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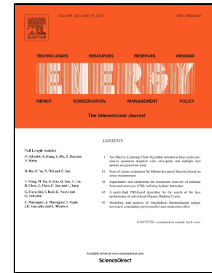
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Qing'an Li, Takao Maeda, Yasunari Kamada, Naoya Mori

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# Investigation of Wake Effects on a Horizontal Axis Wind Turbine in Field Experiments (Part I: Horizontal Axis Direction)

Qing'an Li\*<sup>1</sup>, Takao Maeda<sup>1</sup>, Yasunari Kamada<sup>1</sup> and Naoya Mori<sup>1</sup>

1. Division of Mechanical Engineering, Mie University, 1577 Kurimamachiya-cho, Tsu, Mie 514-8507, JAPAN

## ABSTRACT

In order to investigate the effects of turbulence intensity and wind shear on the wind turbine wake characteristics, this paper presented the wind velocity distribution of Horizontal Axis Wind Turbine (HAWT) in the horizontal axis direction by field experiments. The test wind turbine had a generator capacity of 30 kW, a rotor diameter of 10.0 m and a hub height of 13.4 m. The reference wind velocity was measured with an ultrasonic anemometer. In the upstream wind measurement mast, the three-cup type anemometers and arrowhead type wind vane were installed. An ultrasonic current meter (SAT-550) which was mounted on the after-stream measuring device equipped which was used for the measurement of the wake at multiple points. Furthermore, the experimental condition of the wake measurement was set at the different inflow velocities and the tip speed ratios. As a result, the maximum velocity deficit in the wake was reduced with the increase of the turbulence intensity. Moreover, as the increase of the wind shear index, the maximum velocity deficit in the wake was increased. The maximum deficit amount of the non-dimensional wind velocity ratio  $U_{NR}$  in the wake increased with the increase of the tip speed ratio.

*Keywords:* Horizontal Axis Wind Turbine (HAWT), wake, turbulence intensity, wind shear, field experiment.

## NOMENCLATURE

$a$	inflow horizontal gradient
$C_p$	power coefficient
$n$	wind shear index
$Q$	wind turbine torque [Nm]
$R$	rotor radius of wind turbine [m]
$TI_{ref}$	turbulent intensity in the horizontal plane
$TI_{ref_U}$	turbulent intensity in the mainstream direction ( $x$ -axis)
$TI_{ref_V}$	turbulent intensity in the lateral direction ( $y$ -axis)
$TI_{ref_W}$	turbulent intensity in the vertical direction ( $z$ -axis)
$U_{hub}$	wind velocity of the hub height in the mainstream flow direction [m/s]
$U_N$	non-dimensional wind velocity
$U_{NR}$	non-dimensional wind velocity ratio
$U_{N_O}$	non-dimensional wind velocity during rotation
$U_{N_P}$	non-dimensional wind velocity when the wind turbine was standstill
$U_{ref}$	reference wind velocity [m/s]
$U_{wave}$	wind velocity in the wind turbine wake [m/s]
$U_z$	wind velocity at the height of $z$ [m/s]
$W$	resultant velocity to blade [m/s]

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