The Floating Continuous Ice Cover Flexural Oscillations When a Load Is Moving Along a Complicated Trajectory

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ABSTRACT

A problem is considered of generation of unsteady three-dimensional flexural oscillations of the continuous elastic ice cover when a concentrated load is moving on its surface along a circle whose center is immovable or propagating straight forward with constant speed. It is determined that the ice cover oscillations are formed by the effect of flexural, flexural-gravity waves of the ship type, and waves of spiral-like shape. An investigation is carried out of the dependence of the amplitude-phase parameters of the induced oscillations on the ice flexural rigidity, angular velocity of the load and its trajectory center movement speed.

INTRODUCTION

The mastering of the polar regions of the world ocean amplified the necessity for investigations in the domain of ice cover dynamics. In particular, the problem of the response of the floating ice on moving loads became acute. The series of studies has been devoted to solving such a problem. In this connection, the moving perturbation's generator was assumed to be a planar front, as well as a bounded pressure area of constant or variable intensity.

Wilson (1958), Kheisin (1967), Bates and Shapiro (1981), Schulkes and Sneyd (1988) considered the generation of the flexural-gravity waves when a planar front of pressure of constant intensity is moving on the ice covering surface of inviscid incompressible fluid. Investigations in the case of the pressure of variable intensity were accomplished by Bukatov (1980), Squire (1986) and Duffy (1991).

Kheisin (1967) and Nevel (1970) studied the ice deflection under an axially symmetric load. In particular, they considered the deflection structure change caused by transfer over the critical speed value being equal to the minimum of the phase velocity of the free flexural-gravity waves.

Dotsenko (1978), Davis, Hosking and Sneyd (1985), and Schulkes, Hosking and Sneyd (1987) carried out an asymptotic analysis of the three-dimensional (3-D) waves of small amplitude induced by a moving pressure area of constant intensity. It was shown that the wave track is formed by waves caused by the ice flexural rigidity, and waves analogous to those in the classic theory of ship waves (Sretenskii, 1936; Cherkessov, 1970; Lighthill, 1978).

An asymptotic analysis of the unsteady 3-D waves caused by a time-oscillating load moving on the ice field was carried out by Bukatov and Yaroshenko (1986).

The flexural oscillations of the ice in the near vicinity of the moving load were considered by Bukatov and Zharkov (1997a) in the case of axially-symmetric distribution of the load. The ice response to the movement of a rectangular load was considered by Milinazzo, Shinbrot and Evans (1995).

The results of experimental studies of the ice bend (Kobeko, Ivanov and Shulman, 1946; Eyre, 1977; Beltaos, 1979; Haspel et al., 1981; Squire et al., 1985, 1987; Takizawa, 1985, 1988; and Wadhams, 1986) are in agreement with theoretically predicted results on the whole. An extended analysis of the results of the study of the ice flexural oscillations caused by moving loads was given by Squire, Hosking, Kerr and Langhorne (1996).

All the mentioned works concern the investigation of the ice response to the rectilinear movement of the load. One of the possible tools for generating the ice flexural oscillations is a flying aircraft. Davis, Hosking and Sneyd (1985) noted the possibility of predicting the response of a strainmeter to the load on the ice during the approach of a landing aircraft. In this connection, the load becomes more concentrated as the aircraft descends. Moreover, in the experiment of Squire et al. (1987), the aircraft was the only possibility of studying the wave pattern from high velocity loads.

However, it is interesting to consider also the loads moving curvilinearly. In particular, it may be an aircraft turning before
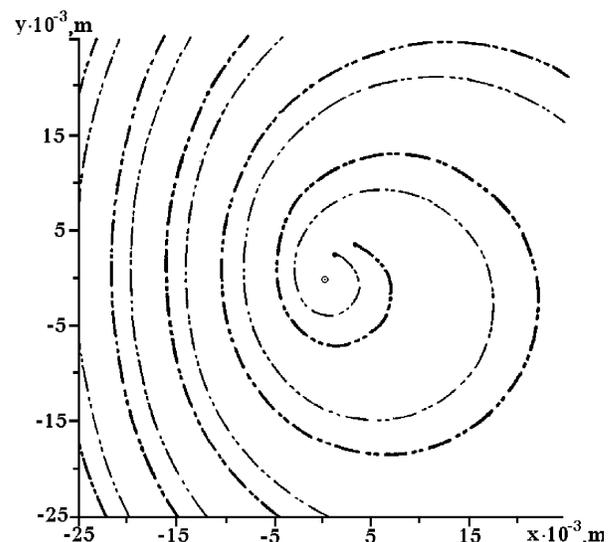

Fig. 1 Phase pattern of spiral-like waves ($i^* = 1$): Parameter values; $H = 10^3 m$, $h = 2m$, $v = 40 m \cdot s^{-1}$, $\omega = 5 \cdot 10^{-2} s^{-1}$, $r = 3 \cdot 10^2 m$