شبكة المعلومات الجامعية
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NUMERICAL INVESTIGATION OF HORIZONTAL AXIS WIND TURBINE PERFORMANCE USING PLASMA-BASED FLOW CONTROL

By

Mostafa Kamal Abdelkareem Abdelmohsen

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Aerospace Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Title of Thesis:

NUMERICAL INVESTIGATION OF HORIZONTAL AXIS WIND TURBINE PERFORMANCE USING PLASMA-BASED FLOW CONTROL

KeyWords:
CFD; Wind Turbine; Airfoil; Dimensionless wall distance; Plasma actuator

Summary:

Wind turbine performance is quite important in the field of renewable energy. Hence, optimizing the performance of the wind turbine blade in the off-design points is quintessential to capture more energy. Our main objective is to computationally maximize the power of the base-line wind turbine at off-deign points using plasma actuator which has been demonstrated to be effective in several applications including flow separation and boundary-layer control.

Eventually, after obtaining the new characteristics with actuation, the blade element momentum theory was used to evaluate the performance of the NREL wind turbine blade at different tip-speed ratios.

Overall, the power was quantitatively increased by an overall percentage 32.7 % comparing to the base-line case at the off-design points which is quite good for energy recapture.

Disclaimer

I hereby declare that this thesis is my own original work and that no part of it has been submitted for a degree qualification at any other university or institute.
I further declare that I have appropriately acknowledged all sources used and have cited them in the references section.

Name: Mostafa Kamal Abdelkareem Abdelmohsen Date: / / 2021

Signature:

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Nomenclature

A	Area
a	Axial induction factor
a'	Angular induction factor
c	Chord
c_l	Nondimensional lift coefficient
c_d	Nondimensional drag coefficient
c_p	Power coefficient
$\vec{E}$	Electric field
$\overrightarrow{f_b}$	Body force vector per volume
$\vec{F}$	Body force vector
H	Blade height
L_e	Length of the electrode
p	Absolute pressure
r	Local radius
R	Total radius
Re	Reynolds number based on inlet velocity and axial chord
U	Absolute velocity
U_r	Relative velocity
U_{inf}	Wind speed
y^+	Non dimensional wall distance

Greek Symbols

α	Angle of attack measured from the chord line
ε	Permittivity
ε_o	Permittivity of free space
ε_r	Relative permittivity
θ_t	Twist angle
θ_{p_0}	Reference pitch angle
κ	Turbulence kinetic energy
λ	Tip speed ratio
λ_d	Debye length
μ	Dynamic viscosity of fluid
μ_t	Eddy viscosity or turbulent viscosity
ν	Kinematic Viscosity of fluid
ν_t	Kinematic eddy viscosity
ρ	flow density
ρ_c	Net recharge density
Φ	Total electric potential
φ	Electric potential due to the net charge density
ϕ	Electric potential due to the external electric field
ω	Turbulence specific dissipation rate