Met4Wind

Metrology for enhanced reliability and efficiency of wind energy systems (19ENG07 Met4Wind)

Mechatronics Circus

Thursday 7th April 2022

Aalto University
School of Engineering

Met4Wind

Title: Metrology for enhanced reliability and efficiency of wind energy systems (19ENG07 Met4Wind)
Duration: 3 years (September 2020 – August 2023)
Total budget: 1.97 M€, Aalto 0.34 M€

EMPIR

EURAMET

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

PTB
CZECH METROLOGY INSTITUTE
DFM Danish National Metrology Institute
INRiM ISTITUTO NAZIONALE DI RICERCA METROLOGICA
Newcastle University
VTT
Aalto University School of Engineering
AARHUS UNIVERSITET
DTU
ABB
HEXAGON MANUFACTURING INTELLIGENCE
moventas
NCMT
SKF
Vestas
ZEISS
BGA British Gear Association
Contact Gearing
CMM CLUB
KONECRANES
MCAE
ŠKODA
messtronik
SIEMENS
Finnish Wind Power Association
VATTENFALL
WIND POWER LAB
ZF

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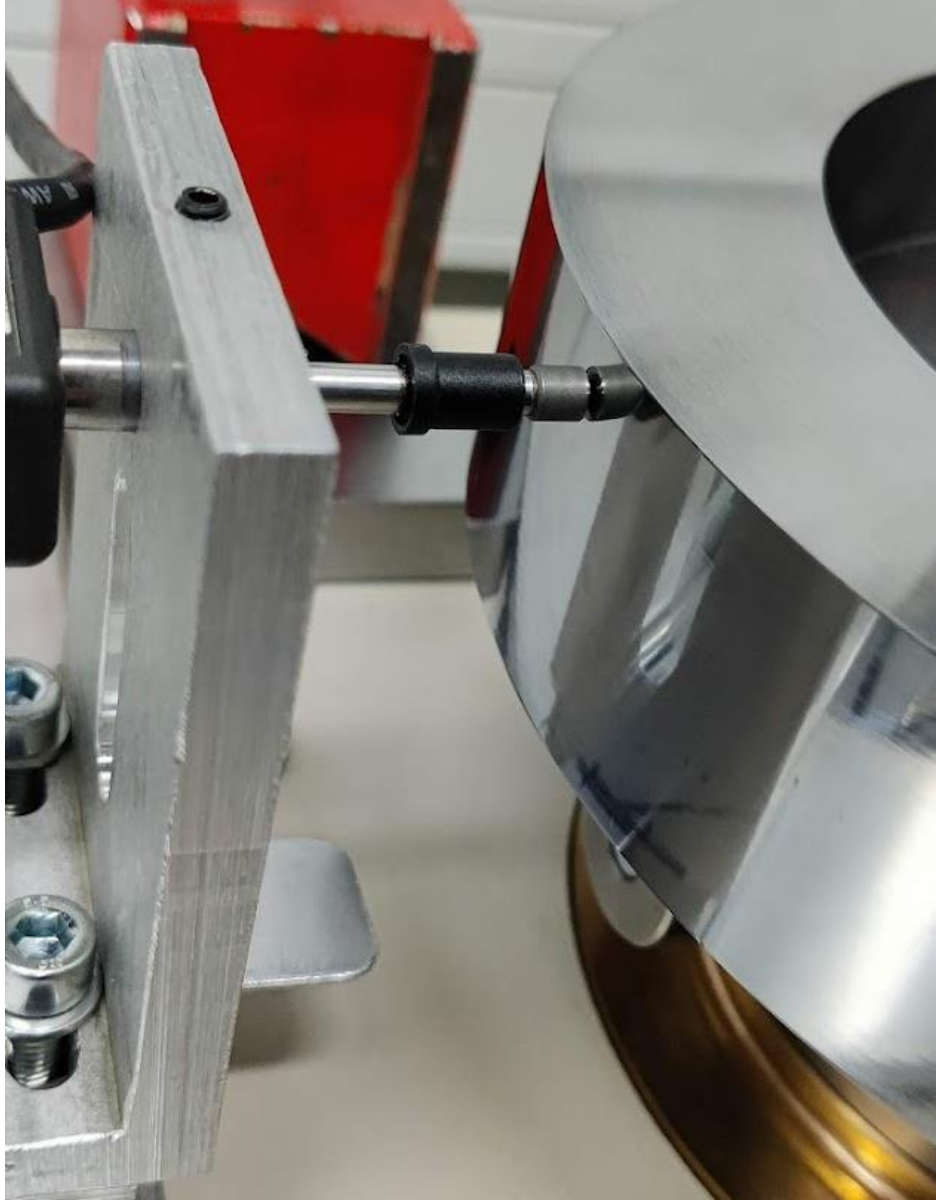
Outline

Met4Wind research highlights:

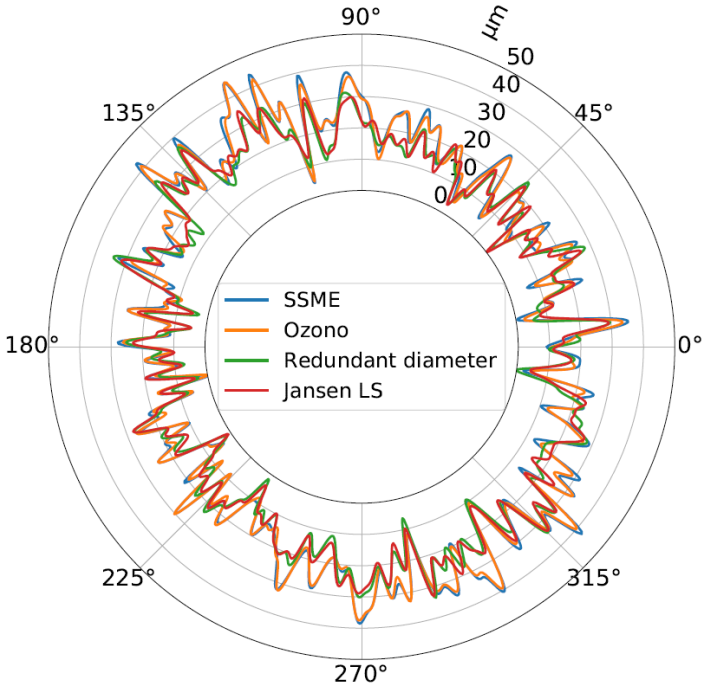
- **Development of roundness measurement procedures**
- **New measurement instruments**
- **Investigation of eddy current probe errors**



Roundness

Deviation of profile from true circle

- **Following definitions in ISO 12181-1:2011**
- **Relative to center point**
- **Peak-to-peak (RONt)**
- **Root-mean-square (RMS)**



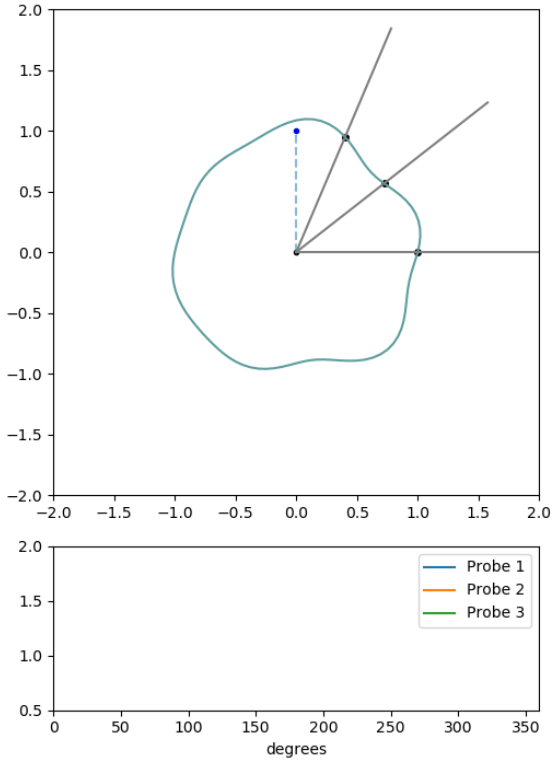
1 µm = 0.001 mm

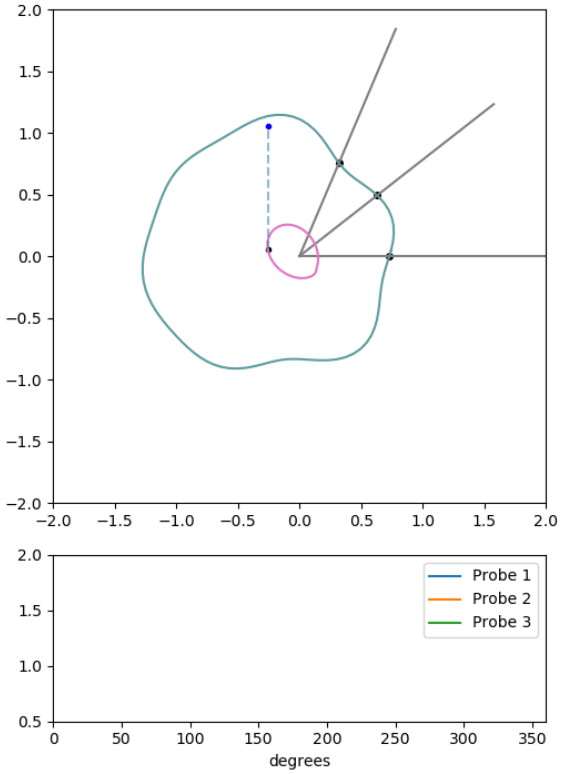
Two types of roundness measurement

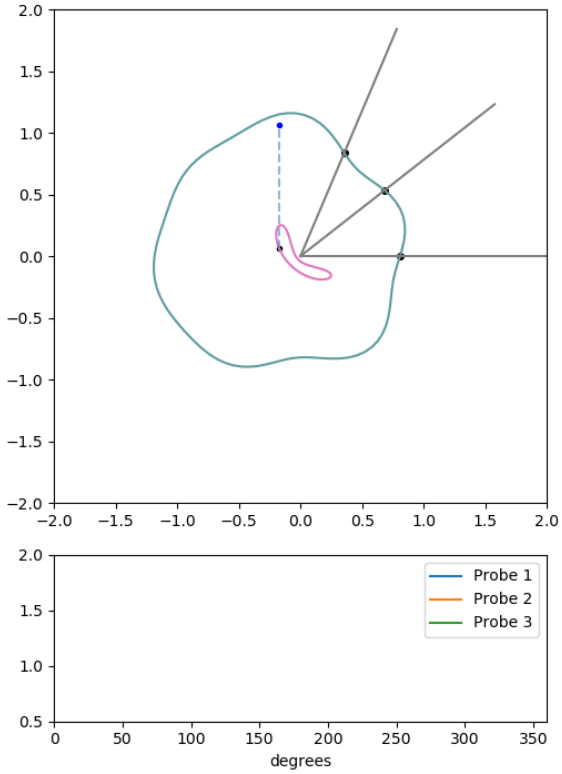
(a)

(b)

Multi-probe roundness measurement







Solve roundness profile and center point movement from multiple measured probe signals.

https://users.aalto.fi/~tiainet2/cpm/cpm.html

New measurement instruments

Simulations

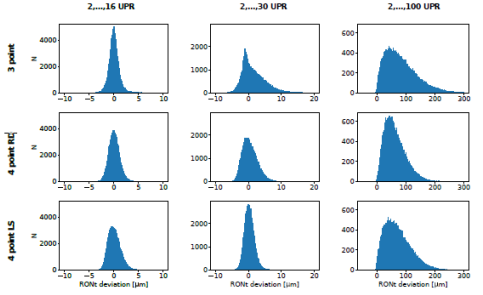
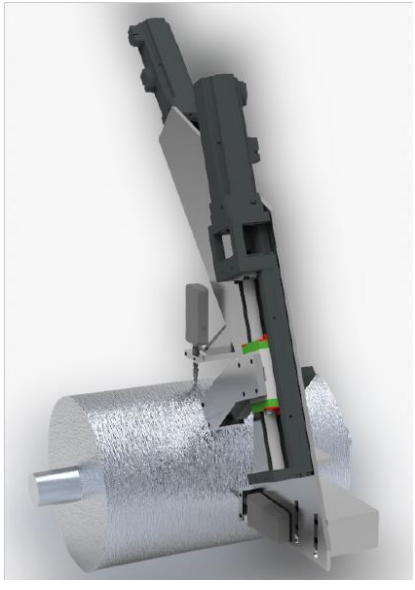
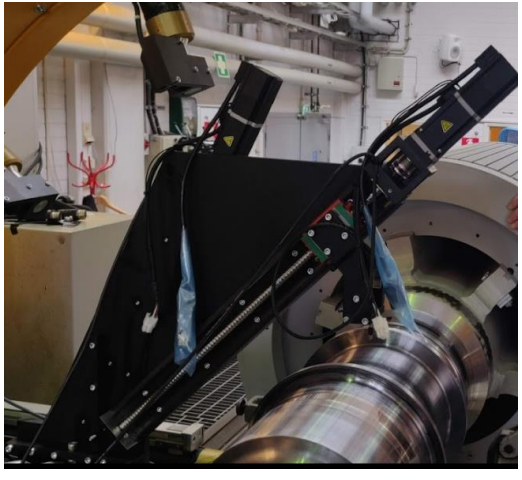


Figure 4.1. Distributions of the calculated peak-to-valley roundness deviation (RONt) values with the investigated methods with different filter levels (ideal band pass filter).

ROMES device

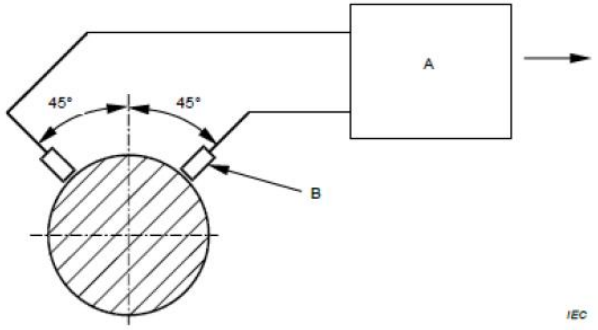


Verification and testing



Measurement of relative shaft displacement

- **Several IEC, API and ISO standards [1]**
- **For condition monitoring, prevent excessive vibration**
- **Eddy current probes specifically required in some standards [1]**



Key
A signal conditioner
B transducer

Figure 5 – Preferred circumferential position of transducers for the measurement of relative shaft displacement

[1] T. Tiainen, R. Viitala, T.P. Holopainen, B. Hemming, Analysis of total rotor runout components with multi-probe roundness measurement method, Measurement, Volume 179, 2021, 109422,ISSN 0263-2241, https://doi.org/10.1016/j.measurement.2021.109422.

Limits defined in standards

API 546: 12.5 µm

2.4.5.1.7 When vibration and/or axial-position probes are furnished, or when provisions for probes are required as described in 3.8, the rotor shaft sensing areas to be observed by the radial probes shall be concentric with the bearing journals. All sensing areas (both radial vibration and axial position) shall be free from stencil and scribe marks or any other surface discontinuity, such as an oil hole or a keyway, for a minimum of one probe-tip diameter plus one half of the total end float on each side of the probe. These areas shall not be metalized, sleeved, or plated. The final surface finish shall be a maximum of 0.8 µm (32 µin.) R_a, preferably obtained by honing or burnishing. These areas shall be properly demagnetized to the levels specified in API 670 or otherwise treated so that the combined total electrical and mechanical runout does not exceed the following when measured in accordance with 4.3.3.1.

a) For areas to be observed by radial vibration probes, 25 % of the allowed unfiltered peak-to-peak vibration amplitude or 6.4 µm (0.25 mils), whichever is greater.

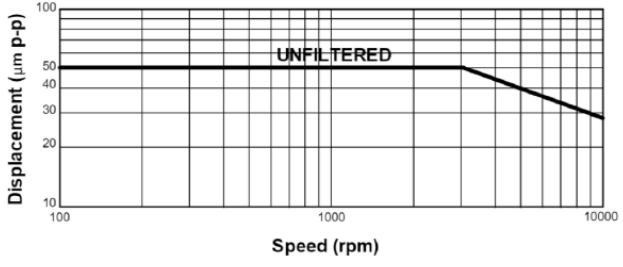


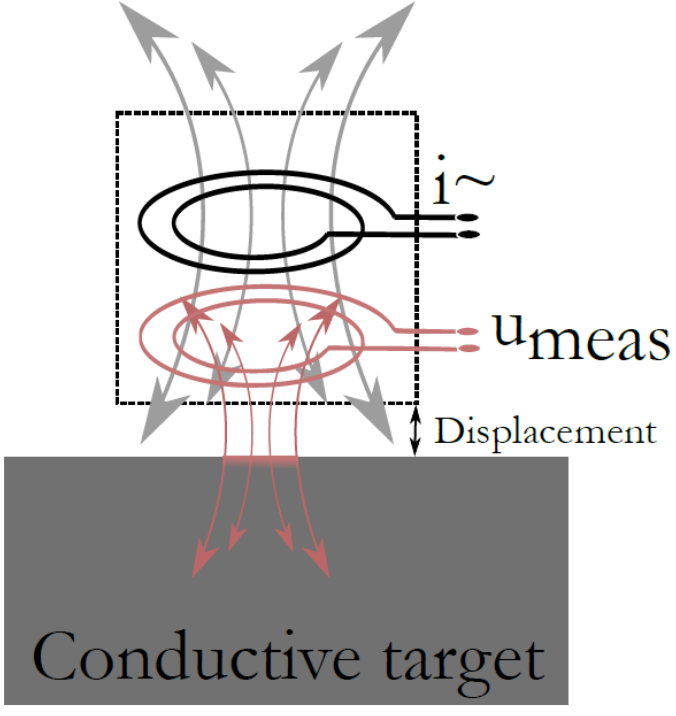
Figure 2—Shaft Vibration Limits (Metric Units, Relative to Bearing Housing Using Non-contact Vibration Probes) for All Hydrodynamic Sleeve Bearing Machines with the Machine Securely Fastened to a Massive Foundation

Eddy current probe errors

Measured signal is affected by:

- **Displacement ←**
- **Changes in surface roughness**
- **Resistivity of surface**
- **Magnetic permeability**
- **Something else?**

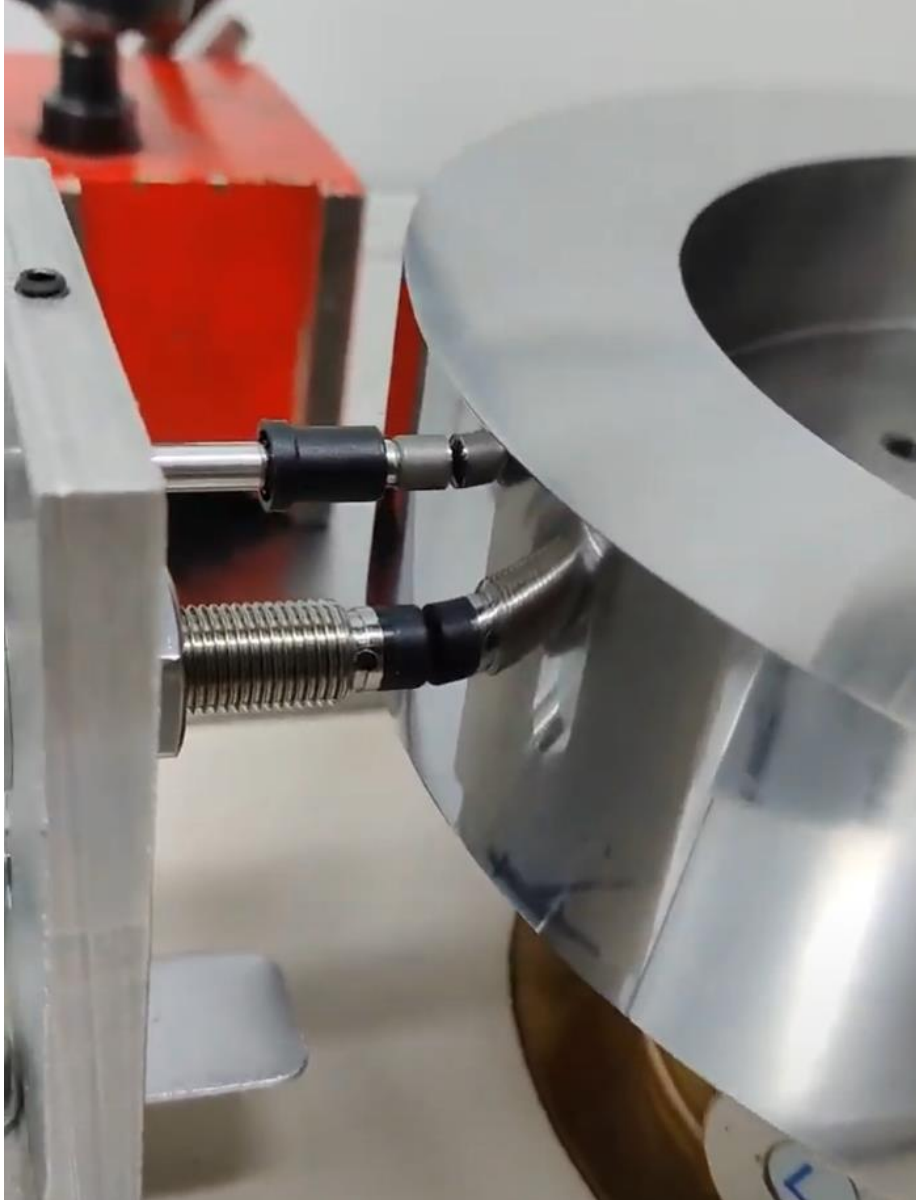
Eddy current probe error is called electrical runout in standards.



Eddy current probe errors

Investigation with test specimens:

- **Test setup with simultaneous tactile and eddy current measurement**
- **Measure various surface properties**
- **Test manufacturing methods and heat treatments to reduce error**

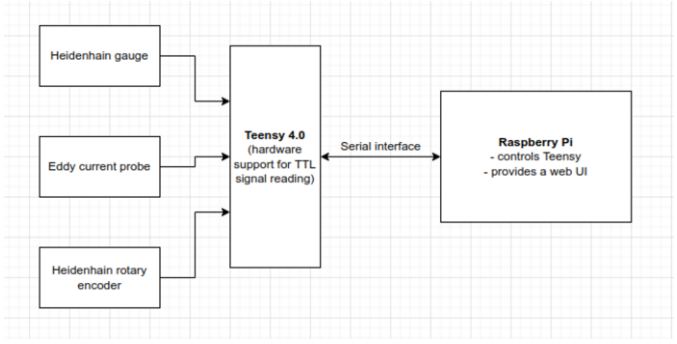


Electrical runout analyzer

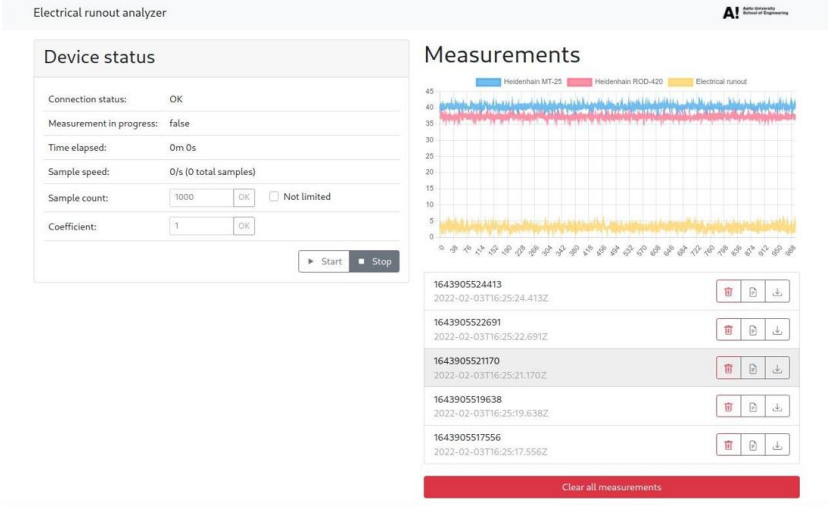
Measurement device for electrical runout data collection

Simultaneous measurement with tactile probe and eddy current sensor

- **Convenient measurement of electrical runout**



Browser interface with WebSocket



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