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Effect of concentrator geometry on wind velocity augmentation

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South Africa is experiencing acute energy shortages leading to prolonged load shedding. Renewable energy can be a solution to this energy problem. From the renewable energy resources, wind has a great potential of increasing the energy mix and help in abatement of climate change. It is one of the fastest growing energy technologies that can substitute fossil fuels in electricity production. Most wind turbines that are available on the market need wind speeds above 5 m/s to produce meaningful electricity. Regrettably some areas don't have such high wind speeds. Several researches have been done in coming up with techniques for improving wind turbine power output in low wind speed areas. Concentrator Augmented Wind Turbines (CAWTs) have been proved to increase the effectiveness of the wind turbines in low wind speed areas by increasing the wind speed upstream of the turbine. However, the effect of concentrator geometry on the velocity augmentation capability of the concentrator is not clearly understood to enhance the designing of competitive CAWTs. This study investigated the effect of concentrator geometry on velocity augmentation. Computational fluid dynamics was used for the investigations. A model was analysed in ANSYS Fluent® software and validated by experiments. The performance of 45 concentrators was investigated in terms of concentrator efficiency and velocity augmentation ratio (*vr*). The concentrators had the same outlet radius and their geometry was varied by changing the concentrator length (*L*) and the outlet radius (*R*). It was observed that the changes vr was affected by the change in both the *L* to *2R* ratio (*Lr*) and the difference between inlet and outlet radii to *2R* ratio (*Rr*). As *Lr* was increased from *Lr* = 0.1, the *vr* increased to pick at *Lr* = 0.4 and then decreased with farther increase in *Lr*. Also, as *Rr* was increased from 0.025, the *vr* increased to peak at *Rr* = 0.1 and then decreased as *Rr* was increased. It was also shown that the energy losses due to friction have more negative impact on velocity augmentation than energy losses due to large concentrator tilt angle at high *Lr* because friction on the walls occurred over a large range. From a distance L before the inlet, the wind accelerated constantly to a maximum speed at the concentrator outlet. It continued with this speed up to *0.5L* distance behind the concentrator and started to decelerate. The velocity was maximum from the concentrator centre to 80% of the outlet radius. It decreased to 0 m/s on the concentrator wall. At any distance greater than *0.1r*, the wind velocity was higher than the concentrator inlet velocity. For optimum Lr and Rr, maximum velocity was achieved at the concentrator outlet. It was concluded that when constructing a CAWT, the turbine rotor should be placed at any distance between the concentrator outlet and *0.5L* behind the concentrator and the blade tips of the turbine in a CAWT system should be at least 10% smaller than the concentrator outlet radius, for the rotor to receive wind with augmented velocity.

Apply to be considered for a student ; award (Yes / No)?

No

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N/A

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