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HYDROKINETIC TECHNOLOGIES AND APPLICATION

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Abstract: Known by all parties, the use and prevalence of renewable energy is essential because of the global warming and environmental pollution effects of fossil fuels. Hydrokinetic is a renewable energy source. Marine currents and river currents at high-altitude internal regions create significant hydrokinetic potential. Hydrokinetic energy conversion systems are in development and new application stages. Researchers and organizations are working intensively on this topic. During some systems are in the phase of research and prototype development, others are at commercialization phase. This study presents some informations to understanding the existing systems, the implementation possibilities, the application difficulties and some solution suggestions.
Keywords: renewable energy, hydrokinetic potential, hydrokinetic energy conversion systems

INTRODUCTION

Depleting fossil fuels, increasing environmental pollution due to the widespread use of fossil fuels, changing and developing consumption habits, and rising energy consumption per person require the introduction and better evaluation of new and alternative energy sources Hydrokinetic energy has a significant place among these sources. The power of the water current creates hydrokinetic energy. Renewable hydrokinetic energy can be harnessed from water currents via hydrokinetic technology [1].

Hydrokinetic technologies are similar in many aspects to wind energy conversion systems. With another explanation, we can think of them as being immersed in water of wind turbines by taking necessary precautions. Hydrokinetic sources can be divided into two groups as ocean /sea and river currents. In some cases, tidal energy and wave energy are considered hydrokinetic sources. However, they vary in terms of their structure, conversion systems, and Technologies. Since water is 832 times denser than air, hydrokinetic energy conversion systems are able to obtain the same power from much smaller rotor swept area comparing with wind energy.

Process losses are occurring in all of the conversion systems. Therefore process efficiency emerges during such conversions. All of these losses are substituted by the system performance coefficients. The performance coefficient of the hydrokinetic and wind energy conversion systems are limited to the Betz limit of 59.3%, which is the maximum theoretically possible conversion efficiency.

Special incentive schemes are being implemented in some developed countries to promote the development and deployment of hydrokinetic Technologies [2]. Interest in the progress and development of hydrokinetic energy conversion technology has grown significantly in recent years. The hydrokinetic industry has advanced by taking necessary steps beyond the testing and prototype phase and will soon install demonstration projects with arrays of full-scale devices [3].

Despite all this, hydrokinetic energy conversion systems and technologies are in the developmental stage in some aspects. In addition, there are many prototypes or new project implementation stages. It is important that these studies are gathered together and discussed. In this context, it is essential to raise awareness what is the application frame of the hydrokinetic energy, how it is applied, and the challenges and differences in applications. In this work, hydrokinetic energy, the power to be obtained from it, performance coefficient, classification of turbines, application and information about turbines have been tried to be given.

MATERIAL AND METHODS

Hydrokinetic power

Hydrokinetic turbines generate power only from the kinetic energy of moving water (current). This power is a function of the density of the water and the speed of the current cubed. The available hydrokinetic power depends on the speed of the river, ocean, or marine current [3]. Most of the principals of this type of turbine are based upon wind turbines, as they work in a similar way. During the quiet flow state, a column of wind upstream of the turbine with cross-sectional area A of the turbine disc has kinetic energy passing unit time as follows [4-6].

$$P=1/2\ \rho.A.U^3 \quad (1)$$

The power that can be obtained from the hydrokinetic turbine or wind turbine when using the performance coefficient instead of process and conversion losses is as follows [6].

$$P_T=1/2\ \rho.C_P.A.U^3 \quad (2)$$

where:

- » ρ the density of the fluid passing through the turbine (kg/m^3)
- » C_P performance coefficient of the system
- » A rotor swept diameter (m)
- » U free water flow velocity (m/s)

The system performance coefficient indicated by Cp is limited by the Betz limit as mentioned earlier and can be maximum

59.3%. However, in practical applications it seems to vary between 0.1 and 0.4, Figure 1 [7].

As water is involved in hydrokinetic conversion systems, the density may vary depending on the salt content of the water. In addition, the system performance coefficients vary depending on the flow rate (velocity). Creating power is raising in proportion the rotor diameter. The power to be obtained from the system varies with the cube of the free flow velocity.

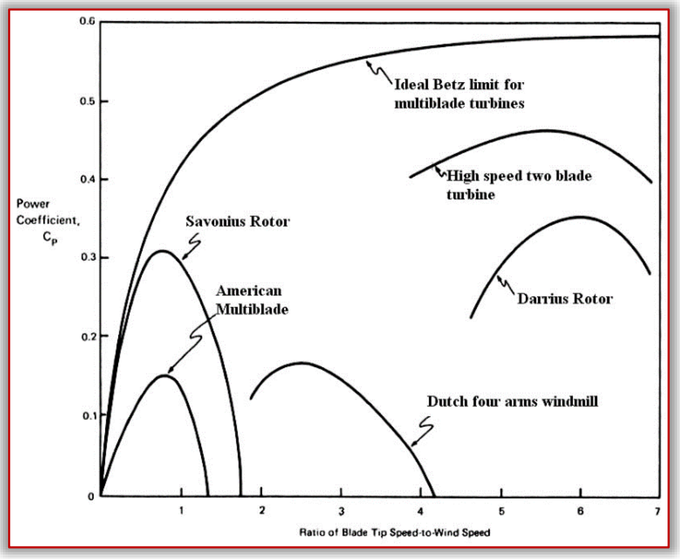

Figure 1. The power coefficient C_p as a function of the tip speed ratio for different wind machines designs. [7]

The total hydrokinetic energy resource in a region can be estimated using two alternative methodologies. The first approach involves calculating energy expenditures in rivers, and second involves tracing potential hydrokinetic energy back to its source. In the second approach, total potential hydrokinetic energy for a region equals the sum of the potential energy of the water that drains towards the outlet [8].

Hydrokinetic turbines

The classification of hydrokinetic turbines can be made basically as horizontal axis and vertical axis. The horizontal axis turbines can be separated into two groups. The rotational axis of the first one is parallel to the water stream direction. The rotational axis of the other is perpendicular to the water stream direction. Water wheels or cross-flow turbines can be classified as perpendicular horizontal axis turbines, axial flow turbine can be usually constructed as two-, three- or multi-blade. The structure can be opened or ducted [9]. Horizontal axis turbines have passed the development phase and are now starting to commercialize.

If the rotational axis of turbine rotor is perpendicular to the water surface, such turbines are named vertical; typical examples of vertical axis are Savonius, H- Type, Darrieus, Helical turbine [9]. H-Type (cross-flow), Tropostien/Darrieus and Gorlov helical turbines are encountered in practice and work extensively on various organizations and researchers. They can be reached partly by commercializing among vertical axis turbines. In addition, the combination of Darrieus and Savonius turbines in a single body has been tested.

RESULTS AND DISCUSSION

Hydrokinetic turbines can be arranged directly to the regions where the ocean or marine water correct occurs. This application can be done to sea bottom as well as close to sea level. Horizontal axis turbines are often seen in this type of marine application. In practice of this type, it is possible to take measures to increase the water flow rate by using ducted structure. Vertical axis helical turbine is used in surface applications. In this case floating platforms and mounted turbines are involved. The hydrokinetic turbines can be utilized in principle at the main turbine outlets in the hydroelectric power plants based on the water accumulation and drop because the water velocities are very high. Axial turbines seem to be more suitable here, but it is important to consider how and where the turbine base mechanism is to be mounted. Axial turbines can be directly applied in river application if there is adequate water depth available. Necessary precautions should be taken in these applications by taking into account special conditions such as river sediment structure, movements and flood cases. Moreover, hydrokinetic turbines can be conveniently and optimally used in manmade water flow channels, such as water mill channels formed at the edge of the river. In that application, measures to prevent fish and other aquatic entrances from entering the channel can also be easily taken. Turbines can be serially connected in succession into these hydrokinetic channels. Both horizontal and vertical axis turbines can be used in these channels. The system may be simpler by vertical axis turbines since components such as generators and speed increasers can be mounted on the water level. Furthermore, It is also possible to increase the water flow velocities 2 to 3 times by using smooth surface channel materials as the sediment structure decreases water flow in the river [6, 9].

CONCLUSIONS

Hydrokinetic turbines are immersed in water from wind turbines. Significant increases in hydrokinetic turbine applications should be expected over the next decade although not as much as the prevalence of wind turbines. The main bodies of the turbines will not be as noticeable as the wind turbines because they are usually underwater in the sea and ocean applications. In such applications, it should be possible to establish well the regions where there are sufficient water currents and to establish and construct the transmission lines which will be produced with electricity so as not to obstruct the sea traffic and marine life. In such applications it is necessary to determine well the regions where there are sufficient water flows. it is important to safely transport the electricity to be produced. Transmission lines should not obstruct and harm marine traffic and marine life. Wind turbines are capable of delivering 1 MW power at wind speeds of 13-14 m / s with rotor diameter of 50 meters. Hydrokinetic turbines can reach the same power values at water speeds of about 3 m / s with 11 meter rotor diameter units. Utilizing the water currents in the rivers will gain prevalence even easier via hydrokinetic channels. The hydrokinetic channels that will be formed here will offer advantages both in terms of increasing of water speed and ease of taking precautions to prevent any live habitat entry. Also, changes in water velocities in the canal will be very slight, so they will not be too complicated in frequency regulating mechanism. Consequently, It is possible to convert both the ocean and the river water current into electricity by well-designed, with scrutiny measuring systems for potential negative effects on the environment.

Note

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References

[1] http://www.ucsusa.org/clean-energy/renewable-energy/how-hydrokinetic-energy-works#bf-toc-2 09.09.2017
[2] https://www.nrel.gov/docs/fy10osti/47688.pdf 09.09.2017
[3] Laws, N. D., & Epps, B. P. (2016). Hydrokinetic energy conversion: Technology, research, and outlook. Renewable and Sustainable Energy Reviews, 57, 1245-1259
[4] Twidel J, Weir T. Renewable energy resources. Second ed. London and NY: Taylor & Francis; 2006.
[5] Manwell JF, Mcgowan JG, Rogers AL. Wind energy explained. Second ed. UK: John Wiley & Sons; 2009.
[6] Guney, M. S. (2011). Evaluation and measures to increase performance coefficient of hydrokinetic turbines. Renewable and Sustainable Energy Reviews, 15(8), 3669-3675.
[7] Ragheb, M., & Ragheb, A. M. (2011). Wind turbines theory-the betz equation and optimal rotor tip speed ratio. In Fundamental and advanced topics in wind power. InTech.
[8] Mantilla R., Markfort C., Estimating potential hydrokinetic energy and recovery fraction in Iowa waterways, Iowa Energy Center 2016.
[9] Güney, M. S., & Kaygusuz, K. (2010). Hydrokinetic energy conversion systems: A technology status review. Renewable and Sustainable Energy Reviews, 14(9), 2996-3004.

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