WEIGHT REDUCTION OF CAST METAL COMPONENTS THROUGH SENSOR INTEGRATION

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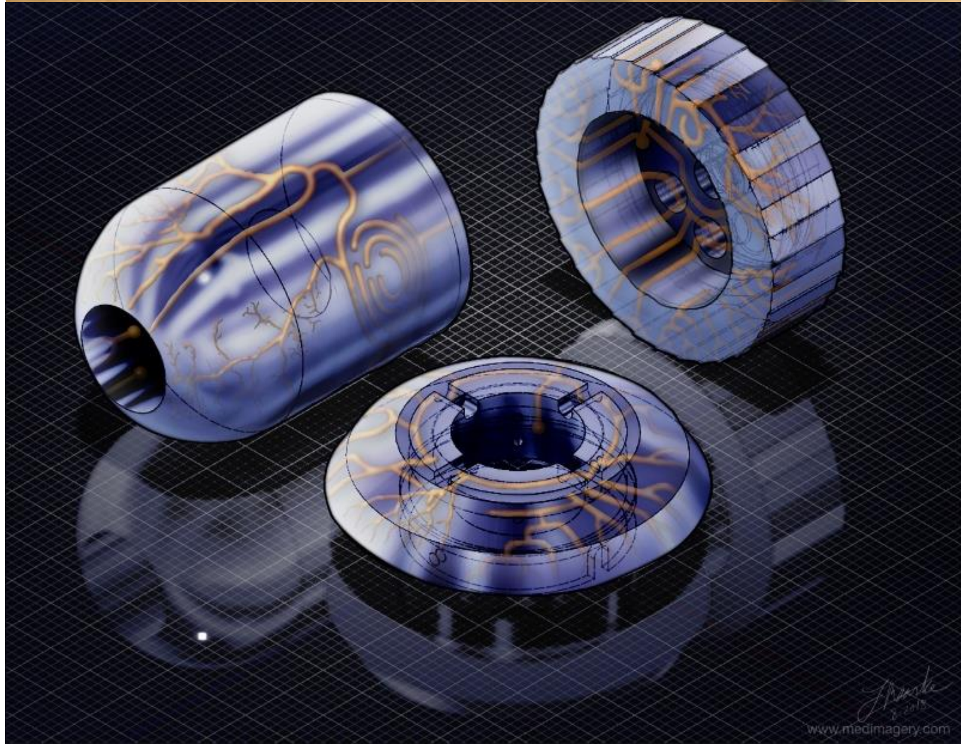

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Material and Production Processes

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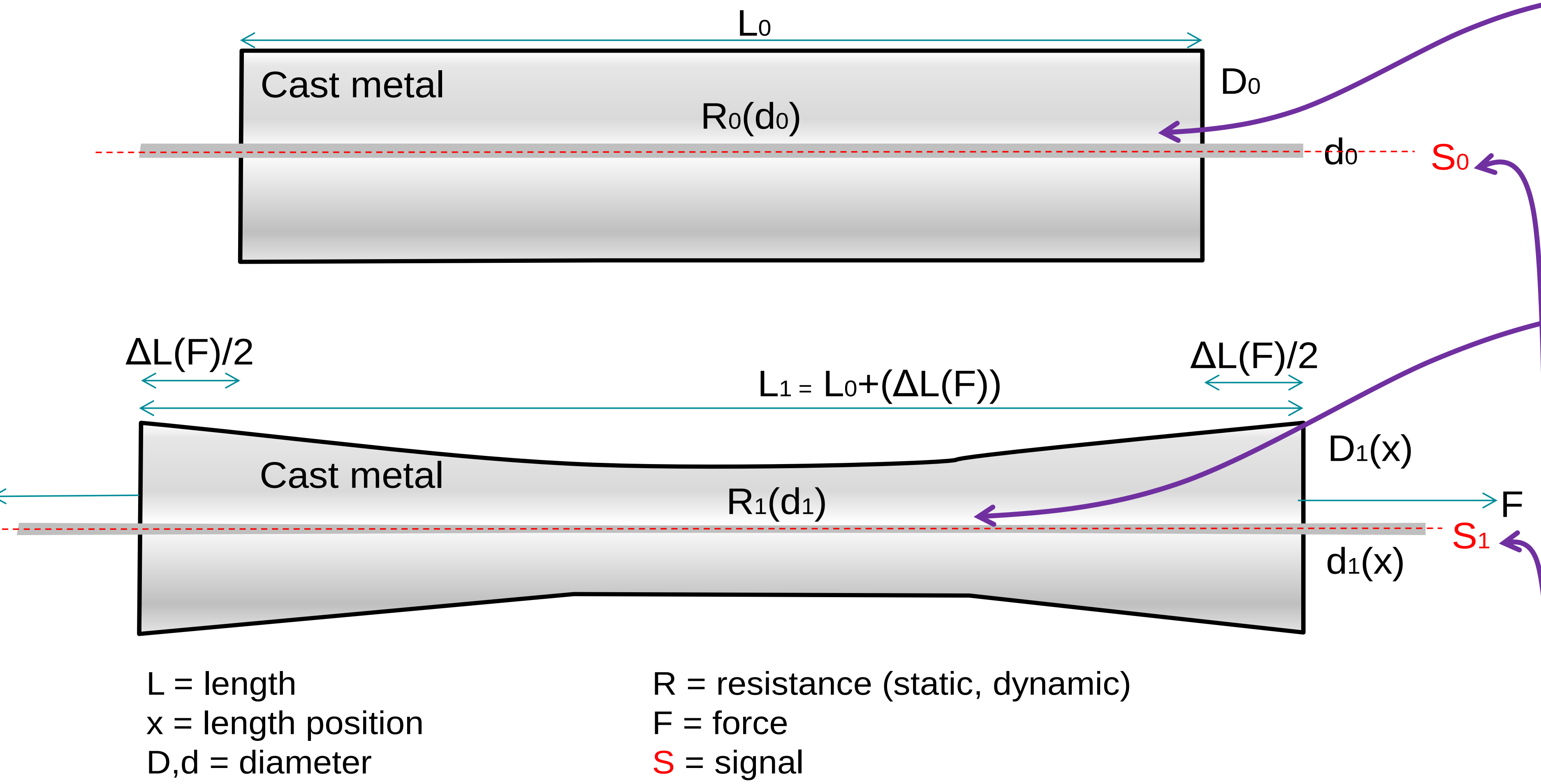
Sensor integration – an alternative way to achieve weight reduction

- With active sensing it is possible to control the load on a component, allowing for lighter components either using thinner walls or different materials

So, how the do we integrate sensors into cast metal?

Initial hypothesis



1. A signal carrying wire may be added during metal casting ca 600C - 1500C .

2. Force (or other physical disturbance) impacts also such a metal-embedded wire.

3. Changes in the signal read through the wire will reflect the physical disturbance to the cast metal.

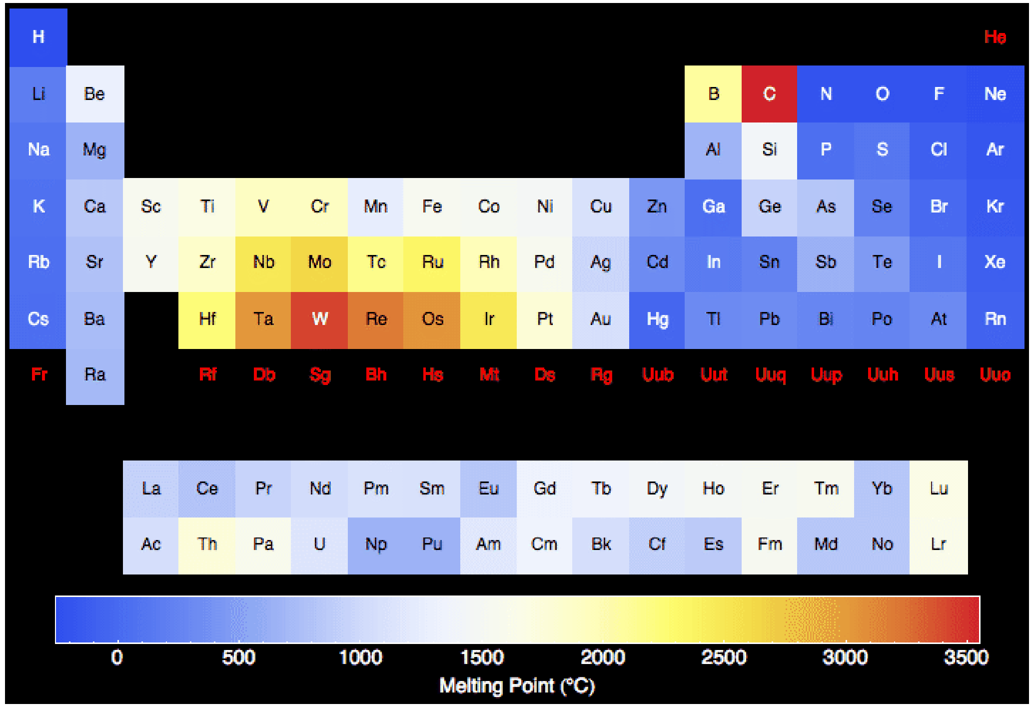
Why integrated sensors?

Possible advantages compared to other sensor types

- More robust adherence to the component
- Better protection from harsh conditions
- More informative signals
  - increased sensitivity
  - possibility to measure e.g., gradients (temperature etc.)

Challenges

- Finding the right material combinations
  - high melting point needed for sensor materials
  - mechanical properties should match with casting material
- Extracting the signal
  - physical connection
    - must be able to survive machining
  - wireless connection
    - interference from surrounding metal



Integrating connector/signal carrier materials into cast iron: experimental setup

L. Elmquist, R. Carlsson, C. Johansson, *Cast Iron Components with Intelligence, Materials Science Forum*, Vol. 925, pp. 512-519, 2018

Connector/signal carrier materials used:

Material	Thickness [mm]
Quartz (SiO_2) tube	2.5
Alumina (Al_2O_3) tube	2.5
Titanium wire	0.5
Tungsten wire	0.7
316L Stainless steel wire	0.16
Kanthal wire (FeCrAl-alloy)	0.8 x 0.1 flat ribbon

Irons used:

- Ductile iron
- Grey iron

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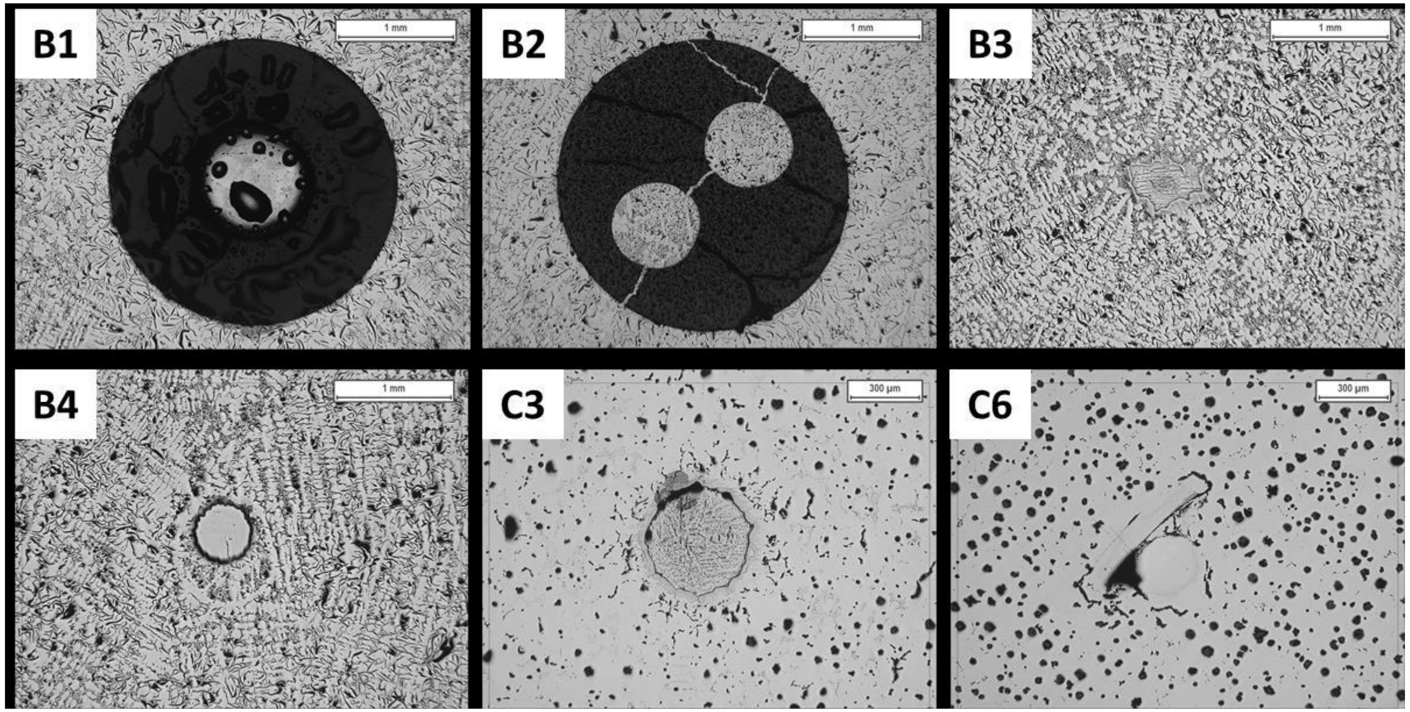
Quartz tube in grey iron

Alumina tube in grey

Titanium wire in grey iron



Tungsten wire in grey iron

Titanium wire in ductile iron

Kanthal ribbon (FeCrAl-alloy) in lamellar iron

Tensile tests of sensor equipped cast aluminum and iron beams

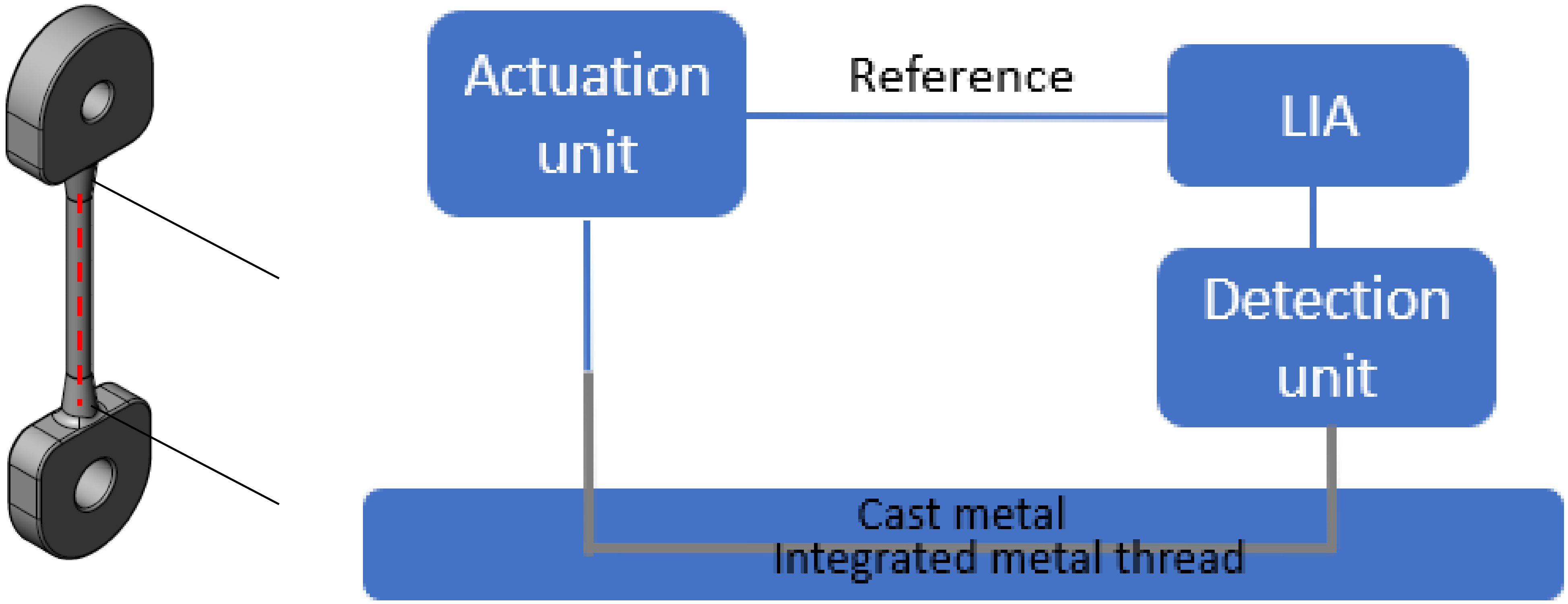
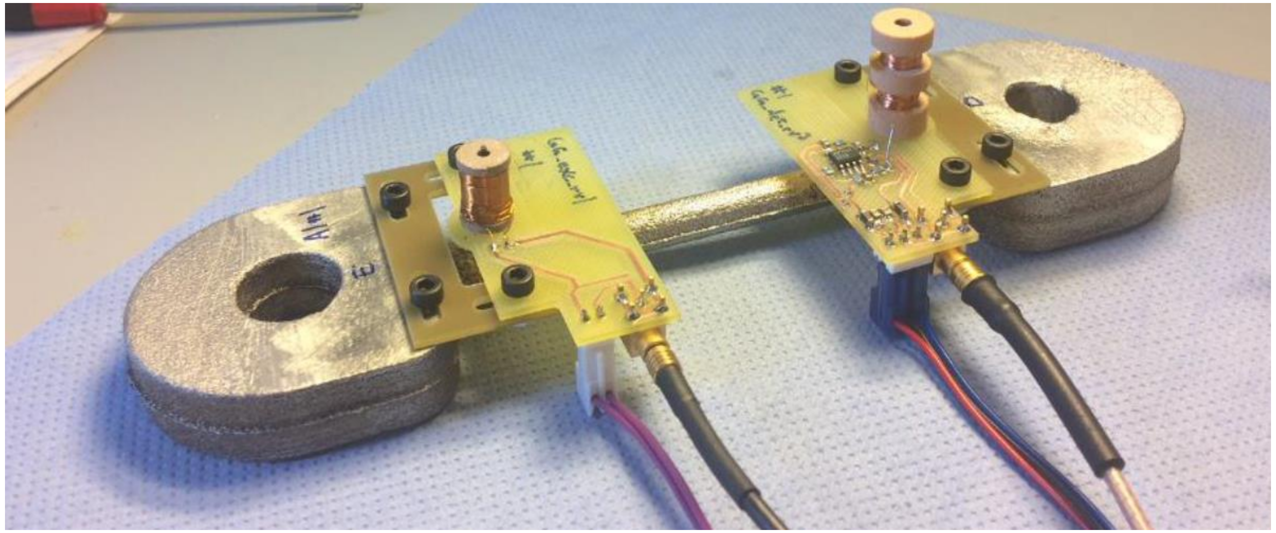
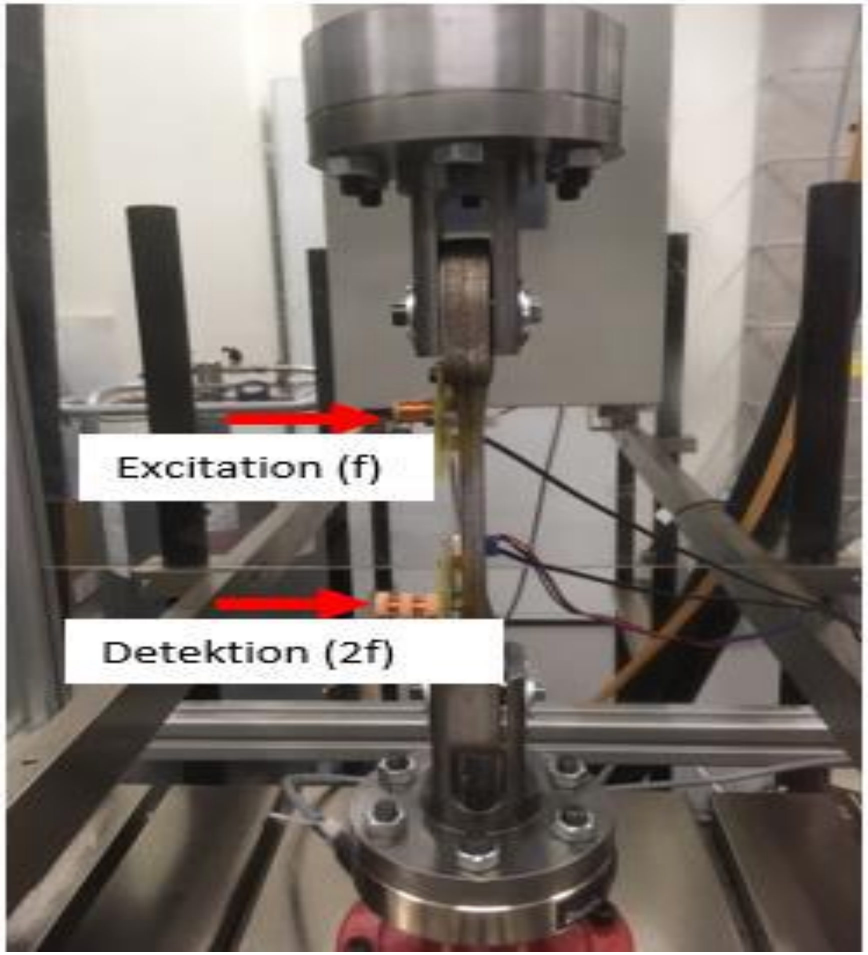


Figure 2: The different parts in the meaurement unit to actuate and sense the oscillations of the interagted metal wire. The actuation unit and the lock-in-amplifier (LIA) are all controlled by a computer (Labview pogram).

Tensile tests of sensor equipped cast aluminum and iron beams





Results: Oscillation versus excitation frequency

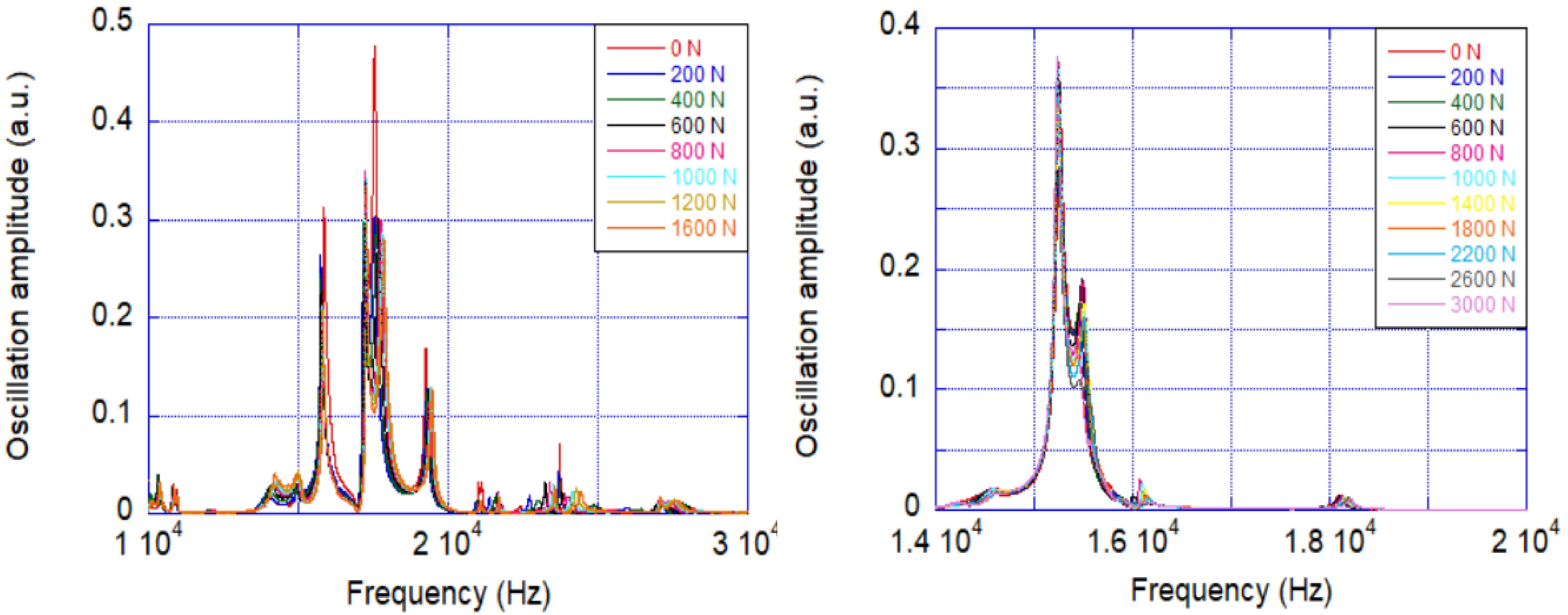


Figure 3: Oscillation versus excitation frequency for aluminium casting (left) and the iron cast metal (left) at different applied forces to the prototypes. The figure shows the spectra were the resonances are located in frequency space. At lower and higher frequencies no resonances can be found for both aluminium and iron cast.

Resonance frequency shift due to applied force

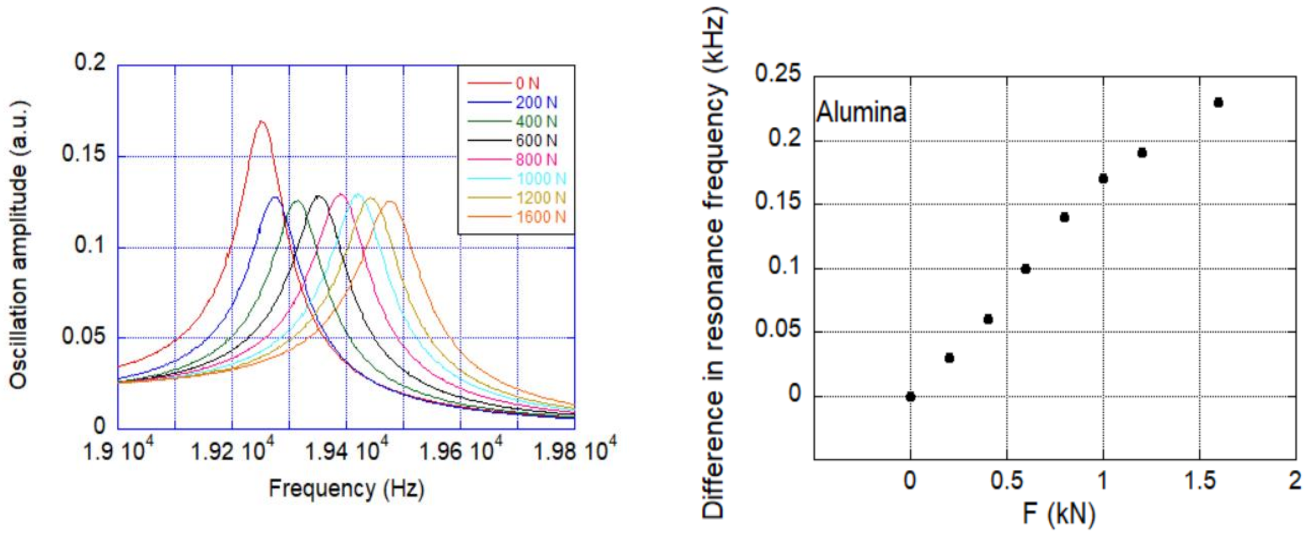


Figure 4: Oscillation versus excitation frequency for the aluminium casting (left) around frequencies of 19.2 kHz and the difference in resonance frequencies (relative to the 0 N value) (right) at different applied forces.

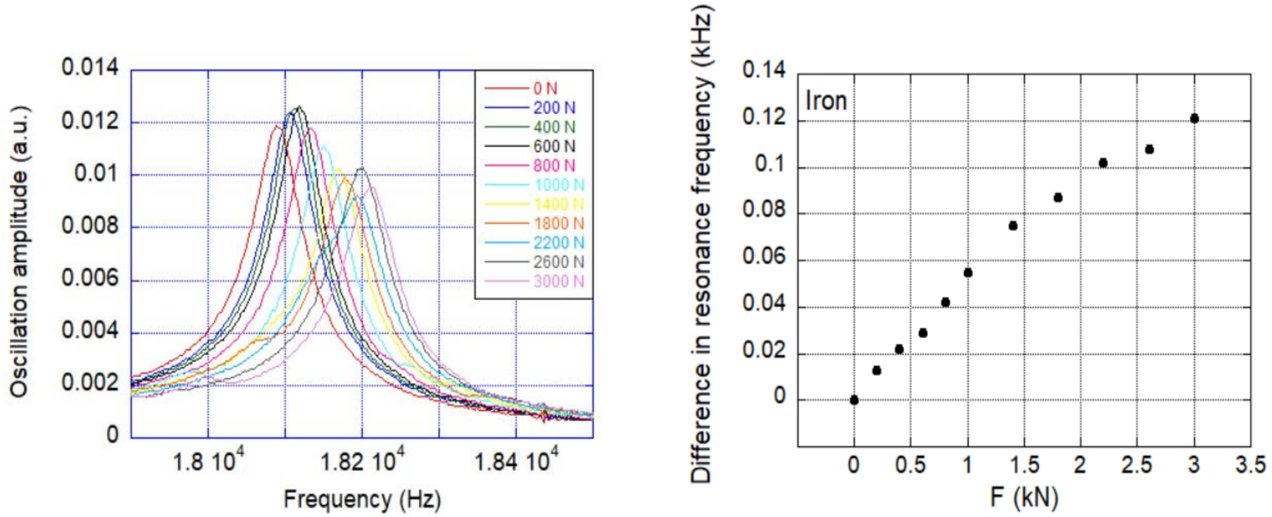


Figure 5: Oscillation versus excitation frequency for the iron casting (left) around frequencies of 19.1 kHz and the difference in resonance frequencies (relative to the 0 N value) (right) at different applied forces.

Conclusions

- It is possible to integrate signal carrying metal wires during the cast metal process.
- The integrated wire can be used to measure mechanical forces in cast metal systems.
- Experiments show parts of the resonance spectrum correlates well with applied force – this can be used for force monitoring.

Next steps: Widen consortium and continue research

Prototypes to continue this research

THANK YOU FOR YOUR ATTENTION!

QUESTIONS?

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