GEOMETRICAL MODELLING OF PROFILES OF THE SEA WAVES BASED ON THE TROCHOIDAL MODEL

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***Summary.* The scheme of the mechanical propeller of the transformed energy of waves of the sea on the basis of orthogonal system with a mobile point of subweight is provided.**

***Keywords:* wave power, engine mechanical, power conversion waves of the sea, the phase portrait.**

Formulation of the problem. The use of wave power is one of the leading positions in a number of renewable energy sources. The generally accepted view is considered, according to which wave energy should be used in the open sea, not along the coast, where the level specified significantly reduced energy due to friction on the bottom and return water circulation.

At the heart of the operation of wave energy power stations is the impact of waves on the working bodies in the form of floats, pendulums, blades, shells, and more. Mechanical energy of motion is converted into electricity by using specially designed generators [1,2]. To justify the scheme practical use of this kind of energy need to have descriptions of the profiles waves depending on the depth. This work is a step to solving this problem.

Analysis of recent research. By transducers that monitor the profile of the surface waves is "Salter's Duck" (Figure 1), and outline the Kokkerel's raft (Figure 2). More promising are transducers that use energy fluctuations of the water column in the "wells" (Figure 3). In the clash of the waves in the open cavity partially submerged under water, fluid column in the "wells" begins to fluctuate, causing the pressure in the cavity above the water (it can be used, for example, to move turbines). The disadvantages of such transducers have a large material consumption, low efficiency But in the case of freezing sea "well" can be transported under water, which simplifies installation and disassembly increases the average capacity utilization of [4,5]

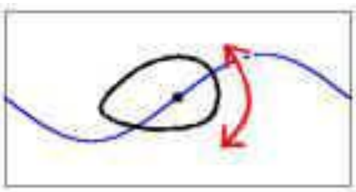

Fig.1. Salter's "Duck".

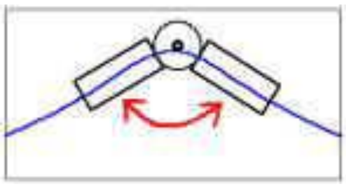

Fig.2. Kokkerel's raft.

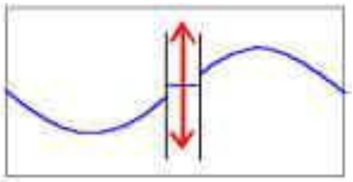

Fig.3. Fluctuation water column.

Fig. 1-3 lines of action of mechanical propulsion convert wave power indicated by the arrows. Appearance movement of water particles in the excitement of the water was first found experimentally.

Fig. 4 photo shows the powder particles wax in "rough" water made brothers Weber [1,2]. Later these observations were confirmed by theoretical studies. Revealed the following geometric properties of waves [4-5]: a subsurface layer of liquid particles move in elliptical trajectories; the trajectories of particle motion in the vertical plane carried out in one phase; waves in the water do not cause masoperenis liquid; Power is transferred by waves is proportional to the square of the amplitude and period.

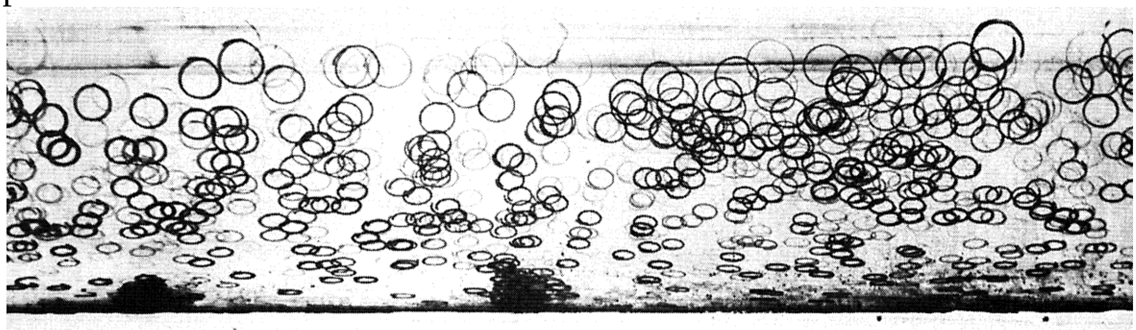

Fig. 4. Trajectories powder wax within the 'rough' water.

For important geometric studies is that of describing elliptical trajectory, and generaly trochoid describe. Therefore, the current study will be transformed into mechanical propulsion energy waves, which are based on models trochoidal waves.

Formulation of Article purposes. Develop software simulations profiles of the waves in the water and on the surface, based on the model trochoidal formation of waves. Inquire the possible scheme of mechanical engine converted wave power based on wave models trochoidal.

Main part. According to the theory Gerstner [4,5] consider the shape of the surface waves when the excitement extends to the right (Fig. 5). It is evident that the elevation of water particles move towards wave propagation, and immersion - in the opposite direction. Marking through l wavelength, t — a rotation particles equal time during which unrest spreads to a distance l, finally, through v - speed of wave propagation, i.e. the distance at which the waves move in one second, we obtain equality $l = vt$.

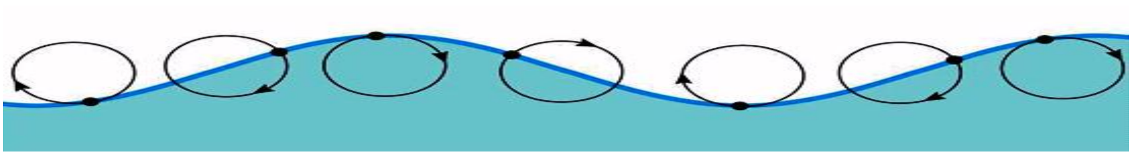

Fig. 5. The shape wave
according trohoidal model Gerstner.

Note that the description of wave-like movement at great depths the bottom gives the exact solution of partial equations of hydrodynamics in the form of Lagrange [5]. The reason for the similarity of these solutions is the sine wave and proximity profiles trohoid. The coordinates of any point of the liquid at the time *t* This movement reflected in features such time and coordinates *a* and *b* in relation to the same point in time *t* = 0.

$$x = a + r\sin\theta \quad \text{i} \quad y = b + r\cos\theta\,, \tag{1}$$

where $r = Re - nb$, $\theta = 2\pi/\lambda\ (a - ct)$, $n = 2\pi/\lambda$, $c = \sqrt{\frac{g\lambda}{2\pi}}$ and R not more $1/n$.

The equation of the free surface intersection curve vertical plane:

$$x - ct = R\sin\theta + \theta/n; \quad y = R\cos\theta. \tag{2}$$

Equation (2) described trohoid which formed a point at a distance *R* from the center of a circle of radius 1/*n*, which rolls without sliding on a straight line parallel to the axis *X* and it is above the length 1/*n* (fig. 5). This movement of fluid in every place there vortex rotation, rotational speed which have the greatest value on the free surface and decreases rapidly with depth. Note that trohoidal Gerstner wave theory is valid only for regular two-dimensional waves are observed in the case of free wind waves - that ripple. In the case of three-dimensional wind waves orbital paths of particles will not be closed circular orbits.

To implement algorithmic models trohoidal waves in a flat vertical section of the water believe that the large and small axis of the ellipse decrease in depth exponentially. Then the coordinates of an ellipse will calculate the formulas:

$$x = x_0 - Ae^{ky_0}\cos(kx_0 - wt); \tag{3}$$

$$y = y_0 - Be^{ky_0}\sin(kx_0 - wt)\,,$$

where (x_0, y_0) – certain circle center coordinates, *A* i *B* – wave amplitude along the horizontal and vertical, *w* – circular frequency, *k* - factor weakening wave.

The following mechanical propulsion scheme designed for converting sea wave energy systems using circular floating-point suspension. Structurally mechanical engine consists of float and submerged cargo, which looks like a disk to reduce water resistance (Fig. 6).

It is assumed that the suspension pendulum attached to the float, because it moves in an elliptical trajectory, and the weight of the cargo does not cause dive float. Moreover, thanks to the constructive design of pendulum oscillation plane is in the plane perpendicular to the direction of waves.

The equation of the trajectory of the pendulum suspension mounting points to ask general parametric form x = X(t); y = Y(t). As parameter fluctuations choose the angle θ(t) thrust deviation (up one standard unit) load (weight of one standard unit) relative to the vertical. The differential equation of oscillations of a pendulum floating-point suspension according to [6] will choose as:

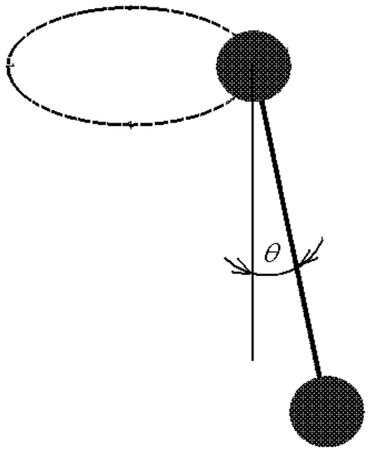

Fig. 6. Driving float rushiya.

$$\left(\frac{d^2}{dt^2}\theta(t)\right)+\left(\frac{d^2}{dt^2}X(t)\right)\left(\cos\theta(t)\right)+\left(\left(\frac{d^2}{dt^2}Y(t)\right)+9{,}81\right)\left(\sin\theta(t)\right)=0. \quad (4)$$

It was composed of solving equation (4) based on these initial conditions: Θ(0) = 0,5; Θ′(0) = -0.5. Fig. 7 shows the phase portrait of fluctuations in the coordinate system Oθθ′. Fig. 8 shows the phase portrait of the pendulum to the initial conditions Θ(0) = 0; Θ′(0) = 0.

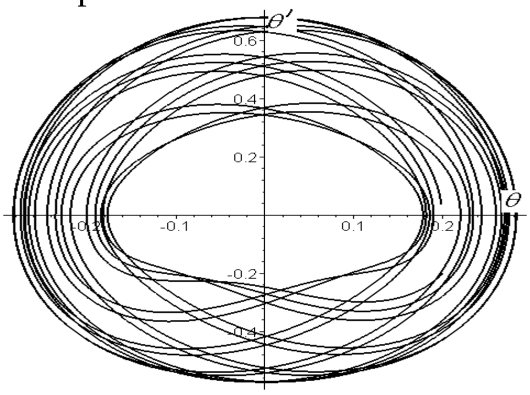

Fig. 7. Phase portrait oscillation of the pendulum to the initial conditions:
Θ(0) = 0,5; Θ′(0) = -0.5.

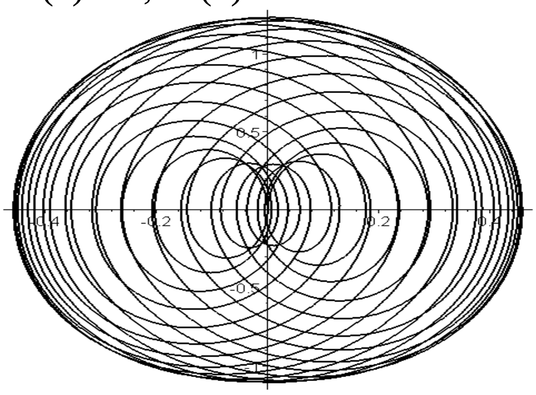

Fig. 8. Phase portrait oscillation of the pendulum to the initial conditions:
Θ(0) = 0; Θ′(0) = 0.

Fig. 9 shows the trajectory of the pendulum to load initial conditions: Θ(0) = 0,5; Θ′(0) = -0.5, and Fig. 10 - for the initial conditions: Θ(0) = 0; Θ′(0) = 0.

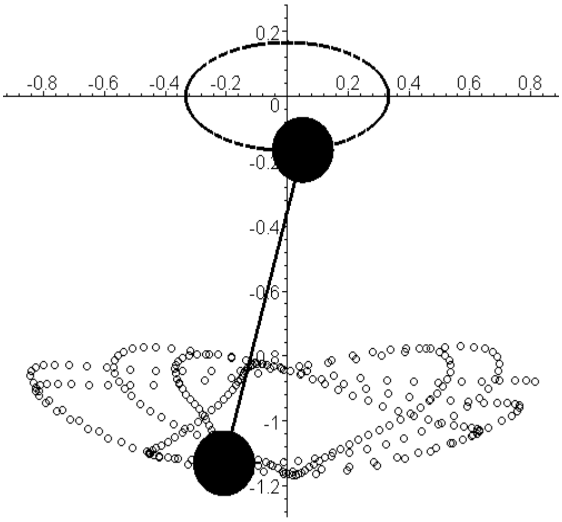

Fig. 9. The trajectory of cargo pendulum for primary conditions: Θ(0) = 0,5; Θ′(0) = -0.5.

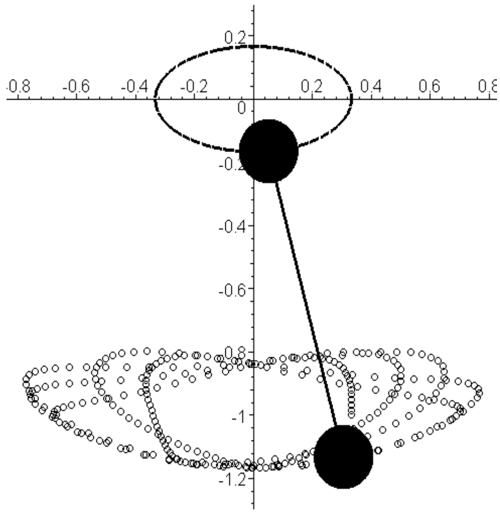

Fig. 10. Trajectory cargo pendulum for primary conditions: Θ(0) = 0; Θ′(0) = 0.

Conclusions. Simulation profiles waves from trohoidal model their formation can count pendulum-type engine converted wave power.

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