GfM Gesellschaft für Maschinendiagnose mbH

Explanations

for the machine diagnosis report / wind energy converter

These explanations describe to approach at the measurement, signal analysis and the creation of the diagnosis report

They are destined for the explanatory transfer to the customer.

1 Data collection

The data collection is carried out by employees of the GfM or by external purchasers, e.g. by maintenance staff for wind energy converters. Therefore the eight channel data collection device PeakStore or PeakStore400 is used.

PeakStore:
At first the vibration data are collected with a sampling rate of 50 Hz / channel (resolution = 16 bit sample & hold, band with 22 kHz) with a measurement time of ca. 26.2 s or 52.4 s. From this signal the envelope curve is created by alignment. Both, the order signal and the envelope curve signal are saved as 2 kHz low-pass-filtered and to 10 kHz reduced and with 262144 values per channel. Simultaneously the drive is collected as a time signal by a sampling rate of 10 kHz.

PeakStore400:
The vibration data are collected with a sampling rate of 50 kHz / channel (resolution = 16 bit, sample & hold, band with 22 kHz). Measurement times ca. 26.2 s, ca. 52.4 s ca. 188.7 s as well as a not defined measurement time are available. The original signal is stored. Simultaneously the speed is collected as a time signal with a sampling rate of 5 kHz.

For the data collection the vibration of the drive is collected from different measurement points in several groups by means of 8 channels. At first eight accelerometers are placed using magnetic clamps, and the first measurement is activated. During the measurement the speed is controlled at the display of the PeakStore or PeakStore400 and it is checked if the effective value of velocity is in a plausible value range. The data are stored and if necessary a second or third measurement is executed in the same way with a changed accelerometer arrangement.

Alternative to the accelerometers inductive travel sensors can be connected. This is reasonable for the analysis of especially slowly running rolling bearings.

After the data collection all data are existent as time signals.

2 Measurement data analysis

The time data of the collected channels have to undergo a spectral analysis.
Therefore the spectrum and the envelope spectrum of the signal are created at first. Using the speed signal a spectrum and an envelope curve spectrum are calculated.

During the creation of a spectrum and an envelope curve spectrum a time-related vibration signal has to undergo a Fourier transformation. The units at the abscissa of the spectrum and envelope curve spectrum is in Hz. During the order analysis the time-related signal is converted into a revolution-related vibration signal by using the drive channel. This has to undergo a Fourier transformation. Therefore the quantity of the order spectrum and envelope order curve spectrum is the "order". With order is meant the multiple of the reference frequency. This is normally the rotary frequency of the highest-speed shaft.

For the analysis spectra, envelope curve spectra order spectra and envelope order spectra are available from all measuring points.

3 Calculating the kinematics

It is essential to know the mesh and roll-over conditions of the drive for the analysis.
As basis data are needed:

- the speed (unless it was not collected and the drive is absolutely rotation number-constant during the measurement),
- all number of teeth on gear,
- all types of bearing and the product of gears, generators and/or motors,
- a drive diagram, which shows the adjustment of all drive elements (assembly drawing) as well as
- the information about foreign exciters (engines, pumps, aerators and so on).

With this data all kinematic frequencies respectively orders are calculated and summarized in a kinematic table. This includes:

- all frequencies of drive,
- all frequencies of gear mesh,
- the roll over frequencies on gear wheels by planetary stage as well as
- for all bearings:
  the roll-over-frequency of one point of the external ring,
  the roll-over-frequency of one point of the internal ring,
  the roll-over frequency of one point of the rolling elements and,
  the cage-rotation-frequency.

4 Analysis

All calculated spectra, envelope curve spectra, order spectra and envelope curve order spectra are analysed for typical frequency examples of irregularities on the basis of kinematics.

5 The creation of a machine diagnosis report

At last all located appearances are illustrated comprehensibly in a machine diagnosis report.

The chapter "Diagnosis results" contains a summary of the located irregularities in a tabular form. It is subdivided into different categories:

- located irregularities
- trend
- recommendation
- conditional failure probability in a year, abbreviation $P_{\tau<1a}$

"located irregularities" shows the mechanic causes, which could be read from the respective signal.

"trend" shows the comparison to the reference measurement.

"recommendation" describes further necessary arrangements in case of assuming confinements of availability and therefore a need for action is seen.

"conditional failure probability in a year ($P_{\tau<1a}$)" is a subjective, on experiences based intent for the quantification of irregularities. Stated is the estimated probability, which is based on the vibration diagnosis estimated irregularity, which causes a breakdown in less than 12 months. For the probability of breakdown four steps are indicated:

(no statement)	no irregularities diagnosable
< 5 %	minimal irregularities detectable, generally no action need
20 %	one of five of these irregularities cause a breakdown within a year
50 %	one of two of these irregularities causes a breakdown within a year

In the capture "Spectra" all spectra, which are necessary for the understanding of the relevant diagnosis' interpretation are shown.

In the capture "Kinematics" is found the table of kinematics.

Of the demonstration of all spectra is the abstract of formal dispended. We are pleased to send you optionally mappings of all calculated spectra, envelope spectra, order spectra and envelope curve order spectra or as well all data on a CD-ROM.

6 Abbreviations / Explanations

2x BSF	pass frequency of a rolling element irregularity on both raceways
BPFI	ball pass frequency of an irregularity on inner race
BPFO	ball pass frequency of an irregularity on outer race
BSF	ball spin frequency
Bearing seat problems	indications of micro movements in the bearing seat (See as well hitting parts or fit problems)
Cage	cage rotary frequency
Envelope curve order spectrum	envelope curve spectrum of an order related signal
Envelope curve spectrum	spectrum of the envelope curve of a signal, here are shock-pulse appearances verifiable
Fit problems	advice that a rolling bearing has micro movements in a seat (See also hitting parts bearing seat prob-lems)
GfM No.	GfM report number
Hitting parts	indications that parts of the revolving shaft are hit-ting one time per rotation (See as well fit problems or bearing seat-problems)
Local deviation of flank shapes	advice for irregularities of one or several flank of tooth of a gear
Rolling elements	number of rolling elements
Order spectrum	spectrum of an order-related signal
$P_{\tau<1a}$	failure probability for one year
PF annulus	pass frequency from a point of the annulus
PF planet	pass frequency of a point of the planet
PF sun	pass frequency of a point at the sun
Reference report no.	reference report number
Rel. rotary frequency of planet	spin frequency related to the planet carrier
Revolving deviation of flank shapes	advice for irregularities of all flanks of a gear
Rot. freq.	rotary frequency
Rot. freq. planet	rotary frequency planet carrier
Rot. freq. sun	rotary frequency sun
Spectrum	spectrum of a signal here are sinus-oidal appear-ances detectable

7 Interpreting spectra, envelope curve spectra, order spectra and envelope curve order spectra

The physical measured variable found is assigned at the ordinate in the spectra and envelope curve spectra, mostly acceleration (a in m/s²), and the variable assigned at the abscissa is frequency. For the interpretation relevant spectral lines, as far as possible, the respective frequency as explanation are written in our graphics.

Example: "12.5 Hz - rotary frequency" or "187.6 Hz - tooth mesh."

The physical measured variable is also assigned at the ordinate in the order spectra and envelope curve order spectra. The abscissa is indicated with the physical unit "order". The unit order is "1" and not written down. The order is a nominated frequency through the frequency reference. Which frequency was taken as reference frequency can be extracted from the kinematic table. The commentaries at the spectral line have to be named correctly rotation **order** instead of rotary **frequency**. Since it is difficult to understand for our customers, who are not familiar with the order analysis, we continue to use the normal definition of rotary **frequency** in the order spectra and envelope curve spectra. For this little incorrectness we ask for your understanding.

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