Bolt Monitoring by Silicon Strain Gauges

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Motivation

- Sensor for continuous monitoring of the condition of bolted joints in hard-to-reach places with miniaturised sensors
- Easy, reliable and flexible mounting of the sensor
- Wired or wireless data transmission
- 24/7 monitoring
- Real-time protocol and connection to networks

Damaged wind turbine (iStock.com/Pbouman)

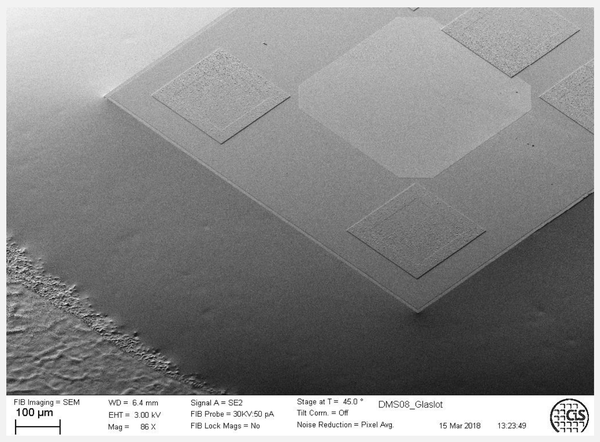
The Sensor

- Consists of 2 or 4 silicon strain gauges
- Smaller than foil strain gauges (0.5 x 0.5 mm²)
- High K-factor (approx. 80 instead of 2)
- Full or half bridge (Wheatstone circuit)
- Temperature stable up to 300 °C)

Two distributed sensors mounted on the screw head to correct measurement errors in the event of inclined loads

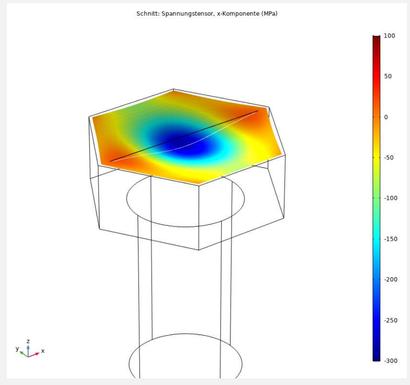
Glass Frit Bonding

- Joint connection for
  - Bonding of the Si stain gauge on the bolt with
  - Simultaneous transmission of mechanical stresses
- Differences CTE (stainless steel, silicon) must be taken into account



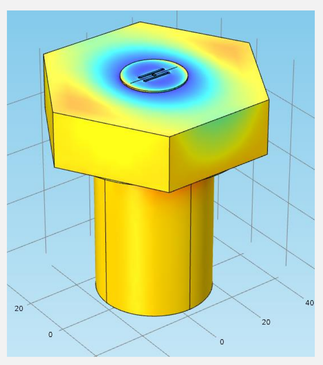
Si strain gauge embedded in a glass frit

Bolt Monitoring

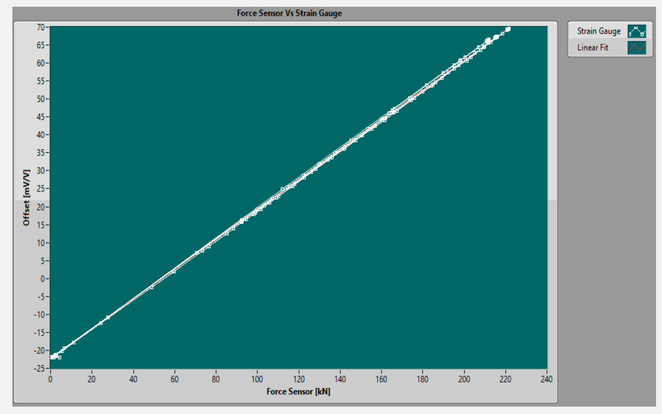


Component of the mechanical stress tensor

- The appropriate position of the Si strain gauge is determined using FEM analysis.
- With symmetrical loading of the Si strain gauge (full bridge) no signal -> positioning of the Si strain gauge off-centre.
- The use of a mounting bracket allows the Si strain gauge to be positioned in the centre of the bolt head
  -> Low transverse strain sensitivity, simpler joining process (test specimen mounting carrier).
- Positioning in the centre is independent of the bolt size.



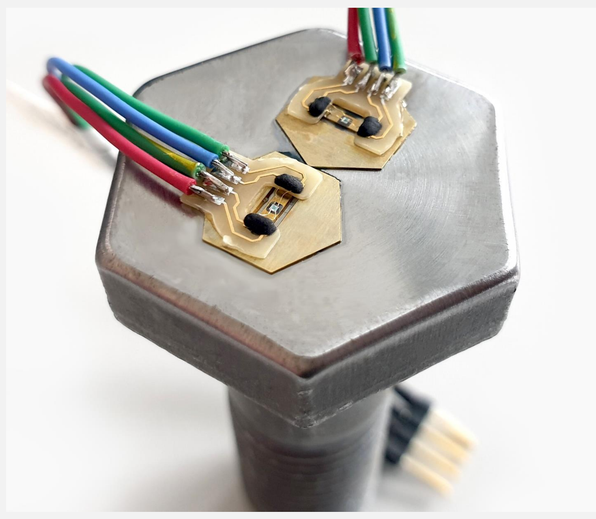
Bolt head with mounting bracket



Calibration of the sensor in the test bench

Summary

- The monitoring of bolted joints can be realised by monitoring the preload force on the bolt head.
- The measurement of operating forces is also possible.
- Force measurement with sensitive washers can also be realised.



Bolts with two MEMS-Sensor

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