GfM Gesellschaft für Maschinendiagnose mbH

Explanations

for the machine diagnosis report

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

They are destined for the explanatory transfer to the customer.

1 Data collection

The measured data is collected with the mobile data acquisition system PeakStore5 or with the online condition monitoring system Peakanalyzer or comes from other sources.

1.1 PeakStore5

Depending on the hardware configuration, the vibration data are recorded in four, eight or twelve channels with a sampling rate of 51.2 kHz per channel (resolution = 24 bits, sample & hold, bandwidth 22 kHz). Different measuring times of approx. 1.3 s to 164 s and an unaccounted measuring time are available. The original signal is stored. At the same time, the speed is recorded and stored as a time signal with a sampling rate of 6.4 kHz.

For data acquisition, the vibration of the drive is recorded at different measuring points in several groups. If the number of required measuring points is greater than the number of measuring channels in the PeakStore5, several measurements must be carried out with newly placed accelerometers. First, the accelerometers are placed on the drive by means of holding magnets, and a first measurement is triggered. During the measurement the speed is checked via the display of the PeakStore5 and it is checked whether the effective value of the vibration velocity of the accelerometers is in plausible value ranges. The data is stored and a second, if necessary, third measurement is carried out in the same way.

As an alternative to the accelerometers, inductive displacement transducers can be connected. This makes sense for the analysis of particularly slow running rolling bearings.

After data acquisition, all data is present as time signals.

1.2 Peakanalyzer

The vibration data acquisition takes place with 50 kHz per channel, resolution 16 bit and a bandwidth of 20 kHz. At the same time, the speed is recorded.

1.3 other Sources

The type of data collection is specified by the client or described in the report. Should the data quality be in the way of a qualified diagnosis, this is explicitly referred to.

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. By using the speed signal, the order spectrum and the 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 of 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 unit of the order spectrum and envelope curve order 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.

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

3 Calculating the kinematics

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

- the speed (unless it was not collected and the drive is absolutely speed-constant during the measurement),
- all number of teeth on gear,
- all types of bearing and the brand 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 these different categories:

- located irregularities
  shows the mechanic causes, which can 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, abbreviation $P\tau<1a$
  is a subjective, an sole experience based test 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 irregularity diagnosable
< 5 %	minimal irregularity detectable, generally no action needed
20 %	one of five of these irregularities cause a breakdown within a year
50 %	one of two of these irregularities cause a breakdown within a year

  On customer's request, other levels are also used, as far as this satisfies the purpose of the measuring task.

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

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

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

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 problems)
GfM No.	GfM report number
Hitting parts	indications that parts of the revolving shaft are hitting 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 sinusoidal appearances 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 spectrum, mostly acceleration a in m/s², and at the abscissa assigned the variable 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 quantity "order". The 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 rotary **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 small incorrectness we ask for your understanding.

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