Design Tools

As wind turbine designs become more complex, computer codes are an increasingly important tool for the wind turbine designer. The National Renewable Energy Laboratory's (NREL's) National Wind Technology Center (NWTC) and its subcontractors have developed a variety of sophisticated computer codes that model wind characteristics, the interactions of the wind with turbine blades, turbine structures, power output, and total wind system operation. These codes help wind turbine designers create new designs or investigate design problems that show up during testing.

This fact sheet briefly highlights design codes and provides directions for obtaining the codes. Selected codes are also available via file transfer protocol from the NWTC home page at http://nwtc.nrel.gov

The Center welcomes industry participation in developing and testing new design tools. Please check the insert entitled *User Facility Agreements* to see how your firm can work with engineers at the Center.

Turbine Structures

The YAWDYN code models simple blade motion and yaw in two- and three-bladed rotors. This easy-to-learn code is well suited for preliminary design studies. It provides quick estimates of important loads and machine responses to incoming winds. It also performs simple studies of blade pitch or aileron controls.

The FAST code is an intermediate-level structural design code that permits more detailed modeling of the entire turbine, including the effects of yaw motion, two- and three-bladed rotors, and two-bladed, teetering hubs. Its blade-modeling capabilities include elastic flap and edgewise motions. It can model tower motions in two directions, parallel and perpendicular to the wind. It can also model drivetrain torsional flexibility. With the FAST code, designers can model machine start-up, shutdown, variable-speed operation, and constant-rotor-speed operation. Developed at Oregon State University, the code is currently being validated at NREL, where researchers are adding a control simulation for modeling blade pitch and aileron controls.

Warren Gretz, NREL PIX 00359

NREL researchers use the ADAMS-WT code to build a wind turbine on the computer screen. Once the turbine is built, ADAMS software performs a detailed analysis of its structure and operation.

The ADAMS-WT preprocessor and the ADAMS software constitute the most comprehensive computer model of a wind turbine system available. ADAMS produces a very complex turbine model, including detailed operational modes, loads, and turbine responses to steady winds and turbulence. Because of its complexity, it is best suited for the analysis of complex problems observed during prototype testing and final design of a new wind turbine when designers have detailed turbine input data.

The ADAMS-WT preprocessor uses a graphical interface to assist the user in setting up an ADAMS model. To set up the model, the user must input detailed design data on the characteristics of blades and other components. Without the preprocessor, developing a model that runs correctly can take months; with the preprocessor, developing a model takes a few days.

NREL has prepared user manuals for ADAMS-WT and ADAMS . The manuals include examples of turbine configurations such as a simple two-bladed, teetering-hub machine with blade flap and machine yaw. To help the user better understand the

model-building process, examples of elastic blades and detailed tower and drivetrain models are also included.

Even with ADAMS-WT, the ADAMS software can take months to learn. Subcontractors can come to the Center for help using ADAMS. NREL recommends that turbine designers consider a week-long course offered by Mechanical Dynamics, Incorporated, the software developer.

Inflow

SNLWIND-3D, a variant of a code developed by Sandia National Laboratories, simulates wind flowing into a turbine rotor. The code was designed for use with other design codes, including YAWDYN, FAST, and ADAMS. SNLWIND-3D creates different types of turbulent winds for the turbine under study. It simulates turbulent inflow to a single turbine or a multi-row wind power plant. The code also simulates turbulence according to specifications from the International Electrotechnical Commission.

Aerodynamics

Used for both design and analysis, the PROPPC code predicts the power output of turbine rotor designs. When the user specifies blade geometry, shape, and airfoil performance characteristics, PROPPC will calculate the rotor's power curve.

The WT-PREP code prepares an input data set of airfoil characteristics, such as the coefficients of lift and drag, for the PROPPC code. WT-PREP interpolates performance characteristics between Reynolds numbers and between different airfoils, saving the user significant amounts of time in using PROPPC.

An electronic data table for NREL-designed airfoils developed since the mid-1980s is also available for use with PROPPC. The data table contains the coefficients of lift, drag, and moment for more than 30 different airfoils. The data table, the PROPPC code, and the WT-PREP code are available from NREL.

PROP93 is a graphics-based version of PROPPC, developed and sold by the Alternative Energy Institute.

The PROPID code works the opposite of the PROPPC code. If a designer specifies the performance characteristics of a rotor, the code calculates the blade shape that will produce the desired performance. For example, given a range of five blade lengths and a range of five peak power ratings, PROPID can produce 25 candidate blade geometries within minutes.

Where To Obtain Turbine Design Codes

YAWDYN, blade motion, yaw
Dr. A.C. Hansen
Department of Mechanical Engineering
University of Utah
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e-mail: hansen@me.mech.utah.edu

FAST, turbine structures
Dr. Robert E. Wilson
Department of Mechanical Engineering
Oregon State University
Corvallis, Oregon 97331-6001
(541) 737-2218 fax: (541) 737-2600
wilsonr@ccmail.orst.edu

ADAMS , complete wind turbine system
Dr. Andrew S. Elliott
Mechanical Dynamics, Incorporated
6530 East Virginia Street
Mesa, Arizona 85215
(602) 985-1557 fax: (602) 985-1559
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SNLWIND-3D, wind inflow
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National Renewable Energy Laboratory
National Wind Technology Center
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PROPPC and WT-PREP, power performance
NWTC Library
National Renewable Energy Laboratory
National Wind Technology Center
1617 Cole Boulevard
Golden, Colorado 80401
(303) 384-6963 fax: (303) 384-6999
e-mail: jennifer_doran@nrel.gov

PROP93, power performance
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Alternative Energy Institute
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PROPID, blade shape
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