

Application Note

Vibration Measurements on Rotating Machines Using m+p Analyzer



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1. General information

Vibration measurement on rotating machines is an important activity for equipment manufacturers, installers, operators and maintenance companies.



IEPE accelerometer



Optical tach probe



NI Ethernet CompactDAQ



m+p Analyzer 16ch with mixed instrumentation for QC on electrical motors

The rotational dynamics module within m+p international's m+p Analyzer now includes the functionality required to measure and analyse both fixed and variable speed rotating machines for development diagnostics, commissioning evaluation, post-maintenance performance checks and a host of other monitoring applications.

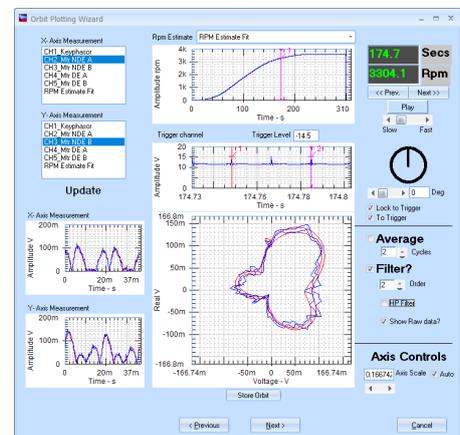
In these applications RMS, peak and peak-peak measurements of acceleration, velocity and displacement are valuable indicators of machine condition. More advanced fault detection and diagnosis can be achieved with the addition of spectral 3D maps, order analysis, orbit analysis, envelope analysis, etc.

1- or 2-plane balancing can be applied to improve the machine behaviour.

m+p Analyzer includes on-line and post-processing capabilities to make all these measurements based on the variable speed of the machine or, when running at constant speed. Time-based logging provides time history statistics, spectrum analysis as well as order analysis with both amplitude and phase results. All these functions are available in parallel for complete and immediate on-line results and flexible post-test diagnostics.

Balancing, bearing condition and performance characteristics can all be evaluated for quality control, commissioning checks, wear comparison over time, diagnostic validation between machine builds before and after maintenance etc. Short-term measurements over seconds to long-term monitoring over days and weeks are all possible.

Input sensors can be accelerometers, velocity sensors or proximity (displacement) probes while software processing selections provide acceleration, velocity and displacement results from the same input channel. Together with pre-filtering, these flexible processing options meet the requirements of the numerous standards in this area such as ISO 13373, ISO 7919, ISO 10816, VDI 2056, ISO 2372, NF 90-300/310, BS 4675 or the API acceptance testing series etc.

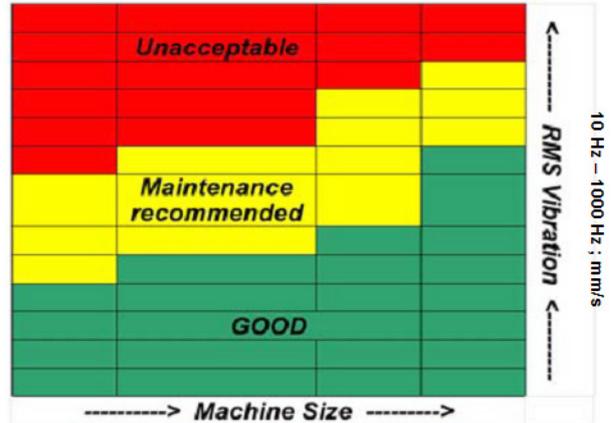


Orbits from raw and filtered histories

2. Machine evaluation

The list below shows some typical condition evaluation applications.

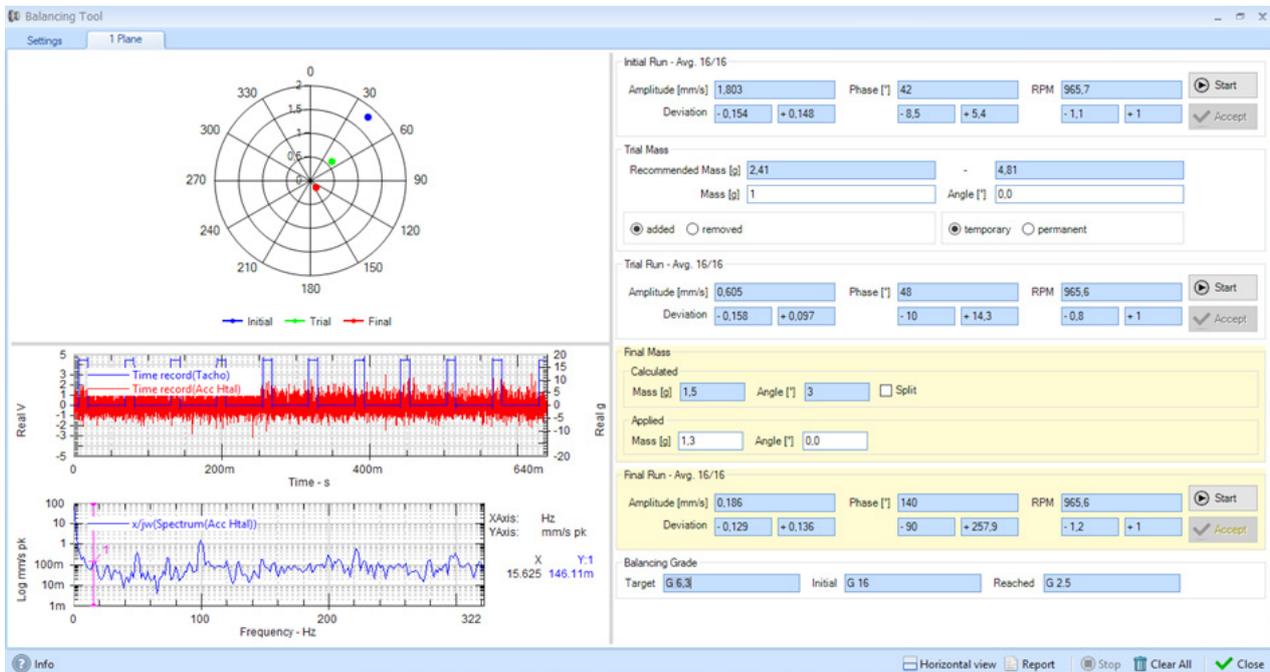
- For electric motor performance: checks measurements over a few minutes to compute velocity peak time history together with displacement peak or peak-to-peak following a user-defined band-pass filter (e.g. 10 Hz to 1000 Hz).
- For generators with roller bearings: velocity rms is often required while displacement is required as peak or peak-to-peak data, both with a band-pass filter from 10 Hz to 1000 Hz. Measurements can be run for days to evaluate condition trends.
- On large gas turbines for power generation: a useful pre-delivery and commissioning test involves order 1 (amplitude + phase) together with velocity peak both from accelerometer inputs.
- For residual unbalance evaluation: velocity rms or peak filtered between 10 Hz and 1 kHz is commonly used on machines running above 600 rpm.



Many standards are available to define appropriate levels

3. Balancing

A completely revised module/wizard is now available in m+p Analyzer revision 5.2, providing engineers with the capability to perform 1- or 2-plane balancing on site, fast & effectively.



1-plane procedure

The Balancing Wizard includes a range of powerful & user friendly tools:

- Most of the m+p Analyzer settings are selected automatically in relation to the machine speed. The user has to define the transducer sensitivity and the trigger level for the tachometer signal.
- The user settings can be saved and recalled for a next balancing application
- Balancing grades

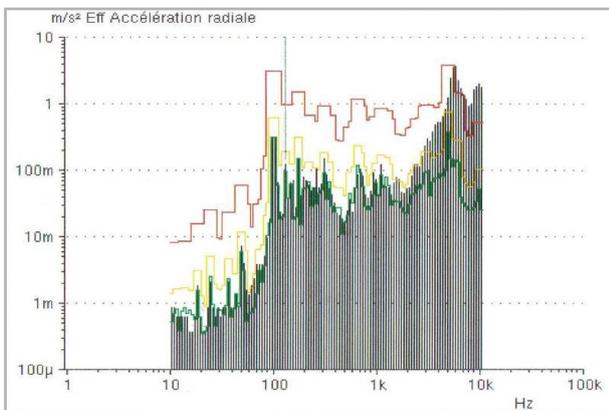
- rpm stability check
- Easy GUI provides help for trial mass selection & positioning
- Data can be viewed in a number of formats, table, 2D graphs (time and spectra), polar plot
- Permanent or removable trial mass(es)
- Split for mass correction
- Word or pdf report including initial and final spectra in Acceleration and Velocity

4. Bearing fault detection and diagnosis

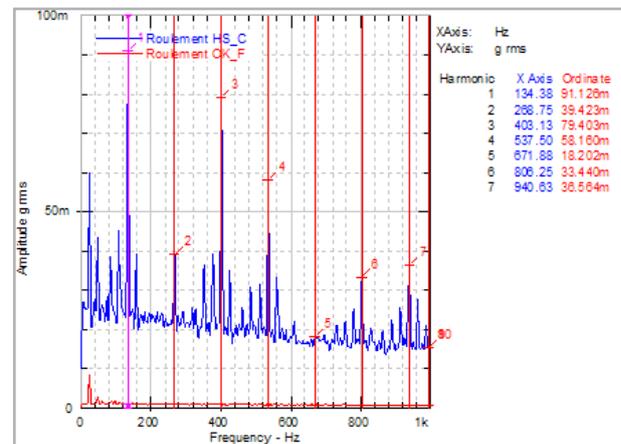


A band-pass filtered acceleration signal from 10 Hz to 10 kHz or 1 kHz to 10 kHz or 3 kHz to 10 kHz is commonly used for fault detection. By measuring both rms and peak values, crest factor can be computed as a performance metric. Another method would be to compute Kurtosis from the time history. All the above methods and many more are possible with m+p Analyzer giving the user a flexible and easy to use system for all types of diagnostic testing across a wide range of machinery monitoring applications.

Instead of using (or in addition to) scalar values, we can use frequency analysis (Constant Percentage Bandwidth mode) for fault detection, and envelope analysis for precise and early fault diagnosis. (See dedicated application note listed in chapter 8.)



Bearing fault is related to high frequency level increase (example from a cement plant)

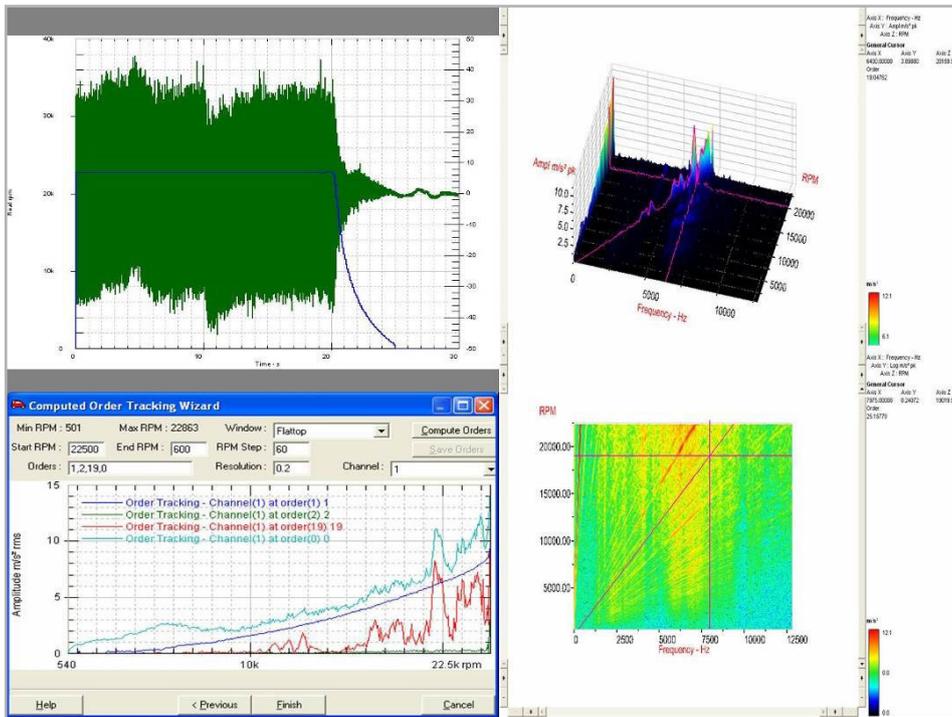


Envelope analysis for a fault on a rotating bearing ring

5. Variable speed

To find if a large vibration level is mainly related to the housing or to the rotating parts. The following example illustrates a resonance excited by a blade passing frequency.

Radial acceleration was acquired onto a high speed rotating machine. Variable speed from 550 rpm to 22500 rpm, 19 blades.



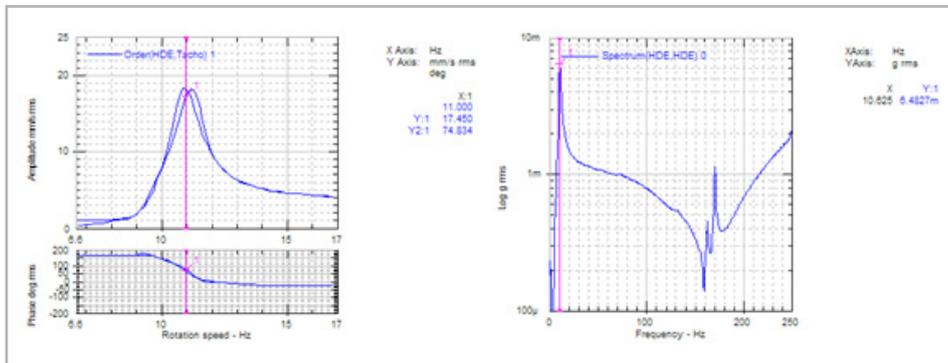
Upper left: throughput data and rpm profile
Bottom left: order analysis vs rpm

Upper right: 3D plot - spectra vs rpm
Bottom right: Campbell plot of the 3D plot

By using 3D plot (spectra vs rpm) and order analysis, we can see on the previous graph:

- Unbalance effect that does not pass through a maximum (see order 1 – dark blue curve).
- The blade passing frequency (order 19 - red curve) that excites a resonance at # 6500 Hz.

Below is another example by applying a run up/coast down, and a hammer test on an electrical motor.

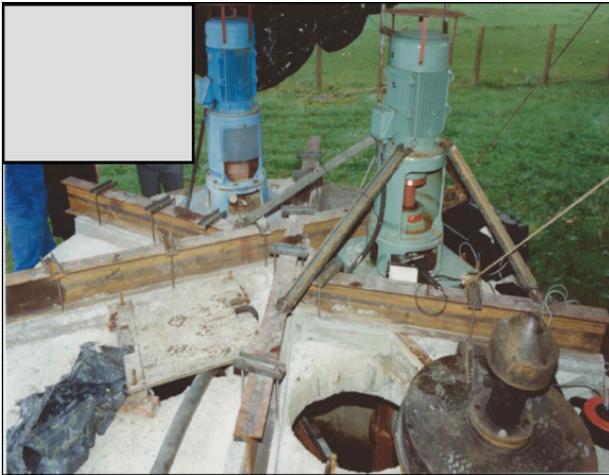


Left: order 1 (amplitude, phase) during a run up and a coast down

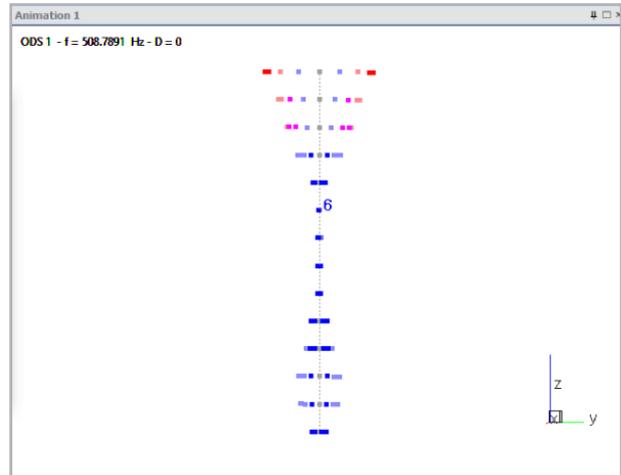
Right: hammer test at the same location (horizontal drive end)

Both results show there is a structural resonance at # 11 Hz. By applying a Structural analysis (ODS, OMA, Modal analysis) we can have a better understanding of the structural dynamic behaviour.

6. ODS for structural behaviour analyses



Water pump feed overview with the temporary brackets



ODS view at F_{rot} with m+p Analyzer (without the brackets)

Here is a very short summary about an expertise done on a water pump feed. By doing several measurements along the pump line (before the installation of brackets on the well cover, we had a large overall vibration level on the motor top (# 20 mm/s)). Only ODS on Y direction is shown (right picture). We have similar behaviour on X direction, too.

Within all the spectra the main vibration levels were at the motor pump rotational frequency (50 Hz = 3000 rpm). So the origin could be a large unbalance or a trouble in the pump house.

By using ODS tool we get a global overview of the pump assembly behaviour. After installation of stiffeners (brackets), the pump assembly vibrations attenuate to more acceptable values. Later on, the coupling box between the motor and the pump shaft was redesigned and replaced.

On large machines (i.e. turbomachines) ODS can be applied on time signals gathered with a multichannel analyzer.

For commissioning, Acoustic Sound Power measurement can be done by using m+p Analyzer, too. Additional measurements such as voltage, current, temperature may be helpful to acquire.

The m+p Analyzer solution can be used also for “dynamic signal and system analysis” training, fault detection and diagnosis on rotating machines, balancing, etc.



Test bench for roller bearing



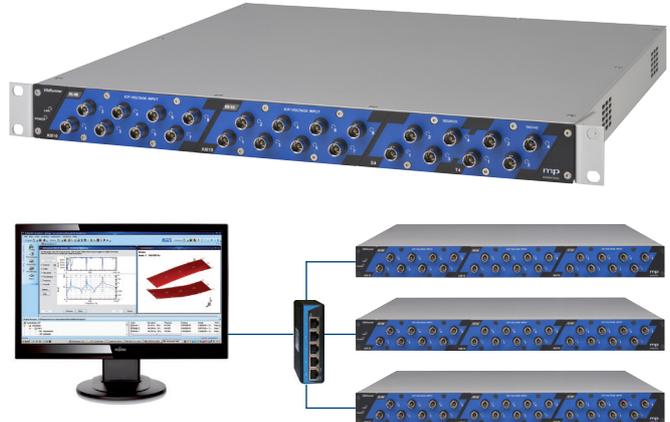
Fault detection and analysis
Test bench for balancing in a French University

7. Instrumentation

Various hardware configurations are possible providing the best of portability and flexibility together with integrated online diagnostics and analysis.



m+p VibPilot from 2 to 48 channels, battery in option



m+p VibRunner front-end from 8 to ... channels



m+p VibMobile front-end from 8 to 64 channels (embedded PC and battery)



Ultra-portable 4-channel module from National Instruments



PCP digital ICP-USB signal conditioner for 2 channels

In addition, m+p Analyzer also supports National Instruments PXI and CompactDAQ instruments from low- to multi-channel count applications.

8. Literature

- Bearing Fault Detection and Diagnosis with m+p Analyzer application note

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