Gearbox

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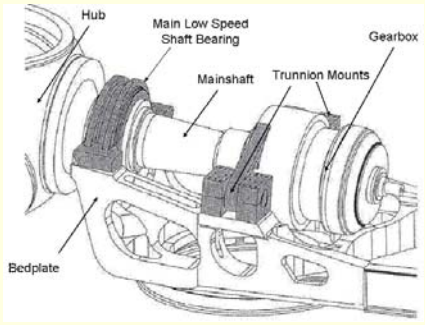
Gearbox Mount

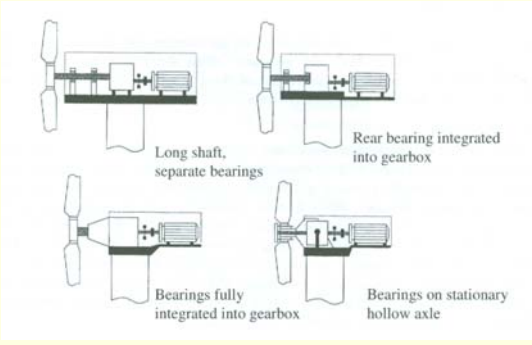


Peeters, Vandepitte, and Sas (2003)

Typical Gearbox

http://social.windenergyupdate.com/industry-insight/turbine-longevity-pro-active-gearbox-maintenance

Main Shaft Options

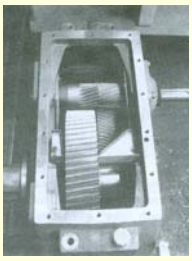


J.F. Manwell *et al.* (2002), p. 298

Gearbox Classification

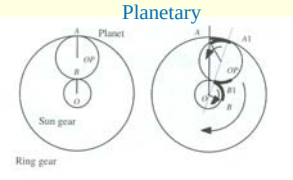
Basic types of gearboxes:
- ✓ Parallel shaft gearbox
- ✓ Planetary gearbox

Parallel shafts



J.F. Manwell *et al.* (2002), p. 300

Planetary

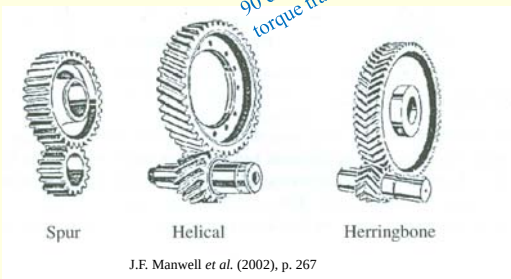


J.F. Manwell *et al.* (2002), p. 301

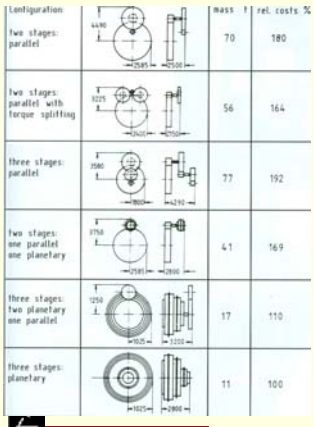
Gear Types

Basic type of gears:
- ✓ Spur (parallel teeth)
- ✓ Helical (teeth under angle)
- ✓ Herring bone ("V" shape teeth)

90 degree torque transfer



J.F. Manwell *et al.* (2002), p. 267



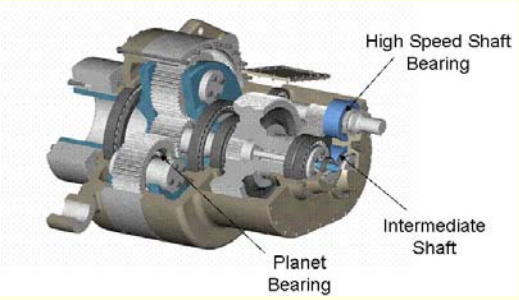
Gearbox Configurations

Single-stage gearbox
=
2 shafts

Two-stage gearbox
=
3 shafts

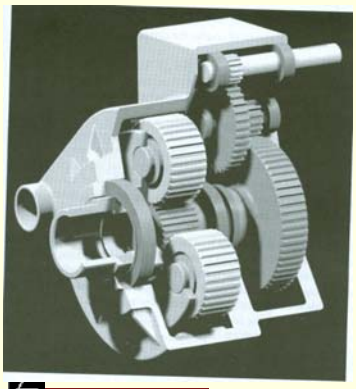
 E. Hau (2006), p. 291

Gearbox Schematics



 Poore *et al.* (2003)

Standard WT Gearbox

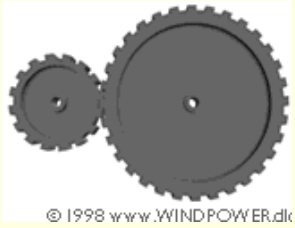


One planetary stage and two parallel shafts

WindPower 2010

Gearbox (Clipper)

Power Train



- ✓ The power from the wind turbine rotor is transferred to the generator through the power train, i.e., the main shaft, the gearbox, and the high speed shaft

Why to Use a Gearbox?

- ✓ Could the generator be driven directly with the power from the main shaft?
- ✓ If we used an ordinary generator, directly connected to a 60 Hz AC three phase grid with two, four, or six poles, we would have to have an extremely high speed turbine with between 1200 and 3600 rpm
- ✓ A 40 meter rotor diameter would imply a tip speed of the rotor more than twice the speed of sound, which is not acceptable

Changing Generator Rotational Speed

- ✓ A possibility is to build a slow-moving synchronous AC generator with many poles
- ✓ If one wanted to connect the generator directly to the grid, one would end up with a 200 pole generator to arrive at a reasonable rotational speed of 30 rpm
- ✓ The problem is that the mass of the generator's rotor has to be roughly proportional to the torque (turning force) it handles, therefore a direct driven generator would be heavy and expensive

Less Torque, More Speed

- ✓ Gearboxes (converting high speed to lower speed) are used in industrial machinery and cars
- ✓ A turbine gearbox converts slowly rotating, high torque of the wind turbine rotor into and high speed, low torque power, of the generator
- ✓ The gearbox in a wind turbine does not "change gears"
- ✓ It normally has a single gear ratio between the rotation of the rotor and the generator
- ✓ For a 600 or 750 kW machine, the gear ratio is approximately 1 to 50 (Europe)

1.5 MW turbine gearbox

Less Torque, More Speed

- ✓ This particular gearbox is somewhat unusual, since it has flanges for two generators on the high speed side (to the right)
- ✓ The orange gadgets just below the generator attachments to the right are the hydraulically operated emergency disc brakes
- ✓ In the background the lower part of a nacelle for a 1.5 MW turbine can be seen

History of Gearboxes

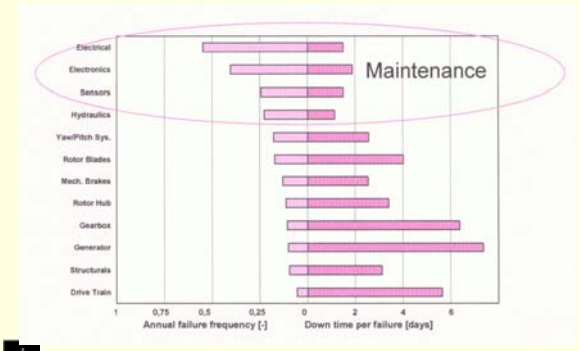
- ✓ 35 kW: Helical stage gearboxes ~ 1979
- ✓ 100 – 200 kW: Helical stage gearboxes ~ 1989
- ✓ 600 – 900 kW: Helical/planetary gearboxes ~ 1995
- ✓ 1 – 2 MW: Helical/planetary gearboxes ~ 2000
- ✓ 5 MW: Double planetary gearboxes ~ 2005

Reliability

Transition from kW to MW

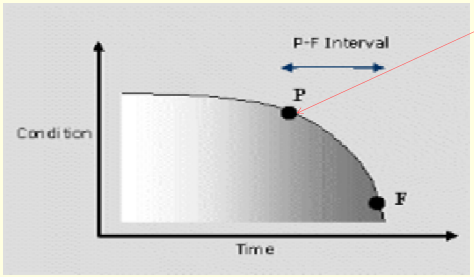
- ✓ Components
- ✓ Accessories
- ✓ Systems

Failure Frequency and Downtime



 B. Hahn, ISET

Condition Monitoring Theory: P-F Curve

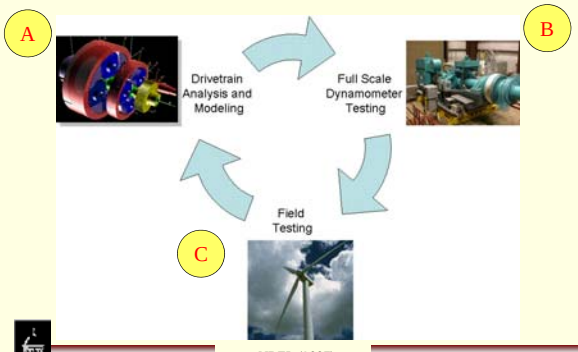


Condition indicator

PF = Potential Failure, F = Failure

R. Dupuis (2008), GasTOPS

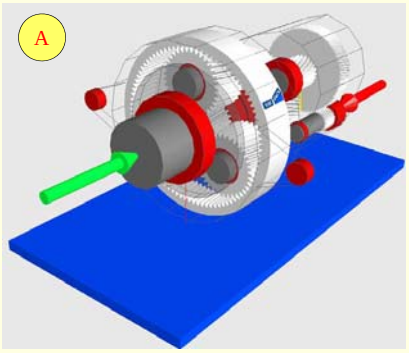
Reliability Analysis and Testing



 NREL (2007)

Drive Train Analysis

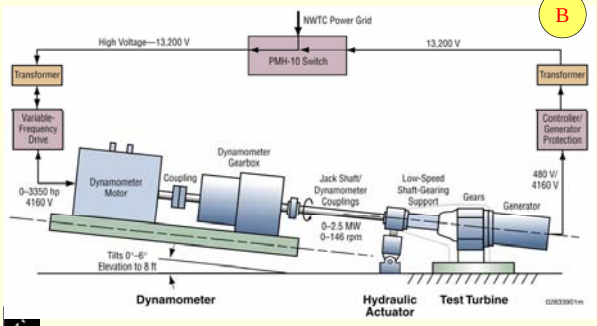
A



Model of Gearbox using SimPack™ software

NREL 2.5 MW Dynamometer Testing Facility

B



Ponnequin Farm Test Site, CO

C

http://fsv.homestead.com/Ponnequin.html

Acknowledgement

The material included in the presentation comes largely from the Danish Wind Industry Association