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Utilising water wave energy – technology profile

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Abstract

The use of wave energy was studied at the Maritime University of Szczecin. The two main subjects were wave-energy conversion and using wave energy to protect the seashore against the hazardous effects of extreme waves. A construction of new technologies were outlined. Future research and intended cooperation were presented.

Wave energy conversion

The growing demand for energy in developed countries and the necessity to ensure energy security for those countries make the search for new, effective methods to produce energy from renewable sources real. One of these sources is seas and oceans. Among currently-developed generation technologies for deriving energy from seas and oceans, we should distinguish systems that produce energy from (Chybowski & Kuźniewski, 2015a):

- rippling water;
- sea currents;
- sea tides;
- salinity gradient;
- temperature gradient.

Energy converters can be classified into three basic groups (Wallace, 2014), depending on their method of functioning:

- point absorbers, characterised by small size relative to the incident wavelength;
- attenuators, in which the production axis of the device is perpendicular to the wave front and energy is intercepted by device components moving due to the passing wave;
- terminators, in which the principal axis of the device is parallel to the wave front and energy is acquired by interception of a wave.

Nowadays, there are constructions utilising energy-conversion systems based on the following systems:

- power hydraulics;
- pneumatics;
- electromagnetics;
- complex mechanical gears.

Wave-energy conversion is very complicated and has difficulties caused by a complex wave-propagation process and a continuous, cyclical change in wave direction in every vertical cross-section parallel to the direction of wave propagation (Chybowski & Kuźniewski 2015a).

The study results are two simple constructions of wave energy converters, which have a patent granted (Kuźniewski, 2013) and patent pending (Chybowski & Kuźniewski, 2015b). The subject matter of the invention is the method of transforming wave energy into electricity (Figure 1).

It requires installation of a generating set, composed of a generator and an engine with a gear box at a distance from the shore, beneath the surface of sea rippled by waves, on a platform moored to the sea floor (Chybowski & Kuźniewski, 2015a). Energy for the generator propulsion is acquired directly from the oscillating water by means of a driving unit installed on the engine shaft (Figure 2).

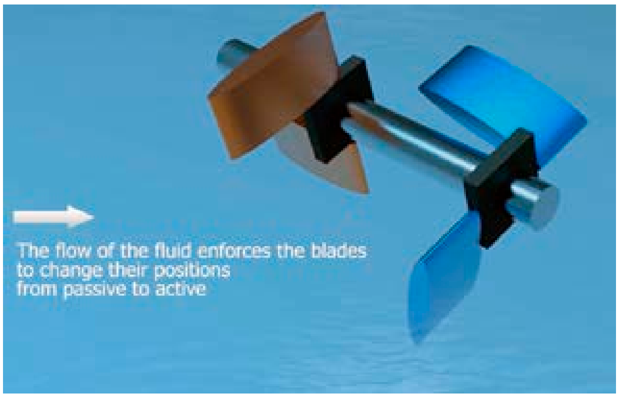

Figure 1. Principle of energy-converter work (MUS, 2015)

The construction of the device vertically with the drive shaft line is presented in Figure 3. Working in this layout required a change in the construction of the blades, changing the kinematics of a blade by the use of elements (6) and changing the geometry of the drive transmission system. The device consists of the motor (1) that drives the power receiver (7), namely the direct drive electric generator through the clutch (8) or through the mechanical gear.

The motor is comprised of a drive shaft (4) on which are two pairs of blades (2 and 2'). The purpose of the blades (2, 2') is to intercept the thrust of the passing fluid and transfer it to the drive shaft (4), which transmits the energy to the receiver. Blades (2, 2'), which work in pairs, ensure a constant direction of shaft rotation regardless of the current direction, sense, and magnitude of the driving fluid thrust, all of which vary in time. Blades (2, 2') are connected to the drive shaft (4) via bearings (3). The passing fluid pushes against one of the blades (2), which is in the active state, and at the same time the other cooperating blades (2") switch to the passive position. The thrust is transmitted from the blades (2) to the drive shaft, which rotates and drives the power receiver.

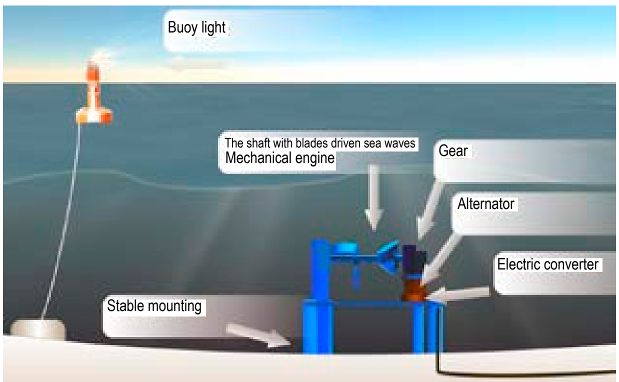

Figure 2. Main components of the underwater wave-energy converting system (MUS, 2015)

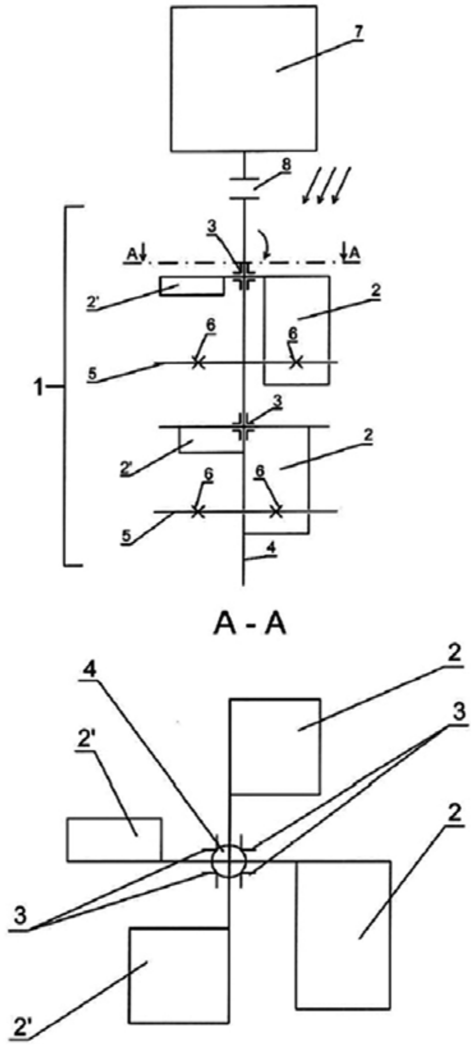

Figure 3. Energy converter construction (Chybowski & Kuźniewski, 2015)

Innovative aspect of the invention

The proposed solution, compared to currently-operated power stations generating electric energy from sea waves (CMTT, 2014):

- has a much simpler construction and is cheaper;
- offers a variety of installation methods (flexible system, direct or indirect propulsion, etc.);
- looks more attractive than floating systems currently in use.

Shore protection against sea waves

As a result of studies at the Maritime University of Szczecin, there is a concept of suppressing sea power with its own energy (Kuźniewski, 2007). An active technology of shore protection has been proposed that is different from passive methods used so far. This active technology uses wave damping before it reaches the shore. In other words, it is a breakwater installed and submerged in the distance between several and several-hundred meters off of the coast (Chybowski & Kuźniewski, 2015a).

The submarine breakwater consists of vertically--installed pipes closed from both sides and mutually joined by rigid clamps (Figure 4). The breakwater weight is less than the displaced water quantity, as it stays submerged and is stabilised by ropes moored to the sea floor. A modular breakwater construction is based on the principle of an equilateral triangle where the length of the triangle side determines the distance between the pipes, which varies from one to several meters (Chybowski & Kuźniewski, 2015a).

The essence of how the system works is depicted in Figure 5 where an assembly that damps the sea waves' energy is shown in both the horizontal and vertical view. Vertical elements (8) are interconnected by means of clamps (7) and rigid truss sections (9). The damping assembly, the weight of which is considerably smaller than the buoyancy force, is kept under the surface of water by means of tie rods (6) attached to anchor elements (5) resting on the seabed (4).

Figure 5 depicts the assembly damping the energy of sea waves in a horizontal view with its front located in the rippling layer of water. Also, it shows a unit for seashore protection consisting of three damping assemblies located in rows in the water at a sufficient distance from the shoreline (11), behind the wave transformation line. The vertical component (8) is a tube, closed at both ends, being a natural floater with a specific buoyancy force.

On each vertical element, in their top and bottom part, there are clamps (7) which are attached to the cut-off tops of rigid spacers (9), namely truss sections. Spacers (9) join the individual vertical elements (8) in their top and bottom part to form two rigid trusses. The essence of the method proposed in the patent application for damping the water waves is that the damping assembly is placed in the layer of rippling water. The said assembly consists of a large number of vertically spaced pipes, closed at both ends and interconnected by means of rigid brackets.

Wave-induced forces compensate owing to their interaction with breakwater components whose distance to each other is equal to half of the wave length in the direction of wave propagation. Simultaneously, with the forces' compensation, wave energy dissipates and wave height decreases. The breakwater effectiveness increases when additional components with improved damping properties are installed (Chybowski & Kuźniewski, 2015a).

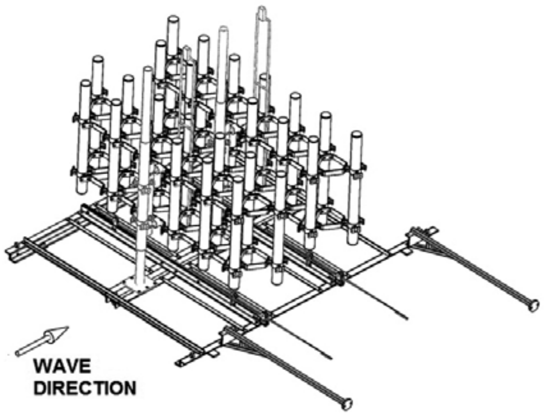

Figure 4. View of an active damper (NCRD, 2010)

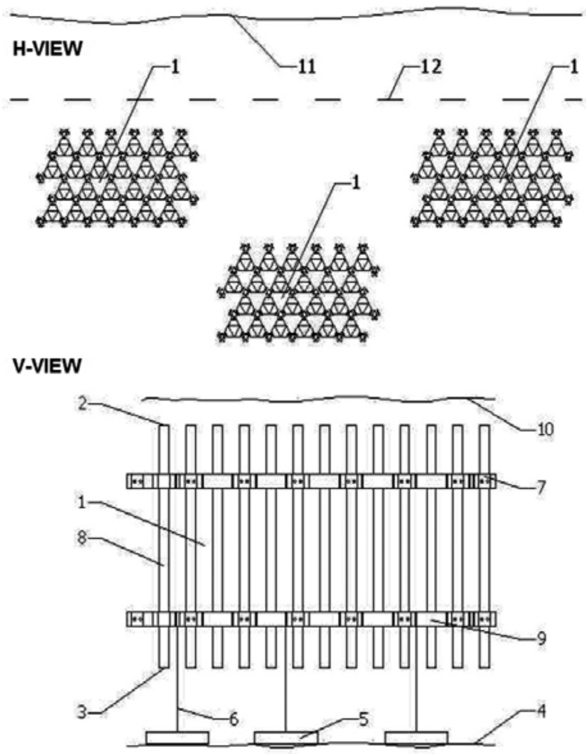

Figure 5. Active damper construction (NCRD, 2010)

The design work was supported with state-of-the-art computer simulation software. Experimental research (Figure 6), which was carried out in the model pool of the Ship Hydromechanics Division, Ship Design and Research Centre SA in Gdańsk, has confirmed that the damping device functions as stated in the theses of the developed concept.

The research findings showed that the damping of the water wave exceeded 70% and the level of compensation of the horizontal forces was high. The positive results of experimental research, after their verification and further studies in more complex sea conditions, will create the possibility of practical application of a new method of seashore protection against storm surges.

Figure 6. Testing the submarine breakwater prototype in the towing tank of the Ship Hydromechanics Division, Ship Design and Research Centre SA, Gdańsk (NCRD, 2010)

Innovative aspect of the invention

The proposed solution, compared to existing ferroconcrete breakwaters, mainly in the form of star-shaped blocks (CMTT, 2014):

- is much cheaper;
- looks more attractive (important for seaside resorts);
- is easier to install (a wide range of system parameters modifications).

The proposed active technology of the coastline protection against erosion resulting from storm waves is environmentally friendly, does not affect the nature of the coast, reduces its running costs, and its construction still promotes the attractiveness of the coastline for recreational and tourist purposes.

Intended cooperation

Presented inventions need to be fully checked in their field conditions. In addition, we would like to test in real conditions the newly-developed concept from the Maritime University of Szczecin that uses composite metal materials for construction of the elements of presented solutions (Gawdzińska, Chybowski & Przetakiewicz, 2015; Gawdzińska et al., 2016).

In the event that you are interested in getting a licence or performing research and engaging in industrial co-operation, please contact MUS Innovation Centre LLC (http://innoam.pl/).

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