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Unsteady Effect of Successive Shock Pulses on a Floating Sheet

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ABSTRACT

This paper deals with the linear two-dimensional task concerning the effect of the impulsive loads on a viscoelastic ice plate on the water surface. The three-dimensional experimental investigation of unsteady behavior of polymer plate due to successive and simultaneous shots is presented also. Analysis is made of the following factors: the variable depth of the basin, the time interval and the sequence of impulses activation on the amplitude of the plate deflection. There was derived that the maximum plate deflections occur at a sequential-applied in pairs regime of impulses(from the ends to the center, the central impulse is the last). Good agreement of theoretical and experimental results is obtained.

KEY WORDS: Viscoelastic ice plate, instantaneous impulsive load, flexural-gravity wave, plate thickness, depth of a basin.

INTRODUCTION

Ice blasting is known to be one of the ways of ice cover destruction. A number of charging devices are very often used to do it, they being located at a certain distance from one another and actuated either simultaneously or successively.

The effect of a singular shock impulse on an ice sheet has been investigated well enough by Kerr (1976), Fox (1993), and their other works. An extensive bibliography on ice cover destruction is presented by Squire *et al* (1996).

The problem of the effect of a shock pulse load (modeled by the delta function of time and of coordinates, as well) on the ice cover deflection (modeled by infinite elastic plate) was first considered by Kheisin (1967). In the works by Kozin and Pogorelova (2004) and Kozin and Pogorelova (2006) the problem was further developed for viscoelastic plate in axial-symmetric and two-dimensional tasks. The paper by Kozin and Zhyostkaya (2008) is devoted to a numeric solution of the problem on the effect of a shock pulse on the ice plate. The asymptotic investigations by Lu and Dai (2006) are dedicated to detecting the ice-covered and free-surface waves at a distance from the impulse point load or from the initial ice-plate deflection. The work by Lu and Dai (2008) continues these investigations for the dynamic responses of ice-cover fluid to a submerged point mass source.

The elastic deflection of a floating plate under the effect of some steady equally removed loads was discussed by Kerr (1959). However, there still remains unsolved the problem of viscoelastic deflection of the plate under several simultaneous or successive impulse loads located at a certain distance from one another. The solution of the problem (theoretical as well as experimental ones) would let find more effective techniques of ice cover destruction by blasting.

It is rather laborious to study on location the ice cover behavior under the effect of dynamic loads. Additional difficulties in obtaining reliable results are caused by the time unsteadiness, the dependence of physical and chemical features of the ice on the temperature gradient, the effect of such factors as the snow, the current, and etc. Modeling investigations are known (Kozin, 1993) to diminish the laborious effects in experimental studies and to receive trustworthy results.

To consider the ice cover deflection under the effect of several shock pulses in this work the ice has been simulated by a polymer plate.

Thus the aim of the article is experimental (on the polymer model of ice plate) and theoretical investigations of the viscoelastic plate deflection under several shock pulses.

MATHEMATICAL STATEMENT

The solving of the problem on the effect of successive shock pulses on the viscoelastic plate deflection is based on the earlier results obtained by Kozin, Pogorelova (2006).

The problem considered is two-dimensional. Let a thin viscoelastic ice plate float on an ideal elastic fluid. At first the plate is at rest, in a state of equilibrium and is then at the time moments $t_1, t_2,..t_n$ actuated by shock impulses $Y_1, Y_2,..Y_n$. The coordinates are positioned as follows: the coordinate basic origin is combined with the impulse application point Y_1, the axis Ox coincides with the unperturbed line water interface, and the axis Oz directs vertically upward. It is assumed the fluid motion is potential and the fluid density equals to r_2.

According to Kheisin (1967) and Freudenthal, Heiringer (1962), the Kelvin-Voigt law of deformation of a delayed-elastic linear medium is used for ice.

By analogy with Kerr (1959) it is supposed that to describe the ice plate deflection we can use the technique of the superposition of its wave disturbance by shock pulses $Y_1, Y_2,..Y_n$, applied to points $x_1, x_2,.. x_n$.

The differential equation of small vibrations of the floating plate will be as follows: