Rasio Diameter dan Basin Turbin Air Vorteks Skala Piko terhadap Unjuk Kerjanya = The Effect of Diameter-to-Basin Ratio on the Performance of a Pico-Scale Vortex Water Turbine

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Abstrak

Turbin air vorteks skala piko menjadi salah satu alternatif pembangkit listrik ramah lingkungan yang cocok diterapkan di wilayah terpencil. Penelitian ini mengkaji pengaruh rasio antara diameter turbin dan diameter basin terhadap kinerja sistem, terutama pada parameter torsi dan efisiensi. Tiga rasio diuji, yaitu 0.7D, 0.8D, dan 0.9D. Evaluasi dilakukan melalui pendekatan teoritis menggunakan analisis segitiga kecepatan serta simulasi numerik berbasis metode Computational Fluid Dynamics (CFD) dengan model turbulensi SST k–Ï. Hasil menunjukkan bahwa rasio 0.9D memberikan performa tertinggi, dengan efisiensi maksimum 34,98% dan torsi puncak sebesar 82,26 Nm pada kecepatan putar optimal 60–70 RPM. Rasio 0.8D menunjukkan kinerja yang seimbang dan stabil, sementara rasio 0.7D memiliki efisiensi terendah akibat jangkauan bilah yang terbatas terhadap zona aliran utama. Interaksi antara sudu dan aliran pusaran sangat dipengaruhi oleh jangkauan radial bilah terhadap distribusi fluida dalam basin. Secara keseluruhan, konfigurasi 0.9D terbukti paling optimal karena mampu memanfaatkan volume fluida yang lebih besar dan menghasilkan konversi energi yang paling efisien.

.....Vortex water turbines at pico scale present a promising renewable energy solution for electrification in remote areas. This study investigates the effect of the ratio between turbine diameter and basin diameter on system performance, focusing on torque and efficiency parameters. Three diameter ratios were evaluated: 0.7D, 0.8D, and 0.9D. The analysis was conducted using a theoretical approach based on velocity triangle analysis and numerical simulations utilizing Computational Fluid Dynamics (CFD) with the SST k–Ï turbulence model. The results show that the 0.9D configuration delivered the highest performance, with a maximum efficiency of 34.98% and peak torque of 82.26 Nm at an optimal rotational speed of 60–70 RPM. The 0.8D configuration demonstrated balanced and stable performance, while the 0.7D ratio showed the lowest efficiency due to limited blade reach within the main flow zone. The interaction between the blades and the vortex flow is significantly influenced by the radial reach of the blades relative to the fluid distribution in the basin. Overall, the 0.9D configuration proved to be the most optimal, as it captured a larger fluid volume and achieved the highest energy conversion efficiency.