Continuous Operation Test to verify 175.000h Operation hours

Content

1. Summary:

1.1 Objective:

The continuous operation test verifies that the specified design lifetime of 20 years (175,000 h) will be reached.
For this purpose a high load pattern is applied to the WinDrive for 500h which exceeds the equivalent wear and fatigue of 20 years of operation.

1.2. Results:

The result of the test run and evaluation ensures that the functionality of the WinDrive is also assured after 175.000 hours of operation with the existing design and manufacturing process.

- The WinDrive easily withstood 5,400 kW at 2.5 times rated torque !
- The WinDrive easily withstood the overspeed of 150% !
- Neither damages nor wear were found !

1.2.1 Summary of evaluation:

- Gear unit: all parts o.k.; good contact pattern, no edge carriers, no marks
- Antifriction bearings: all o.k.; no damage to races, cages, contact surfaces and rims
- Converter: o.k.
- Pressure chamber: all surfaces o.k.; no mechanical wear, contact pattern varnish still visible
- Gaskets towards converter: 3 gaskets o.k.;
- Fretting rust: Optimization in series necessary (SKF, DeWind) -> determination by SKF and VTWH

- Test results are very positive !

2. Load Spectrum

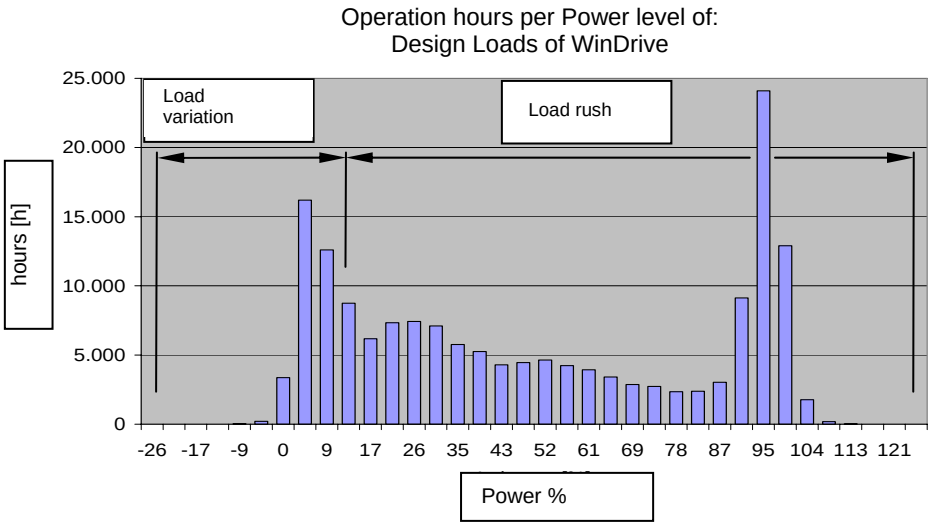
2. 1 Performance of design loads in test program

2.1.1 Classification of types of burden

The power stages from the load retention time distribution (LDD) are split into two zones and evaluated at their frequency.

Load retention time distribution from “Specification design loads WinDrive D8.2 60Hz IEC II“

The total sum of all loads corresponds to the loads experienced over 20 years (175,000h) as per IECII and its distribution in the power spectrum



2.1.1.1 Field of Load Variation

The field of load variation comprises all power stages possibly causing alternating input torque to the WinDrive. These include wobbling, synchronization process and the zone of alternating generatoric - motoric operation.
The number of start and stop procedures as per GL is exceeded 5-times.

2.1.1.2 Field of Load Rush (swelling loads)

The power stages causing purely swell input torque in the WinDrive are summarized in the load swelling field. This field corresponds to about 80 % of the operating time, respectively 400h test time.

2.1.1.3 Special types of burden as per Germanischer Lloyd / load variation field

Type of burden	Frequency		Origin of request	Checked in
	Per year	**in 20 years**		
DLC 2.3 overspeed	10	200	Germanischer Lloyd	Test sequence 1.2
DLC 14.C1 Max. torque		20 s duration	Customer	Test sequence 2.3
DLC 3.1 Start process	1100	22000	Germanischer Lloyd	Test sequence 1.3
DLC 4.1 switching-off	1100	22000	Germanischer Lloyd	Test sequence 1.3

2.2. Fatigue strength / load pulsating (swelling/rushing) field

Basis for the WinDrive design was the load pattern “WinDrive D8.2 60Hz IEC II“ with the respective safety factors for gear root breakage and flank contact pressure.

Required safety factors	Flank contact pressure s_H	Gear root breakage s_F
DeWind	1.3	1.8
Germanischer Lloyd	1.2	1.5
Applied	1,68	1.93

2.3. Selection of load pattern:

Load specification and safety factors result in a design, whereas due design impacts safety factors are utilized differently.

The highest load in the gear stages is in the annulus gear of the super imposing gear stage. For the performance of the test run a Load Spectrum was chosen, according to the theories of Miner, of approx. 115% of the design loads for 20 Years (175.000 hours).

3. Survey of test sequences (by Germanischer Lloyd + special Voith tests)

3.1. Step 1 - (100 h) - field of load variation

3.1.1 Test sequence 1.1
- Determination of characteristic diagram

3.1.2 Test sequence 1.2 - (20h)
- Illustration of overspeed (GL)

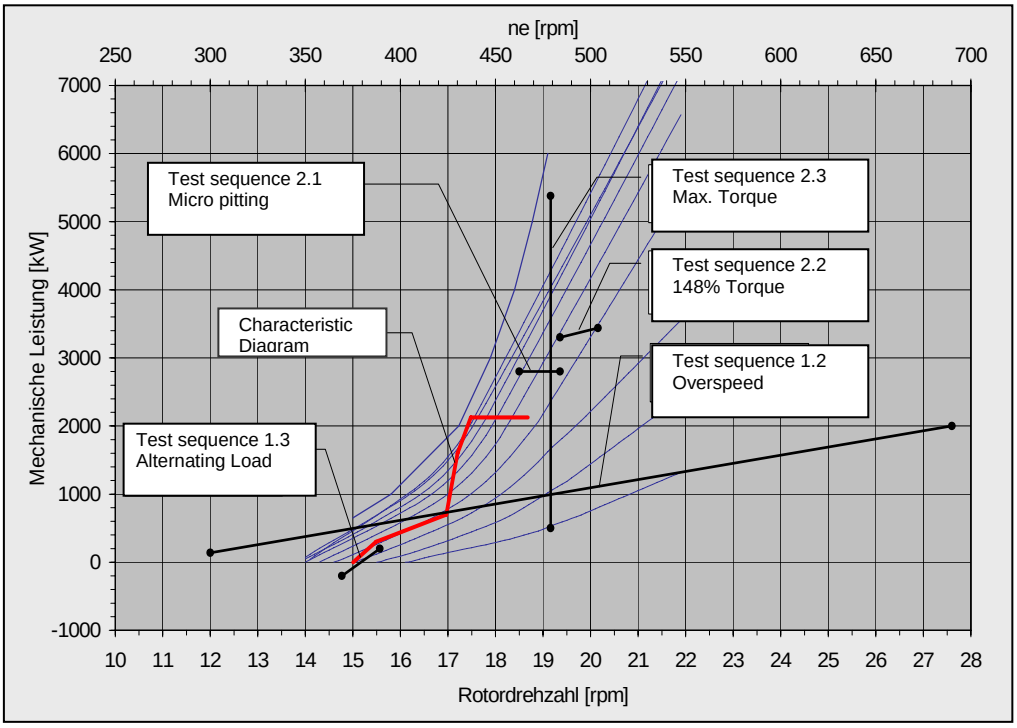
3.1.3 Test sequence 1.3 - (80h)
- Alternating generatoric-
motoric operation. (GL)

3.2. Step 2 - (400 h) - load swelling field

3.2.1 Test sequence 2.1 - (200h)
- Micropitting

3.2.2 Test sequence 2.2 - (200h)
- Control range with
input torque of 148%
of rated torque with 0.5 Hz

3.2.3 Test sequence 2.3
- Maximum torque (GL)

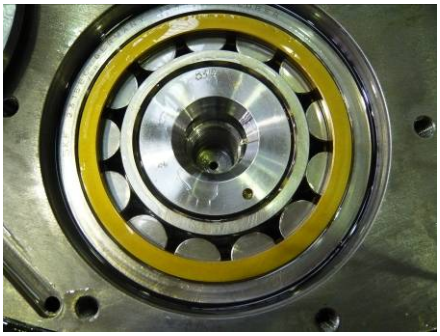


4. Evaluation

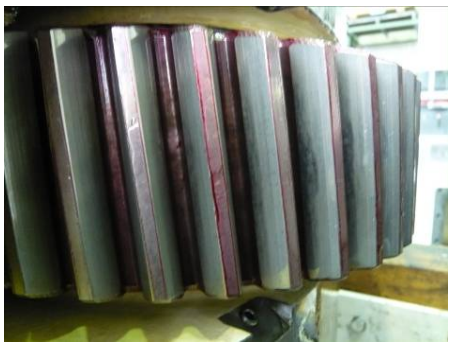
After completion of the test the WinDrive was completely disassembled and all parts were evaluated in detail.
Attached some pictures:

4.1 Superimposing Gear Stage

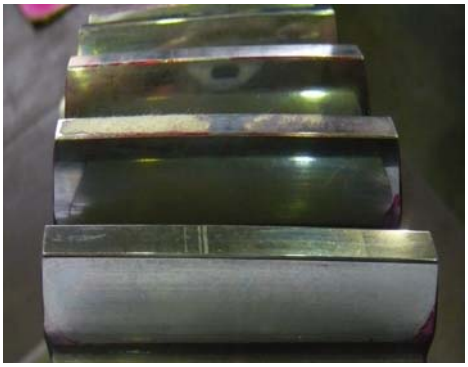
4.1.1 Bearing: Superimposing Gear

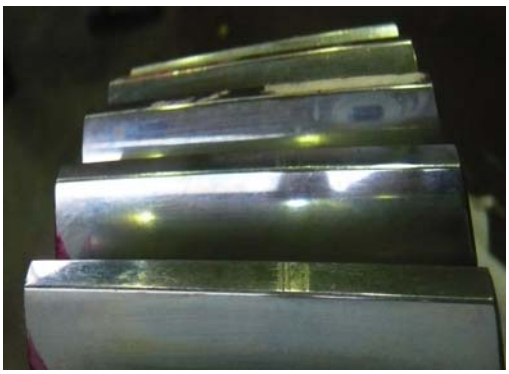


4.1.2 Planets: Superimposing Gear

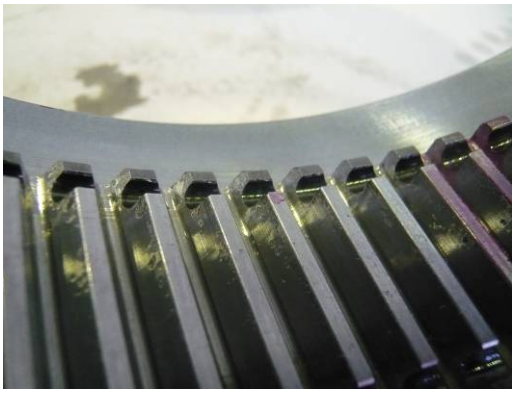


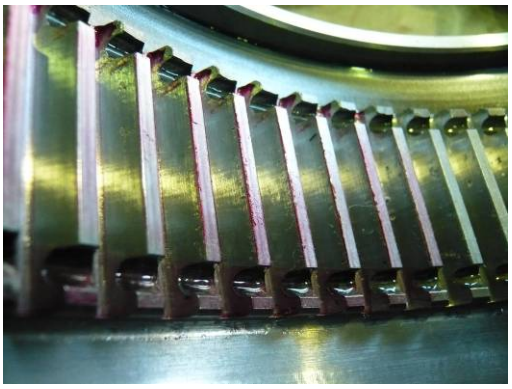
4.1.3 Sun: Superimposing Gear





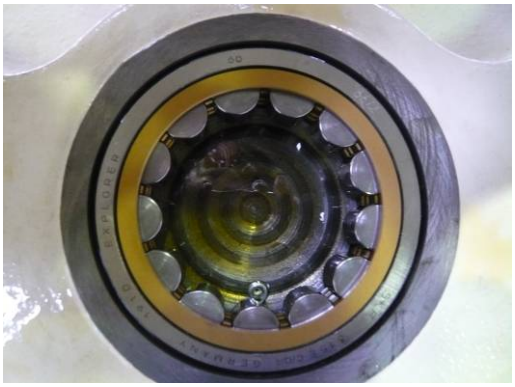
4.1.4 Annulus Gear: Superimposing Gear



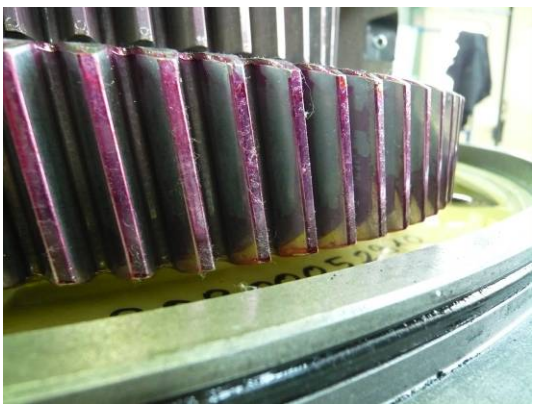


4.2 Fixed Planet Gear Stage

4.2.1 Bearing: Fixed Planet Gear Stage

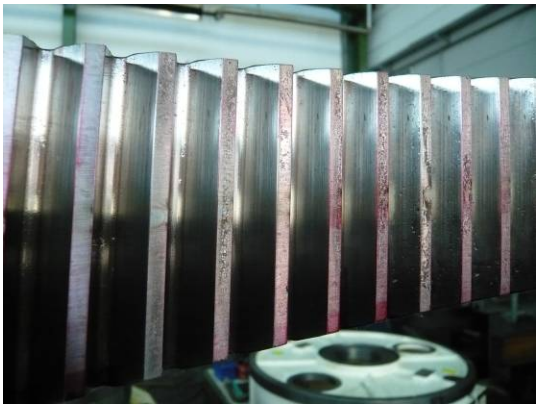


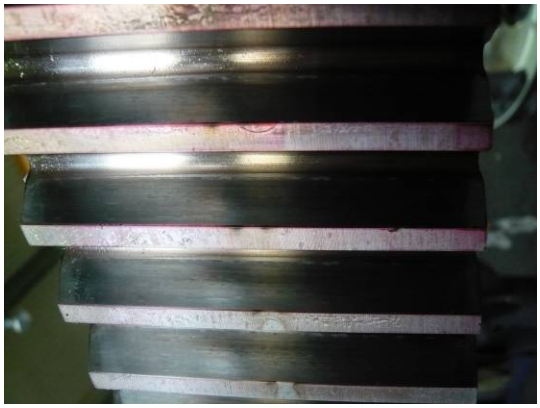
4.2.2. Planets: Fixed Gear Stage



4.2.3 Sun: Fixed Gear Stage

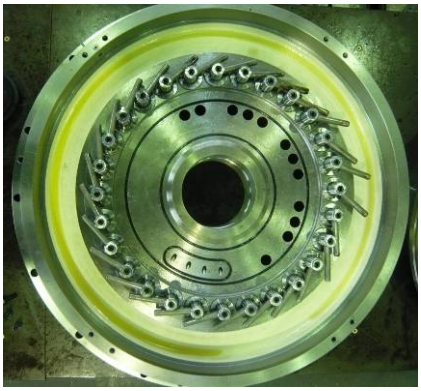
4.2.4 Annulus: Fixed Gear Stage





4.3 Converter

4.3.1 Converter



4.3.2 Guide vanes

4.4.3 Connecting Rods