WAVE ENERGY

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Contents

Summary

Renewable energy of windwaves in oceans, seas and large lakes is charged by the solar radiation and wind. The mean specific power of perturbations in the World Ocean is estimated as 2.7 W m^{-2}. However in waves that are traveling hundreds of kilometers the energy becomes concentrated. The mean specific power of waves is about 25 kW per meter of wave front for the countries of the Northern Hemisphere. The technical potential of the waves is estimated to be some 2.7 billion kW. This is about the same figure as the power of power plants of the whole world. The electric power demand of the most developed countries of Europe, Asia and America can be covered by 20% only using coastal wind waves.

Wave energy is renewable, environmentally clean. Utilization of this energy does not produce wastes and does not need land estrangement. Deployment of wave power plants decreases the expenses for coastline protection. Wave devices may combine functions of levees and dams.

Unfortunately usage of wave energy is also associated with some disadvantages that hamper it's market penetration. First, it is in most cases impossible to match the produced power with customer's demand. Second, there are problems of siting and fixing wave devices offshore, problems of transmission of energy to the customer, problems of survival in stormy conditions and others.

The first engineering design of wave converters was elaborated more than 200 years ago, whereas the first real device that converted wave energy into electricity appeared at the beginning of the 20th century.

Up to today more than 2000 technical designs for wave power extraction have been proposed. A lot of R&D on wave power utilization is carried out in UK, Japan, US, Norway and other countries. The two first wave power plants (WPP) were built in Norway.

There are many proposals on how to use the energy produced by a WPP: to feed it into an existing power grid, to supply isolated power consumers, to recharge batteries and gas-cylinders, to liquefy air, to desalinate sea water, to lift the deep ocean water to the surface, to supply offshore rigs and platforms with potable water, etc.

Development of highly efficient WPP is impossible without summarizing experience and systematization of known configurations. Many attempts have been made to classify the proposed configurations, however, up to now there is no classification of WPP that would satisfy everyone because many of the WPP are characterized by multi-stage energy conversion, a great number of components within a WPP have complex functioning.

Enumeration of advantages of wave engineering, introduction of modern economic methods that take into account environmental benefits of WPP, intensive R&D in this area aimed to upgrade technical schemes of wave energy conversion raise hopes that they will have a significant share in energy balance of coastal countries.

1. Waves Origin

Waves on the water surface are the most visible part of energy in seas, oceans, large lakes and storage ponds.

There are four types of energy sources in nature that produce perturbations in the sea: wind, that originates ripple and wind waves; seismic distortions, causing tidal or tsunami waves; solar and lunar gravity fields that become a source of larger tidal waves; and movement of objects on the sea surface.

Only wind wave utilization has been demonstrated in industrial devices. Tsunami waves are random and have very high specific energy. It makes it very difficult to utilize them. Tidal waves are converted by special technique Waves produced by objects are also random and so powerless and are therefore of no interest.

Solar power that is consumed either by the land surface or by water mass is the origin of the renewable energy of wind waves. However, in the waves the energy appears to be more concentrated. Air above warm water moves upward, squeezing colder and heavier air down. Besides there is a general air circulation in the atmosphere, whereby warm air above the equator waters goes up and moves towards polar region, where it is cooled, goes down and streams back. The shape of the landscape and the earth rotation affects air circulation. The general picture of wind circulation is presented on Figure 1.

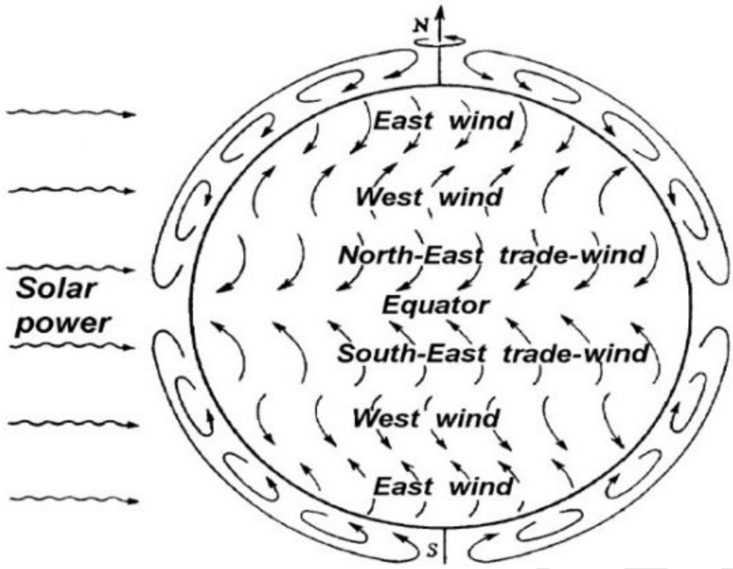

Figure 1. Prevailing winds caused by solar radiation

Despite the fact that the mean density of energy sources charged by the sun is much less than the original solar one, their energy in some cases becomes more concentrated. For example, the mean specific power of the solar radiation in latitude 15^o North is 0.17 kW m^{-2}. Average wind velocity at this latitude in the middle of the Pacific is about 10 m s^{-1}, and the specific power is 0.58 kW m^{-2}. Whereas the specific power of a middle- sized wave in this region is 8.42 kW m^{-2}.

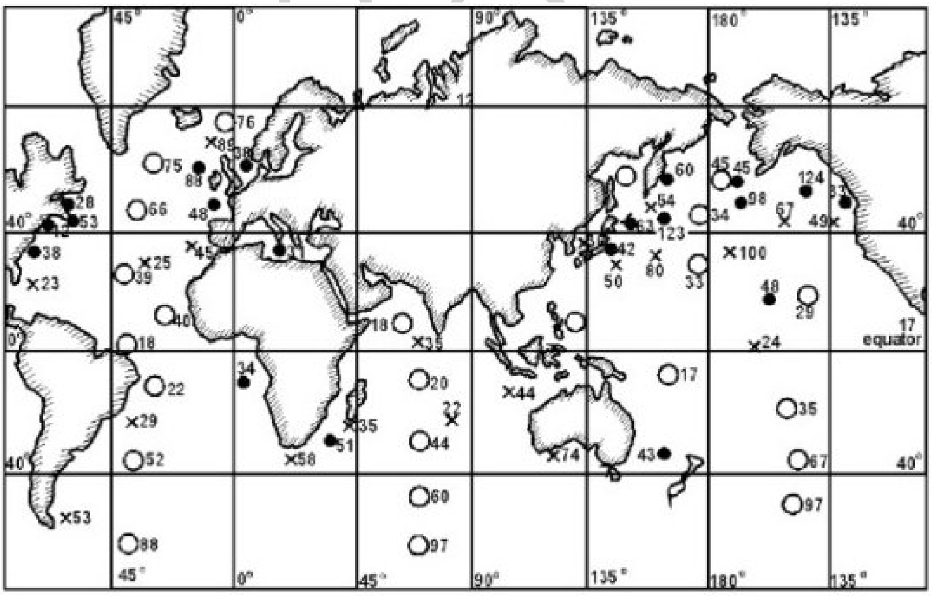

Figure 2. Wind wave specific power, kW m^{-2} according to: • - Halls; × - Tornkvist; o - Sichkarev

The mean specific power of the World ocean surface is 2.7 W m^{-2}, i.e. less than mean specific density of solar radiation by about 100 times. However traveling substantial distances of hundreds km, perturbation accumulates energy. Subsequently, when it meets wave power devices, it is already concentrated (see Figure 2). So, the energy flow of a 1 m deep water layer with a wave height of 3 m and a period of 10 s is three times higher than the solar constant (1.36 kW m^{-2}), and when the wave's height is 5 m and the period is 13 s, it exceeds the solar constant by a factor of 7. That is why the usage of derived energy from sun and wind is of high interest.

2. Energy of Wind Waves

Wind wave energy is a type of mechanical energy of ocean water masses (Figure 3). The energy is renewable, predictable, environmentally friendly and can be economically used. The electric power demand of most developed countries of Europe, Asia and America can be covered by only 20% of the available coastal wind wave power. One can mention such benefits of wave energy as absence of wastes and estrangement of land, and decrease of expenses due to coastal erosion. Improvement of environmental conditions and economy of fossil fuel in many regions can be achieved by replacing conventional power plants with wave power plants.

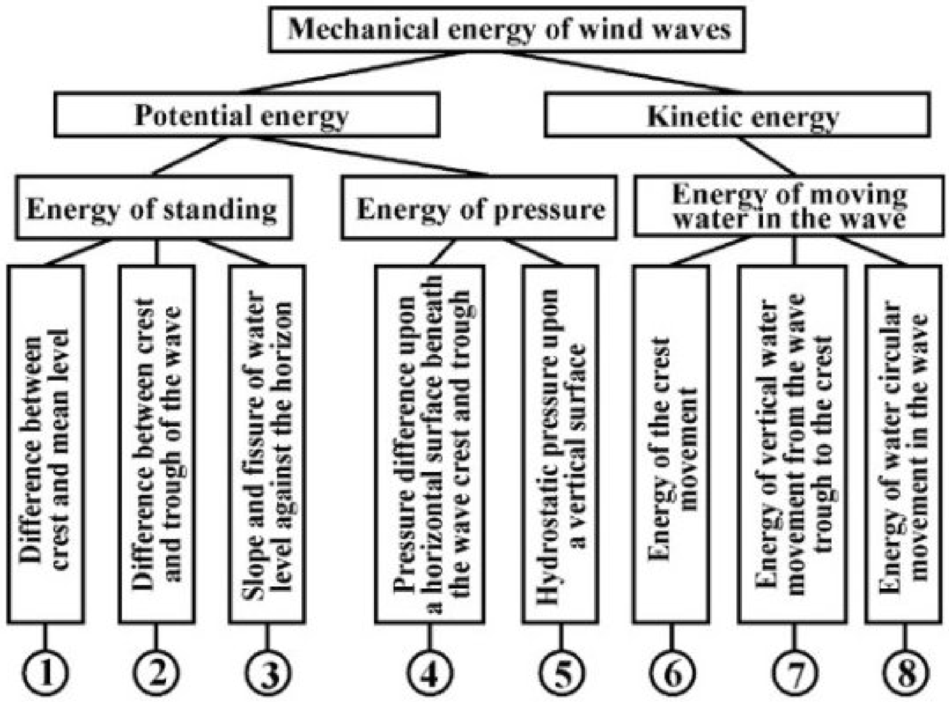

Figure 3. Main types of kinetic and potential energy of wind waves

However, being so attractive, wave energy still suffers from a number of disadvantages that withhold it's wide usage. The most significant disadvantage is that the energy is intermittent. Most of WPP’s can not fit consumer’s needs due to rapid changes in meteorological conditions. That is why it is important to minimize this disadvantage by using energy storage facilities or integrate WPP into a system with alternative power sources. A rather low density of wave energy increases the WPP dimensions, subsequently increasing the amount of materials and cost. Special methods and ways of energy extraction are necessary due to substantial fickleness of the mean wave energy.

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Biographical Sketches

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