Design Concept and Market Aims of the WINWIND Wind Energy Converters

Our wind energy converters are designed according to the MULTIBRID principle. This originated from AERODYN GmbH, has been worked out there 1997-99 and was also patented. The basic idea came from an internal study, investigating the basic question " direct drive or gearbox" which concluded surprisingly clearly that a direct drive makes a wind energy converter unduely expensive. Why?

Because the driving factor for the size of an electric machine is torque, not power. The generator mass is armature iron sheet and copper. The price of copper does not fall in case of series production as much as for example machined components. And armature iron is more expensive than construction steel. The generator generates a cost problem, which is still growing when upscaling the machines. This is simply because enlarging the diameter means also reducing the rotational speed, and the torque increases nearly with the power of three with the diameter.
This basic technical problem can only be solved purely on the economic side by manufacturing at least inverter and blades in the own workshop. Then the generator cost can be compensated by the margins of other components and the whole plant might become economic.

If someone tries to buy all the individual components of a direct drive wind energy converter, he will end up with a sum of component cost which is equal or above the market price of the machine. An economic manufacture is not possible. When two colleagues of mine and I calculated several models of entering the wind power branch in 1999 at Finland's second largest utility, PVO, we came to the same conclusion as at AERODYN GmbH two years before.

Now it would have been tempting to follow the "normal" way of designing, so to speak a three-stage gearbox, three-point suspension, doubly-fed induction slipring generator with roughly 1800 rpm, as many other manufacturers do. But the frequent gearbox damages of that time, together with detail arguments against the slip ring machine spoke clearly against this decision.

Analyzing the gearbox damages, however, revealed, that there was no real gearbox problem. Instead there was a problem, how the wind power branch had handled the gearbox design and development. This gave us enough confidence to decide in favour of a geared concept, but with the conservative precaution to limit the speed. The gear ratio of our WWD1 is roughly i=6 and the generator rated speed 150 rpm.

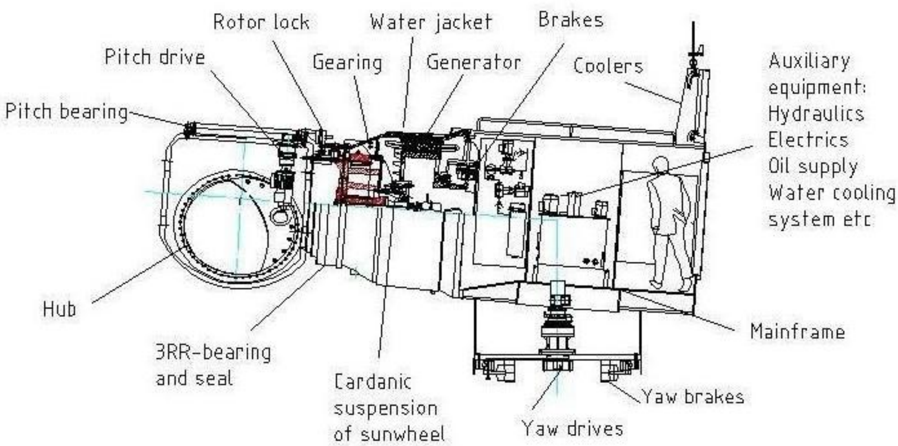

Fig. 1 Cross section of the WWD1

Here in detail the well-known gearbox problems and our measures against:

Stall-dynamic and power fluctuations underestimated
=> variable speed and pitch concept, well-defined torque

Insufficient oil filtering and cooling, too small amount of oil for the gears
=> Bypass-filter and ample cooling

Gliding within rolling bearings due to falling below the minimum load
=> Cutout at too low torque, waiting in braked position.

Reversing motor/generator-operation leads to impacts on axial bearings due to the gearing angle and bearing play
=> all axial bearings are play-free four-point bearings.

The carrying capability of spherical roller bearings has been overestimated, resp. the negative influence of the geometrically induced slip underestimated
=> no spherical roller bearings, only plain roller bearings or ball bearings

Influence of casing deformation on bearing- and gear load distribution neglected
=> symmetrically round casings within the whole drive train, FEM - Analysis of the deformations and their influence. Additionally fully cardanic suspension of the sunwheel

Undefined additional loads on the gearbox coming from the threepoint suspension.
=> as before, round flanges, gear and generator as rotationally symmetric units.

Operation at too low temperature of with too large temperature differences
=> careful cutin with preheating, idling, limited power up to achieving uniform temperature

Oscillations within the drive train (as for ex. TW600)
=> The frequency converter analyses oscillation tendencies and actively eliminates them.

Dynamic doubling of the brake torque due to the drive train elasticities
=> The brake torque is equal to rated torque. Even including dynamic effects, the gearbox is not overloaded

Micropittings on the gears due to waiting in braked position without lubrication
=> a certain forced lubrication also when standing

Electric current damage of rolling bearings
=> Isolation of the relevant bearings and measurements to confirm the function.

Torque peaks from the generator, damaging the gearbox
=> A slip clutch limits the torque to two times of rated torque

Rust within the gearbox during longer times of stillstand
=> Lubrication already in the assembly phase, if necessary with the help of a mobile generator

Overheating during the grinding process and other manufacturing defects
=> Quality control

Respectively the generator was designed with the following rules in mind:

Temperature level => due to the slow rotational speed and the permenent magnet excitation the specific loss power per area of cooling surface is inherently low. Water jacket and internal air circulation keep the temperature at about 90 C at full load. The operating temperature is thus far below the rated insulation class F (155 C).

Winding insulation => preformed copper bar winding, same as with medium voltage machines, but the insulation thickness is matched to the far lower voltage of 660V 25 Hz

dU/dt-stress => Filter, maximum 1kV/usec voltage gradient

Air gap => the length/diameter-ratio of 0.3 is normal and a mechanical air gap of about 3mm is used. The bearing play is maximum 0,5mm and the pole wheel structure extremely stiff. Neither thermal expansion nor mechanical stress result in any danger of an air gap collision. Additionally there is a sensor, which has only symbolic value. There is no need to minimize the air gap as with direct drives.

Humidity and salt accretion when cooling with ambient air => The cooling happens largely through the water jacket. The internal air circulation goes through its own heat exchanger and has very few and only indirect contact to the ambient air.

Bearing lifetime => General geometry results in bearing sizes, which have inherently ample lifetime.

Can the gearbox oil possibly damage the winding insulation? => Tests and statements from experts regarding chemical stability, everything ok.

The frequency converter has been specified and tested with all windpower-specific demands in mind, as for example corrosion, vibration, lightning protection etc.

The WWD3 has a higher stepup gear ratio to cancel the slower rotor, but the design is similar The prototype has been taken into operation in winter 2004/2005.

The mentioned design concept need not be paid with high top mass. The compact concentric drive train saves the usual mainframe, which cancels the additional mass of the slow generator.

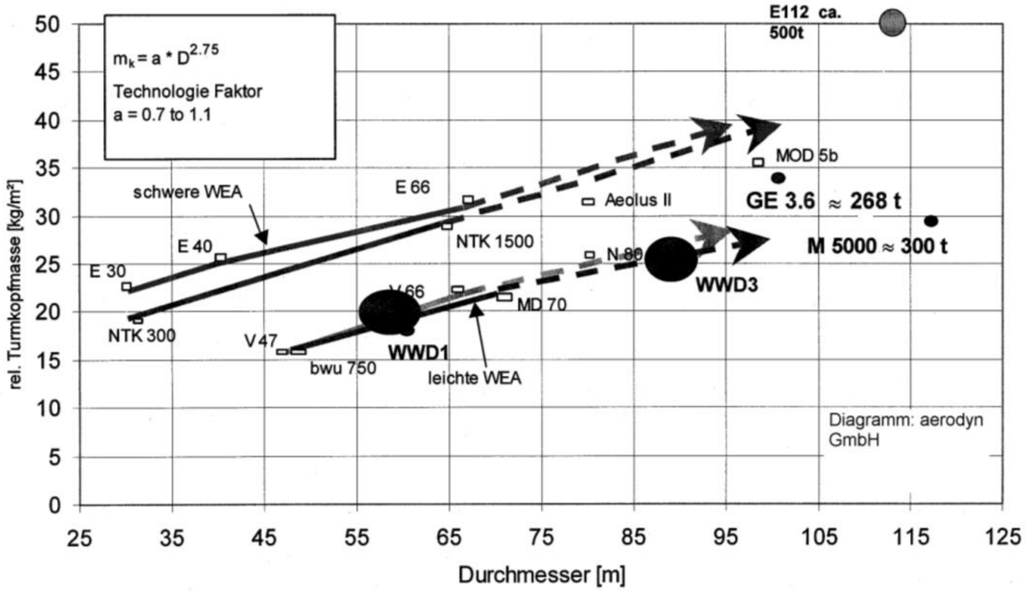

Fig 2. Specific tower head mass

The design concept aims at gaining best possible operational safety for a lifetime of at least 20 years without changing main components. Thus the machines are especially suited for the following applications:

* Wind farms in remote locations
* Low-temperature versions for arctic sites in Scandinavia, Kanada, possibly Siberia
* Projects of low rentability (low electricity price), featuring break-even times of around 15 years (Finnland)
* Offshore (using larger machine sizes than 1 or 3 MW)

In cooperation with a Finnish company, having developed a blade heating, also this can be offered as an option.

Presently 15 units WWD1 are running (2006), thereof 10 in Finland, also 2 machines WWD3 (both Finland). Exports are scheduled to Sweden and Estonia, in China there is a joint venture. Also a daughter company Winwind Iberica exists in Lisboa, Portugal.

For a newcomer the achieved availabilities are high (ca. 96...97%), suffer, however, from imported problems of bought components. Despite ISO 9001, present industrial products feature a quality standard which is far below that, which was general practice in the 1980'ies.

The well-known 5 MW-MULTIBRID plant in Bremerhaven ist also designed according to the MULTIBRID- drive train concept. Winwind und Multibrid Entwicklungs GmbH are not in competition, we cooperate and exchange informations. The companies, however, are financially separate.

More about Winwind you can see on our homepage.

Journal articles referring to gearbox problems and solutions

[1] K. Josef, L. Bäckermann: Getriebeschaden-was nun? Windkraft Journal 3/2000 S.12
[2] P.Bollmann, H. Krueger, Allianz: Getriebeschäden gehen weiter Windkraft-Journal 2/2000 S. 8
[3] NEG-MICON, Randers, DK: NEG-MICON's Retrofit Programm, WKJ 2/2000 S.12
[4] H.L. Pedersen, VESTAS und J. Virtanen, VALMET: Kein Serienschaden bei 600 kW-Getrieben. WKJ 3/99 S.10
[5] P.Luebker u.a. NEG-MICON, M. Eggelwisse u.a., Flender: NEG-MICON und Flender unterzeichnen Kooperationsvertrag, das grösste Serienproblem...WKJ 6/99 S. 36
[6] E. de Vries: No simple solutions to gearbox problems, Windstats 4/1999 S.1
[7] S.Skriver, T.Möller: Gears wearing too fast, Windstats 2/1999 S.5
[8] D. Koennemann: Getriebeschäden unter der Lupe Sonne Wind und Wärme 2/2000
[9] T.Möller: Another gear box failure warningWindpower Monthly 12/ 2000 P.29
[10] SKF-Systemanalyse mit FEM, WKJ 3/2000 S. 68

Books

[11] Brändlein, Eschmann u.a. Die Wälzlagerpraxis, Vereinigte Fachverlage GmbH
[12] HRE-Handbuch Grosswälzlager (dort besonders die Ausführungen über Anschluss-Steifigkeiten)

MULTIBRID - Concept

[13] G.Böhmeke, R.Boldt, H. Beneke: Direct drive, geared drive, intermediate solutions. .EWEC 1997 conference proceedings (erste Veröffentlichung des Konzeptes)
[14] S.Siegfriedsen u.a.: MULTIBRID technology..EWEC 1999 (Vorstellung Multibrid)
[15] G. Böhmeke Development and operational experience...EWEC 2003 (Winwind Anlagen)
[16] M. Lehnhoff Multibrid 5000 Lessons learned EWEC 2006 (Prototyp 5MW)

Internet pages

http://www.winwind.fi/
http://www.multibrid.de/
http://www.aerodyn.de/

added information by September 2010:
www.futurepower.fi