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Electromagnetic solutions

Non destructive measurement of thickness by eddy current technique

Application to difficult cases: measurement of tube thickness and additive manufactured pieces

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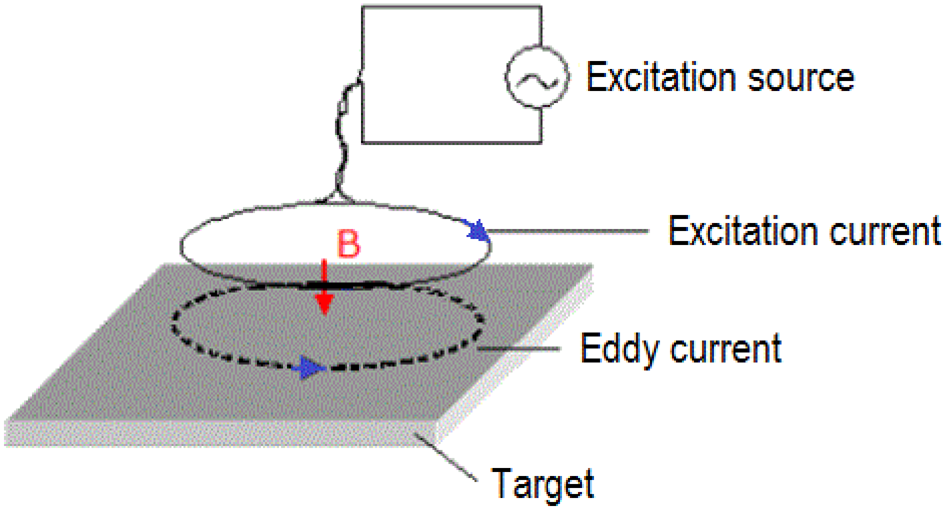
How to measure thickness ?

- Classical methods: using the caliper
- Non destructives methods
  - Ultrasounds $\Rightarrow$ works well on thick wall, requiring coupling liquid
  - Ionizing radiation (X, γ) $\Rightarrow$ dangerous, expensive
- And now: **multi-frequency eddy current**
  - works well on thin wall, complementary to ultrasounds
  - no coupling liquid, rapid, easy to deploy
  - **A green testing method !**

The working principle of eddy current NDT

- Electromagnetic method, no liquid coupling required
- Works well for low thickness (few mm)
- Conductive materials only: metals, graphite, carbon composite (CFRP).

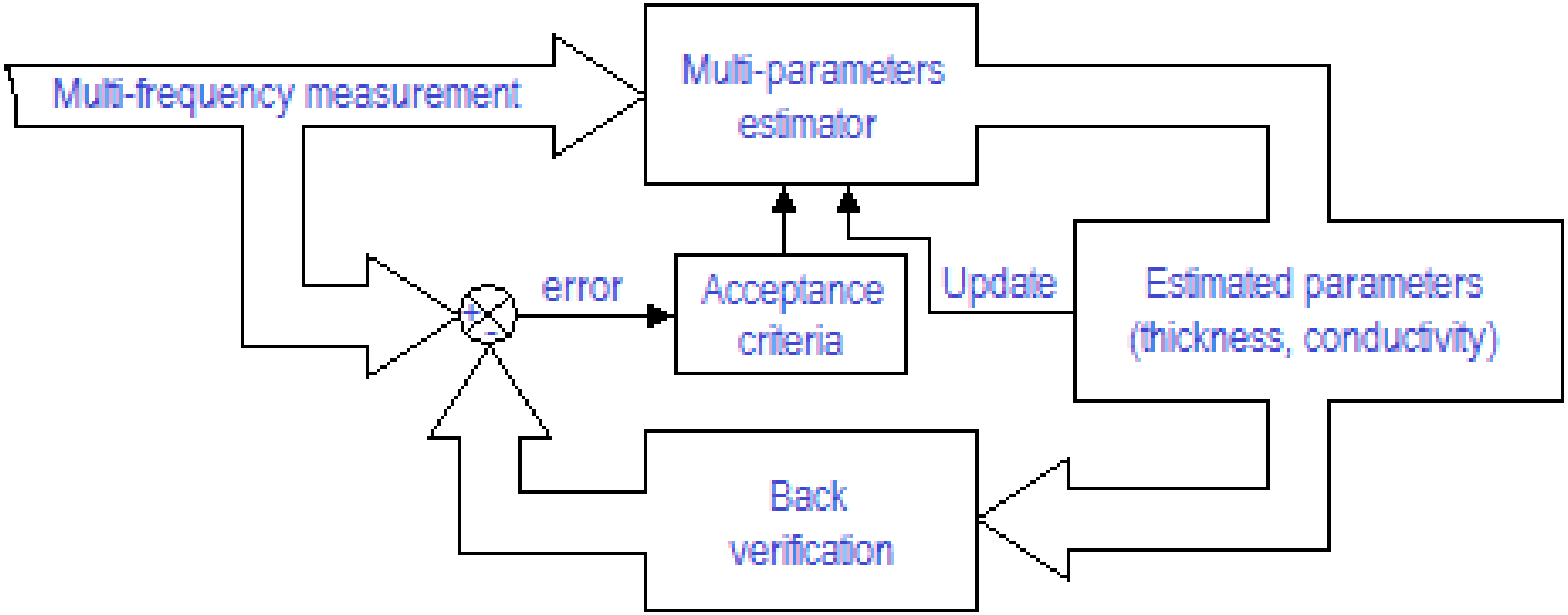


Eddy current testing, what's new?

- Well-known technique invented in the 19th century
- Main applications:
  - Detection of flaws, materials sorting
  - Thickness measurement required calibration
  - Susceptible to material change, to lift-off variation
  - New material $\Rightarrow$ new calibration $\Rightarrow$ time lost, high cost of calibration standards
- **New: multi-frequency eddy current**
  - **Self adaptive to material change**
  - **Good accuracy for thin wall**
  - **Easy to deploy (hand-held probe, surface preparation not required)**

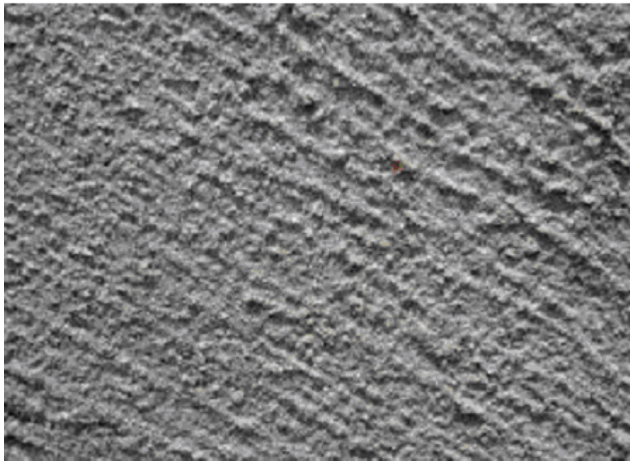
How it works?

- Multi-frequency technique , rich in information
- Advanced analysis of signal based on mathematical computer model

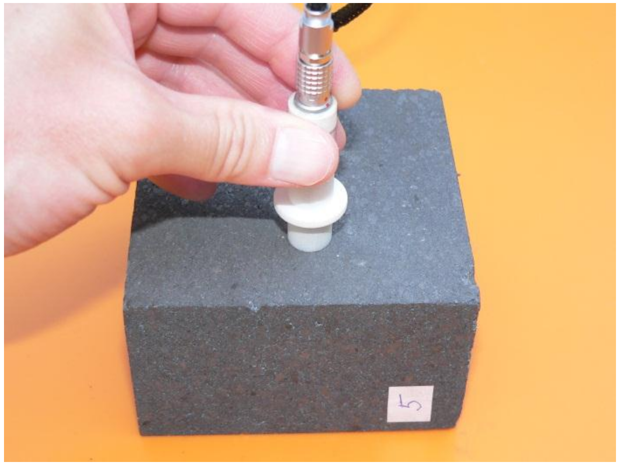


Advantages of the multi-frequency eddy current method

- Works well on thin walls, complementary to the ultrasound method
- Works on rough surfaces
- Works on additive manufactured pieces (DLMS)
- Good tolerance with respect to lift-off and material conductivity variation
- Calibration on 1 point only



A rough surface of a piece issued from DLMS

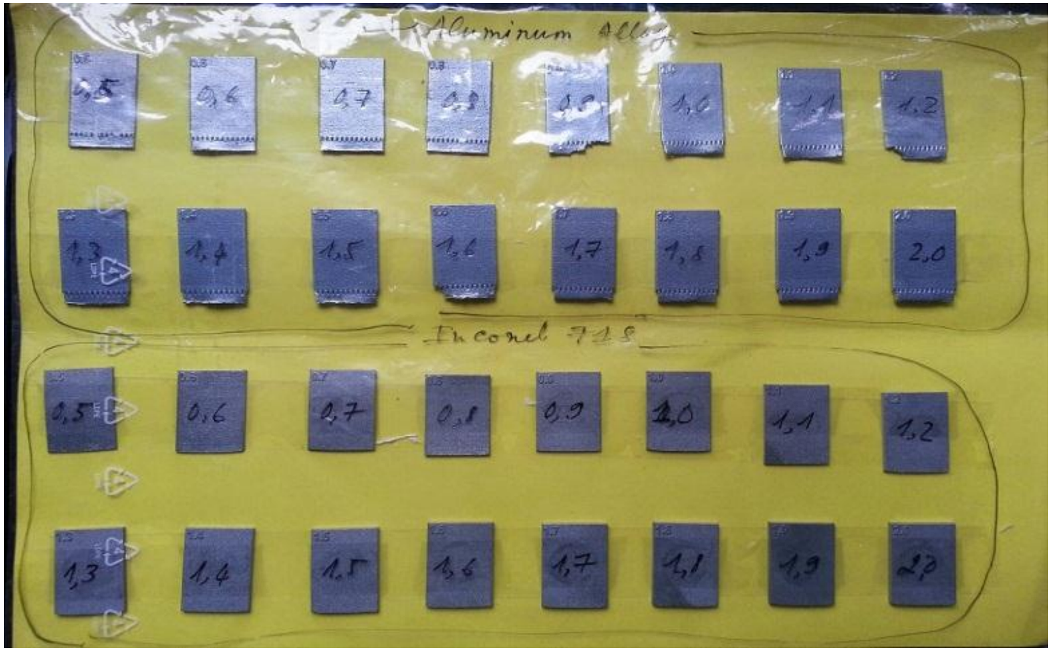


Manual testing on a rough surface

Performances of the technique

Case #1 : measurement of thickness of pieces issued from the additive manufacturing

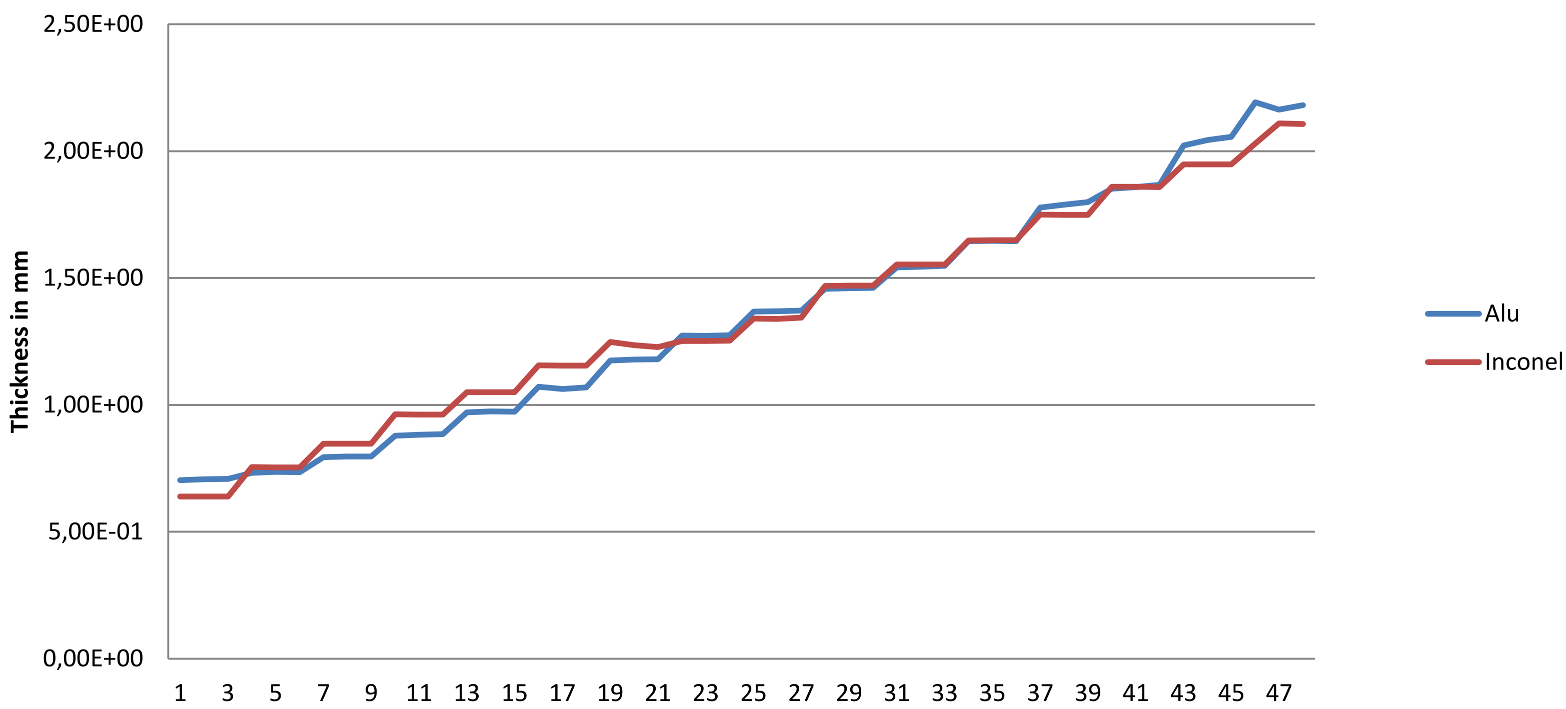
- Small plates made by additive manufacturing (DMLS).
  Materials: aluminum and Inconel 718.
- Nominal thickness: from 0.5 mm to 2.0 mm by 0.1 mm steps
- Real thickness: 0.1 mm tolerance due to the manufacturing process



Performances of the technique

Measurement of thickness of pieces issued from additive manufacturing

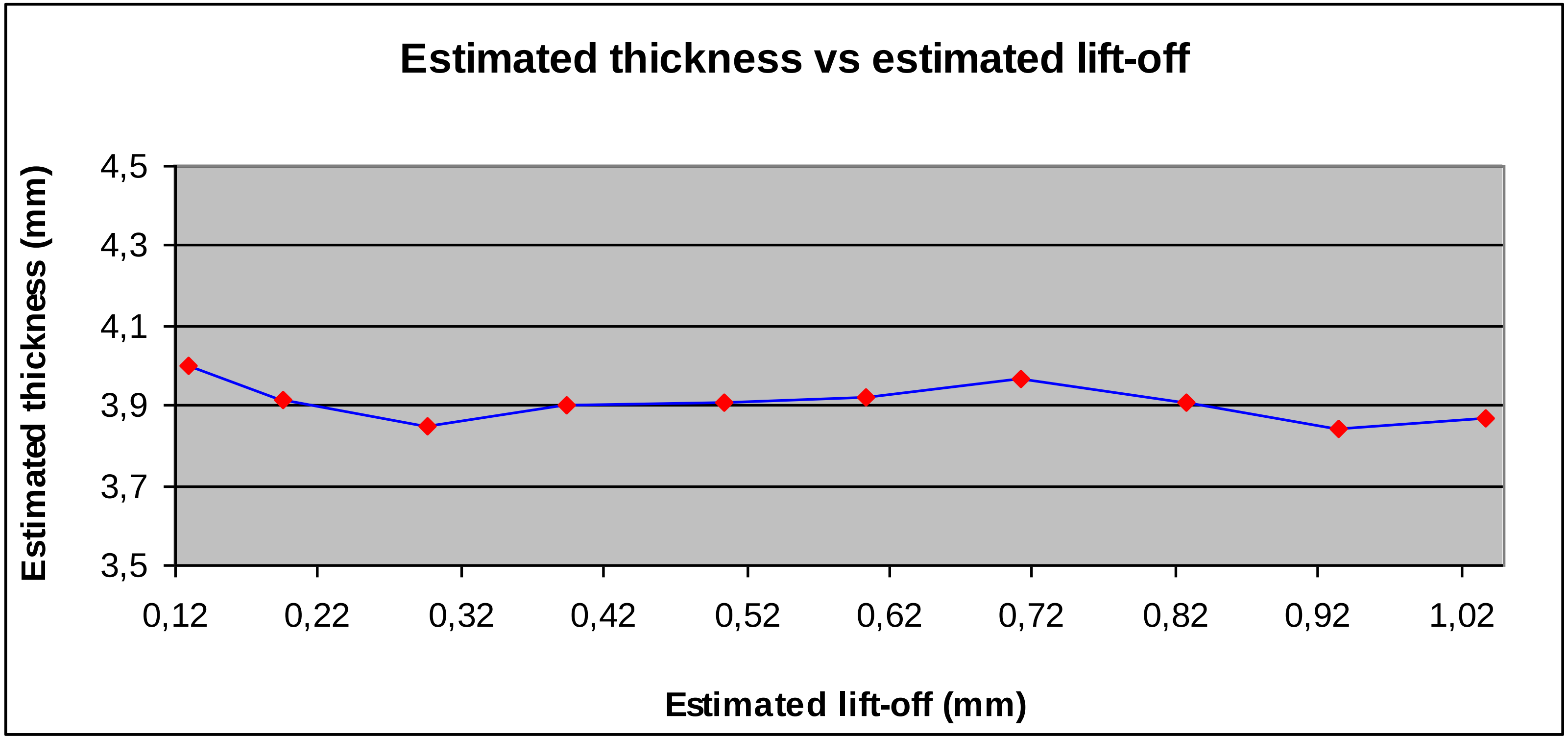
Measurement of pieces manufactured by additive method in aluminum alloy and Inconel 718



Pieces manufactured by modern additive methods often have a rough aspect and a granular internal structure. Ultrasound users experience inaccuracies when measuring their thickness. The eddy current measurement allows to quickly determine the real thickness of the pieces with more accuracy.

Performances of the technique

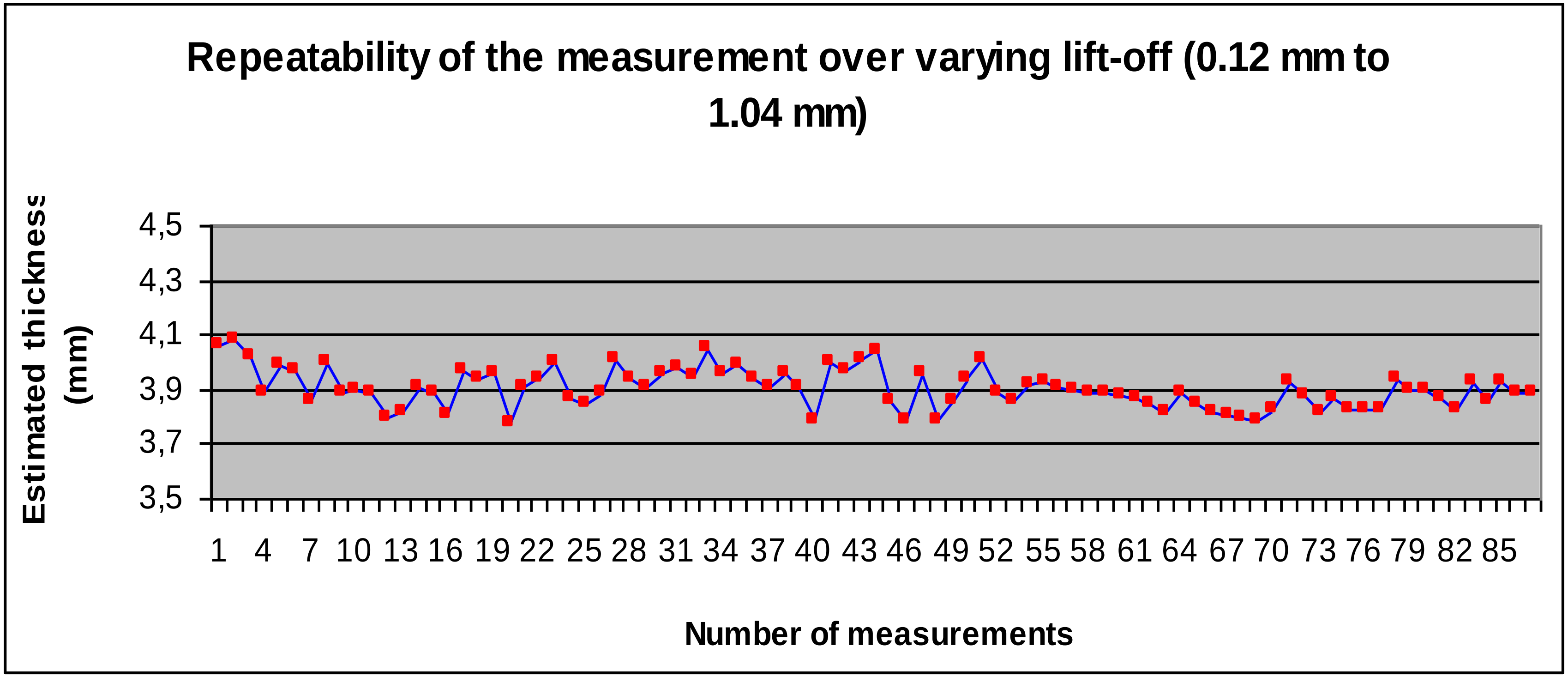
Case #2: measurement of thick plates in high conductivity alloy (aluminum 2024 alloy)



Eddy current thickness measurement on a 2024 aluminum alloy plate of 3.9 mm thick, with a lift-off varying between 0.1 mm and 1 mm. The lift-off is also measured at the same time.

Performance

of the measurement on aluminum 2024 plate



Repeatability of the thickness measurement over 88 lift-off values (from 0.12 mm to 1.04 mm).

The mean thickness value over the 88 measurements is 3.903 mm

Performance of the technique

Case #3 : measurement of thickness of titanium tube

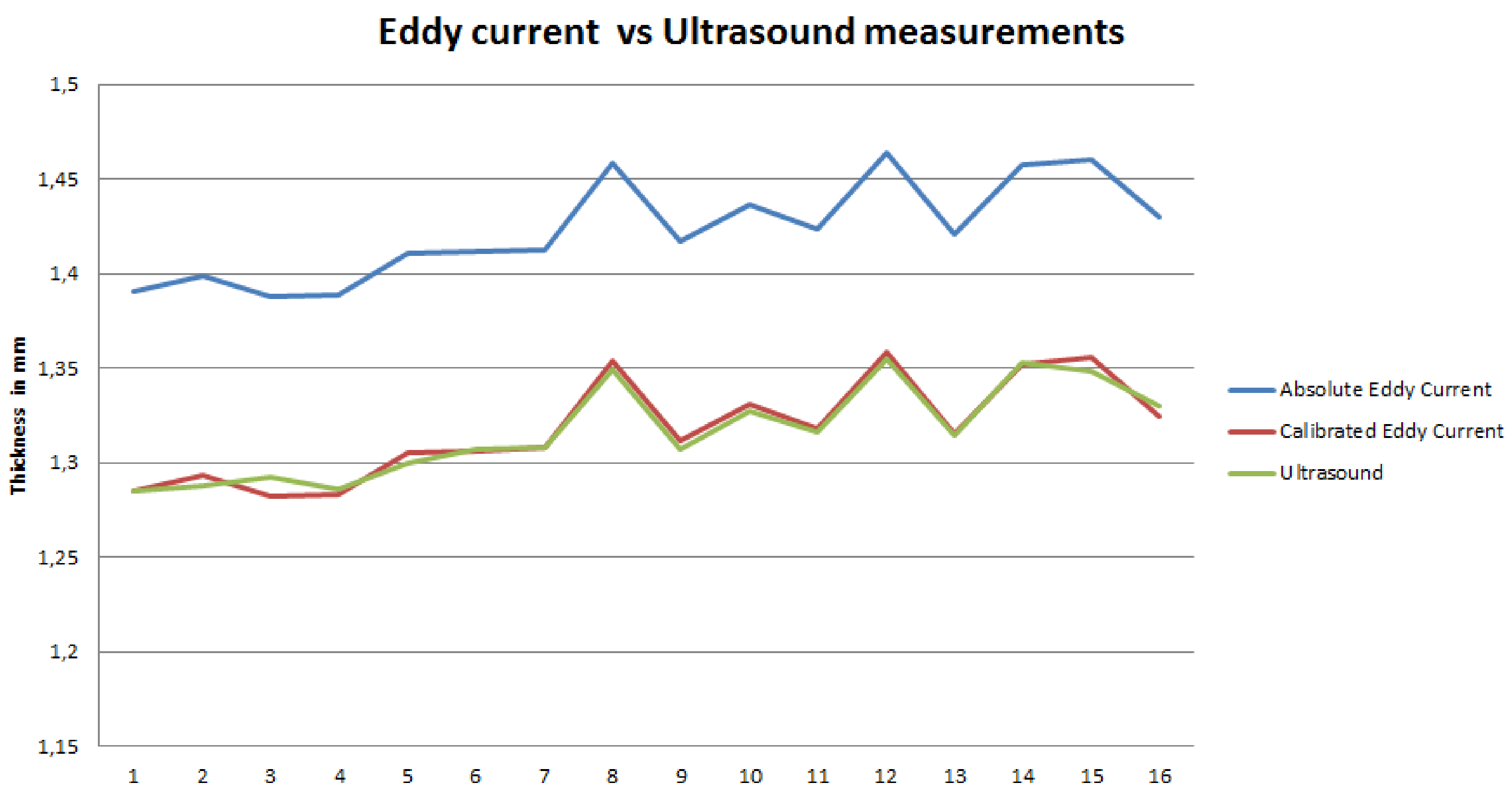
Determination of the thickness on 4 generatrices of a tube in titanium

- Goal: to determine the eccentricity of the tube in order to predict the elastic return when bending
- The measurement can be carried out by hand, from the OD of the tube

Performances of the technique

comparison with the ultrasound method

- Below: measurement result on a tube, The ultrasound measurement (green, using an Olympus DL35) is calibrated. The absolue eddy current measurement (blue) is not calibrated.
- With calibration on 1 point, the eddy current and ultrasound methods are nearly identical



Conclusion

- **Multi-frequency Eddy current**
  - Easy to deploy, coupling not required
  - Good tolerance to lift-off, material changes
  - Well suited for additive manufacturing products
  - Good accuracy for thin walls
- **Ultrasound**
  - Good accuracy for thick walls
  - May not work on rough surfaces or granular internal structures like that of additive manufacturing products

For more details

- [Web](http://www.sciensoria.fr)
  - http://www.sciensoria.fr
  - http://www.sciensoria.com
- Demonstration videos on Youtube
  - http://youtu.be/WC5suY4gcqU
  - http://youtu.be/CN5WH1Tl9ps
  - https://youtu.be/bUlzhF82AQU
  - https://youtu.be/Iv8TCL5uVvY