Improving the Efficiency of Small Wind Turbines by Optimizing Blade Number and Solidity

Jessica Swanson[1], and Dr. Kenneth Visser[2]
Department of Mechanical and Aeronautical Engineering

Experiments were conducted to investigate the effect of blade number and solidity on small horizontal axis wind turbines. Previous numerical results [1] have indicated increasing the blade number and/or solidity above conventional design practice improves the aerodynamic efficiency. All tests were performed at Clarkson University's subsonic wind tunnel. A series of blades were developed using an SG6043 airfoil, optimized for a Reynolds Number of 100,000. The blades were made from a plastic resin material using a process known as stereolithography. A test matrix was designed to allow comparison of blade number at a constant solidity. For example, a solidity of 10% was chosen and blade number was varied from 3 to 6 to 12. Blade number was also held constant and solidity was varied from 5% to 10% to 15% as shown in Table 1.

Table 1. Test Matrix

	5% Solidity	10% Solidity	15% Solidity
3 Blades	X	X	X
6 Blades		X	
12 Blades		X	

The blades were mounted on a Rutland 500 Windcharger generator after removing the original blade set. Figure 1 illustrates two configurations mounted in the wind tunnel.

(a) **(b)**

Figure 1. Wind Tunnel Turbine Geometries

[1] Class of 2004, Department of Civil and Environmental Engineering, University of Tennessee at Knoxville
[2] Project Mentor, Department of Mechanical and Aeronautical Engineering, Clarkson University

The different blade sets were tested at various wind speeds and run through a range of electrical resistive loads to locate the maximum power coefficient, Cp, where

$$Cp = \text{Aerodynamic Power}/(.5 * \text{Air Density} * (\text{Velocity})^3 * \text{Swept Area}). \quad \textbf{(1)}$$

Initial data indicates that increasing the solidity increases the power coefficient. Figure 2 presents an increase in maximum Cp from the 10% solidity case to the 15% solidity case.

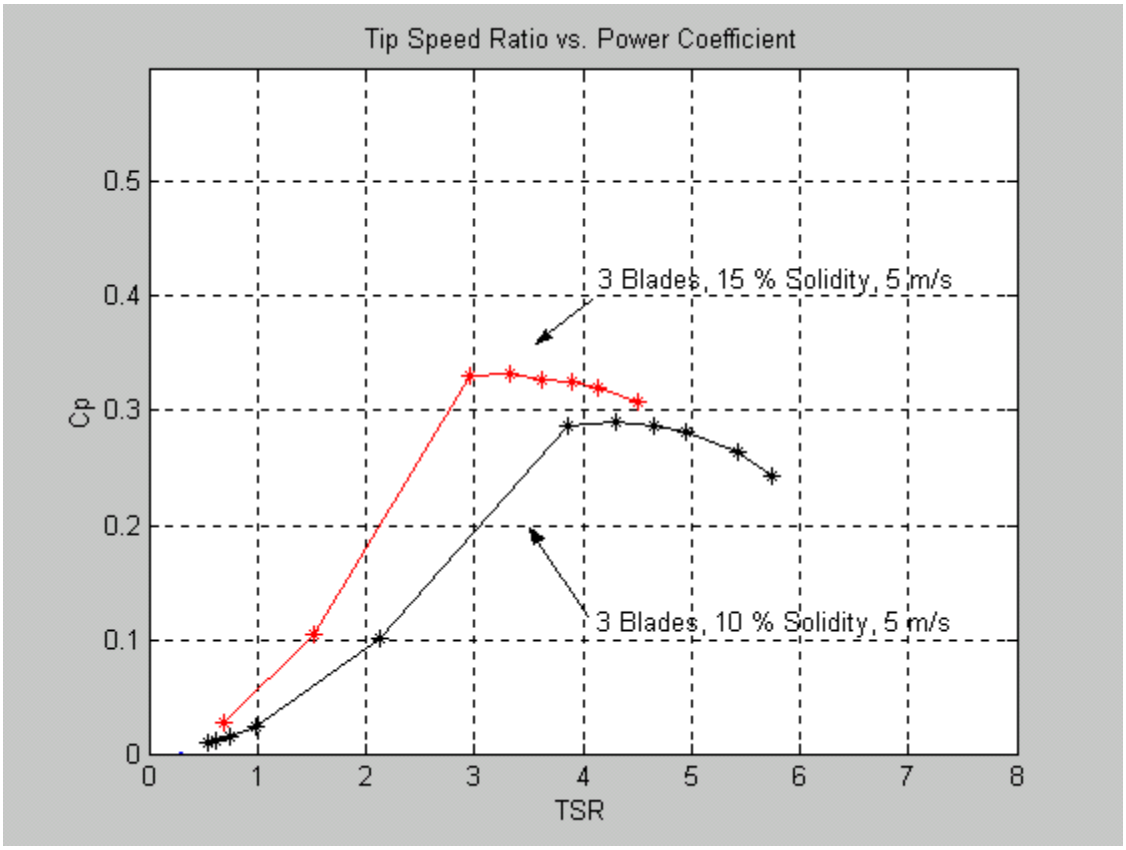

Figure 2. Effect of Solidity on Aerodynamic Performance

Experiments also indicated a decrease in efficiency when blade number was increased at a constant solidity of 10%. Figure 3 illustrates the effect of blade number at a constant solidity.

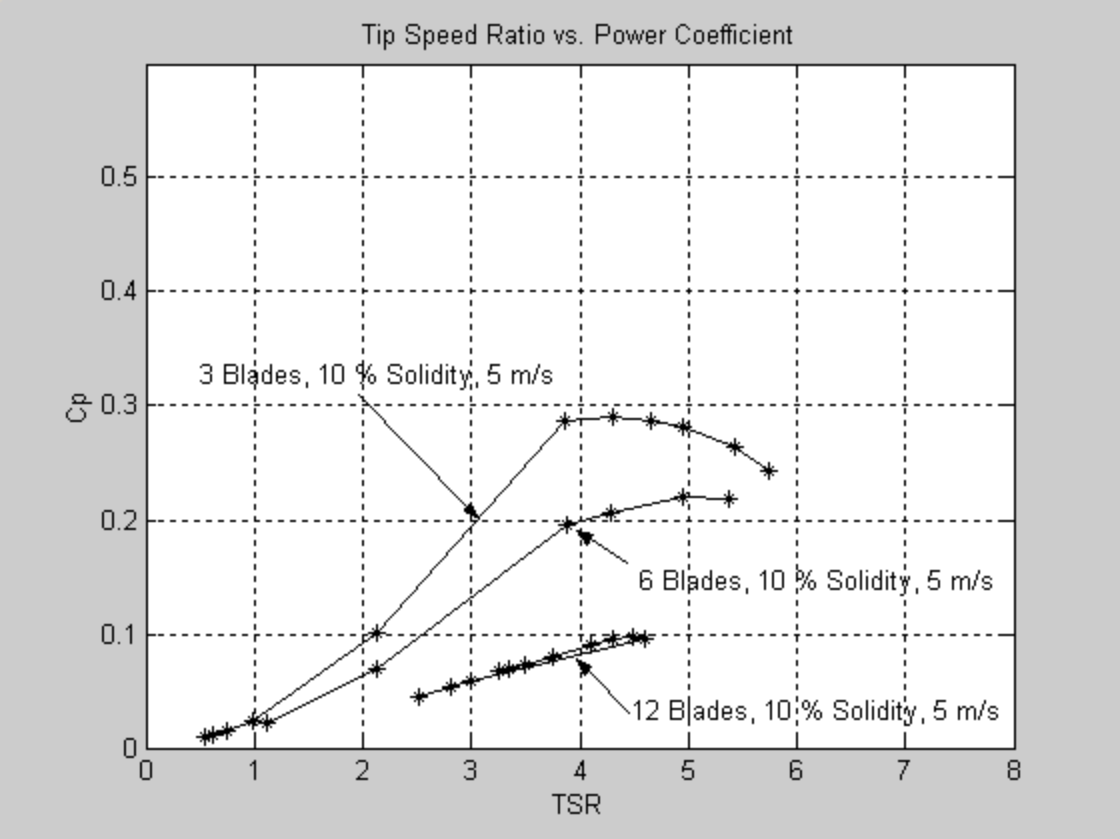

Figure 3. Effect of Blade Number on Aerodynamic Performance

Previous experimental research [1] corresponds to the lack of efficiency improvement found in this set of experimental results when blade number was increased at constant solidity. It is proposed that the influence of local blade Reynolds Number may be the cause for the discrepancy between these results and the previous numerical study [1]. Further tests are being conducted to investigate these effects.

References

1. Duquette, M.M.,"The Effect of Solidity and Blade Number on the Aerodynamic Performance of Small Horizontal Axis Wind Turbines", Master's Thesis, Clarkson University, June 2002