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IRIS M
Enhancing Vision

Real-time vibration and operational deflection shape analysis of machines and structures with the Motion Amplification® optical technology

IMC 2023 - EPFL Lausanne - 12th September, 2023

Dipl. Ing. Luca Del Nero
DarkWave Thermo Schweiz KLG

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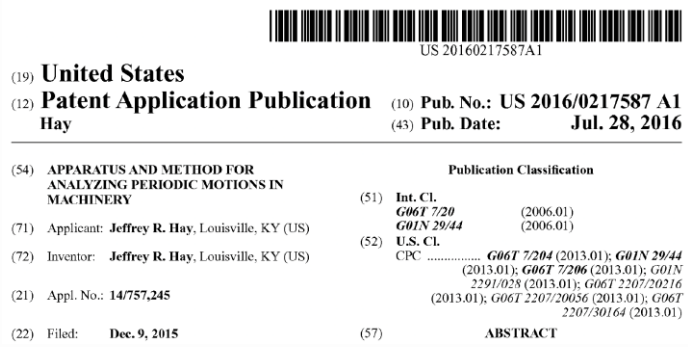


US 20160217587A1

(19) **United States**

(12) **Patent Application Publication**
Hay

(10) **Pub. No.: US 2016/0217587 A1**
(43) **Pub. Date: Jul. 28, 2016**

(54) **APPARATUS AND METHOD FOR ANALYZING PERIODIC MOTIONS IN MACHINERY**

(71) Applicant: **Jeffrey R. Hay**, Louisville, KY (US)

(72) Inventor: **Jeffrey R. Hay**, Louisville, KY (US)

(21) Appl. No.: **14/757,245**

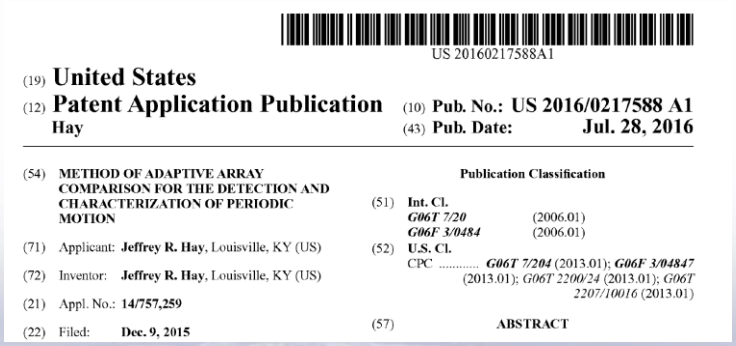
(22) Filed: **Dec. 9, 2015**

Publication Classification

(51) **Int. Cl.**
G06T 7/20 (2006.01)
G01N 29/44 (2006.01)

(52) **U.S. Cl.**
CPC ***G06T 7/204*** (2013.01); ***G01N 29/44*** (2013.01); ***G06T 7/206*** (2013.01); *G01N 2291/028* (2013.01); *G06T 2207/20216* (2013.01); *G06T 2207/20056* (2013.01); *G06T 2207/30164* (2013.01)

(57) **ABSTRACT**



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(43) **Pub. Date: Jul. 28, 2016**

(54) **METHOD OF ADAPTIVE ARRAY COMPARISON FOR THE DETECTION AND CHARACTERIZATION OF PERIODIC MOTION**

(71) Applicant: **Jeffrey R. Hay**, Louisville, KY (US)

(72) Inventor: **Jeffrey R. Hay**, Louisville, KY (US)

(21) Appl. No.: **14/757,259**

(22) Filed: **Dec. 9, 2015**

Publication Classification

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G06T 7/20 (2006.01)
G06F 3/0484 (2006.01)

(52) **U.S. Cl.**
CPC ***G06T 7/204*** (2013.01); ***G06F 3/04847*** (2013.01); *G06T 2200/24* (2013.01); *G06T 2207/10016* (2013.01)

(57) **ABSTRACT**

The Patent applicant stated…

- "Analyse the video file by an adaptive array comparison technique to find a selected number of pixels that have the most intensity variation over time, i.e., the most physical movement."
- "Find the best frames to use (i.e., optimal frame spacing) to maximize the frame differences and best determine the periodicity of the movement."
- "Apply various mathematical functions, such as fast Fourier transform analysis (FFT) to derive richer physical information from the observed movement waveform."
- "To isolate and reject wanted and unwanted signals respectively."

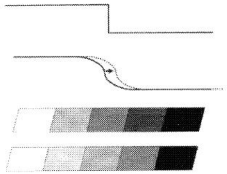

FIG. 20A

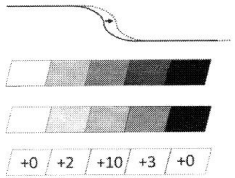

FIG. 20B

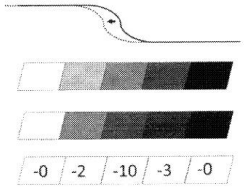

FIG. 20C

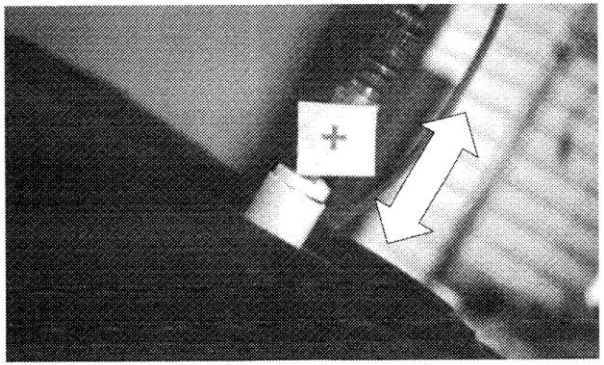

FIG. 6

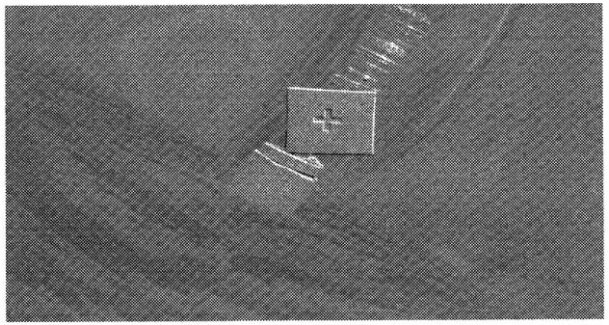

FIG. 7

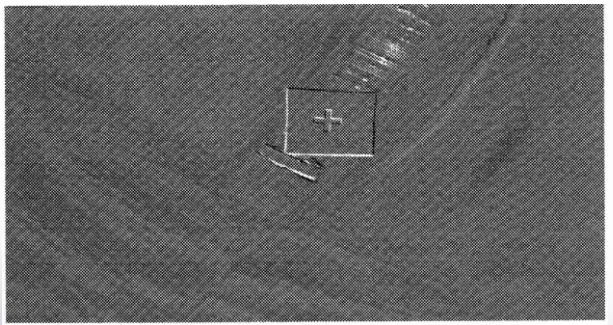

FIG. 8


310 MD145

Which displacement can be resolved, with standard lenses?

Target distance from camera	Lens focal lenght	Displacement resolution
2 meters	25 mm	1 micron
2 meters	50 mm	0.5 micron
1 meter	50 mm	0.25 micron
100 meters	100 mm	12.5 micron

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1536.28 Hz

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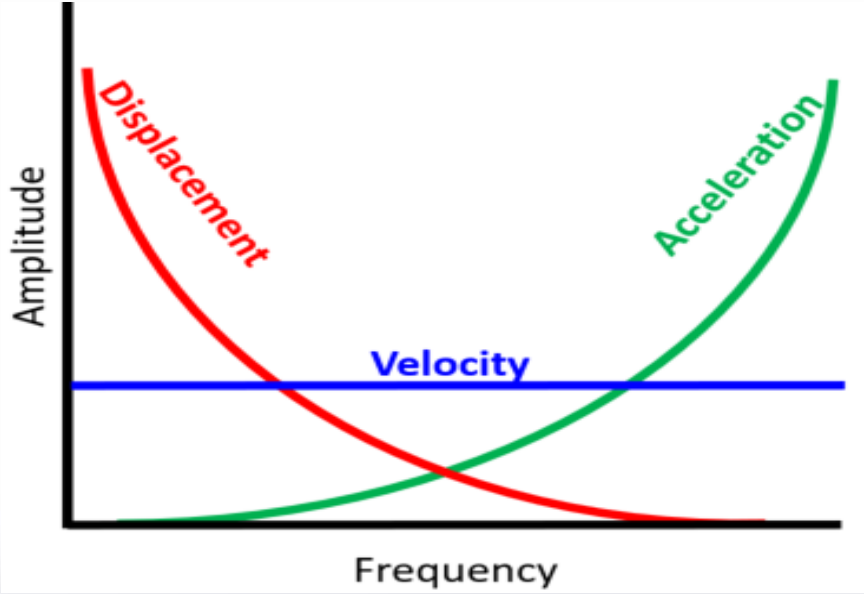


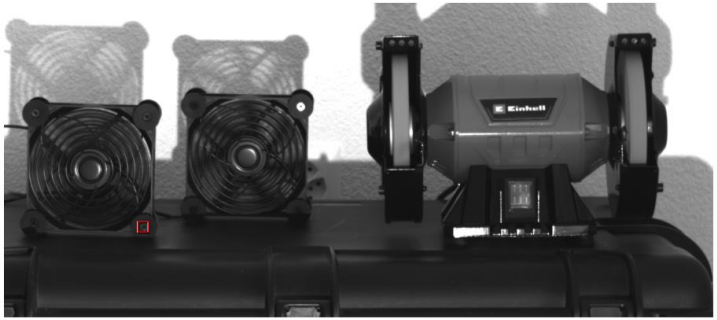
We can then use the MA for:

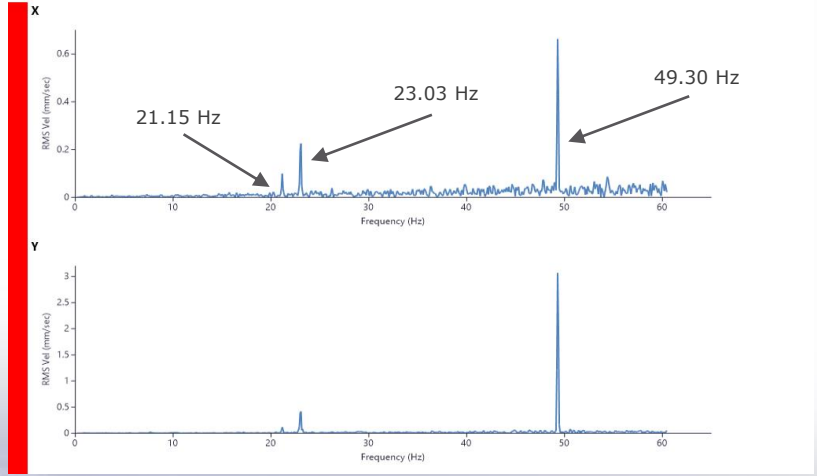
- Typical low and middle frequency issues (imbalance, misalignment, resonance, …)
- Periodical or non periodical motions
- Large motion analysis
- ODS and Modal Analysis
- …but normally NOT for bearings and gearboxes issues (very high frequencies and very low displacement)

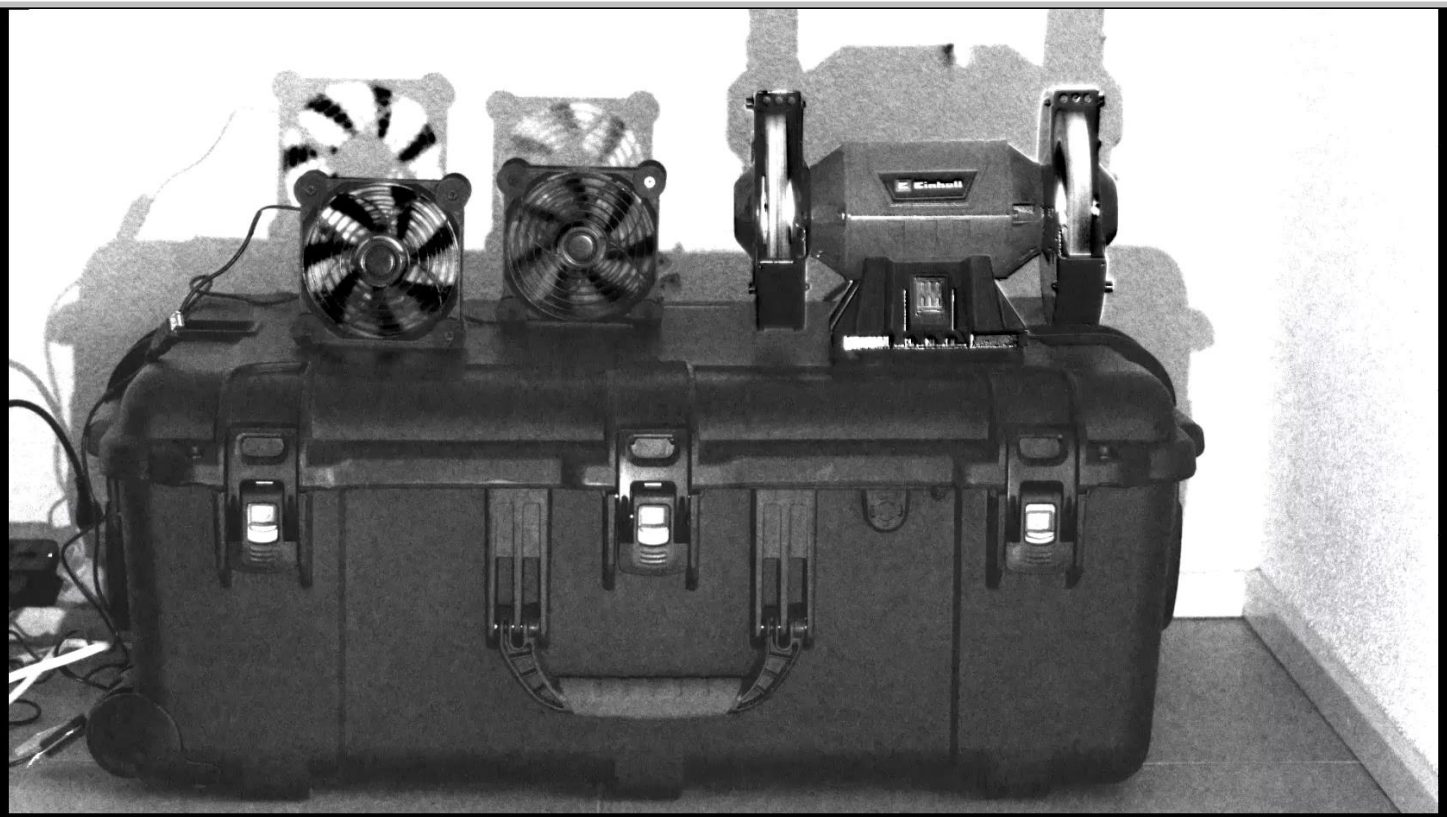

Einhell

What can we do with MA, in fact?

- Measure vwaveforms and spectra
- Filter in frequency
- Rebuild the motion
- Amplify and slow down
- ...and much more...

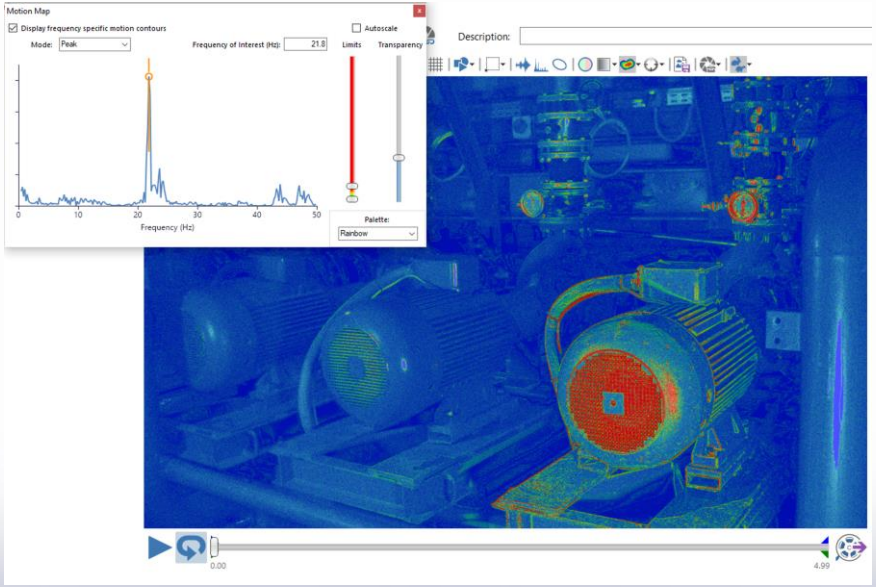


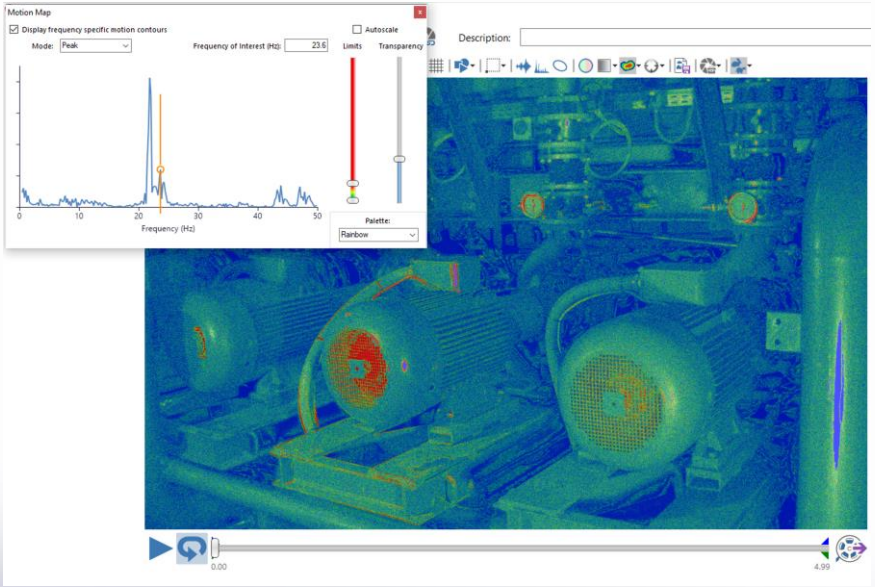




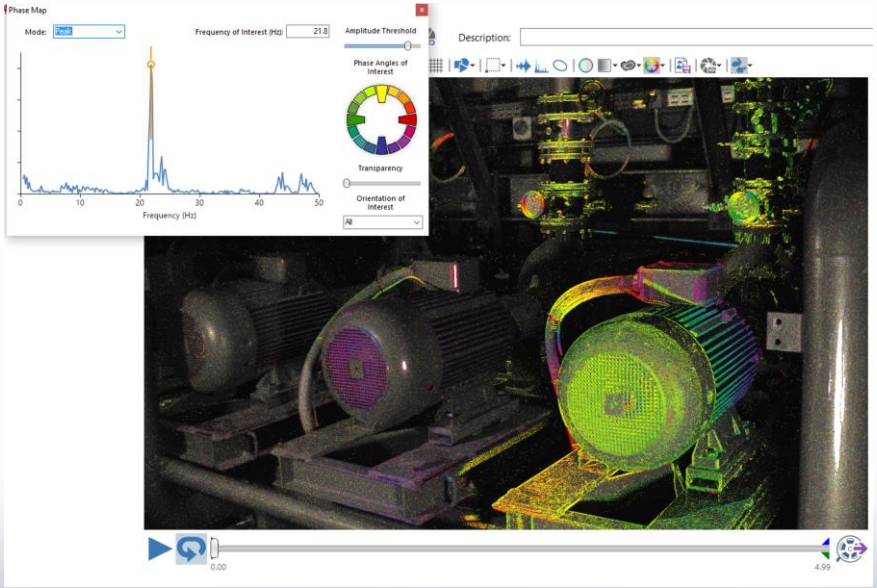
Not filtered

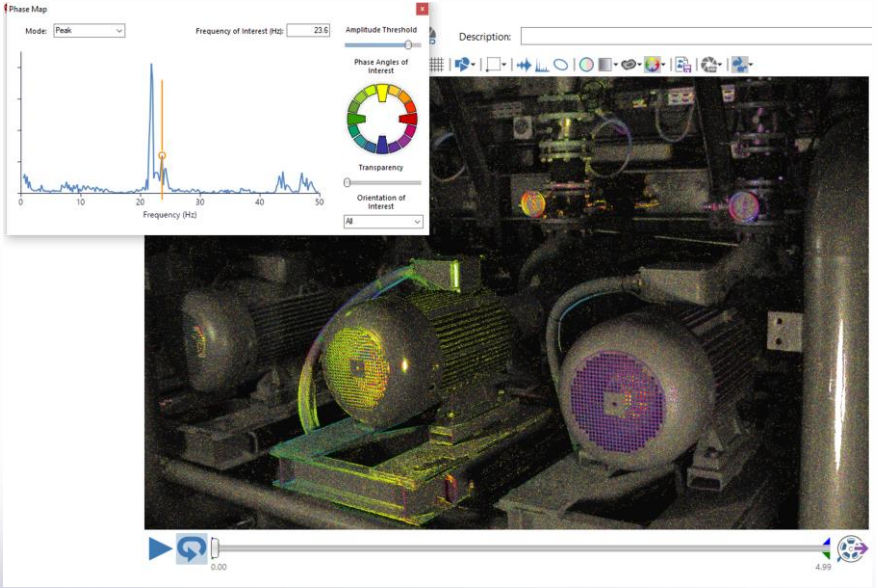
Visual frequency detection...





Visual phase detection...






Leonova
SPM

It is NOT ALWAYS a replacement for "old fashion" vibration analysis!

It is something that sometimes replaces and sometimes integrates standard measurement technology.

PROS...

- ✓ Allows motion frequency separation
- ✓ Provide quick analysis on high complexity systems
- ✓ Measurement points can be quickly moved
- ✓ Can be used at a distance, on dangerous components, on high temperature surfaces, ...
- ✓ It is the only viable mesurement & analysis system in several situations
- ✓ Improve communication dramatically

CONS...

- ✓ Continuous light is necessary
- ✓ Frequency range is limited by camera, light, displacement
- ✓ It is less accurate than accelerometers or laser
- ✓ Long term acquisitions require stable light condition
- ✓ Spot checks are less repeatable between inspections, due to differences in positioning
- ✓ Data size can be an issue

What we typically investigate?

- ✓ Spot issues – e.g. resonances, structural failures, etc.
- ✓ Passenger comfort improvement
- ✓ Sound impact reduction (e.g. in urban environment)

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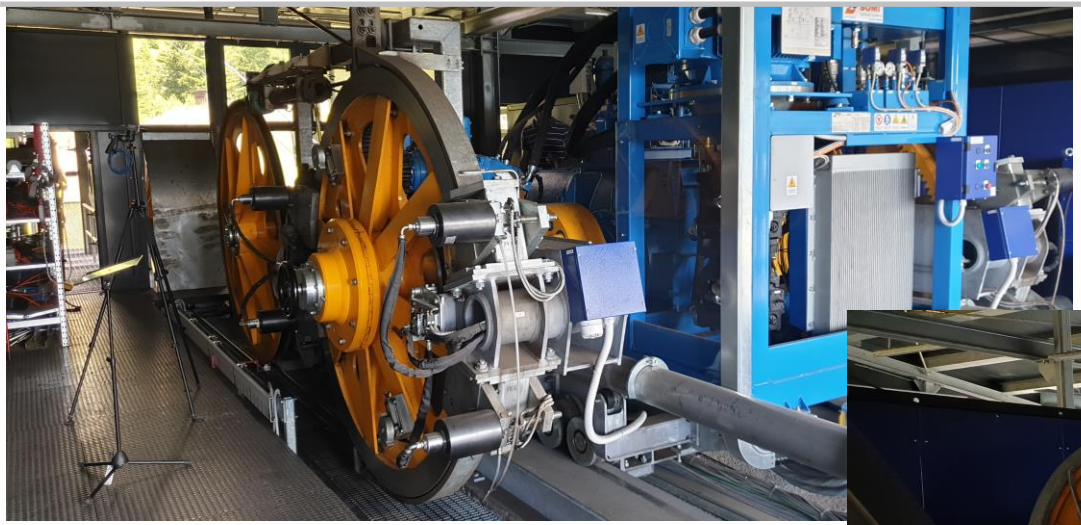

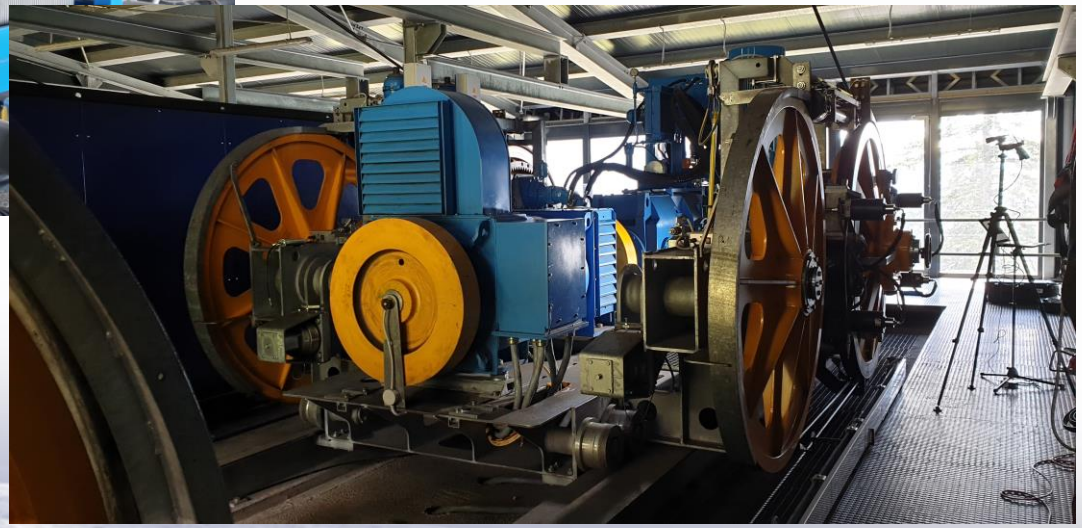

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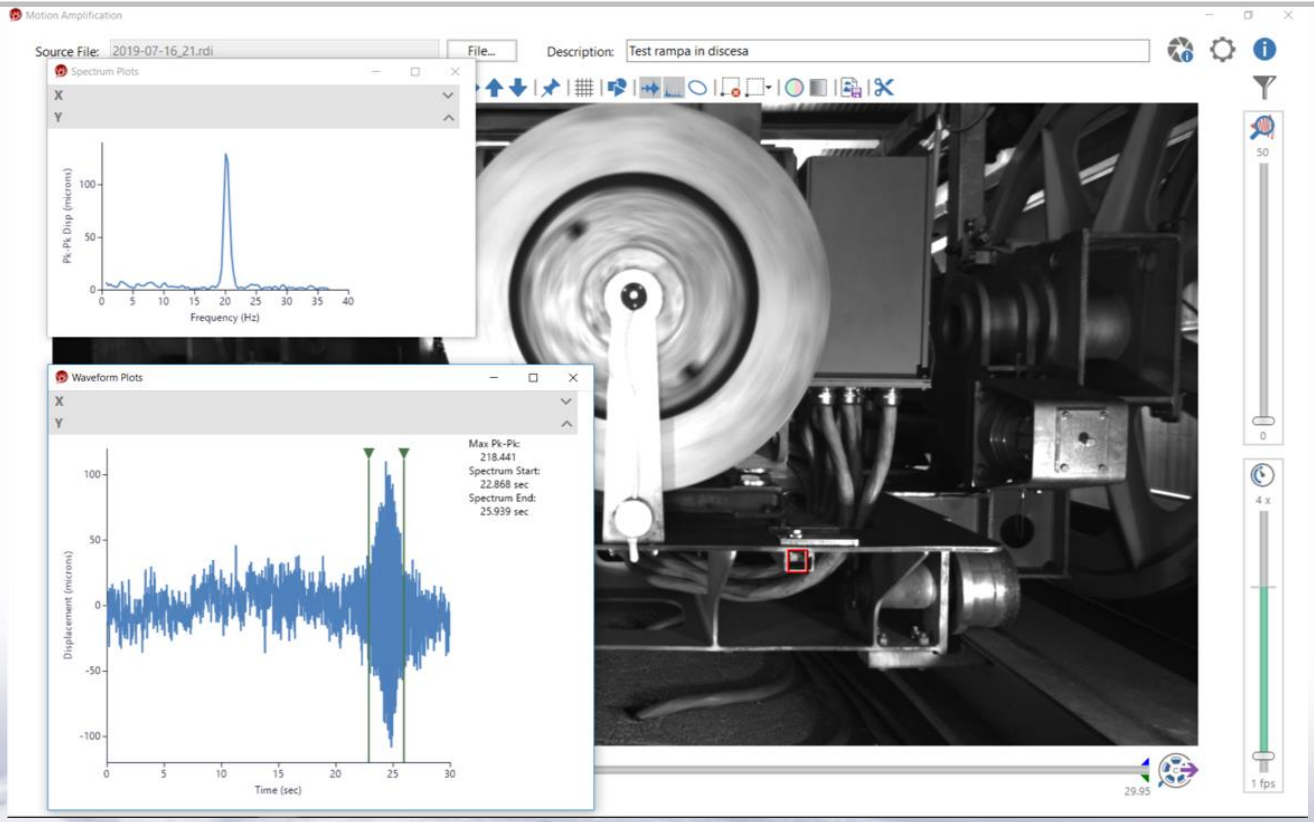
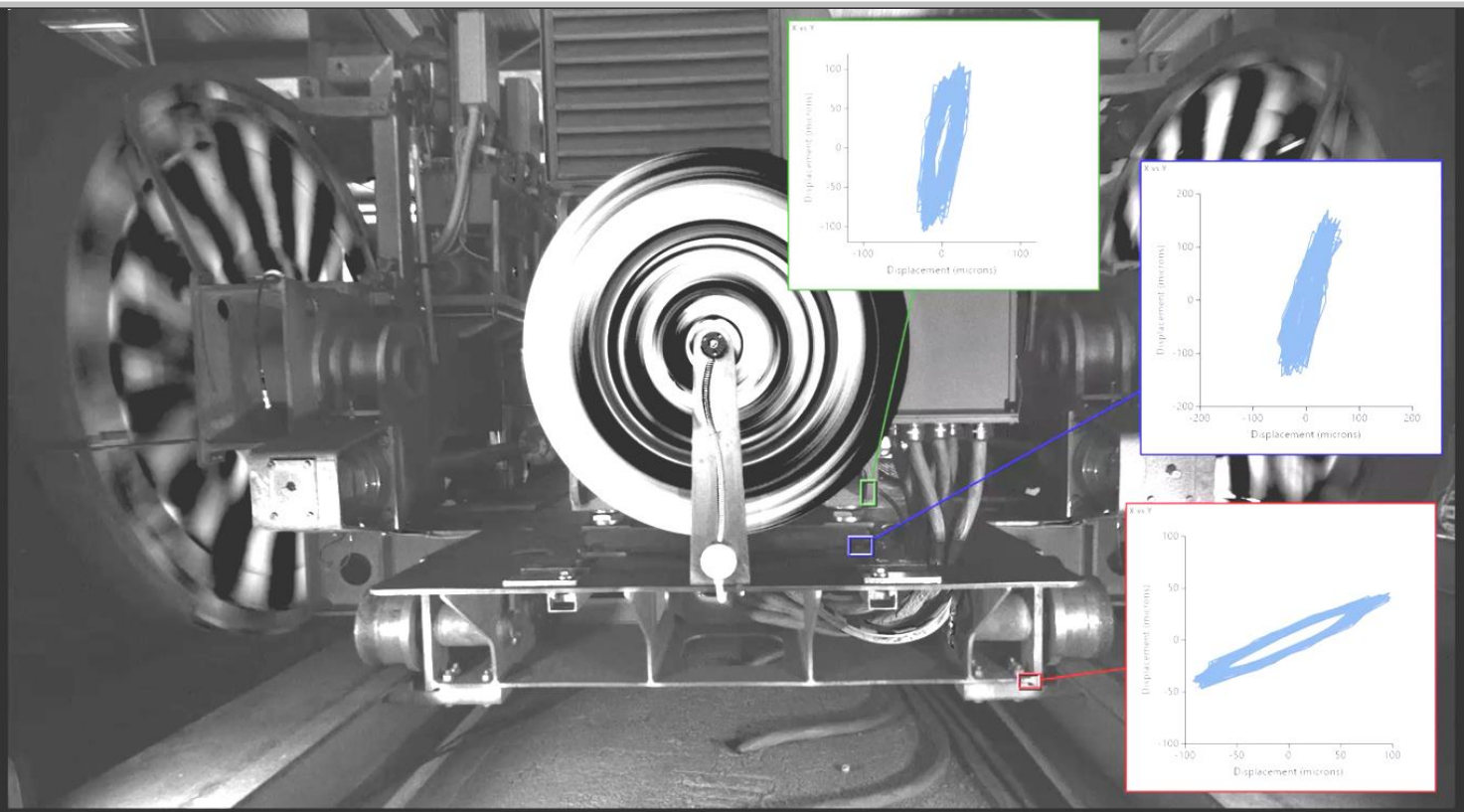
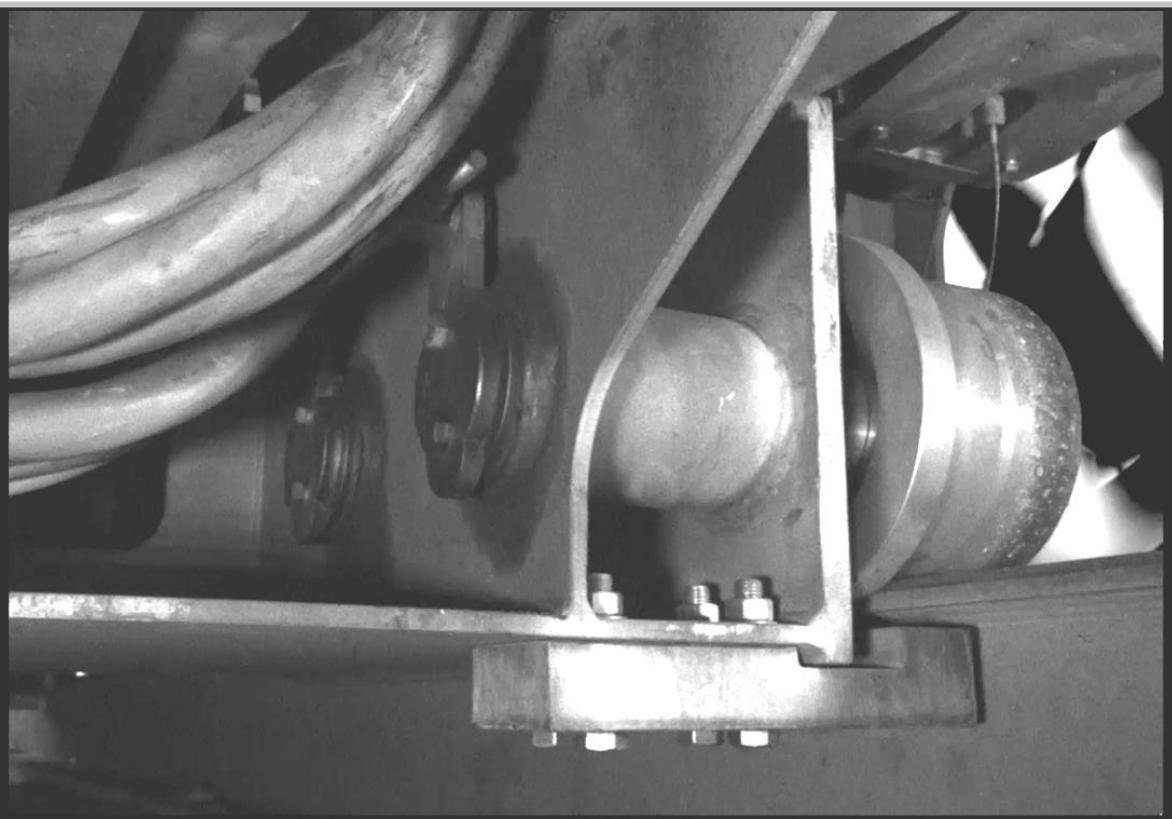
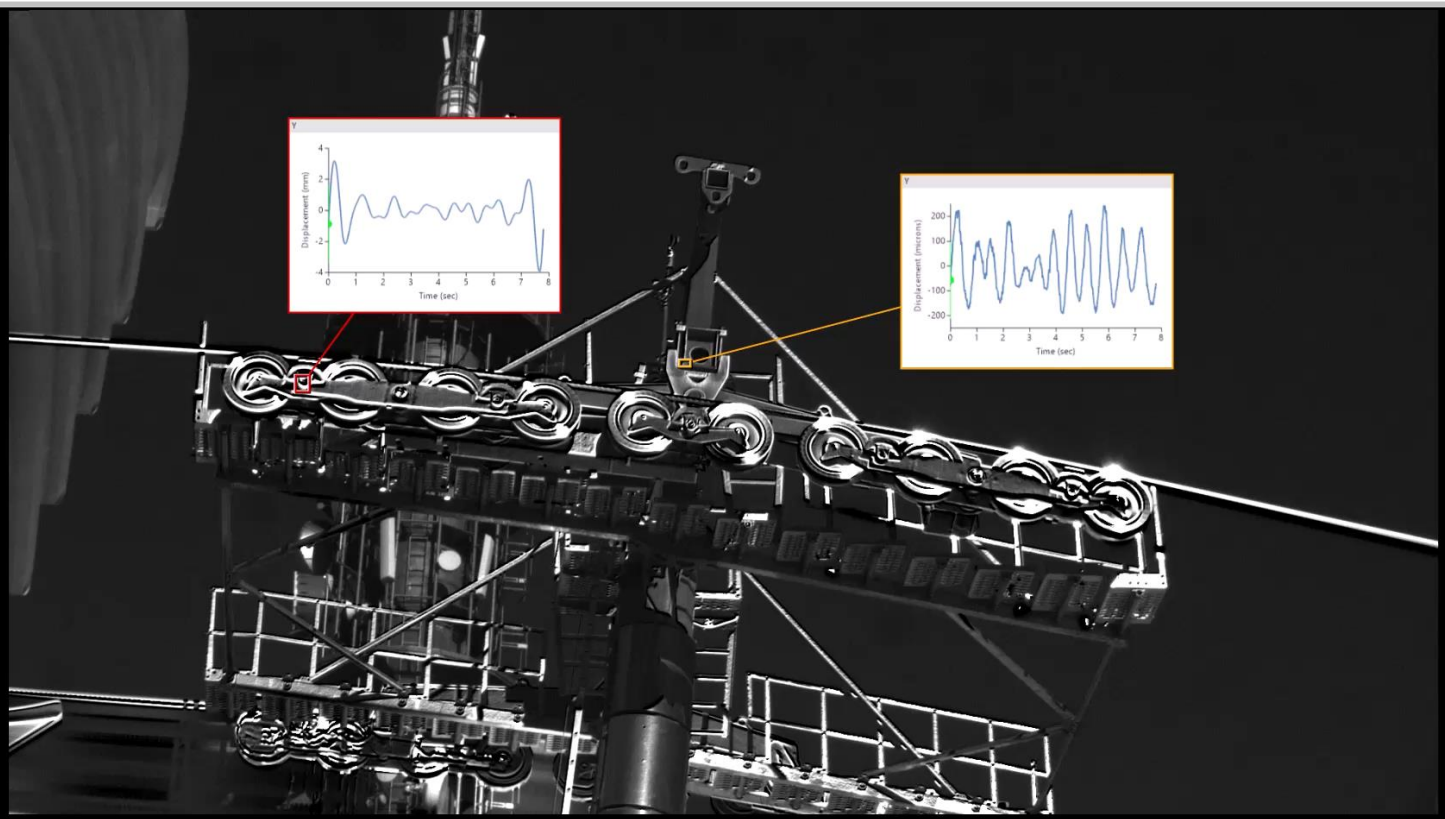
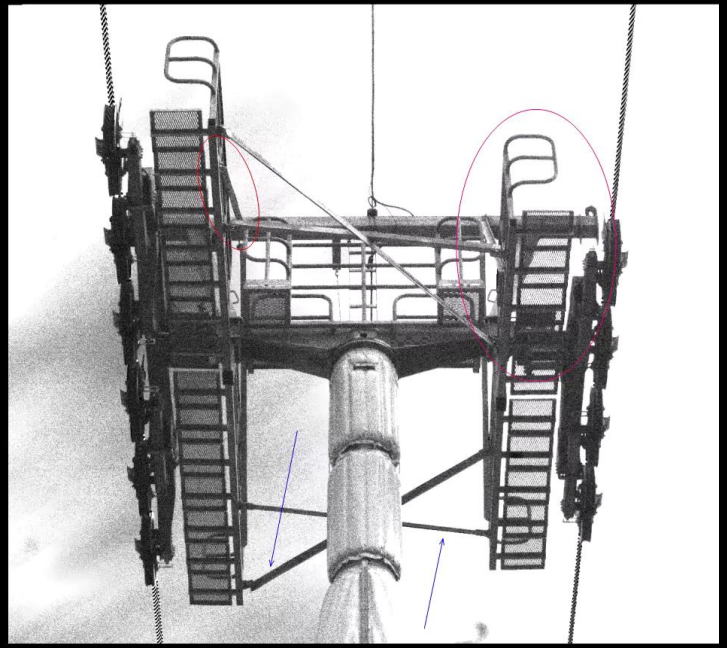

Motion Amplification
Source File: 2019-07-16_21.rdi
File...
Description: Test rampa in discesa
Spectrum Plots
X
Y
Pk-Pk Disp (microns)
Frequency (Hz)
Waveform Plots
Max Pk-Pk: 218.441
Spectrum Start: 22.868 sec
Spectrum End: 25.939 sec
Displacement (microns)
Time (sec)
50
0
4 x
1 fps
29.95


X vs Y
Displacement (microns)
Displacement (microns)
X vs Y
Displacement (microns)
Displacement (microns)
X vs Y
Displacement (microns)
Displacement (microns)




Displacement (mm)
Time (sec)
Displacement (microns)
Time (sec)

Amplification Factor: 500 Playback Speed: 40 fps



HDR Filtered 74.6 Hz

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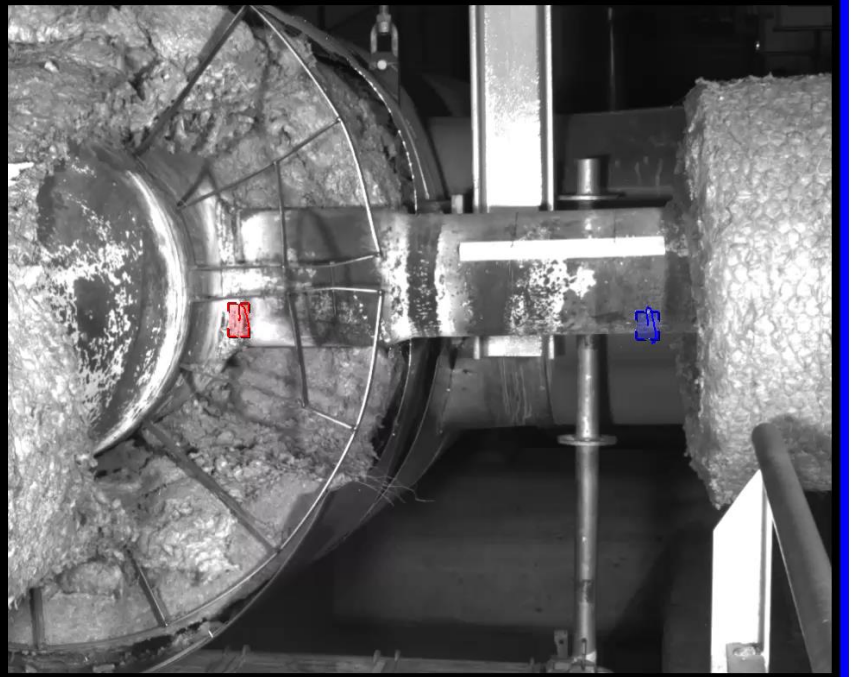
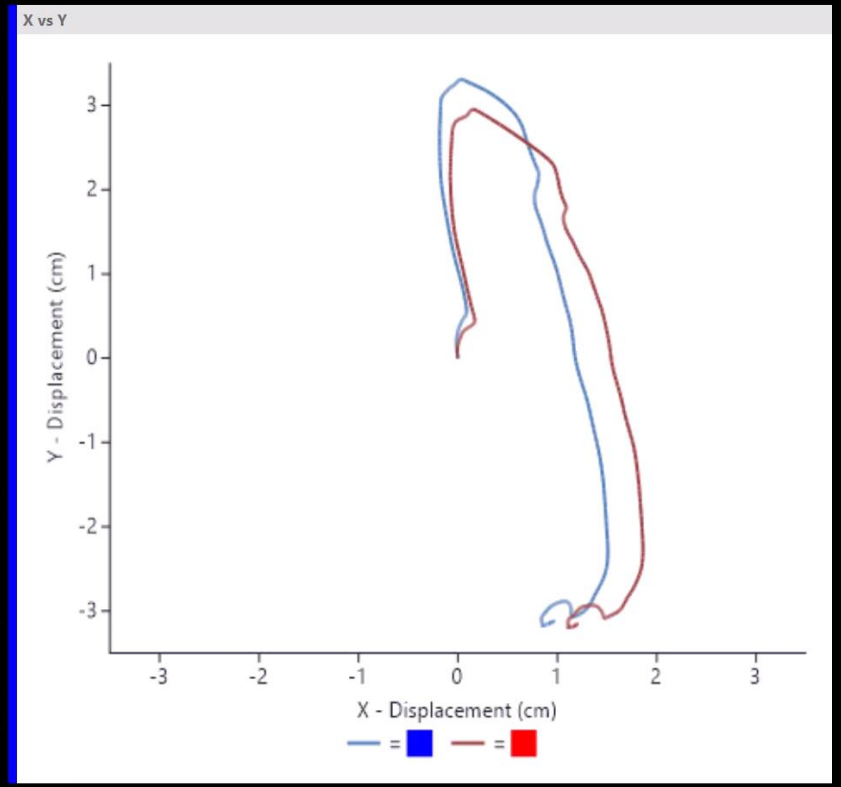
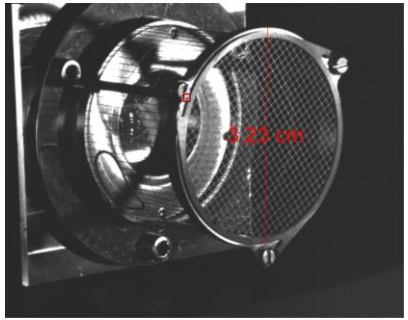
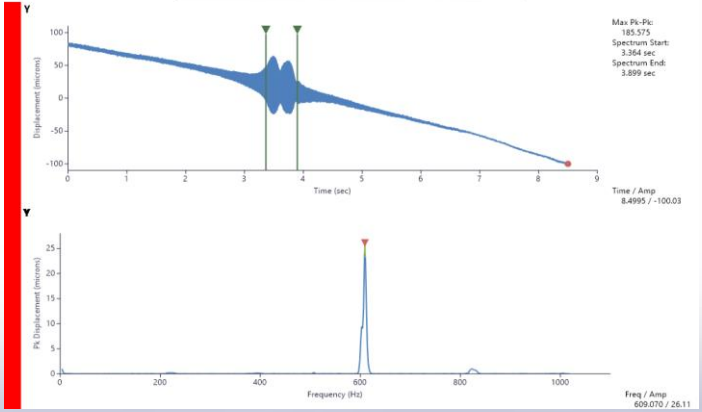
Some difficult or uncommmon analysis



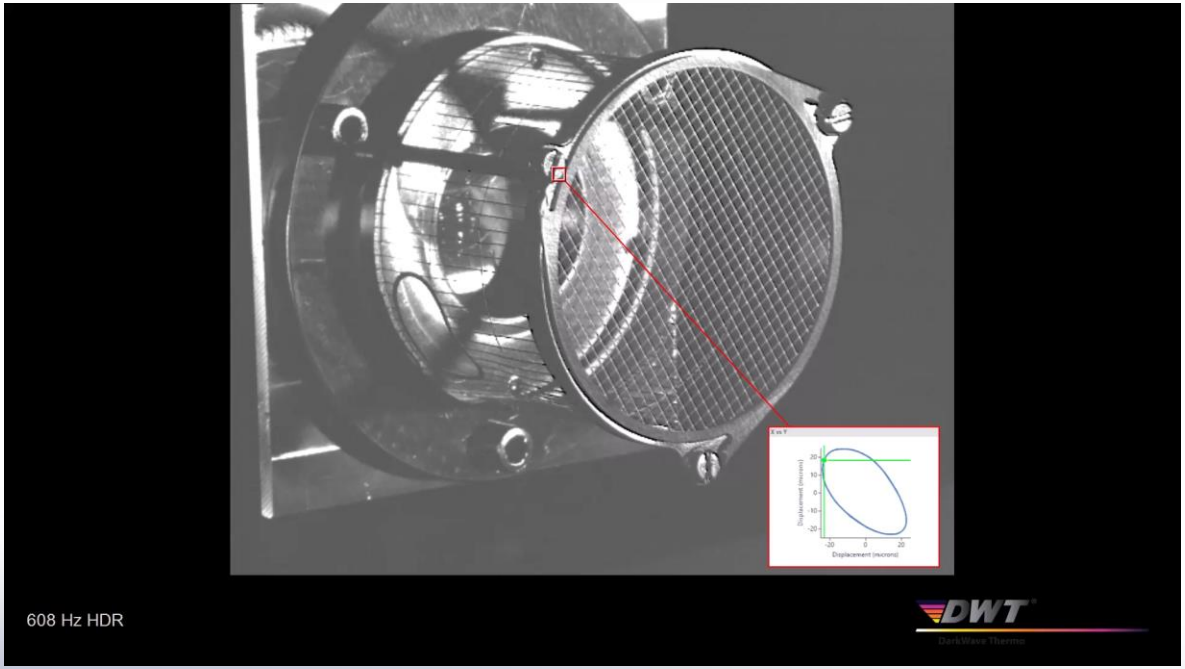


Gas power generation plant: time lapse thermal growth



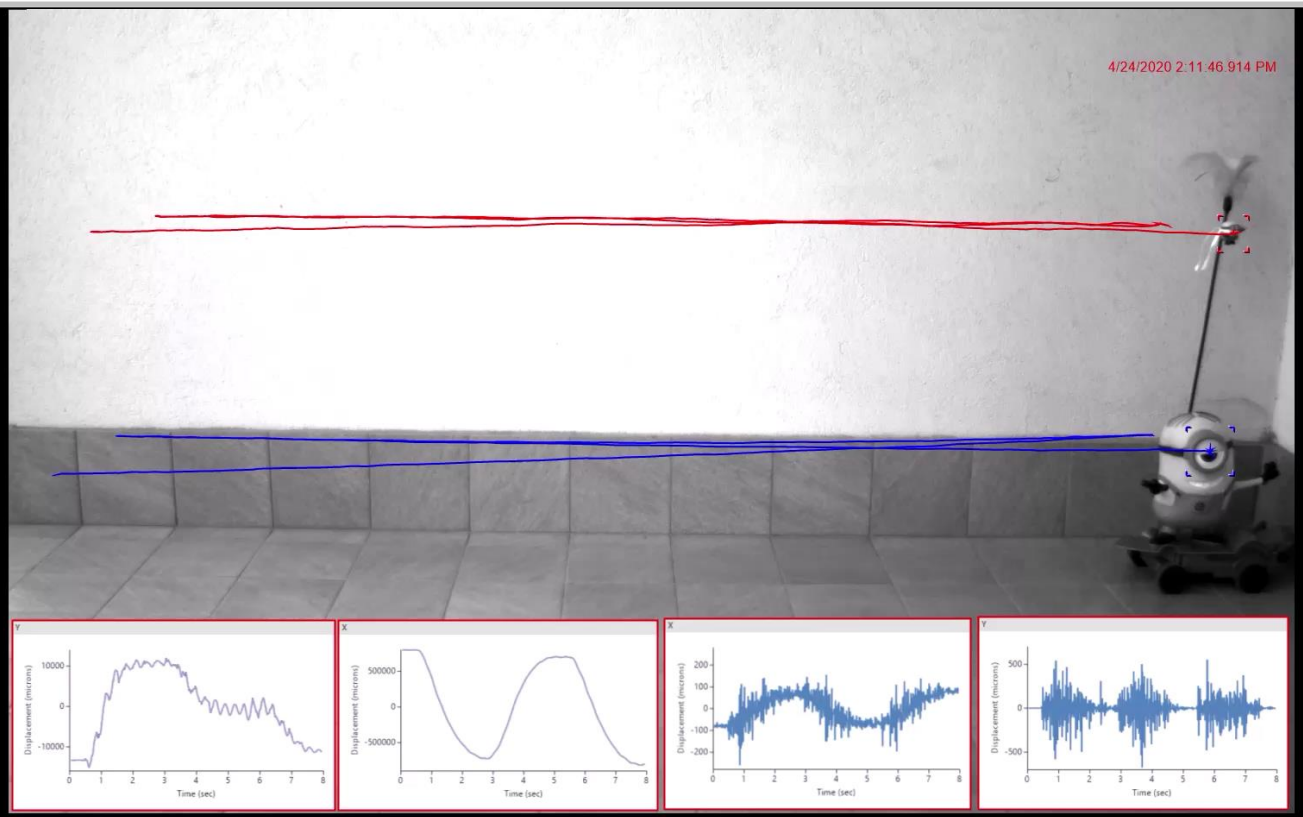


Courtesy of Space Research and Planetology division - University of Bern

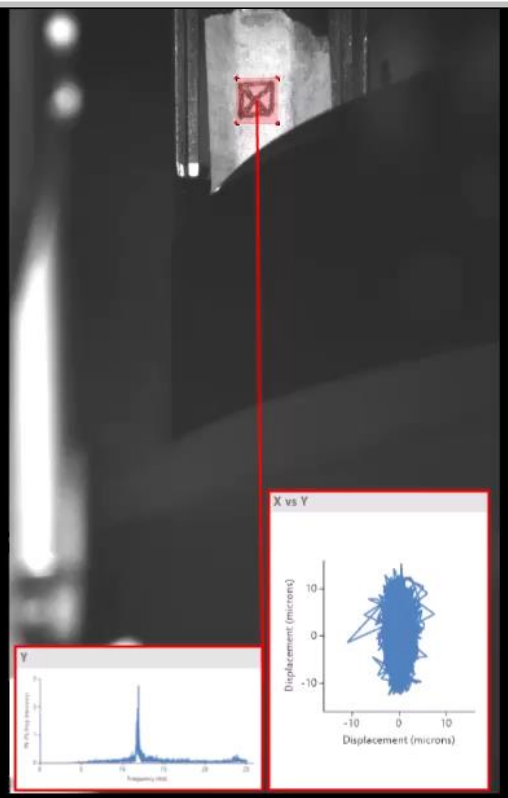


Petrochemical furnace: T air: 980°C – T pipe: 580°C

Transient motion analysis


4/24/2020 2:11:46.914 PM
Y
Displacement (microns)
Time (sec)
X
Displacement (microns)
Time (sec)
X
Displacement (microns)
Time (sec)
Y
Displacement (microns)
Time (sec)

Picture from Emag website

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