DOCUMENTATION

For direct access to information, the Users Guide and Help manual are available via your favorite navigator (HTML).

PLATFORMS

The modeling environment of SAMCEF for Wind Turbines is available on Windows NT, 2000 and XP Pro. However, remote computations can also be launched on any UNIX workstation.

SERVICES

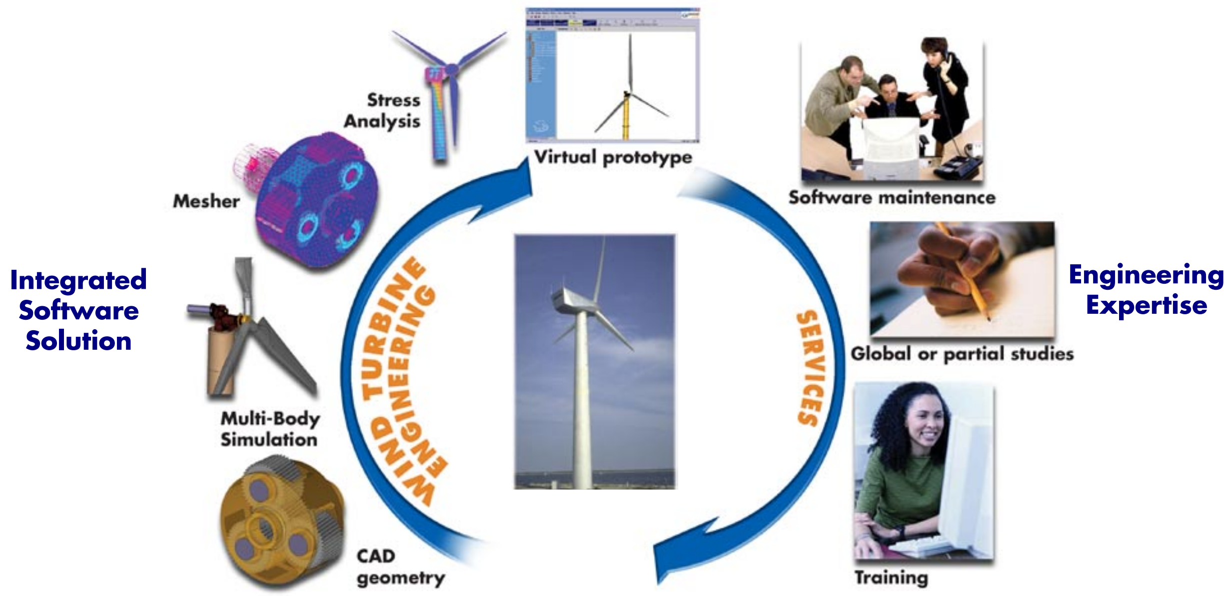
SAMTECH provides worldwide engineering professional solutions to Wind Turbine manufacturers and components suppliers.

SAMTECH also provides services from punctual assistance to partial or global subcontracting design projects.

Continuous improvement of SAMTECH CAE technologies allows SAMTECH to provide a high level expertise to Wind Power industries.

The offering of high technological professional solutions as well as of a full range of associated services allow SAMTECH to face the challenge of a competitive and evolving market.

SAMTECH IS A GLOBAL SUPPLIER OF CAE SOFTWARE AND ASSOCIATED SERVICES



SAMTECH Headquarters
Parc Scientifique du Sart-Tilman
Rue des Chasseurs-Ardennais, 8
B-4031 Angleur-Liège, Belgium
Tel. : +32 4 361 69 69
Fax : +32 4 361 69 80
http://www.samcef.com

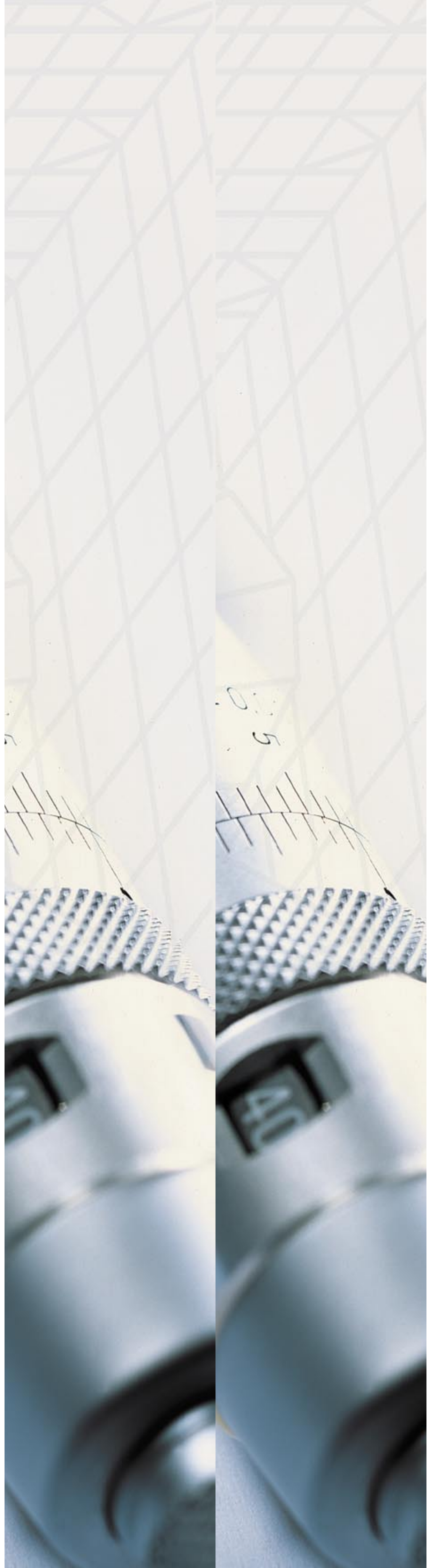
SAMTECH Deutschland
Oskar-Kalbfell-Platz 8
D-72764 Reutlingen, Germany
Tel. : +49 7121 92 20 0
Fax : +49 7121 92 20 90

SAMTECH France
Paris
14, avenue du Québec
Bât. K 2.1, SILIC 618
Villebon-sur-Yvette
F-91945 Courtabœuf Cedex, France
Tel. : +33 1 69 59 22 80
Fax : +33 1 64 46 29 65
Toulouse
11, rue Marius Terce
F-31300 Toulouse, France
Tel. : +33 5 34 55 20 99
Fax : +33 5 34 55 15 00

SAMTECH Italia
Via Guido d'Arezzo, 4
I-20145 Milano, Italy
Tel. : +39 02 48 559 407
Fax : +39 02 46 94 998

SAMTECH Iberica
C/Codonyer 8-10
E-08017 Barcelona, Spain
Tel. : +34 667 755 717
Fax : +34 932 802 439

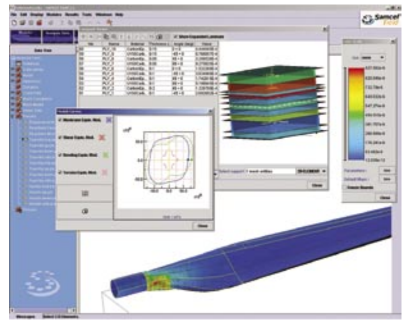
SAMTECH, Integrating CAE towards Professional Solutions

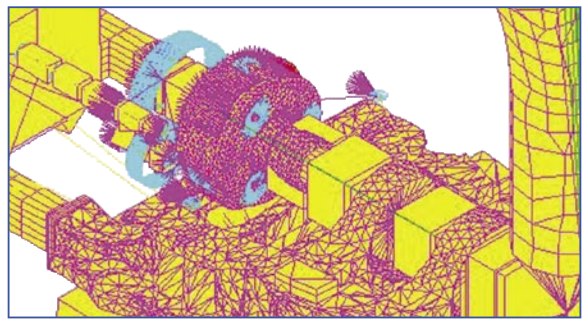


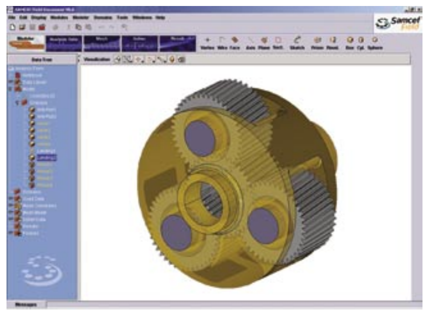
SU04/SAMMKG_broch/33an_a

SAMCEF for Wind Turbines

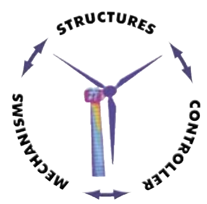
SAMTECH Mechatronic Solutions







Innovative professional solution dedicated to wind turbines engineering combining structures, mechanisms, controllers design and analysis.



SAMTECH, Integrating CAE towards Professional Solutions

SAMCEF for Wind Turbines offers a unique environment for the global design and the detailed mechatronic verification of Wind Turbines, using non-linear Finite Element Method.

MECHATRONIC MODELING ANALYSIS

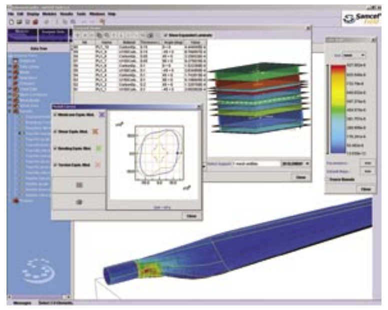
In the past, the mechanical design of Wind Turbines was mainly based on simplified Multi-Body-System simulation possibly including control loops and on separate local structural analysis using the Finite Element Method.

SAMCEF for Wind Turbines proposes now innovative solutions based on the integration of complementary disciplines like non-linear FEM technologies for composite blades and structures, state of the art gearbox modeling capabilities, generator models, servomechanisms and turbine controllers into a unified modeling environment.

• Blade modeling

Detailed blades models including all composite plies, orientations and reinforcements are designed in SAMCEF Field starting from CAD geometries that can be imported from most commercial CAD systems. Efficient tuning of blade Eigen-frequencies (flap wise, edgewise, etc.) can be performed in SAMCEF coupled with BOSS quattro using Model Updating Techniques, without need for modifying the original Finite Element Model.

The user can either build his own anisotropic composite blade model, modeling all relevant features using the Composite Material Library (including an extensive library of non-linear anisotropic composite material models) or import existing Finite Element models from external programs like MSC/Nastran, Ansys, CATIA/Elfini…

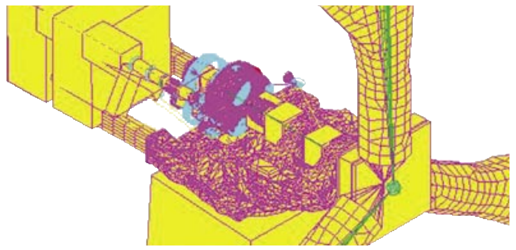


• Gearbox modeling

SAMCEF for Wind Turbines includes advanced modeling capabilities for most usual gearbox designs:

- Planetary stage & two helical parallel stages;
- Three helical parallel stages;
- Load bifurcation at first stage & reunifications at High Speed Shaft (HSS);
- Bifurcation at last gearbox stage with two HSS exits for two generators, etc.;
- …

All gearbox models display details like every bearing, shaft and gear geometries, including the gearbox housing in terms of condensed Finite Element Models (Super Element Technique). The bearing models incorporates axial and radial clearances in terms of non-linear stiffness functions, with eventually coupling of radial and axial bearing stiffness in order to account for the dependency of radial bearing stiffness on axial bearing load. In order to investigate the impact of local gearbox modifications like gear and bearing clearances, bearings type with & without axial or radial stiffness, one or bi-directional axial stiffness, with or without bearing bending stiffness (cylinder, tapered or spherical rollers, etc.), the user can update the properties of each bearing individually and analyze the impact on the entire gearbox dynamics.

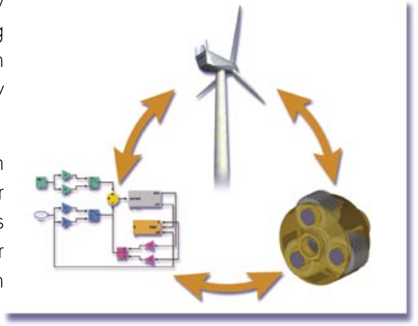


The gear models include all geometrical and mechanical properties in terms of gear tooth geometry and clearances, non-linear gear stiffness including parameter excitation for variable number of gear teeth in contact, friction and damping between meshing gears, transmission error due to fabrication, etc. All shafts of gearbox and rotor are modeled properly by Finite Elements in terms of non-linear beams.

• Generator Coupling, Overload Slip-Clutch, Disc Brake

Elastic Generator Couplings incorporate an overload slip-clutch, which can be easily adapted to the respective turbine configuration. Like the overload slip-clutch, the disc brake model is based on a Generalized Coulomb Law in order to represent properly stick-slip effects, occurring eventually during overload in the slip-clutch, or respectively in the disc brake.

Using the optimization platform BOSS quattro, the insight for choosing proper slip-torques and/or time constants for optimal braking procedure can be enhanced significantly.



• Generator model & Controllers

Several models for synchronous and asynchronous generators are available. The electromagnetic torque is represented by non-linear generator-torque versus generator-slip/speed functions which might depend on time and on control parameters.

The user can either define control boxes directly in SAMCEF, or import digital control boxes from external functional simulation tools like MATLAB Simulink®. Sensors for measuring shaft accelerations can be applied as inputs for controllers and actuators, which on its turn send back the outputs of the controllers to the mechanical generator model.

The generator model includes all inertias and masses of generator stator and rotor, as well as both bearings with radial and axial clearances.

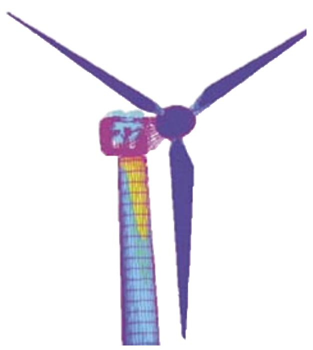
• Wind loads

Wind loads are either imported from external software packages like Flex5 or Bladed or respectively generated within SAMCEF for Wind Turbines.

• Tower and bedplate/frame

The tower can be modeled in parameterized form either by non-linear Shell or Beam elements, thus allowing an efficient analysis of the influence of tower modifications on the entire wind turbine dynamics. The bedplate/frame is presented by Finite Element Models, which are condensed for computational efficiency to non-linear Super-Elements.

Reminding that the SAMCEF Wind Turbine Model relies on Finite Element models and most advanced Multi-Body-System procedures, at any time of the transient dynamic analysis, the user has access to detailed information of structural components like local mechanical stresses (hot spots) in bedplate, composite blades or gearbox housing, and access at the same time very detailed information about bearing and gear tooth forces, axial vibrations of the planet carrier, etc.



MODELING ENVIRONMENT

The modeling environment of SAMCEF for Wind Turbines is SAMCEF Field, which is the main pre- and postprocessor of SAMCEF. This standalone software allows the complete graphical modeling of a Wind Turbine as well as the choice of modeling complexity and of the analysis type from the same data definition completely based on geometry:

- Parts with rigid/flexible behavior, with linear/non-linear material behavior;
- Management of super-elements (creation, use and restitution) to reduce CPU Time if the behavior is linear;
- Assembly/kinematical joints (hinge joint, prismatic joint, cylindrical joint, slider, gears, etc.);
- Motors and control boxes written by the user or generated by commercial functional simulation tools.

CAD GEOMETRY AND MESH IMPORT

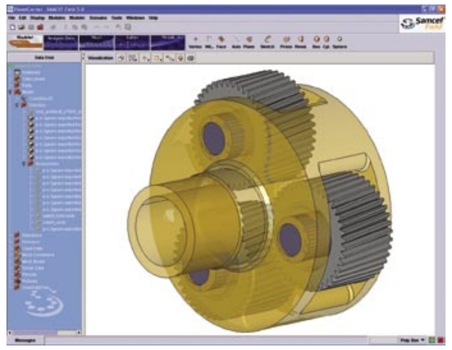
SAMCEF for Wind Turbines provides efficient tools to import and correct geometries coming from usual commercial CAD systems, through:

- Import of industrial neutral formats: IGES, STEP;
- Direct import of proprietary formats: CATIA V4, CATIA V5, EUCLID 3, BREP;
- Import of meshes: NASTRAN, ANSYS, IDEAS Master Series.

CREATION OF CAD GEOMETRIES

SAMCEF for Wind Turbines benefits from a very efficient integrated parametric modeler. The user can, if required, create its own CAD models or import existing models and then optimize them. The geometry can be parameterized and automated functions provided by BOSS quattro allow the users to optimize the geometrical parameters.

SAMCEF for Wind Turbines integrates simulation in the design process. It includes 3D design tools making it easy to create simple or complex parts in a very intuitive way, but also to rework existing mechanical systems starting from imported geometries.



- Surfacic et volumic geometries;
- Parameterization of geometries;
- 1D, 2D and 3 D modeling.

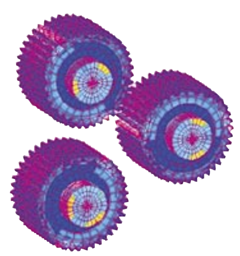
Nearby the creation of complex geometries in a single and integrated environment using powerful modeling tools, SAMCEF for Wind Turbines allows to:

- Offer advanced modeling and solving capabilities;
- Provide tools to optimize wind turbine components like gearboxes, rotor shaft concepts, blade design or control issues for disconnection, overspeed, e-stop etc.;
- Apply modification to the geometry at any stage of the design process;
- Enable the user to view the model in assembly kinematics mode to avoid any undesired interference between parts.

ANALYSIS DATA

A key feature of SAMCEF for Wind Turbines is that it maintains the associativity between the data and the geometry; for example when changes are made to the grid, all related items are easily updated.

SAMCEF for Wind Turbines provides you with intuitive tools for data definition and pre-visualization, as well as import and use of existing data libraries.



- Use of the mechanical engineering language;
- Assignment of the analysis data to the geometry or the F.E. mesh;
- Pre-visualization and association of a symbol to each data;
- Linear and non-linear isotropic and orthotropic materials (elastoplastic, hyperelastic, etc) for thermo-mechanical analysis;
- Physical data for volume, shell, membrane, beam and bar element;
- Flexible or rigid behavior;
- Mass & inertial moments in rigid behavior;
- Boundary conditions and loadings;
- Definition of springs, contacts and gap constraints;
- Joints (cylindrical, prismatic, hinge joints, gear, slider, sensor, distance, etc).

SOLVERS

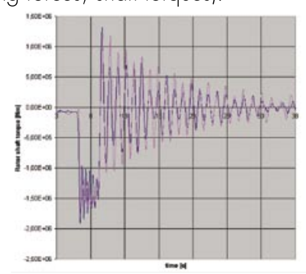
From the same modeling infrastructure of SAMCEF Field, SAMCEF for Wind Turbines gives a direct access to:

- Rigid body simulation (SAMCEF Mecano);
- Linear static, modal analysis (SAMCEF Asef, SAMCEF Dynam);
- Non-linear structure analysis (SAMCEF Mecano);
- Creation/Restitution of super-elements (SAMCEF Dynam);
- Rigid body simulation with super-elements (SAMCEF Mecano);
- Coupled rigid body simulation with super-elements and non-linear structures (SAMCEF Mecano);
- Linear structure analysis on a linearized configuration coming from SAMCEF Mecano (SAMCEF Asef, SAMCEF, Dynam).

ANALYSIS RESULTS

SAMCEF for Wind Turbines benefits of advanced post-processing capabilities depending on the analysis type. Results are post-processed graphically in the form of iso-values contour maps, animations (mode shapes, kinematical modes, successive configurations, strains, stress contours...) or X-Y plots (examples: time evolution of gear or bearing forces, shaft torques).

In addition to standard graphical outputs, results may also be inserted in tabular forms in the analysis report. Results may be displayed in many different forms over the whole structure or locally through user's defined cross sections. Navigation and video functionalities (zoom, replay, etc.) allow you to rotate the part, to observe details thanks to simultaneous multi-windowing, to scan a shape, etc.



Experimental vs SAMCEF for Wind Turbines predicted results.