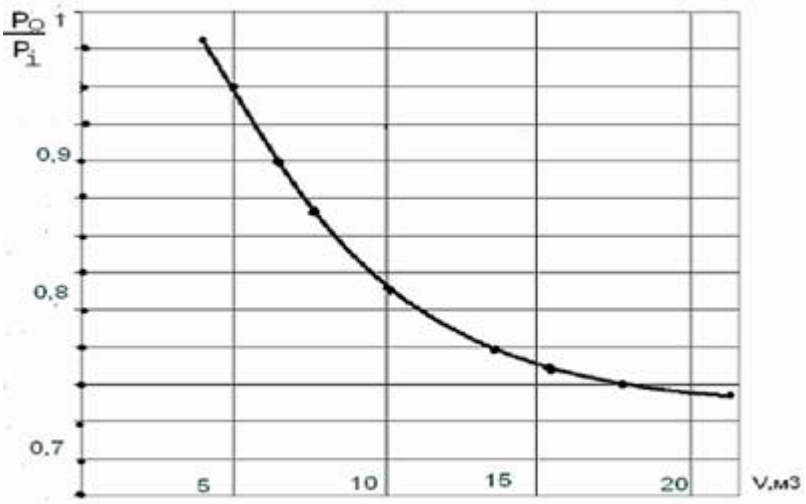

Figure 2: The diagram shows the dependence of the comparative pressure Po/Pi from the substance capacity Vm for the motor tank

2.2 The harmonic sound source is located into the cylindrical container

There is second method of acoustic measurement liquid ore solid substance capacity in the cylindrical motor transport tank when the tank is transported to the place of discharge by a car and installed stationary on surface for same time (Fig.3). It is appropriate to use the harmonic sound source and locates it into the cylindrical container. The graph of attitude pressure levels Po/Pi and capacity of black oil Vm for case which shown on Fig.3 is similar to Fig.2. Thus there are some channels of scattering the sound energy: the damping properties of the black oil surface, the exit of the energy through the open tank hole, the energy of scattering through the metallic border.

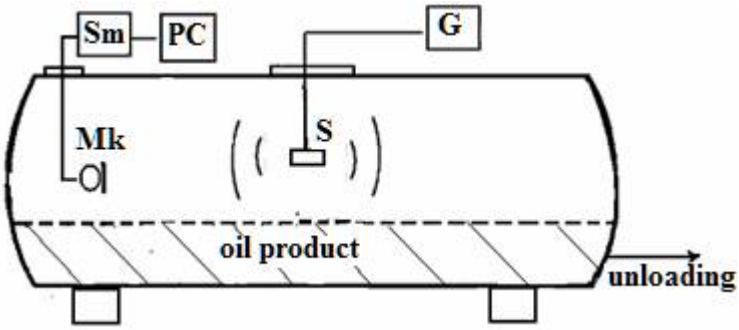

Figure 3: The measuring installation of the cylindrical container: Sm is the sound level meter, Mk is the microphone, S is the loud-speaker, G is the harmonic oscillator and PC is the computer

2.3 Approximate model of the harmonic sound source

The solution of the problem with a point source located in the point (r, ϕ, z) can be obtained in case of boundary conditions

$$U_n|_G = \left.\frac{\partial P}{\partial n}\right|_G \cdot \frac{1}{\rho\omega^2} = 0 \tag{1}$$

If the located point source is switched on at time t=0 than the solution of the time-dependent problem has view:

$$\left(\Delta - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)\tilde{P}(r,\varphi,z,t) = F_0\delta(\bar{X}_c - \bar{X}_{ict})f(t) \quad , \tag{2}$$

where $\bar{X}_i, \bar{X}_c$are coordinates of the source signal and microphone, Δ is Laplas' operator, Fo is a coefficient, f(t) is the source function, c is sound speed.

The equation (2) can be solved by Laplas' method and the acoustic pressure into the cylindrical container is represented in the form

$$P_{\bar{m}}(t) = \frac{F_0\delta(\bar{X}_c - \bar{X}_{ist.})}{2\pi_j}\int\limits_{A-j\infty}^{A+j\infty}\frac{e^{pt}\hat{F}(p)dp}{p^2+\omega_{\bar{n}}^2} \tag{3}$$

where ω are eigen frequencies, δ is Dirac' function.

3 Conclusions

The constructed analytical solution of the problem is correct for the whole interval of frequencies. But the most interesting experimental results in the area of medium frequencies acoustical waves were fixed.

References

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Vitaly Kolykhalin, St. Petersburg State University of Cinematography and Television, St. Petersburg, Russia